Research Contribution 47

Production and Costs of Cut-to-Length Thinning: Experience from the Willamette Young Stand Project

by

Loren D Kellogg

Ben Spong

December 2004

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Forest Research Laboratory

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The Authors

Loren D. Kellogg is a Professor and Ben D. Spong is a Graduate Research Assistant in the Department of Forest Engineering, Oregon State University, Corvallis.

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Abstract

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Young Douglas-fir stands were commercially thinned to achieve vegetation- and wildlife-related objectives. Harvesting and forwarding production and costs were compared among three mechanized thinning treatments: light thin [(115 residual trees per acre (tpa)], light thin with 0.5-ac openings (92 residual tpa), and heavy thin (53 residual tpa). The sites were 40- to 50-yr-old stands in the Willamette National Forest in the Cascade Mountains of central western Oregon.

Using multiple linear regression equations with indicator variables, we compared both harvesting and forwarding cycle times among treatments. We conducted detailed time studies on a harvester and a forwarder and used these data to develop two regression equations to predict delay-free harvest cycle times and delay-free forwarding cycle times. Delay information was gathered from both shift-level and detailed time studies. Total costs for each treatment were obtained by combining costs for harvesting, forwarding, and moving equipment in and out for the entire operation.

Harvesting and forwarding costs did not differ significantly between light and heavy treatments, but were higher in the light-thin-with-openings treatment. Total thinning costs among the three treatments ranged from \$28.08 to \$34.62/100 ft^3.

Keywords: commercial thinning, mechanized harvesting, harvesting costs, silvicultural treatments, logging research

A list of published reports from the Willamette Young Stand Study is available at the following website: http://www.fsl.orst.edu/ccem/yst/pubs/pubs.html

Contents

Box: Unit conversions and abbreviations

1 foot (ft) = 0.305 meter (m)

1 inch (in.) = 2.54 centimeters (cm)

1 ft^2 = 0.093 m^2

1 ac = 4046.86 m^2 or 0.4047 hectares

1 ft^3 = 2.83 x 10^{-2} m^3

CCF	hundred cubic feet (ft^3)
DBH	diameter at breast height
MBF	thousand board feet
tpa	trees per acre
SD	Standard deviation

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Introduction

Federal forest policy and land use management objectives in the Pacific Northwest have shifted from timber production to ecosystem management in recent years. Ecosystem management recognizes that natural systems must be sustained in order to meet the social and economic needs of future generations (Kellogg et al. 1999). Harvesting activities in this region have therefore shifted rapidly from old-growth to second-growth stands (Kellogg and Bettinger 1992).

In this changing environment, land managers need to make sound economic and environmental decisions, including critical evaluations of harvesting methods and costs associated with alternative silvicultural prescriptions. With hundreds of thousands of forested acres in the Pacific Northwest in early seral stages (<50 yr old), commercial thinning of forest stands could provide a valuable supply of wood and wood fiber. However, further studies of the operational methods in different thinning regimes are needed to aid decision making (Curtis and Cy 1996).

Because of the large amount of small-diameter trees available for commercial thinning in second- and third-growth forests, the use of cut-to-length systems has increased dramatically in recent years (Brown and Kellogg 1995, unpublished report, Department of Forest Engineering, Oregon State University). In the Pacific Northwest, cut-to-length harvesting systems have been used increasingly for thinning gentle terrain because they handle small-diameter stems very efficiently, provide a safer, enclosed working environment, and consistently produce high-quality end products at a reasonable cost (Kellogg et al. 1992).

The Willamette Young Stand Project is a long-term multidisciplinary study undertaken by the Cascade Center for Ecosystem Management, Willamette National Forest, Oregon State University (OSU), University of Oregon, and the USDA Forest Service Pacific Northwest Research Station. It has been assessing the costs and benefits of managing young stands of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] for multiple resources in the western Cascades of Oregon. The aims are to determine the harvesting economics and resource implications, monitor wildlife impacts and vegetation response, evaluate tree growth and yield, assess mushroom productivity, and analyze social perceptions of three thinning treatments. These treatments were accomplished with three logging systems: small to mid-size skyline yarding, tractor skidding, and a mechanized (cut-to-length) system.

The harvesting economics and resource impacts were divided into four parts: planning and layout costs, logging production and costs, stand damage, and soil compaction. This paper summarizes detailed production and cost information for the mechanized (cut-to-

length) system. Kellogg et al. (1999) reported the results from the skyline yarding system, and those from the tractor skidding system will be reported in another paper. Planning and layout (Kellogg et al. 1998), stand damage (Han 1997; Han and Kellogg 1997), and soil compaction (Allen 1997) have already been described. Other aspects of the project will be reported as results become available. A list of published reports from this study is available at the following website: http://www.fsl.orst.edu/ccem/yst/pubs/pubs.html

Our specific objectives in this study were to

- develop regression equations that predict delay-free cycle times for harvesting and forwarding
- obtain information on harvesting and forwarding delays
- determine production rate and logging costs per unit volume for the whole system, and
- determine if harvesting system costs differ significantly among thinning treatments.

Project Description

Study Sites and Treatments

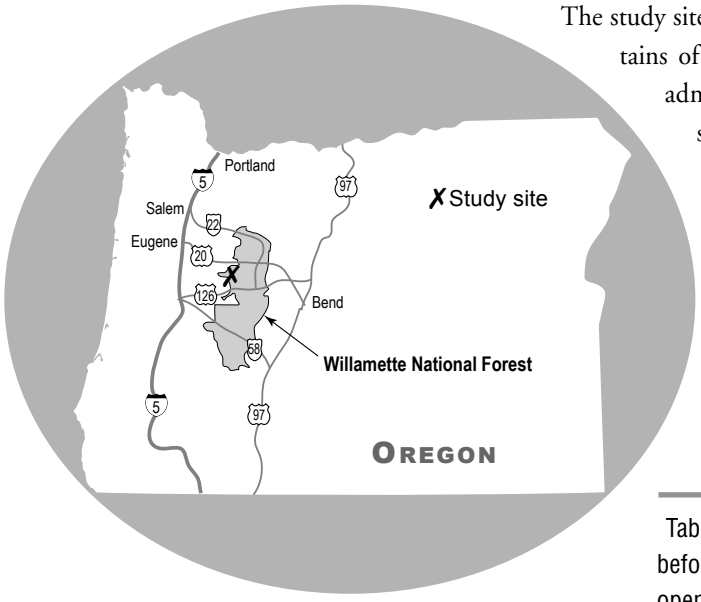

Figure 1. Study location (not to scale).

The study site (Figure 1) was located in the central western Cascade Mountains of Oregon. The study, named the Flat Thin Timber Sale, was administered by the Oakridge Ranger District. The dominant species on the site was second-growth Douglas-fir with some scattered western hemlock [*Tsuga heterophylla* (Raf.) Sarg.)] and western red cedar (*Thuja plicata* Donn ex D. Don). The site was clear-cut during the mid 1940s and early 1950s (Kellogg et al. 1999). After initial logging, the sites were broadcast burned and allowed to regenerate naturally for 2–4 yr before being interplanted with Douglas-fir. Detailed stand characteristics and physical environment before harvest for each treatment are described in Table 1.

Table 1. Physical environment and average site characteristics before commercial thinning of the light thin (LT), light thin with openings (LTO), and heavy thin (HT) treatment areas.

Treatment	Study area (ac)	Slope (%)	Season logged	Age (yr)	DBH (in.)	Tree height (ft)	Basal area (ft^2/ac)
LT	79	0–20	Fall	46	11.5	98	190
LTO	96	0–20	Fall/winter	46	11.8	100	163
HT	50	0–20	Summer/fall	46	10.6	102	206

The study site received four silvicultural treatments (Figure 2):

- Control (C), no thinning, with approximately 250 trees per acre (tpa). (This treatment was evaluated in other segments of the Willamette Young Stand Project, but is not treated in this report.)
- "Light thin" (LT), with 110–120 residual tpa. This was considered the traditional thinning treatment and is referred to as the base treatment throughout the report.
- "Light thin with openings" (LTO), residual tpa the same as in the LT treatment, but with additional 0.5-ac openings dispersed systematically throughout the unit to encompass 20% of the total unit area. After logging, the openings were planted with a mixture of Douglas-fir, western hemlock, and western red cedar.
- "Heavy thin" (HT), leaving 50–55 residual tpa, followed by underplanting with a mixture of Douglas-fir, western hemlock, and western red cedar.

The USDA Forest Service planned the sale, delineated treatment boundaries, and marked the residual leave trees. The timber sales were thinned from below, leaving the dominant and codominant trees after harvest (Kellogg et al. 1999). Volume removal for all thinning treatments ranged from 55% to 85% of the preharvest stand volume. The initial stocking levels and specific treatment prescription determined the total volumes removed in each treatment (Table 2).

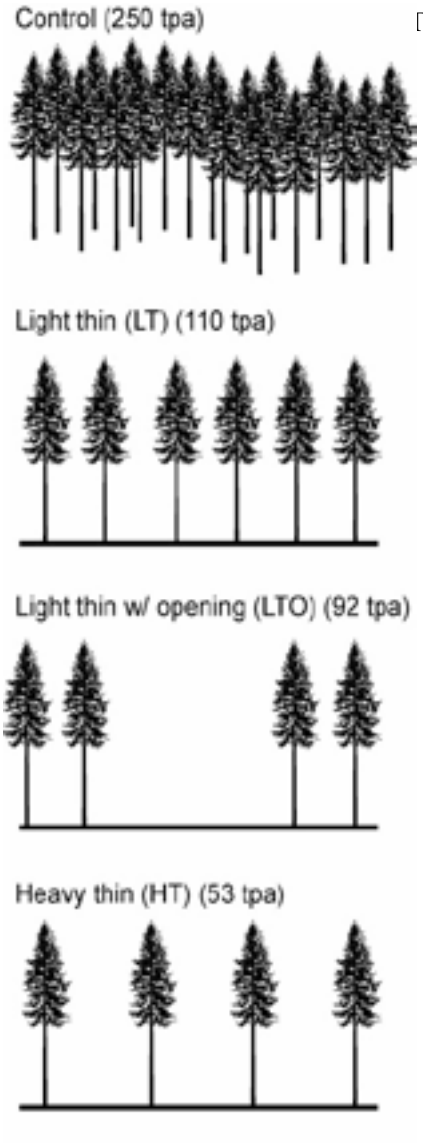

Figure 2. Thinning treatments (Hossain and Olsen 1998).

Table 2. Stand density before and after thinning and volume harvested in the light thin (LT), light thin with openings (LTO), and heavy thin (HT) treatments.

	Average stand density (tpa)		Tpa removed	Volume harvested	
Treatment	Preharvest	Postharvest	by thinning	MBF/ac	CCF/ac[a]
LT	262	115	147	12.67	39.78
LTO	214	92	122	13.47	42.29
HT	334	53	281	15.99	50.21

[a]Derived from conversion factor of (3.14)(MBF) = CCF (MBF and CCF obtained from scale ticket information).

Forest Operations

A single harvester-forwarder pair was used to complete the thinning. The harvester was a Timberjack 2618 (tracked carrier; Timberjack, Moline, IL) with a squirt boom and a Waterous (Timberjack, Moline, IL) 762b hydraulic harvesting head ($410,000 US). A single harvester operator with >1 yr of experience was timed for all the treatments in the detailed time studies.

