APPENDIX D
Riparian Function Module

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Riparian Function Assessment:

Overview

Riparian function can be defined as the interaction of various hydrologic, geomorphic, and biotic processes across a range of spatial and temporal scales within the riparian environment. As a result, riparian function encompasses a wide variety of processes that determine the character of the riparian zone and exert an influence on the adjacent aquatic and terrestrial environment.

In the context of watershed analysis, riparian function is defined more narrowly, focusing on two specific processes: (1) the recruitment of large woody debris (LWD) to aquatic systems, and (2) the provision of shade to aquatic systems. This assessment is designed to evaluate riparian areas relative to their capability to supply (LWD) and shade to streams, lakes, and wetlands within the WAU. Both functions play an important role in maintaining the integrity of the aquatic ecosystem, and both can be significantly influenced by forest management.

Part 1 of the riparian assessment evaluates LWD recruitment potential in the near term (10-20 years) and in the long term (20-200+ years). Information about the potential for LWD recruitment is gathered in sufficient detail to characterize riparian condition at both site-specific and watershed-wide scales. As a result, prescription teams should have enough information to develop meaningful riparian prescriptions.

Part 2 evaluates current canopy closure relative to target levels established with the TFW temperature screens for western and eastern Washington. Where warranted, the analyst can expand the assessment by more extensive field measurements to refine their understanding of the temperature regime for the watershed. Both parts provide information useful in developing a monitoring program.

Part 1. Large Woody Debris Recruitment

Introduction

The riparian zone is commonly described as the transition zone between upland and aquatic zones (Oakley et al. 1985). The flow of sediment, water, wood, and energy into and out of the riparian zone is controlled by climatic, geologic, topographic, vegetative, and management-related factors. Forest practices may alter the routing of such elements directly through management within the riparian zone or indirectly through management of upland areas.

The riparian zone serves as the primary source area for large woody debris. Large woody debris, including tree boles, root wads, and large branches, has been recognized as an important structural component of stream systems (Harmon et al. 1986; Bisson et al. 1987). In the stream, large woody debris diverts and obstructs streamflow, thereby increasing channel complexity. The formation of pools and backwater eddies, both of which are important components of fish habitat, is strongly influenced by the presence of large, stable woody debris (Andrus et al. 1988; Robison and Beschta 1990a). Large woody debris plays an important role in stream nutrient dynamics by retaining fine organic matter such as needles and leaves (Sedell and Triska 1977; Bilby and Likens 1980), and it also provides cover from predators and refuge during high streamflows.

Large woody debris creates storage sites for inorganic sediment in both fish-bearing streams and non-fish-bearing streams. Sediment deposits upstream from debris accumulations in larger fish-bearing streams form spawning riffles and retain fine sediments (Bisson et al. 1987). In smaller headwater streams, large woody debris has been shown to be the primary factor in controlling the routing of sediment to downstream reaches (Megahan 1982; Potts and Anderson 1990; O'Conner and Harr 1994). Several studies have shown that the loss or removal of woody debris from stream channels can result in significant changes in channel morphology, a loss in sediment storage capacity, and an increase in the rate of sediment transport (Beschta 1979; Bilby 1984; Heede 1985). Bisson et al. (1987) suggest the primary benefit of the sediment storage capacity of woody debris is in buffering downstream reaches against rapid changes in sediment loading that could degrade spawning gravels, fill rearing pools, and reduce invertebrate populations.

Large woody debris is also structurally important in wetlands, lakes, and reservoirs. In these systems, accumulations of woody debris can provide a substrate for the development of macroinvertebrates that serve as a food supply for a variety of fishes. Submerged woody debris also provides a complex physical structure that fish of many different sizes can use for cover. The recruitment of large woody debris occurs by a variety of mechanisms including windthrow, bank undercutting, mass wasting, overstory mortality, and transport from upstream stream reaches. The relative importance of these processes vary within the stream network; in general, windthrow is a more significant factor along smaller streams while the importance of processes such as channel migration and bank undercutting increase with stream size (Keller and Swanson 1979).

There is relatively little information related to source distances for large woody debris in Northwest streams. In one study, McDade et al. (1990) found that approximately 80% of in-channel large woody debris pieces associated with 80+ year old conifer stands in western Washington and Oregon originated within 66 feet of the streambank and 90% originated from within 100 feet. In a separate study conducted in southeast Alaska, Murphy and Koski (1989) found that 95% of in-channel large woody debris pieces associated with old-growth conifer stands originated from within 66 feet of the streambank and 99% originated from within 100 feet. The difference in relative recruitment reflected by these studies indicates that LWD recruitment is a function of the height of native tree species.