The forwarder was an eight-wheel-drive Timberjack 1210 ($293,000 US) fitted with bogie tracks on the rear tires. Three forwarder operators were timed for the treatments in the detailed time studies: one operator for both the LT and HT forwarding, and two operators for the LTO. Two operators were experienced; the third had <1 yr of experience with the machine. Short-log trucks (B-trains) were used to transport logs to the mills (Brown and Kellogg 1995, unpublished

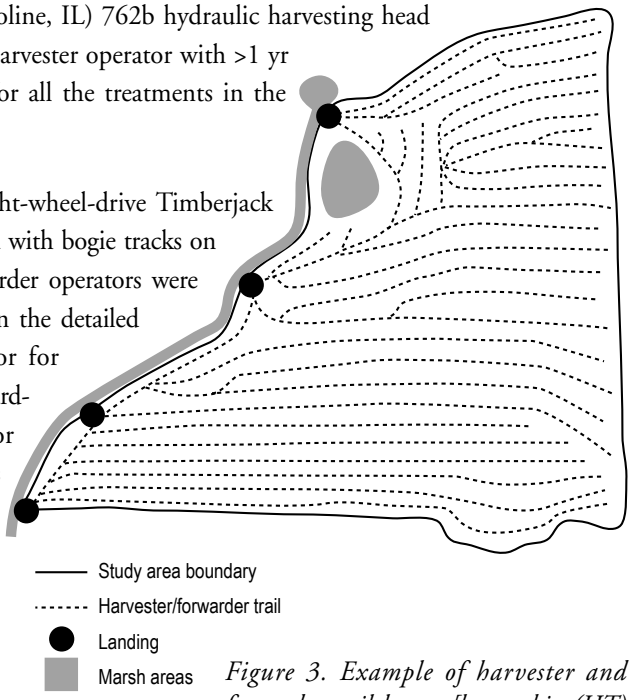

Figure 3. Example of harvester and forwarder trail layout [heavy thin (HT) treatment, Flat Thin site].

report, Department of Forest Engineering, Oregon State University, Corvallis). Figure 3 illustrates harvester and forwarder trails and landings in the HT treatment as an example.

Study Methods

Harvester Cycle

The trees to be harvested during the study were each marked with a number; diameter at breast height (DBH), species, and slopes were then recorded. Heights and volumes for each tree were estimated from cruise data and regression equations adapted from Zumrawi and Hann (1993). Tree data were later linked to the appropriate cycle time gathered during the study.

The harvester cycle for this study covered the harvest of a single tree. The cycle was broken up into the potential activities and delays described in Glossary 1. Times (centimin) were allotted to defined activities as they occurred during the cycle, which were then combined to give the total cycle time.

Glossary 1: Harvesting Elements and Delays

Element	Definition
Position	Any time the harvester is moving or positioning the boom; starts when the harvester begins traveling to its desired position or positioning the boom, and does not include boom or vehicle positioning during processing. The time ends when the felling begins.
Fell	Starts when the harvesting head grasps the tree, ends when tree is on the ground or processing begins
Process	Starts when the tree is fed through the harvesting head, ends when the tree has been completely processed and the operator is ready to begin the next task
Swing	Time spent bunching/moving logs beyond what occurs during processing
Delay	
Mechanical	Nonharvesting time occurring because of the machine
Personal	Nonharvesting time occurring because of the operator
External	Nonharvesting time occurring because of external influences to the production system (machine or operator). External delays include time for planning, crew meetings, or talking to the sale administrator.
Brushing	Any time spent clearing brush
Chain and bar	Time spent fixing/replacing saw chains or bars
Obstacles	Time spent moving obstacles (large rotten cull logs) out of the travel path
Miscellaneous	Additional personal and mechanical delays

Productive cycle time was summarized from observed data as the portions of total cycle time that the harvester was delay-free (positioning, felling, processing, and swinging). The delay-free cycle time for the harvester was calculated from the harvester regression equation (Equation 1, p. 14) and average values of the independent variables.

Forwarder Cycle

The forwarder cycle began as the empty machine left the landing to pick up a load and ended after it unloaded the last log from its bunks. Load volumes were estimated by recording the number and types of pieces loaded onto the forwarder and multiplying by the average volume per log for each log type. Average sawlog volume was obtained from the sample scaling of sawlog loads. The average pulpwood volume was obtained from the harvester's onboard computer, which measured and tracked each piece of pulpwood as it was harvested. The forwarder filled its bunks with a single product, traveling through the unit picking up large sawlogs, small sawlogs, or pulp. Once a complete load of the single product type had been made, the forwarder traveled to the landing and offloaded logs into separate decks based on the log type. Occasionally a mixed-product load would be made if there were not enough of the primary product to create a full load.

Times (centimin) were again allotted to defined activities and delays as they occurred during the cycle and combined to give the total cycle time for the forwarder. The forwarder's cycle was broken down into the potential activities described in Glossary 2.

Productive cycle time was summarized from observed data as the portions of total cycle time that the forwarder was delay-free (travel out + loading + travel loading + travel full + bunk to deck unloading + bunk to truck unloading). The delay-free cycle time for the forwarder was calculated from the forwarder regression equation (Equation 2, p. 16) and average values of the independent variables.

Detailed Time Study

Detailed time studies were conducted to collect data on machine work cycles, small delays, and production rates. The recorded data included productive cycle time elements and other independent variables associated with each activity as defined in Glossaries 1 and 2. Two researchers collected the detailed time-study data.

Each productive work element time and delays for both harvester and forwarder were recorded in centimin on a Husky Hunter II hand-held computer and SIWORKS3 (Danish Institute of Forest Technology 1988) software package. Data were downloaded to a personal computer for data management and analysis. We used forward stepwise multiple regression (Statgraphics Plus 2.0, Manugistics Inc., Rockville MD) to develop equations for predicting delay-free cycle times for harvesting and forwarding. The independent variables were selected as significant from the regression when $P < 0.05$. Ten percent of the detailed time study data was reserved before the

Glossary 2: Forwarding Elements and Delays

Element	Definition
Travel out	Time spent traveling to where the first log is loaded
Loading	Time spent loading the forwarder's bunks (stationary)
Travel loading	Time spent traveling during loading
Travel full	Time spent traveling to the landing with a full load
Bunk to deck	Time spent unloading the bunks to decks
Bunk to truck	Time spent unloading the bunks to waiting trucks
Delay	
Mechanical	Nonforwarding time that occurred because of the machine
Personal	Nonforwarding time that occurred because of the operator
External	Nonforwarding time that occurred because of external influences to the production system (machine or operator)
Branding	Time spent applying brand and/or paint to log butts
Wait for truck	Time spent waiting for trucks on the landing
Load trucks	Time spent loading trucks from decks. Truck loading times were calculated by summing the unload-to-truck, wait-for-truck, and load-truck times for a given cycle. Total unloading time for the forwarder's bunks was calculated by summing the unload-to-deck and unload-to-truck times.
Clean/brush	Time spent removing brush from bunks or gathering brush to place on trails

regression model building for use in validating the regression models. Predicted cycle times were compared with observed during validation by a paired *t*-test ($\alpha = 0.05$).

The LTO and the HT treatments were compared with the LT base treatment. For the LTO treatment, the data for the LT between the openings (LTBO) were analyzed separately from those from the openings (OP) in order to capture the actual effects of the openings. A weighted average based on volume removed from each area (LTBO and OP) was applied when determining production rates and costs.

Shift Level Study

Shift-level studies were conducted to gather data on scheduled hours, daily production, and large delays (>10 min). Harvester and forwarder operators were responsible for filling out the

Table 3. Average number of pieces and volume per forwarder cycle, by type, in the LT, LTO, HT, and all treatments.

Piece type[a]	LT	LTO	HT	All treatments
Large saw	5.00	4.00	6.90	5.25
Saw log	62.35	47.73	69.33	59.45
Pulp	0	26.76	0	9.39
Total pieces	67.35	78.49	76.23	74.09
Total volume (CCF)	6.58	5.71	7.73	6.64

[a]Forwarder loads comprised a mixture of piece types:

0.3091 CCF/piece (Large saw)

0.0808 CCF/piece (Saw log)

0.0228 CCF/piece (Pulp)

These volumes per piece are the same for the three treatments.

shift-level form daily. Additionally, the loader operator recorded scale ticket information and number of truckloads per day.

Volume information on large saw logs (LargeSaw), small saw logs (SawLog), and pulp pieces (Pulp) was obtained from a random sample of two loads of saw logs and two pulp truck loads that were scaled off site. Average hundred cubic feet (CCF) were calculated for each treatment. The average number of pieces per forwarder cycle by treatment and piece type is shown in Table 3.

Delays

Small delays (<10 min) were captured during the detailed time study and are described in Glossaries 1 and 2. Large delays (>10 min) were gathered from the shift-level information. Data from the two study methods were combined to calculate total percent delay time.

Cost Analysis

Harvesting and forwarding operations costs (Appendix) for owning and operating costs associated with the specific equipment and personnel used were calculated in 1996 dollars. These costs were based on the time of the field study (1996) for comparison with other Willamette Young Stand Project harvesting studies. The reported costs can be updated from 1996 to June 2003 by applying a cost index factor of 1.17 (US Department of Labor 2003). Costs were calculated using standardized values for DBH and volumes and $0.40/CCF added to the total costs shown in the Appendix for move-in and move-out costs.

The PACE (Sessions and Sessions 1986) computer package was used in cost calculation. The unit costs in $/CCF were determined from this cost and the production rate predicted from the regression analysis. Finally, the stump-to-truck extraction costs, not including profit and risk, were calculated. The planning and layout costs for this study, previously reported by Kellogg et al. (1999), and sale administration expenses were not used in this cost analysis.

The following components were used to calculate production rates and costs for harvesting and forwarding:

- *effective hour (min/h)*: productive time, determined from the percent of time lost in delays from the detailed and shift level time studies (felling or yarding) for a site. For example, a site with 20% of its time in delays would have an effective hour of 60(1 – 0.20) = 48 min/h.
- *delay-free cycle time (min/cycle)*: determined by inserting the average values for the independent variables into the harvesting or forwarding regression equation for a site

- *volume per cycle (CCF/cycle)*: volume per piece type (log, top, fiber) determined from the shift-level study; total pieces per cycle determined from the detailed time study
- *owning, operating, and labor cost ($/h)*: determined from a cost appraisal of the specific equipment and personnel used at each site (Appendix)
- *net:gross timber scale*: a ratio of net volume (no defects in wood) to gross volume, determined from the shift-level study.

These components were used to calculate production rates and costs as follows, using data for either felling or yarding:

- production rate = (effective hour/delay-free cycle time) × (volume/cycle)
- cost = (owning, operating, and labor costs)/[(production rate) × (net:gross timber scale)]

Results

Harvesting and Forwarding Models

Harvesting

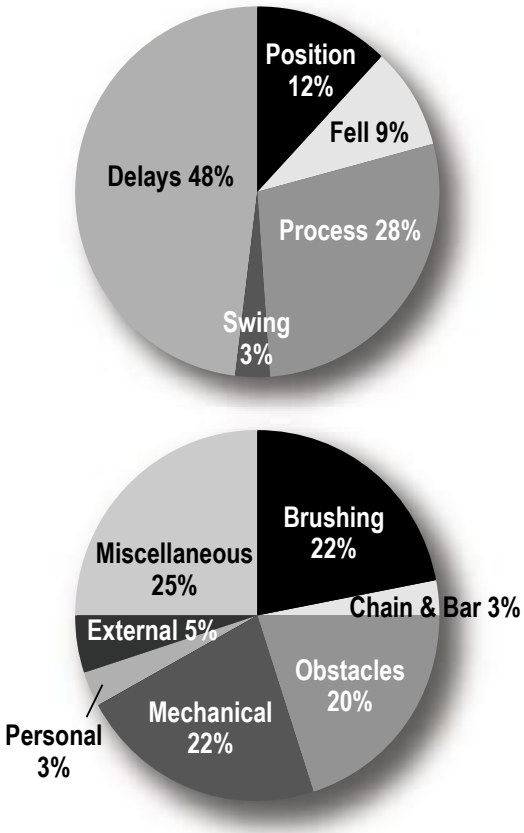

Figure 4. Percentage breakdown of (A) harvesting cycle elements (1.93 min average cycle) and (B) total harvesting delays. See Glossary 1 for descriptions of categories.

The detailed time-study data were used to determine the percentage of each of the harvesting cycle time elements for the three treatments combined (Figure 4A). Harvesting delays (Figure 4B) consumed 48% of the average cycle time. Delays were not treatment specific (Hossain 1998).

In order to predict delay-free harvesting cycle time, we developed the following regression model from the detailed time study data:

$$\text{Harvest (min/cycle)} = 1.1974 + 0.1977\ \text{Logs} + 0.4343\ \text{Hangup} - 0.2059\ \text{DBH} + 0.0106\ \text{DBH}^2 + 0.1567\ \text{OP} \quad [1]$$

adjusted R^2 = 51.51%; standard error (SE) = 0.421 min/cycle; sample size = 765 cycles (trees)

where the variables are as defined in Glossary 3.

Glossary 3: Variables Used in the Harvesting Regression Equations (Hossain 1998)

Harvest	Delay-free harvesting cycle time (min); includes position, fell, process, and swing
Logs	Number of logs/cycle (1 tree = 1 cycle)
Hangup	1 = hang-up occurs in a cycle (the harvested tree is lodged into another tree); 0 = otherwise
DBH	Diameter at breast height of tree (in.)
DBH^2	Diameter at breast height squared ($in.^2$)
OP	1 = harvesting in 0.5-ac openings; 0 = otherwise

Summary statistics for the significant independent variables ($P \leq 0.05$) used to determine the delay-free cycle time for the harvester are given in Table 4. In this model, the OP portion of the LTO treatment differed significantly from the LT treatment, whereas the HT treatment did not.

Table 4. Summary statistics for the independent variables significant in the harvesting regression equation [Equation 1] in the light thin (LT), light thin with openings (LTO), heavy thin (HT), and all treatments.

	Treatment			
Variable[a]	LT (*n* = 161)	LTO (*n* = 343)	HT (*n* = 261)	All (*n* = 765)
Logs (number)				
Average (SD)	3.33 (1.11)	3.39 (1.03)	3.10 (1.18)	3.28 (1.10)
Range	1–8	1–6	1–6	1–8
Hang-ups (0-1)				
Average (SD)	0.02 (0.16)	0.08 (0.27)	0.02 (0.12)	0.05 (0.21)
Range	0–1	0–1	0–1	0–1
DBH (in.)				
Average (SD)	10.80 (3.46)	12.64 (4.00)	10.90 (3.70)	11.66 (3.89)
Range	5.30–19.40	5.30–21.70	5.00–21.80	5.00–21.80
Openings (0-1)				
Average (SD)	0	0.46 (0.50)	0	0.21 (0.40)
Range	0	0–1	0	0–1

[a]Independent variables are defined in Glossary 3.

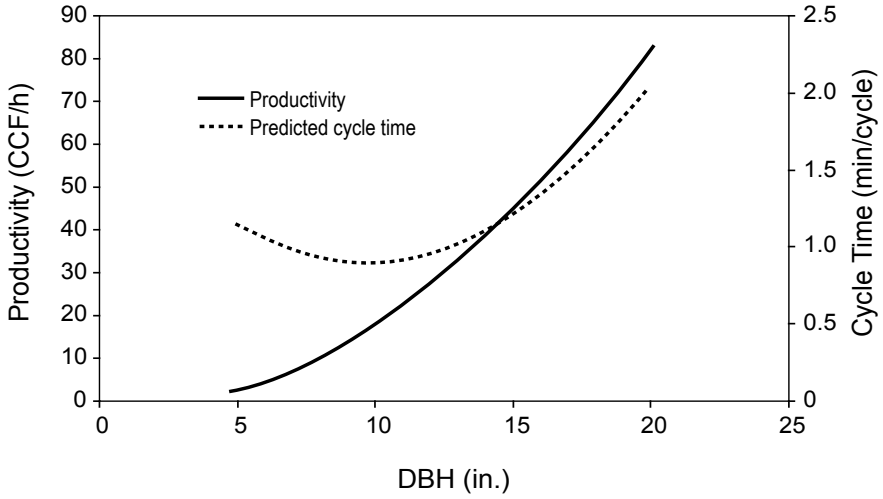

Figure 5. Harvester cycle times as a function of DBH.

Each log added 0.1977 min to the total cycle time. Hanging up a tree during harvester operation increased the cycle time by 0.43 min. The quadratic variable DBH^2 increased the cycle time by 0.0106 min for each unit value of the variable. This was the only curvilinear variable of the regression equation. In the 20% of the cycles within the OP portion of the LTO treatment, the harvester cycle was 0.16 min longer than in the LT treatment. The delay-free cycle times predicted by Equation 1 were used to calculate harvesting production rates in both CCF/h and min/cycle (Figure 5).

Forwarding

The detailed time-study data were used to determine the percentage of each of the forwarding cycle elements for combined treatments (Figure 6A). "Loading" was the most time-consuming element in the forwarding cycle, taking up 39% of the time. Forwarding delays consumed 18% of the average cycle time; their percent distribution is shown in Figure 6B. Delays were not treatment-specific (Hossain 1998).

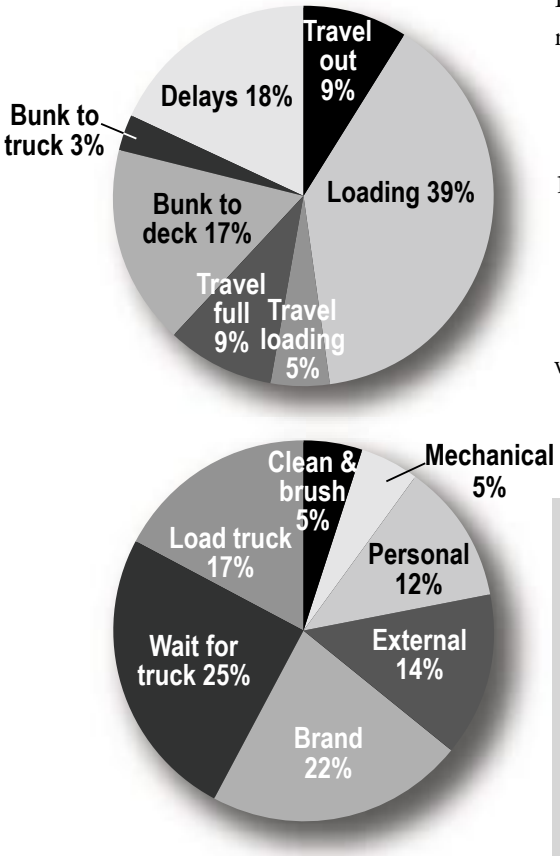

Figure 6. Percentage breakdown of (A) forwarding cycle elements (52.63 min average cycle) and (B) total forwarding delays. See Glossary 2 for descriptions of categories.

In order to predict delay-free forwarding cycle time, we developed the following regression model from the detailed time-study data:

Forward time (min/cycle) = 14.6362 + 0.0051 Outdist + 0.0053 Loaddist + 0.0070 Indist + 0.2533 Largesaw + 0.0698 Sawlogs + 0.0988 Pulp + 11.5297 LTO [2]

adjusted R^2 = 78.14%; SE= 4.20 min/cycle; sample size = 94 cycles (forwarder load)

where variables are as defined in Glossary 4.

Glossary 4: Variables Used in the Forwarding Regression Equations (Hossain 1998)

Forward	Delay-free forwarding cycle time (min)
Outdist	Distance from landing to the point where first log is loaded (ft)
Loaddist	Distance traveled while loading (ft)
Indist	Distance traveled to landing once fully loaded (ft)
Largesaw	Number of large saw logs per cycle (1 cycle = 1 forwarder load)
Sawlogs	Number of sawlogs/cycle
Pulp	Number of pulp logs/cycle
LTO	1 = forwarding in LTO treatment; 0 = otherwise

Summary statistics for the significant independent variables ($P \leq 0.05$) used to determine the delay-free cycle time for the forwarder are shown in Table 5. The LTO treatment variable was the most influential variable in the model. Including the LTO treatment variable added >11.5 min to the LT cycle time. We used the delay-free cycle times predicted by the regression to calculate production rates:

CCF/productive hour (PH) = load volume/(delay-free cycle time/60)

The production curves for largesaw and sawlog products were similar (Figure 7). The sawlogs were loaded faster than the largesaw, but the greater volume/piece of largesaw logs compensated for the slower loading rate when production rates were compared in CCF/h. The cycle time for loading pulpwood was significantly slower than for the other two products.

Table 5. Summary statistics for the independent variables significant in the forwarding regression equation [Equation 2] in the light thin (LT), light thin with openings (LTO), heavy thin (HT), and all treatments.

	Treatment			
Variable[a]	LT *n* = 31	LTO *n* = 33	HT *n* = 30	All *n* = 94
Out distance (ft)				
Average (SD)	626 (381)	676 (262)	1294 (561)	857 (515)
Range	90–1,650	200–1,230	300–2,170	90–2,170
Load distance (ft)				
Average (SD)	250 (274)	293 (324)	334 (532)	292 (393)
Range	40–1,350	30–1,800	35–2,540	30–2,540
In distance (ft)				
Average (SD)	614 (439)	461 (258)	1027 (607)	692 (514)
Range	129–2,100	0–1,000	100–2,000	0–2,100
Large saw (number)				
Average (SD)	5.00 (10.64)	4.00 (9.13)	6.90 (14.53)	5.26 (11.51)
Range	0–35	0–33	0–44	0–44
Saw logs (number)				
Average (SD)	62.35 (29.91)	47.73 (35.22)	69.33(33.63)	59.45(33.93)
Range	0–99	0–92	0–108	0–108
Pulp (number)				
Average (SD)	-	26.76 (55.85)	-	-
Range	-	0–186	-	-
Light w/ openings (0-1)				
Average (SD)	-	1(0)	-	0.35 (0.48)
Range	-	0–1	-	0–1

[a]Independent variables are defined in Glossary 4.

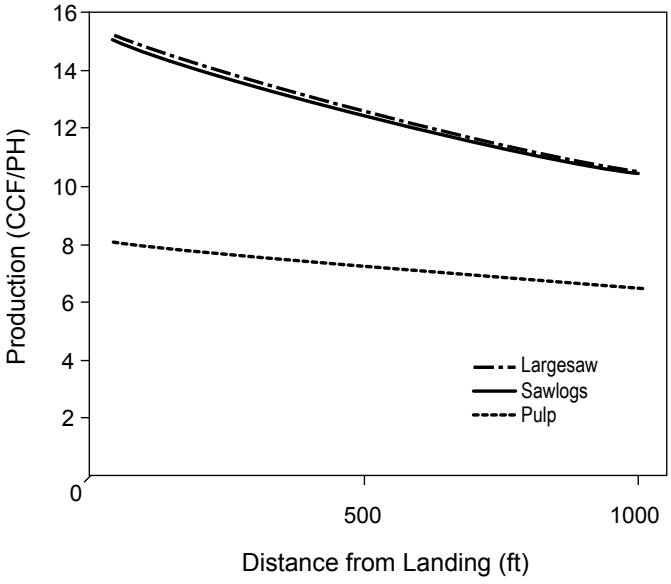

Figure 7. Forwarder production as a function of distance and log type.