Since European settlement of the Pacific Northwest, many land uses, including forest management, have altered the spatial and temporal patterns of large woody debris input in many stream systems. Large woody debris was regularly removed from many streams and rivers during the late 1800s and well into the 1900s to facilitate log transport; similarly, debris jams were removed from smaller streams during the 1940s and 1950s in an effort to “improve” fish passage (Sedell and Luchessa 1982).

Researchers began to understand the ecological importance of large woody debris in the 1970s. They concluded that riparian areas that regenerate to shade-intolerant, early-successional stage forest types such as red alder tend to produce debris that is shorter, smaller diameter, more easily broken, and less well anchored than coniferous debris (Bisson et al. 1987).

The purpose of this portion of the Riparian Function Module is to evaluate existing riparian forests based on their capability to provide a sustainable supply of large woody debris to streams, lakes, and wetlands. Methods for the remote assessment and field validation of existing riparian condition are provided. Guidelines for additional evaluation of the long-term recruitment potential are also given.

Methodology

The standard procedure evaluates current LWD recruitment potential by examining, by remote means, the type (hardwood or conifer), size, and density of riparian overstory vegetation. In-channel LWD levels provided by the channel and/or fish analysts and channel sensitivity ratings provided by the channel analysts are then used to establish the LWD recruitment hazard call. Additional information related to understory vegetation can be gathered to project long-term LWD recruitment conditions. Throughout the assessment, interaction with the channel and fish analysts is very important in order to accurately characterize riparian condition and provide answers to the critical questions.

Critical Questions

What information is available regarding the early character of the riparian zone relative to its ability to supply functional LWD?

What is the current condition of the riparian zone relative to its ability to supply functional LWD in the near term?

What are the dominant processes by which LWD is delivered to streams, lakes, and wetlands in the WAU?

What is the current condition of the riparian zone relative to its ability to supply LWD in the long term?

Assumptions

- Channel morphology is strongly influenced by LWD (Keller and Swanson 1979), particularly in low gradient, unconfined stream reaches (Montgomery and Buffington 1993).
- The majority of functional LWD is recruited from within a distance of 100 feet in western Washington and 75 feet in eastern Washington.
- In the absence of severe disturbance, the composition of a late-successional riparian forest is determined by the tree species mix that was present when the forest was established.
- Well-stocked riparian stands dominated by large conifers will provide adequate and sustainable supplies of LWD.
- Hardwood-dominated riparian stands are not capable of supplying sufficient long-term LWD inputs.

General Approach and Products

The first step in assessing riparian function is to describe what the riparian zones looked like in the past. The riparian analyst uses older aerial photographs or other anecdotal information to reconstruct the early character of riparian areas including the general distribution, type, size, and density of the riparian vegetation. Using this information, the analyst can identify areas that likely had naturally low LWD recruitment, as well as those areas where significant recruitment occurred. The analyst should include a discussion of early land use practices that may have influenced the structure and function of the riparian zone and associated stream channels. Practices such as log drives, splash damming, stream cleanout, salvaging wood from channels, or clearcut harvest of riparian areas that occurred within the WAU should be identified. Agricultural practices, urbanization, and conversion to other land uses may also have significantly altered the riparian areas.

Next, the analyst assesses the current condition of riparian vegetation using information obtained from recent aerial photographs. The assessment area focuses on those channels with less than 20% gradient, unless modified in consultation with the channel and fish analysts. The riparian zones of these channels are divided into unique units referred to as riparian condition units (RCUs). Each RCU is different from adjacent RCUs in its ability to supply functional LWD to the stream channel. The analyst uses aerial photos to evaluate the vegetation type, size, and density of each RCU. Validation of these preliminary photo calls is made by field checking a representative sample of those areas evaluated. Once final calls are made, the analyst generates a working base map (Map D-1: Riparian Vegetation Condition) which describes the current condition of the RCUs relative to their ability to supply LWD in the near term.

Individual RCUs are then classified according to one of three recruitment potential classes which describe the near-term potential for recruiting functional LWD. The recruitment potential classifications are then combined with channel sensitivity ratings and in-channel LWD ratings to assign LWD recruitment hazard calls by channel segment (Map D-2: Near-term LWD Recruitment Hazard). This approach relies not only on the LWD recruitment potential associated with the current riparian vegetation when assigning hazard calls, but also considers existing levels of in-channel LWD as well as the sensitivity of the channel to inputs of LWD.