Sensitivity of Models

Both the linear and quadratic DBH variables in the harvesting regression equation affect the harvesting cycle time and productivity [Equation 1]. For example, the cycle time was shortest for harvesting trees with an average DBH of 10 in., rising exponentially with trees >10 in. DBH (Figure 5). Productivity also increased steadily over this same DBH range, even though cycle time was climbing in the diameter classes >10 in. The larger overall volumes of the larger diameter trees were more

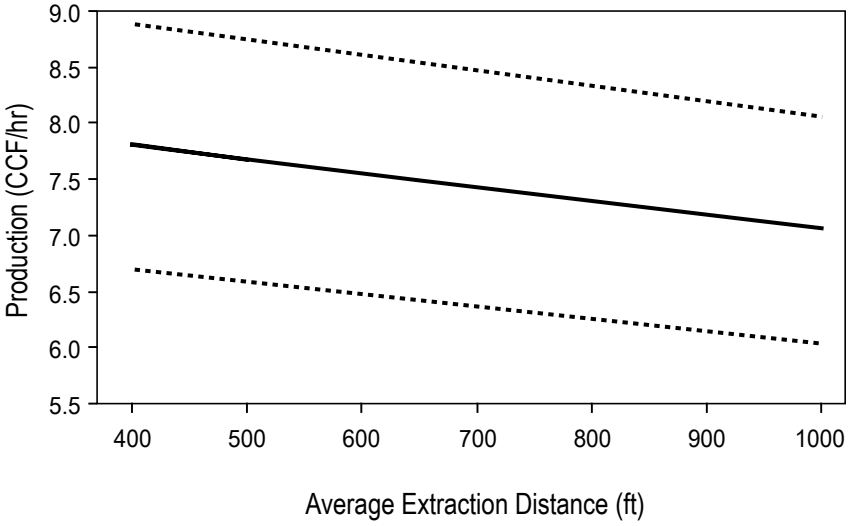

Figure 8. Forwarder production as a function of distance with 95% confidence interval at the light thin (LT) treatment.

significant to the harvesting productivity than were the longer cycle times required to harvest each tree.

The sensitivity of forwarder production in CCF/h with average extraction distance for LT treatment as an example is shown in Figure 8. Forwarder production decreased linearly with the increase of distance.

Mechanized Thinning Costs

The mean harvesting cost decreased with increasing DBH, then leveled out for trees between 10–20 in. DBH (Figure 9) The predicted productivity and harvesting costs were 5.26% higher in the LTO treatment than in either the LT or the HT treatments (Table 6) because the cycle time for the LTO treatment was 0.055 min longer than in the other two treatments. Harvesting costs averaged $11.44/CCF for all three treatments combined. The predicted production rate for the LTO treatment was lower than that for the LT treatment, while the actual production for the LTO treatment was higher than that of the LT treatment. This could be attributed to the larger average diameter of the trees in the LTO treatment (Table 4).

The forwarding costs of the LTO treatment were 34.97% higher than those of the LT and HT treatments (Table 7). The average forwarding cost for all three treatments was $13.07/CCF. The

Table 6. Predicted harvesting production rate and costs in the three treatments using standardized volume and DBH values of the Willamette Young Stand Project.

Treatment	Delay-free total cycle time[a] (min)	Trees/h	Production rate[b] (CCF/h)	Cost[c] ($/CCF)
LT	0.907	33.2	9.67	11.24
LTO[d]	0.962	31.5	9.17	11.83
HT	0.907	33.2	9.67	11.24

[a]From multiple linear regression equation.

[b]Net scale volume: includes all delay time.

[c]Owning, operating, and labor costs were $103.80/h and move in cost was $0.40/CCF. Gross to net scale = 0.99.

[d]Values for the LTO treatment were calculated by using a weighted average of 65% "light between" and 35% "openings", based on volume removed from each area.

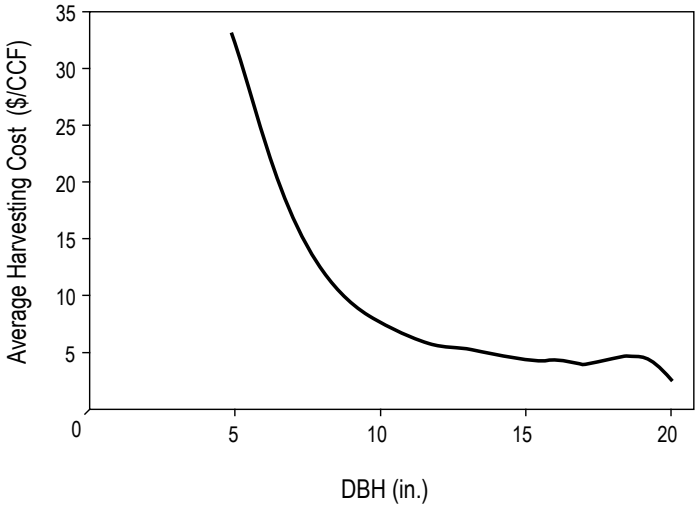

Figure 9. Variation of harvester processing cost with DBH (all treatments).

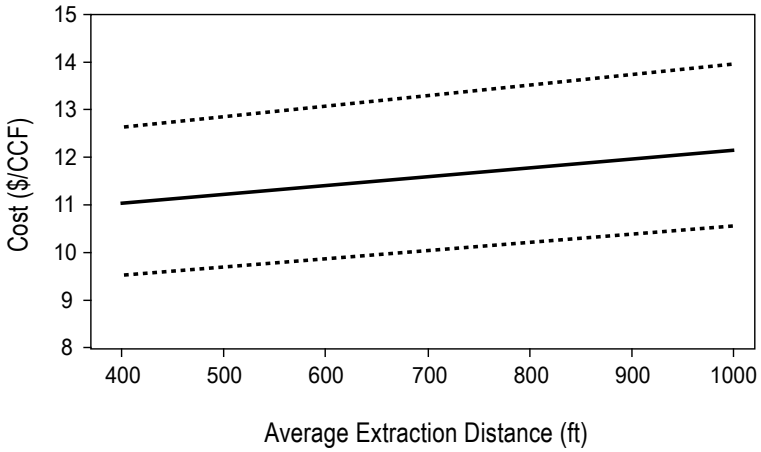

Figure 10. Forwarder costs as a function of distance with 95% confidence interval at light thin (LT) treatment.

mean forwarding cost changed linearly with distance (Figure 10), reaching a minimum when the extraction distance was the shortest.

Total mechanized thinning costs ranged from $28.08/CCF in the LT and HT treatments up to $34.62/CCF in the LTO treatment (Figure 11). The HT treatment costs were identical to the LT costs, whereas the LTO treatment was significantly more expensive.

The total costs of harvesting and forwarding were identical in the LT and HT treatments and significantly lower than in the LTO (P = 0.0218). The LTO mean forwarding cycle time was 11.53 min longer than that of the LT.

Table 7. Predicted forwarding production rate and costs, obtained using standardized volume and DBH values, for the light thin (LT), light thin with openings (LTO), and heavy thin (HT) treatments.

Treatment	Delay-free total cycle time[a] (min)	Production rate[b] (CCF/h)	Cost/CCF[c] ($/CCF)
LT	31.844	7.30	11.71
LTO[d]	43.374	5.36	15.80
HT	31.844	7.30	11.71

[a]From multiple linear regression equation.

[b]Net scale volume: includes all delay time.

[c]Owning, operating, and labor costs were $81.69/h and move-in cost was $0.40/CCF. Gross to net scale = 0.99

[d]Values for the LTO treatment were calculated by using a weighted average of 65% "light between" and 35% "openings", based on volume removed from each area.

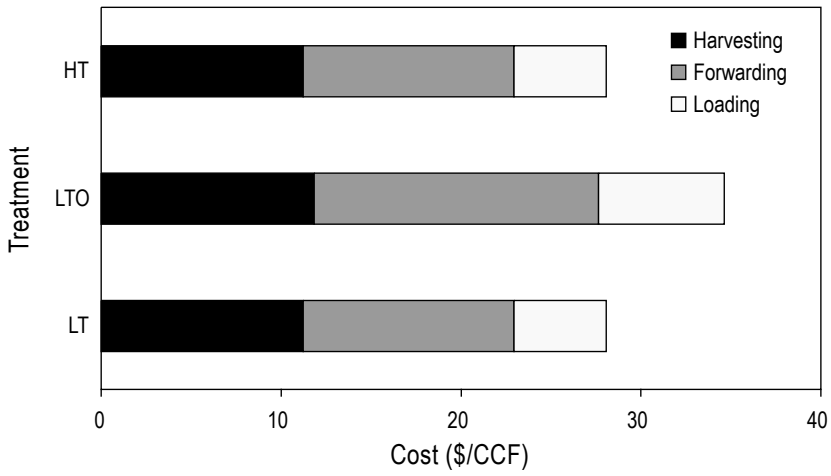

Figure 11. Total mechanized thinning costs, obtained using standardized volume and DBH values, for the light thin (LT), light thin with openings (LTO) and heavy thin (HT) treatments.

Discussion

The major influence governing the thinning costs of treatments was cycle time (min/cycle). The delay-free cycle time for both harvesting and forwarding was statistically longer in the LTO treatment from both the LT and the HT treatments but did not differ between the latter two. In the harvester model, the OP treatment variable, which denotes if harvesting is occurring within one of the 0.5-ac openings, differed significantly from those in the HT and the LT treatment variables. Similarly, the forwarder model showed a significant difference between the LTO treatment and the other two thinning treatments.

Both the initial stand stocking level and the post-harvest residual stand density influenced the thinning removal per acre. Although the number of trees removed in the LTO treatment was expected to be somewhere between the numbers in the LT and the HT treatments, the fewest trees were actually removed from the LTO treatment. Because of the larger tree diameters in the LTO treatment, the volume harvested per acre was intermediate between the other treatments.

According to the manufacturer's specifications, the Waterous 762b harvesting head can handle trees up to 20 in. DBH. Trees with DBH approaching this limit became increasingly difficult for the harvester to handle. Because of their weight, the harvesting head often had to regrip trees, and larger trees occasionally fell out. Some of the larger trees could also not be processed by the head, requiring the operator to swing the boom to facilitate debranching. For this particular harvester head configuration, the highest productivity in terms of trees per hour likely would be realized in uniform stands of trees with DBH of 9–11 in.

For forwarding operations, the higher cycle time and resulting lower production in the LTO treatment raised the cost significantly over the cost for the LT and the HT treatments. The difference in costs between the treatments likely are attributable to operational variables that were not captured in the time study, such as different machine operators, product types, and offloading methods.

The production rate of the forwarder depended on the product type. The expertise of the operator also is very important to the production rate and significantly influences the overall cycle time; 64% of the forwarder's time is occupied by loading and unloading, which require adept operators. The cycle time also was influenced by travel distance, with longer distances requiring more travel time than shorter distances. However, the relatively small contribution of travel time to the full cycle time results in a limited overall impact.

The harvester in this study could process 43% more volume than the forwarder could forward to the landing. This allowed the harvester to work comfortably ahead of the forwarder, increasing the space between working areas and, therefore, increasing the operating safety and creating a productivity buffer. These production rates were a function of tree size, however; the production of the harvester decreased and the production of the forwarder increased with larger trees.

Conclusions

This study provided a good sample of silvicultural treatments using a harvester and forwarder combination. The use of regression equations with indicator variables was effective in establishing significant differences between treatments where they existed. This demonstration is similar to previous studies by Kellogg et al. (1999), Olsen et al. (1998), and Hossain (1998).

The initial stand density levels were not uniform among the treatments. This affected trees removed/ac, even though the desired stand densities were achieved, with an undetermined effect on productivity and costs.