The standard assessment describes both the past and current conditions of the riparian zone relative to its ability to supply functional LWD. Further assessment may focus on developing a picture of the long-term LWD recruitment situation. This assessment requires more detailed information regarding the species composition of both the understory and overstory riparian vegetation. As a result, the analyst must spend additional time gathering field data in order to predict forest succession. Products from this portion of the assessment include descriptions of how riparian areas are expected to develop over time and Map D-3: Long-Term LWD Recruitment Potential. The analyst should include a discussion of how silvicultural treatments or catastrophic disturbances (e.g., debris torrents, dam-break floods, or fire) might affect riparian forest development and thus, future LWD recruitment.

Confidence in Work Products

Completed watershed analyses have shown that an experienced photo interpreter can accurately determine the current condition of the riparian overstory using recent aerial photography. It is important for the analyst to calibrate his/her eye relative to the condition of the riparian vegetation as it appears on the photo. The analyst should therefore spend one or more days checking a representative sample of RCUs for agreement with photo calls. Field work may also be necessary to update those areas that have been altered substantially since the last photo flight due to logging, blowdown, debris torrents, or other disturbances.

Information related to in-channel LWD levels is another component of the assessment. Although the channel and/or fish analysts will be collecting in-channel LWD data, the riparian analyst can expand the sample size by collecting their own information.

The analyst's confidence in the near-term assessment of LWD recruitment potential will be influenced by the quantity and quality of information related to both riparian vegetation condition and in-channel LWD levels. It is therefore important to spend as much time as possible field checking photo calls and assisting the channel and/or fish analysts in collecting in-channel LWD information.

Assessment of long-term LWD recruitment potential is dependent on the quality and extent of information related to riparian species composition. Here again, it is important that the analyst inventory a representative sample of riparian areas to increase the level of confidence in the assessment.

Qualifications and Skills

Skills for assessment of near-term recruitment:

- Ability to interpret vegetation type, size, and density from aerial photographs.
- Ability to use a map wheel.

Education and Training

- Associate's degree in forestry or related field with four years related experience.

Experience

- At least two years of experience in aerial photo interpretation and field work.

Additional skills for long-term recruitment:

- Familiarity with forest inventory methods.
- An understanding of the processes of natural succession within riparian communities under a variety of conditions and how silvicultural practices or other disturbances may alter the successional pathway.

Startup Materials

Maps

- Official WAU base map (1:24,000 scale).
- Stream channel segment map (Map E-1) from channel assessment team.
- USGS 7.5 minute topographic quadrangle maps (1;24,000 scale).

Photographs

- Most recent aerial photographs (stereo pairs). The minimum scale is 1:12,000. Larger scale photographs are preferable, if available.

- Older aerial photographs (stereo pairs, if available) that will provide insight into early riparian conditions. The earliest, highest resolution photographs are preferable.

Other Materials

- Stand information (obtained from landowners) for uplands adjacent to riparian zones or from riparian zones specifically, if available. Note that timber stand data usually applies to uplands and may not be representative of the riparian zone.

- Riparian seral stage and vegetation type inventory data may be available from the TFW Ambient Monitoring Program. Contact Northwest Indian Fisheries Commission at (360) 438-1180.

- Aerial video of streams and riparian zones may be available. Check with landowners, Washington Department of Fish and Wildlife, and the U.S. Forest Service.

Analysis Procedure

Early Riparian Forest Composition

A number of resources may be available to allow the analyst to infer early riparian forest composition. Although the analyst could expend much effort pursuing detailed information, the main objective is to identify riparian areas that naturally supported either hardwood-dominated forests or non-forest vegetation that provided low levels of woody debris and/or shade. In western Washington, most natural non-conifer sites are associated with wet soil conditions resulting from poor soil drainage (including wetlands, beaver ponds and/or frequent flooding). An on-site evaluation will not be necessary for most riparian areas in the WAU, but should be reserved for those riparian areas where the potential for growing conifers is most uncertain.

The following resources have proven useful for watershed analyses and similar projects:

- Older aerial photos provide excellent documentation, especially early, high resolution photos. Although resolution of old photos varies, they are often adequate to determine forest type (conifer vs. hardwood) and tree size. Old photos may be available from landowners, county agencies and/ or libraries (including UW and WSU).

- Field inspection of remaining stumps can provide an on-site indication of species, tree sizes, and densities of preharvest stands. Large conifer stumps, especially Douglas-fir and western red cedar, are quite durable and can be recognizable for up to a century; hardwood stumps remain for several decades. In some cases, tree age can be inferred from stump size, thus providing insight into the frequency of disturbance processes during pre-settlement times. The absence of stumps may not always be definitive of a non-conifer site, due to the potential for other removal processes, such as intentional removal for agriculture or other development activities and various channel disturbances (e.g., channel migration, splash damming) that can remove or bury stumps.