Total cost of mechanized thinning was highest in the LTO treatment. The cost differences between all treatments were relatively small, providing land managers with a variety of potential silvicultural alternatives. Land managers can refer to the results of this study to help guide them through choosing the most appropriate silvicultural treatment to meet the landowner's objective. In addition, the study provides logging contractors with detailed information on equipment productivity and thinning costs with the cut-to-length logging system.

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APPENDIX: Hourly Owning and Operating Costs of Harvester and Forwarder Operation

Table A-1. Hourly owning and operating costs of harvester and forwarder operation, based on 10 h/day and 200 days/yr.

Item	Harvesting costs ($)	Forwarding costs ($)
Timberjack 2618 harvester	94.45	
Timberjack 2010 forwarder		72.34
Pickup 4x4	1.89	1.89
Used landing Cat (D7G)	4.23	4.23
Fire truck (1500-gal, used)	0.25	0.24
Shop truck, 4x4	1.98	1.98
Landing supplies	1.00	1.00
Total cost/h	**103.80**	**81.69**

Notes:
Landing Cat and vehicles pro-rated over a 10-h day.
Reported costs for the pickup, cat, fire truck, shop truck, and landing supplies were divided by 2 to share the costs equally between the harvester and the forwarder.
A Koehring 6630 Tract-Mount Loader costing $37.06/h was used for loading trucks on approximately 30% of the harvest area. The loader was operated by on-site personnel; therefore, no labor cost is included for the loader.

Research Contribution 44

March 2004

An Annotated Bibliography of Selected Guides for Stream Habitat Improvement in the Pacific Northwest

by

Richard F Keim

A Blake Price

Timothy S Hardin

Arne E Skaugset

Douglas S Bateman

Robert E Gresswell

Steven D Tesch

OREGON STATE UNIVERSITY

COLLEGE OF FORESTRY

Forest Research Laboratory

Abstract

Keim, RF, AB Price, TS Hardin, AE Skaugset, DS Bateman, RE Gresswell, and SD Tesch. 2003. *An Annotated Bibliography of Selected Guides for Stream Habitat Improvement in the Pacific Northwest*. Research Contribution 44, Forest Research Laboratory, Oregon State University, Corvallis.

This annotated bibliography is a response to widespread interest in stream habitat improvement in the Pacific Northwest by land managers, governmental and nongovernmental organizations, and the lay public. Several guides to stream habitat improvement have been written in the past, but may not be easily accessible to people from diverse backgrounds. This annotated bibliography reviews 11 guides to stream habitat improvement so that readers can find literature appropriate to their needs. All reviews begin with summaries of the contents, stated audiences, and goals of each guide. Reviews also include subjective comments on the strengths and weaknesses of each guide. Finally, this bibliography includes recommendations of guides and combinations of guides judged most useful for a range of purposes.

Keywords: aquatic habitat, fisheries, restoration, salmonids, stream management

Contents

Introduction

Modifying stream channels to improve habitat for fish has become a common practice (Everest et al. 1991; Reeves et al. 1991), especially for anadromous salmonids in the Pacific Northwest (Armantrout 1991). Interest in aquatic habitat improvement has expanded beyond fisheries managers to include land managers, nongovernmental organizations, and the lay public (Maleki and Moore 1996), partially in response to declining populations of fish (Nehlsen et al. 1991). While eager to undertake projects, many of these people lack background and technical expertise in fisheries, stream ecology, and hydrology, and in how to modify aquatic habitats in order to produce the desired results. For these reasons, there is demand for information about habitat improvement at all levels of complexity and sophistication.

Many technical reports and guides address the subject of stream habitat improvement. The major difficulty faced by individuals who wish to improve aquatic habitat is that there is no single, concise source of information to help them make decisions about whether modifications are appropriate, and how to proceed if they are. This bibliography is intended to serve as a first exposure to stream habitat improvement guides. It is not intended to be a comprehensive list or review of all publications relevant to habitat management.

This annotated bibliography is for individuals who are planning to actively manage stream habitat in the Pacific Northwest. Not all of the stream habitat improvement guides reviewed specifically address the Pacific Northwest; however, the habitat improvement principles and the technical, site-specific practices discussed are applicable to the region. Most important, the management practices are aimed at habitat for salmonids.

The reviews are organized alphabetically by first author and include two types of information for each guide. First, a summary of the contents orients readers to the scope and flavor of the material covered. This section begins with a short synopsis: the *Overview*. Facts relevant to the purpose of the guide are also included: the stated *target audience*, the stated *goal*, and the *spatial and temporal scales* addressed. In general, we defined spatial scales corresponding to stream reaches or small watersheds as "local," and a temporal scale of less than five years as "short term."

Second, a section of subjective ratings places each guide in the context of contemporary social and scientific issues surrounding management of aquatic habitat. The subjective ratings answer five questions:

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

The answer to this question is based on how much material in the guide is presented so that users can understand the situations where application is appropriate, balanced by how much material is presented that lacks sufficient context for proper application. When the context of a guide's contents is not fully conveyed, it is difficult to use it properly to conduct stream habitat improvement. For example, if a text were to prescribe that "eroding banks should be stabilized with a log revetment according to specifications in Table X," readers unaware of how eroding banks vary could install a log revetment inappropriately.

B. ***How is the information presented in terms of active versus passive stream habitat restoration?***

Historically, stream habitat improvement projects have often used active methods to modify stream channels in order to effect discernable and predictable responses by stream habitat. Recent trends have included the use of passive restoration, in which smaller modifications are intended to mimic natural disturbances and processes (Ebersole et al. 1997; Kauffman et al. 1997). Each guide is written according to either or both of these philosophies.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

The answer to this question depends on how well and how easily the presented material can be applied by people considering or carrying out stream habitat improvement projects. Although a large part of any stream habitat improvement project is the process of making decisions about if, why, how, and where to conduct projects, users of habitat improvement guides require documents that are useful when actually in the field carrying out habitat improvement treatments. Specifically excluded from consideration here is whether the guide is conceptually thorough; the rating presumes that the reader is familiar with relevant concepts required for proper selection of techniques and focuses instead only on technical usefulness.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

This question addresses the success of the guide at conveying the underlying concepts—whether simple or complex—that are relevant to the material presented. There are many concepts relevant to stream habitat improvement, including principles of hydraulics, fish biology, stream ecology, and the like. This question is different from question A ("sufficient context") because it is concerned with thoroughness, rather than extensiveness. Guides that present either a broad range of practical, technical tools for habitat modification or a thorough coverage of an identified subset of tools are considered satisfactory.

E. ***What are the guide's biggest asset and biggest liability?***

This assessment reflects our overall judgment as to the best use of the guide, as well as its most glaring weakness.

We refer to "cookbook" approaches in some reviews. By this, we mean that the guide presents methods in a step-by-step manner. Usually, but not always, these cookbooks tend to gloss over the reasons for the steps, and the reader often cannot judge how to modify them to address some local situation most appropriately. Guides that use a cookbook approach tended to be judged deficient in context, but often were still very useful in developing local, applied plans for restoration.

The Reviews

Adams, MA, and IW Whyte. 1990. Fish Habitat Enhancement: A Manual for Freshwater, Estuarine, and Marine Habitats. Publication DFO 4474, Canada Department of Fisheries and Oceans, Vancouver, BC.

Overview

This book covers streams, estuaries, and marine reefs.

The first section, *Ecosystem Functions*, is a series of short overviews of the life histories of individual species and some short, general descriptions of ecosystems.

The next section, *Planning the Project,* outlines considerations and procedures for planning and implementing restoration. The information is specific to the regulatory environment of British Columbia.

Chapters 3–23 describe how to modify habitat, organized by treatment method. Each chapter is organized as *Introduction* (identifies the problem and orients the reader to the technology in question), *Application* (where you should use this tool—discussed in the context of the legal framework of British Columbia), *Design and Installation Guidelines* (details of how to use the technology), *Maintenance, Factors Influencing Cost, Advantages of Technique, Disadvantages of Technique*, *Examples of Use,* and *References*. Of the 21 treatments (listed below), 16 are relevant to freshwater habitat management, 4 address estuaries, and only 1 is limited to marine habitat:

(1) streambank stabilization
(2) riparian planting
(3) streambank fencing
(4) gravel catchment/placement
(5) gravel cleaning
(6) artificial spawning channels
(7) artificial incubators
(8) mainstem rearing habitats
(9) off-channel development
(10) food production
(11) obstruction removal
(12) culverts
(13) fishways
(14) fish screens
(15) streamflow control
(16) stream aeration
(17) marsh creation
(18) access improvement
(19) woody debris/erosion
(20) transplanting eelgrass
(21) artificial reef creation.

Four appendices describe common fish, crustaceans, and wetland and riparian plants. There is one appendix of *Fish Production Bystanders*, which includes benchmarks for habitat, escapement, etc.

- *stated target audience*: None stated. The implied audience is managers who are considering active restoration in British Columbia. The style is oriented to people who are technically aware but not experts.
- *stated goal*: None stated. The implied goal is to describe a range of habitat enhancement procedures.
- *spatial and temporal scales*: Local; short term. Most of the material applies to low- and medium-gradient small streams. Despite a mention of the importance of post-project monitoring, no guidelines are given that allow interpretation of the contents from a long-term perspective.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?:***

Background material is sufficient for technically competent audiences, but not for nonprofessionals.

B. ***How is the information presented in terms of active versus passive stream habitat restoration?***

There is no mention of passive management. A short discussion of the potential ramifications of past, present, and future land management practices provides some balance, but the general assumption is that active procedures compose a project.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide would be most useful for developing active restoration plans in watersheds, estuaries, and wetlands that are similar to the examples. Lack of context would hinder effective use outside of coastal British Columbia.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

The only conceptually basic material is contained in the appendices, which are sufficient only as a base from which to learn more or as a quick reference. The only way social concerns are addressed is by an overview of regulatory requirements for habitat management in British Columbia.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: This book would be easy to use as a reference when applying active stream habitat improvement procedures.

Liability: There is no mention of passive procedures, and there is essentially no way to use this document to determine whether the procedures presented are required.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998 (revised 2001). Stream Corridor Restoration: Principles, Processes, and Practices. GPO Item No. 0120-A; SuDocs No. 57.6/2:EN3/PT.653 (adopted as Part 653 of the National Engineering Handbook, USDA-Natural Resources Conservation Service), FISRWG (15 Federal agencies of the US government).

Overview

Part I: Background is a primer on definitions, processes, and the generally accepted effects of disturbances and land uses on streams. This section covers many topics, including hydraulics, sediment transport, stream chemistry, ecology, and geomorphology.

Part II: Developing a Stream Corridor Restoration Plan presents a model for how to approach, conduct, and evaluate restoration projects. Included are several examples and specific suggestions of both technical and political nature.

The goal of *Part III: Applying Restoration Principles* is to foster the development of field methods and tools for restoration. There are detailed descriptions of some tools and how to use them, but the theoretical contexts for proper application are stressed more than the details of construction. There is also extensive discussion of ways to evaluate and monitor the effects of projects.

The information is presented as a framework for planning restoration:

(1) Define components of the stream corridor and discuss scale and structural concepts.

(2) Present hydrologic and geomorphic information on stream corridors.

(3) Summarize the range of disturbances to ecosystems.

(4) Introduce the first two steps of planning: organization and identification of problems.

(5) Discuss how goals are formed and how alternatives are selected.

(6) Relate the necessary components of implementation, monitoring, and evaluation.

(7) Provide guidelines for initial stream corridor analysis to understand the physical processes, geomorphic and hydrological interactions, water chemistry, and biology.

(8) Relate guidance and techniques, without presenting a cookbook of prescribed solutions.

(9) Discuss construction, management, and monitoring to see whether goals and objectives are met.

An appendix contains details necessary to implement 39 commonly used stream channel and watershed treatments.

- *stated target audience*: Interdisciplinary technical and managerial teams and individuals responsible for planning, designing, and implementing stream corridor restoration initiatives.
- *stated goal*: To be a common technical reference and to provide a framework in which to plan restoration.
- *spatial and temporal scales*: All. Spatial scales from regional to local are considered, and long-term considerations are stressed.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

The conceptual framework presented does supply sufficient background material. Multiple references in the text allow readers to further research unfamiliar concepts.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

The text covers both active and passive restoration procedures by defining three potential pathways to restoration: (1) "noninter-

vention and undisturbed recovery," which is extremely passive; (2) "partial intervention for assisted recovery," which is moderately active but relies on natural recovery; and (3) "substantial intervention for managed recovery," or active restoration.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide provides sufficient scientific and conceptual material to be useful in all settings. The restoration procedures, both active and passive, can be used from small tributary streams to large watersheds.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

This guide thoroughly presents relevant principles and processes. Each chapter discusses the fundamental hydrological, geomorphic, and biological background information relevant to the topic being presented.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: The proposed framework is comprehensive and well developed.

Liability: The large volume of material may be cumbersome, and the broad treatment of some issues may be difficult for nontechnical audiences.

Flosi, G, and FL Reynolds. 1994. California Salmonid Stream Habitat Restoration Manual. 2nd Edition. California Department of Fish and Game, Sacramento.

Overview

This guide explains the approach of the California Department of Fish and Game to aquatic habitat restoration. It is a revision of the first edition, which was originally published in 1991. The guide has been widely distributed and used as a text of standard methods by a variety of people who work with aquatic habitat restoration and resource inventory.

Part I. Salmon and Steelhead Habitat Restoration in California is a history of the loss and restoration of fish habitat in California that provides a legal and social perspective.

The next three sections, *Parts II–IV,* outline methods for collecting data about the conditions of the watershed, streams, and fish populations. Although most of the material is in the format of a cookbook, some of it is presented in a more general and theoretical way. The focus of these sections is on the collection of data, but there are some examples on how to assimilate the data in order to assess the condition of aquatic habitat.

Part II. Preliminary Watershed Assessment is an abbreviated cookbook method on watershed analysis. A very brief primer on watersheds, hydrology, and aquatic habitat follows.

Part III. Habitat Inventory Methods is based on Rosgen's stream channel classification system (Rosgen 1994) and an aquatic habitat inventory system modified from Bisson et al. (1982). Most of the section consists of detailed summaries of both systems, including standardized definitions of habitat types, as well as pictures. The balance of this section is simply a cookbook description of how to collect and record data.

Part IV. Fish Sampling Methods includes details on how to survey for the presence and abundance of fish by diving and electrofishing, and how to count spawning fish, redds, and carcasses.

Part V. Working with the Data begins with a description of how to use two outdated computer programs that manage data collected via methods described in the first four sections of the guide. A few concepts are presented on how to store, analyze, and disseminate data, but these are also outdated. The section goes on to describe the life history and habitat preferences of salmonids; this information is repeated in *Appendix P*.

Part VI. Project Planning and Organization is a conceptual presentation of how to enhance aquatic habitat using the collected data. It frequently refers the reader to other sections for details. Some regulatory and social aspects of implementing aquatic habitat restoration projects in California are included.

Part VII. Project Implementation presents some theory of hydraulics and types of stream reaches where enhancement will be most effective. A discussion of materials that can be used and types of in-stream structures follows. For example, there are details on how to use cables to secure logs in streams, make weirs from boulders and logs, build fish ladders, install baffles in culverts, and plant trees.

Part VIII. Project Monitoring and Evaluation explains why monitoring is important, but little material is presented on the theory of monitoring to insure that it is implemented effectively. As with many other sections, this one also consists primarily of a cookbook method of how to carry out monitoring. The focus of the monitoring discussed in this section is on the individual structure and not the reach level.

Seventeen appendices support the main text. Some examples are details of legal aspects of habitat enhancement and hatcheries in California, sources of data useful for enhancers, hydraulic theory relating to structures, an example stream, a method to inventory large woody debris, and a glossary.

- *stated target audience*: None stated. The implied audience is people in California working in the field of applied habitat restoration. The publication also is secondarily directed towards the public as a way to define techniques

used by the California Department of Fish and Game (DFG).

- *stated goal*: To standardize DFG's approach to restoration, including terminology and technical methods used, in response to a mandate from the California state legislature to restore habitat for anadromous fish.
- *spatial* and temporal scales: Local; short term. While there is some focus on the watershed scale, the emphasis is primarily on the reach scale or smaller, such as habitat structures. The temporal scale most commonly addressed corresponds to the life of a structure.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

Most of the material is provided with sufficient scientific and historical context; for example, many pages are devoted to explanations of channel types. There is a lot of background information that should allow people to use these procedures; however, it is difficult to judge where the treatments presented here fit into broader spatial and temporal scales.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

Most of the material describes active procedures in streams. Passive procedures are not directly discussed, but are alluded to, for example, in *Part VI* as upslope watershed treatments and in *Part V* as livestock fencing.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

The construction details for structures would be quite useful in implementing active restoration. The descriptions of administrative procedures are unique to California, so are of little use elsewhere.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

This guide uses some currently popular social concepts in restoration. These include the involvement of both private and public entities in restoration projects, and the use of educational programs for landowners and managers. Scientific concepts are sometimes incomplete because of lack of background; the cookbook approach limits flexibility of application.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: Some of the practical sections offer help for complex assessment processes, and the extensive construction details should be useful.

Liability: This guide tends toward oversimplification and gives the impression "If in doubt, modify the stream."

House, R, J Anderson, P Boehne, and J Suther, eds. 1989. Stream Rehabilitation Manual: A Training in Stream Rehabilitation, Feb 7–8, 1989, Bend, Oregon. Oregon Chapter of American Fisheries Society, Bethesda MD.

Overview

The sixteen sections include short papers and transcripts of training sessions written by different authors.

Basin-Wide Habitat Analysis is based on the habitat inventory system of Bisson et al. (1982) and the fish population sampling techniques of Hankin and Reeves (1988).

Limiting Factors Analysis is for coho and includes the text of Reeves et al. (1989). It is a detailed cookbook key based directly on that publication.

Monitoring and Surveys is a list of relevant data to collect when monitoring habitat improvement projects. There are some cursory explanations as to why and how to collect the data, but none on how to use it.

Project Planning is a checklist of thought processes relevant to successful planning.

Utilizing Channel Information to Reduce Risk in Developing Habitat Restoration Projects is a primer on morphology and hydrology that emphasizes connections between watersheds and streams and how to predict reactions to perturbations, including restoration.

Design and Location of Instream Structures is a primer on the hydraulics of common structures and where it is appropriate to use them.

Considerations for Using Selected Materials for Stream Habitat Enhancement is a list of common structure materials and how they are used. Many of the newer "soft" (passive) ideas in enhancement are not included.

Cost-Effective Labor and Equipment is a resource for how to think about getting the job done.

Main Channel Structures describes commonly used habitat improvement structures and includes some theory about how to target them to needs. The focus is strongly on design and implementation.

Off-Channel Habitat Enhancement describes how and why to construct side channels and off-channel pools.

Blasting Considerations for Fisheries Enhancement Projects describes how to use explosives to create pools.

The sections entitled *Past Instream Project Failures, Successful Enhancement Case Studies (Coastal and Cascade Streams),* and *Analysis of Failures and Successes, Arid Regions* are short collections of opinions and case studies.

The Use of Models to Evaluate Stream Improvement is a unique section of this guide. This chapter is a short introduction to habitat models and their strengths, weaknesses, and applications.

Biological Evaluation is primarily a series of examples of previous monitoring efforts.

Physical Evaluation of Fisheries Habitat Enhancement Structures is a discussion of how to design and implement a program to monitor physical habitat.

Evaluation of Fisheries Habitat Structures in Western Oregon Streams presents the results of a study evaluating the physical effects of some in-stream structures.

- *stated target audience*: Field managers and fisheries biologists.
- *stated goal*: To provide a state-of-the-art manual that addresses the common failures of past restoration attempts, the growing body of technical knowledge, and public and monetary support for habitat enhancement. This manual attempts to bring together the collective knowledge of professionals and technical experts who have direct experience in designing, constructing, and evaluating projects.

- *spatial and temporal scales*: Vary. The material is intended for use in salmonid-bearing streams in the western United States. The temporal scale is nominally long term, achieved by repeated application of short-term measures.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

This is a collection of papers by many authors. Each paper or "section" provides a different amount of pertinent conceptual and historical perspective. Although the sections are sequentially presented from pre-project habitat analysis to post-project evaluation, there is no overview that ties them all together; the reader is responsible for weaving the material together.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

Active restoration procedures are the primary focus of this guide. This guide was published before widespread discussion of passive restoration concepts, so it represents a step in the evolution of habitat restoration practices and principles.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide will serve well as a reference for the implementation of basic, manipulative restoration efforts.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

Some social concepts are presented, but the treatment is incomplete. Recognition of community involvement is implied by the stated intent of "streamlining" efforts in aquatic restoration. The lack of discussion of passive restoration is the main limitation of the science covered.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: The details of the active restoration procedures represent a lot of experience and are a source of practical ideas.

Liability: This guide is out of date. It lacks a watershed perspective, and there is no discussion of passive restoration procedures.

Hunter, CJ. 1991. Better Trout Habitat: A Guide to Stream Restoration and Management. Island Press, Washington DC.

Overview

This book is one of the first works of its kind, and is partially responsible for establishing the ideals of habitat restoration.

Chapters 1-3 contain a brief history of restoration and primers on trout (life cycles and habitat) and geomorphology (channel morphology, watersheds, and geology).

Chapter 4, *Inventory, Monitoring, and Evaluation*, steps the reader through a reconnaissance process that examines inventory habitat, vegetation, channel morphology, hydrology, insects, and trout population in order to determine what is wrong with a stream. There is a section, *Interpreting Results*, which includes a table of "good" and "bad" habitat.

Chapter 5, *Determining Limiting Factors, Designing, and Initiating the Project*, recommends a limiting-factor analysis to design the stream modifications to be undertaken. The description of this analytical technique is conceptual, but includes two examples.

Chapter 6, *The Role and Function of In-Stream Structures*, is an eight-page chapter that is basically a bulleted list of what structures to use: dams, deflectors, cover, streambank protection/stabilization, fences and crossings for livestock, and construction materials. In-depth treatments of these methods are included only as examples later in the book.

Chapter 7, *Streams Affected by Agriculture*, Chapter 8, *Forested Streams*, and Chapter 9, *Urban Streams*, make up 150 pages of restoration project examples in all regions of the country, including specific examples that illustrate applications from the book.

- *stated target audience*: Lay and professional readers. The implied audience consists of groups involved in restoring habitat.
- *stated goal*: To "make the reader aware of land use impacts on streams and of processes of stream formation." This goal is accomplished by describing how to understand streams as habitat and how to improve that habitat for trout.
- *spatial and temporal scales*: Individual streams (including their watersheds); life of in-stream structures. There are generalized references to longer time scales.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

Both in-depth background and detailed descriptions are included for some concepts, but much of the information is presented as anecdotes and examples.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

This book recommends both active and passive procedures, presenting the material as a balance between land-use management and in-stream structural design. There is a clear message that each stream should be treated differently, and the examples range from total reliance on in-stream structures to total reliance on land management in achieving restorative goals.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This book is designed for use at the local scale. It assumes some watershed conditions common in the Inland West and would be most useful in similar situations. Because of the incomplete technical background, it would be difficult to use this book for restoring streams with different kinds of problems.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

The book is written in a breezy style, which may facilitate communication with an informal audience but hinders formal presentation of complicated scientific concepts. There is a lot of information, but its format makes identification of its bounds difficult. The material is presented in terms that relate directly to habitat restoration, so it is useful. The social audience of this book consists primarily of recreationists (anglers), and the author assumes that fisheries managers will be thinking from that perspective.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: This book should inspire confidence and a sense of mission for restoration workers.

Liability: The enthusiastic, unrestrained style may fail to inspire caution and may deter use by professionals.

Kosicki, KT, CT Gillies, and BJ Sutherland. 1997. Compendium of Watershed Restoration Activities, Techniques, and Trials in Western Canada. Special Report No. SR-119, Forest Engineering Research Institute of Canada, Western Division, Vancouver, BC.

Overview

This is a collection of short, technically detailed, two-page descriptions of restoration techniques for streams and watersheds conducted on harvestable timberlands in western British Columbia. The techniques are divided into six categories: *Roads & Bridges*, *Landings & Trails*, *Riparian Zones & Stand Edges*, *Gullies & Landslides*, *Stream Channels*, and *Other*. Within each category, techniques are further classified into either *Operations*, which describes implementation, or *Research Trials*, which describes research on the effectiveness of the restoration techniques. Each entry includes a general statement of purpose, description of the participants involved, and the funding sources for the example projects. The Forest Engineering Research Institute of Canada continues to add to this collection of trials, helping to keep it current.

Roads & Bridges includes methods to remove roads, install culverts and small bridges, and stabilize cutbanks. *Landings & Trails* describes deactivation and addresses soil compaction in these areas. *Riparian Zones & Stand Edges* is concerned mostly with windthrow. *Gullies & Landslides* addresses raveling slopes and road failures, but not prevention of landslides. *Stream Channels* describes methods of manipulating physical structure in streams, with a focus on large woody debris, rocks, and side channels.

Other is supposed to contain articles about specialized projects or large-scale restoration projects, although none were included as of this writing.

- *stated target audience*: Users of watershed restoration technology: forest managers and contractors who are working with the province-wide Watershed Restoration Program in British Columbia.
- *stated goal*: To compile and disseminate a compendium of articles describing watershed restoration techniques.
- *spatial and temporal scales*: Mainly local; mainly short term. The examples and research experiments might be applicable to other areas, but many projects address problems largely confined to British Columbia. The temporal perspective of this guide is not explicit, and there is little mention of long-term implications or monitoring.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

Because each article provides its own separate background, the context for each varies in quality and quantity. Readers would generally be unable to apply information in this guide without additional context.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

For stream channels, this document presents only active procedures. The remainder of the articles, although manipulative in nature, could be viewed as passive stream restoration because they address watershed conditions.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

The operational details of many of the projects should be particularly useful for local applications.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

Relevant scientific concepts are largely omitted, but each article describes important local features, such as the ecoregion and soil, that would be useful for readers. There is virtually no discussion of the social aspects of the presented projects.

E. *What are the guide's biggest asset and biggest liability?*

Asset: This guide is compact and detailed, and its strong operational focus is a unique feature.

Liability: The text almost completely lacks context. It must be considered a source of operational-level information for active procedures only.

National Research Council. 1992. Restoration of Aquatic Ecosystems. National Academy Press, Washington DC.

Overview

This is a comprehensive study of watershed restoration practices of the past and present with suggestions for future management. It consists mostly of broad-scale definitions of problems and potential solutions, but also contains some examples.

Chapters 1 and 2 seek to define restoration as a new science and to place restoration efforts into a historical context.

Chapter 3, *Planning and Evaluating Aquatic Ecosystem Restoration*, is conceptual in nature and covers the importance of planning and of recognizing the needs and potentials for recovery. This chapter may be the strength of the book, both for its checklist for planning and monitoring projects and for its overview of concepts relevant to the evaluation of the potential for restoration.

Chapter 4, *Lakes*; Chapter 5, *Rivers and Streams*; and Chapter 6, *Wetlands*, are all divided into similar subsections that (1) provide a primer on basic ecosystem functions and values, (2) define broadly recognized types of problems, (3) outline the history of the broad problems, (4) define the political arena in which the problems exist, (5) present general solutions, and (6) present the authors' opinions of needs for research, funding, strategy, and change in outlook. In all cases, the discussions are general in nature with some examples. Some specific tools are presented, but typically lack detailed context.

Chapter 7, *Integrated Aquatic Ecosystem Restoration*, describes restoration at the watershed level. This chapter is similar to Chapters 4–6, but is shorter and includes fewer specific tools.

Chapter 8, *A National Restoration Strategy: Basic Elements and Related Recommendations*, includes 10 specific goals that are largely relevant to federal government and nationwide efforts.

There are 13 appendices that present case histories of restoration efforts, emphasizing political realities, perceived undesirable conditions, and technological solutions. The physical and biological processes are often glossed over in these case histories, but their sociopolitical lessons may be useful for strategy-level planning of other projects.

- *stated target audience*: None stated. The implied audience consists of political leaders (perhaps those with some technical knowledge) and government agencies concerned with restoration issues.
- *stated goal*: To develop a national strategy to restore aquatic ecosystems in the United States.
- *spatial and temporal scales*: Broad; long term. The entire country is included, and the intent is to consider long-term restoration.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

This book does not contain details of natural processes or procedures for restoration, but instead provides context for use in conjunction with other materials. Direct use of the contents is not possible, and other information must be obtained for application of the concepts outlined here.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

Both approaches are considered in the restoration case studies, but the main text is primarily concerned with the justification of restoration as an endeavor, rather than the philosophies of applied restoration. Because of the age of this book, it tends to emphasize active restoration.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

The techniques, policies, and practices described within each of

the case studies could potentially be applied to other habitats where similar conditions exist, but that is not the primary goal of these studies. This book would be insufficient as a sole source of information for implementing specific projects.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

The strongest aspect of this book is its coverage of the social aspects of aquatic ecosystem restoration. The central theme of this material is to justify the involvement of federal, state, and private entities in restoration practices nationwide. The scientific concepts are broad in scope and lack nuanced treatment, which is appropriate given the goals of the book.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: This book provides a sense of the scope and importance of restoration and accomplishes its objective to provide a base knowledge for restoration procedures.

Liability: The lack of specific treatment of local issues may be difficult to translate into real-life solutions, and the comprehensive presentation may be cumbersome for direct use.

Newbury, RW, and MN Gaboury. 1993. Stream Analysis and Fish Habitat Design: A Field Manual. Newbury Hydraulics, Gibsons, BC.

Overview

This guide is a 10-step process, cookbook approach to stream restoration. The first six steps are devoted to planning, reconnaissance, and evaluation of present conditions; the last four steps are focused on the design and construction of structures.

Chapter 1, *Planning Stream Habitat Projects* (steps 1–3), describes guidelines for how to compile and comprehend geologic and hydrologic information. Some references are useful only in Canada, but there are valuable concepts presented overall.

Chapter 2, *Field Exploration* (steps 4 and 5), explains how to measure the hydrology and morphology of a stream. It is the most data intensive of any of the guides and downplays qualitative judgments.

Chapter 3, *The Evaluation of Stream Behaviour and Characteristics* (step 6), presents concepts and details methods of how to analyze the data collected from the methods discussed in Chapter 2. Most of the methods are based on established hydraulic and geomorphic concepts.

Chapter 4, *Design and Construction of Stream Habitat Works* (steps 7–10), explains how to apply the theory and data gathered in the previous chapters. It includes a series of sample streams analyzed according to the 10-step process. This process uses physical principles to achieve desired habitat; thus, the examples are quantitative.

Appendices include habitat requirements and life histories for fish of Manitoba, georegions of Manitoba, checklists for collecting data about streams, alternative ways to measure flow, and less comprehensive examples of the 10-step process applied to streams in British Columbia and other ecoregions.

- *stated target audience*: None stated. Readers with at least moderate technical competence should be able to use this book.
- *stated goal*: To efficiently present a procedure to be used in hydrological restoration. The focus is more on physical processes than on fish.
- *spatial and temporal scales*: Stream reach; inexplicit. Although some material helps the reader to become oriented to the geological setting of a project (this guide is based on Manitoba), most of the analyses and procedures are for the scale of a stream reach. The issue of appropriate temporal scale is not addressed. For example, there is no detailed discussion of long-term monitoring of habitat restoration projects.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

The focus is on hydrology and hydraulics, and these topics are covered in depth. Although some ecological considerations enter into the procedures presented, there is insufficient discussion of these considerations for a full understanding of their complexities.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

There is no mention of passive restoration measures. This guide is limited to active restoration procedures and would be useful to managers who have decided on these types of practices.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

Given that hydrological and geomorphological manipulations are required, this guide would be valuable for its strong treatment of this approach.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

Relative to the context of the material, the amount of background and geomorphologic information is enough that a manager could find this guide useful. None of the social aspects, such as community involvement, public relations, or federal, state, and private landowner concerns, are discussed.

E. *What are the guide's biggest asset and biggest liability?*

Asset: The quantitative, hydrological approach should minimize incorrect modification of habitat structure.

Liability: The guide is geographically limited, presents a minimal range of restoration options, and provides no assistance in using manipulative techniques in an environment of passive restoration.

Oregon Watershed Enhancement Board. 1999. Oregon Aquatic Habitat Restoration and Enhancement Guide. Oregon Watershed Enhancement Board, Salem.

Overview

The *Introduction* provides a brief statement of the goals and nature of the guide.

Section 1—Overview of Restoration Activities is intended to place the guide into a spatial and temporal context and explain what kinds of activities the guide describes.

Section 2—Detailed Description of Each Restoration Activity is a 47-page section that describes restoration activities; each activity is described in one to three pages in terms of general procedures, regulatory requirements, and technical references.

Section 3—Overview of Agency Regulatory Functions and Sources of Assistance includes cursory information on both federal and state agencies, but is largely devoted to describing regulations and resources in Oregon.

Section 4 —Grants and Assistance lists six sources of potential funding for restoration work, two of which are restricted to Oregon. There is one very brief paragraph for each of these sources.

Section 5—Monitoring and Reporting is a one-page section that serves mainly to make readers aware that such activities may be useful and that they may be required for projects funded by agencies in Oregon.

The appendices include a list of acronyms, glossary, list of agency employees, a restoration reporting form for the Oregon Plan, and project design criteria for threatened and endangered species.

- *stated target audience*: Anyone working in habitat restoration who wants funding from the state of Oregon.
- *stated goal*: To help develop restoration projects, encourage aquatic habitat restoration, assist in obtaining state funding, and identify pertinent governmental regulations and assistance.
- *spatial and temporal scales*: Variable; mostly short. The guide suggests viewing prospective activities in the context of a watershed. Some individual activities are described from this perspective, but most are described with a particular spatial scale in mind.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

An introduction to each section provides context for the individual activities. Most of these introductions assume some knowledge on the part of the reader or are very simple and cursory. Most frequently, the contextual information is limited to descriptions of biophysical problems and regulatory background and does not address biophysical processes. The technical references listed are insufficient to provide the necessary background.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

Both passive and active approaches are presented, and there is no specific treatment of the active versus passive approach to habitat restoration.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide is extremely useful for Oregon readers because of its detailed descriptions of Oregon's regulatory and funding environment. Readers outside of Oregon may find some useful information about implementing techniques, but that is not the strength of the guide.

D.***How completely are the social and scientific concepts relevant to the material presented?***

The guide tends toward brevity. The most thoroughly presented material pertains to regulations and the political environment within which restoration takes place. Scientific concepts are sometimes presented but are usually glossed over.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: This is an easily accessible guide to regulatory requirements and funding opportunities in Oregon.

Liability: The guide lacks scientific context.

Seehorn, ME. 1992. Stream Habitat Improvement Handbook. Technical Publication R8-TP-16, USDA Forest Service, Southern Region, Atlanta GA.

Overview

This 30-page handbook applies to trout streams in the Appalachians, but it also describes in-stream structures that are applicable to restoration efforts in the Pacific Northwest. It assumes that restoration structures will have beneficial effects and focuses on the technical details of how to install 15 different structures. The description for each structure is divided into six categories: *Purpose*, *Design*, *Placement*, *Advantage*, *Disadvantage*, and *Cost.* Each description is short (usually one paragraph) and is accompanied by photographs or diagrams. The basic functions of the illustrated structures include creating deeper water, removing sediment by flushing, adding cover for fish, adding coarse substrate and food for other aquatic organisms, and consolidating braided channels.

- *stated target audience*: Fishery managers. It is applicable to USFS fishery managers, private landowners, woodland owners, watershed councils, and others wishing to improve fish habitat through the use of structures.
- *stated goal*: To provide designs for in-stream structures.
- *spatial and temporal scales*: Local; short. The structures are the focus of the guide, and there is little mention of any spatial scale larger than the immediate surroundings of an installation. The guide does not discuss the long-term ecological context of fish habitat in streams, so the time scale addressed corresponds to the lifetime of the structures.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

Very little context is given. This guide assumes that the reader needs no additional background and that in-stream structures are required.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

This handbook focuses exclusively on active procedures, and does not discuss the active versus passive approach to habitat restoration.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide could be very useful at the local scale, once its limitations are recognized. If stream conditions are similar to those cited in this handbook, then the structural designs given should functional well. Details such as the time and materials needed, and specific benefits of various structures could help in formulating and implementing specific plans.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

The relevant social and scientific concepts are presented incompletely or not at all. Nothing is discussed outside the bounds of construction details. The scientific principles are limited to basic hydraulics and simple relationships of variables such as pool depth and temperature.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: The guide does an excellent job of outlining the purpose, placement, advantages, disadvantages, and construction requirements for several types of structures.

Liability: There is virtually no discussion concerning underlying causes of stream degradation, and therefore almost no guidance as to what is appropriate for restoring the stream. This handbook fails to help readers understand how their situation may differ from those presented.

Slaney, PA, and D Zaldokas, eds. 1997. Fish Habitat Rehabilitation Procedures. Watershed Restoration Technical Circular No. 9, British Columbia Ministry of Environment, Land, and Parks, Vancouver, BC.

Overview

This book is an overview of ideas and methods presented in detail in eight other documents from the British Columbia Ministry of Environment, Land, and Parks.

Part I. Planning Stream Restoration Projects includes three chapters of background and concepts: Chapter 1, *Planning Fish Habitat Rehabilitation: Linking to Habitat Protection*, describes the sociopolitical structure of habitat modification plans and the watershed restoration needs specific to British Columbia. Chapter 2, *Watershed Geomorphology and Fish Habitat*, is a primer on hydrology, geomorphology, and aquatic habitat. Chapter 3, *Salmonid Biostandards for Estimating Production Benefits of Fish Habitat Rehabilitation Techniques*, is a framework for fitting restoration to responses in fish populations. Together, Chapters 2 and 3 provide background on watershed geomorphology, fish habitat, benchmark numbers, data reviews of biological and habitat targets, and how to choose which streams to restore.

Part II. Applying Rehabilitation Techniques, a collection of 11 chapters, describes methods for restoring streams, such as how to place large woody debris and rocks as structures, target specific needs of fish with placed materials, fertilize streams, augment summer low flows by regulating output from lakes, and manage beavers.

- *stated target audience*: None stated. The implied audience is people working in the British Columbia Watershed Restoration Program, which is a provincial initiative.
- *stated goal*: To provide the technical basis for a suite of integrated restorative measures that accelerates natural recovery processes in forested watersheds.
- *spatial and temporal scales*: All. This guide uses watersheds as the units of interest and attempts to emphasize long-term effects of activities.

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

This book provides the most technical background material of any operational guide in this bibliography, but sometimes favors construction details and sample projects over theory and nuance.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

Most techniques in this book are modifications of the channel itself, which is active restoration.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide would be useful for implementation of active, in-stream plans. It would be valuable as a way to understand how to apply general goals and as a good source for details of construction.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

The depth and breadth of scientific material presented is considerable. For example, geomorphologic keys help identify types of problems, and several tables summarize fish responses to large woody debris, boulders, gravel, etc. The social concepts are limited to one chapter and are mostly applicable in Canada.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: This guide provides a comprehensive set of tools presented in a way that couples theory and practical solutions.

Liability: By stressing active restoration, there may be too much emphasis on immediate changes in habitat at the expense of longer term changes.

Williams, JE, CA Wood, and MP Dombeck, eds. 1997. Watershed Restoration: Principles and Practices. American Fisheries Society, Bethesda MD.

Overview

This book is intended as a comprehensive guide to watershed restoration principles and practices. It presents a philosophical and scientific framework for restoration; provides thirteen case studies nationwide; and critiques, compares, and outlines the restoration tactics learned from each case study. It is organized into five main sections. Each section provides background information, discusses ethical and legal aspects of watershed restoration, and gives opinions about future considerations. It also continuously stresses the "increasing need to bring together people and the land (watershed) they live on."

An introductory chapter, *Understanding Watershed-Scale Restoration*, defines restoration by contrasting it with enhancement and seeks to develop a framework for evaluating the success of restoration efforts.

Part 1: Principles consists of seven chapters that address watersheds, physical and biological processes, spatial and temporal scales, sociology, and ethics. There is some detail and technical presentation, but the goal is primarily to convey broad concepts relevant to restoration.

Part 2: Building Partnerships includes three chapters that describe political and sociological complexities, strategies, and options for approaching restoration.

Part 3: Key Practices presents six examples of political and technical strategic solutions to complex stream restoration problems. The material is not technically rigorous, but focuses instead on policy and concepts of watershed processes.

Part 4: Case Studies is similar to *Part 3*, but it is based more on implementation than on strategy.

Part 5: A Vision for the Future presents four chapters of perspectives on how to maintain restored watersheds and how to prevent future degradation. Much attention is given to the sociopolitical ramifications of the effects of land use on ecosystems.

- *stated target audience*: Broad readership. This includes federal, state, and private landowners, and the general public.
- *stated goal*: To define watershed restoration and provide the information necessary for initiating this process and improving its success.
- *spatial and temporal scales*: All. This book makes the argument that the spatial scale of a solution must be tailored to the problem and even includes an entire chapter on the subject. These scales range from smaller than a stream reach to entire regions. Likewise, this book points out that restoration planning must consider time scales on which natural systems operate (decades to centuries).

Subjective Review

A. ***Is the information in the guide provided with sufficient context for readers to use it appropriately?***

The book consists largely of background information. Most information is presented in depth, focusing on ecological principles, ethical considerations, social sciences, and adaptive management.

B. ***How is the information presented in terms of active versus passive approaches to habitat restoration?***

Passive restoration procedures are strongly emphasized, but the importance of active management techniques is also stressed.

C. ***How useful is this guide for implementation of stream habitat improvement projects at the local scale?***

This guide is primarily useful for planning rather than for operational considerations; it includes few details of operational implementation.

D. ***How completely are the social and scientific concepts relevant to the material presented?***

The first half of this book relates ethical, social, and historical perspectives concerning watershed restoration practices; this is the strongest treatment of social issues of all guides in this bibliography. The portion of the book that presents scientific concepts showcases some common important practices in flagship examples of watershed restoration. The scientific concepts are sometimes informally presented, and in those cases the ramifications of many of the facts presented are not always explained.

E. ***What are the guide's biggest asset and biggest liability?***

Asset: This book provides a coherent presentation of complex ideas, and can be considered a comprehensive guide to watershed restoration in a broad sense (scientific, social, ethical, historical, economical). The strength of this book is its considerable attention to the interactions between watersheds and society.

Liability: There is the potential for the complex material to bewilder people and not reach those solely interested in small reaches of a watershed.

Overall Assessments

Stream restoration projects generally consist of three phases. The first phase is the recognition of undesirable conditions and the placement of these into scientific and sociological contexts. The second is the identification of general goals and the formulation of a general plan that addresses the issues. The third is the development and implementation of specific solutions. The guides reviewed here tend to take one of two approaches—either they emphasize physical or social theory in a broad sense (the first and second phases) or they emphasize technical prescriptions for individual projects (the third phase). Neither of these approaches is superior, but a combination of the two approaches can address the subject fully. Here, we suggest how to combine these guides for the most complete coverage of the subject (Table 1).

Either *Restoration of Aquatic Ecosystems* (National Research Council 1992), *Watershed Restoration: Principles and Practices* (Williams et al. 1997), or *Stream Corridor Restoration: Principles, Practices, and Processes* (Federal Interagency Stream Restoration Working Group 1998) is important reading for planners to understand the history of stream habitat improvement efforts and their scientific bases. All readers would benefit from the broad concepts that these guides provide and that are required for formulating proper plans.

Once general goals for stream habitat improvement have been identified, several guides can help formulate specific plans for effective implementation of general goals. The guides that most effectively develop pathways from theory to implementation are *Better Trout Habitat:*

Table 1. Summary of uses for the guides.

	Amount of material that is		Usefulness for			
Guide	Introductory	Advanced	Learning scientific concepts	Learning sociopolitical aspects	Formulating specific plans	Implementing plans
Adams and Whyte 1990	Little	Most	Poor	Moderate[a]	Moderate	Excellent
Federal Interagency Stream Restoration Working Group 1998 (revised 2001)	Generous	Generous	Very good	Excellent	Good	Good
Flosi and Reynolds 1994	Some	Some	Moderate	Moderate	Moderate	Excellent
House et al. 1989	Little	Most	Poor	Poor	Moderate	Very good
Hunter 1991	Most	Little	Moderate	Moderate	Good	Moderate
Kosicki et al. 1997	Little	Some	Poor	Poor	Moderate	Very good
National Research Council 1992	Generous	Little	Moderate	Excellent	Moderate	Poor
Newbury and Gaboury 1993	Little	Most	Excellent	Poor	Good	Very good
Oregon Watershed Enhancement Board 1999	Some	Little	Poor	Very good[b]	Moderate	Good
Seehorn 1992	Little	Little	Poor	Very poor	Moderate	Moderate
Slaney and Zaldokas 1997	Generous	Generous	Good	Moderate[c]	Good	Excellent
Williams et al. 1997	Generous	Little	Good	Excellent	Good	Moderate

[a] For California only.

[b] For Oregon only.

[c] For British Columbia only.

A Guide to Stream Restoration and Management (Hunter 1991), *Stream Analysis and Fish Habitat Design: A Field Manual* (Newbury and Gaboury 1993), *Watershed Restoration: Principles and Practices* (Williams et al. 1997), and *Stream Corridor Restoration: Principles, Practices, and Processes* (Federal Interagency Stream Restoration Working Group 1998).

After formulating an appropriate plan and developing specific ideas about how to approach problems, the next step is to implement the plan. This step is best aided by *Stream Rehabilitation Manual* (House et al. 1989), *Fish Habitat Enhancement: A Manual for Freshwater, Estuarine, and Marine Habitats* (Adams and Whyte 1990), *Stream Analysis and Fish Habitat Design: A Field Manual* (Newbury and Gaboury 1993), *California Salmonid Stream Habitat Restoration Manual* (Flosi and Reynolds 1994), *Compendium of Watershed Restoration Activities, Techniques, and Trials in Western Canada* (Kosicki et al. 1997), and *Fish Habitat Rehabilitation Procedures* (Slaney and Zaldokas 1997).

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Forestry Communications Group
Oregon State University
256 Peavy Hall
Corvallis, OR 97331-5704

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