- Descriptions of historical conditions may be available from survey notes, local histories, and recollections of long-time residents (Platts et al. 1987). In some cases, these sources can provide useful information on historic in-channel woody debris loading as well. It is important to evaluate the reliability of information from these sources, since much documentation focuses on exceptional rather than typical conditions. Survey notes are normally available from county agencies.

Near-Term LWD Recruitment

The following guidelines are designed to assist the analyst in evaluating the current condition of the riparian zones relative to their ability to supply functional large woody debris to streams, lakes, and wetlands in the near term:

Define Assessment Area

- The focus of this portion of the riparian assessment is on the function of LWD in stream channels; therefore, the assessment area is based on those channels dominated by fluvial processes. The assessment of LWD recruitment focuses on that portion of the stream network with gradients less than 20%. Deviations from the 20% criterion can be made in consultation with the channel and fish analysts. Prepare an overlay map from the channel map (E-1) that encompasses those channel segments less than 20% gradient. Label this Map D-1: Riparian Vegetation Condition. This will serve as the working base map.

- Determine the width of the riparian evaluation zone on each side of waters on the working base map from above. For western Washington, use an evaluation width of 100 feet horizontal distance; for eastern Washington, use 75 feet horizontal distance. Convert this distance based on the scale of the photos (e.g., 100 feet equals 0.1 inch on a 1:12,000 scale photo). Evaluation width may be modified as necessary for specific site conditions as justified by the analyst. It should be noted that the evaluation width is for assessment purposes only and prescriptions relating to LWD recruitment will be based on the casual mechanism report(s), not assessment width.

Define Riparian Condition Units (RCUs)

- Once the assessment area has been defined, divide the riparian zones into riparian condition units, or RCUs. Each RCU is unique in that it differs from adjacent RCUs in the type, size, and/or density of riparian vegetation. This means that riparian areas on opposite sides of the stream are treated as separate RCUs. The length of each RCU should be a minimum of 2,000 feet (1 inch on 1:24,000 scale overlay map), unless the conditions of smaller areas can be discerned or are warranted (e.g., where the first 1,000 feet contains old-growth conifer and the next 1,000 feet is a recent clearcut). Delineate the boundaries of RCUs using short lines drawn perpendicular to the stream as shown in Figure D-1.

- In addition to defining the standard RCUs described above, work with the channel analyst to delineate channel migration zones or CMZs. The channel migration zone, for the purpose of this module, is defined as the area that streams have recently occupied (in the last few years or less often decades), and would reasonably be expected to occupy again in the near future.

The primary mechanism for channel avulsion or “channel hopping” is the formation of woody debris jams and/or gravel bars during larger floods. If one streambank is substantially higher, then the CMZ is probably associated with the elevation of the lower streambank. A combination of topographic maps, aerial photographs, soil maps, vegetation surveys, and field work can be used to delineate the CMZ. Field evidence that can be used to help define the CMZ includes unvegetated or sparsely vegetated side channels, wetlands, and signs of recent flooding such as wood debris suspended in branches or deposited outside the ordinary high water mark and large amounts of sediment deposition. The zone may have a significant shrub (e.g., vine maple, salmonberry) and/or hardwood (e.g., cottonwood, red alder, big-leaf maple) component, but few conifers. The water table is often near the surface and abandoned or active side channels are abundant.

Because CMZs are areas where the potential for channel migration is relatively high, it is important to assess these areas for their ability to supply functional LWD in the near term. As a result, they will be assessed in the same manner as RCUs and will be bounded by RCUs along their outer margins (Figure D-2).

The riparian analyst should consult with the channel analyst to identify CMZs using a combination of aerial photos and topographic maps. The CMZs that are of interest for this assessment are those where field exam clearly shows they have been migrating in the recent past. Record the preliminary CMZs on Map D-1. The channel analyst can modify the CMZ boundaries if necessary during the field visit. Once the boundaries of all CMZs are finalized, record them on Map D-1.

- Classify the riparian vegetation type (Table D-1), size (Table D-2), and density (Table D-3) for each RCU and CMZ.

Record the riparian condition codes on the map using the following system:

(CMD), where:

C=Vegetation type (Conifer or Hardwood)
M=Tree size (Small, Medium or Large)
D=Stand density (Dense or Sparse)

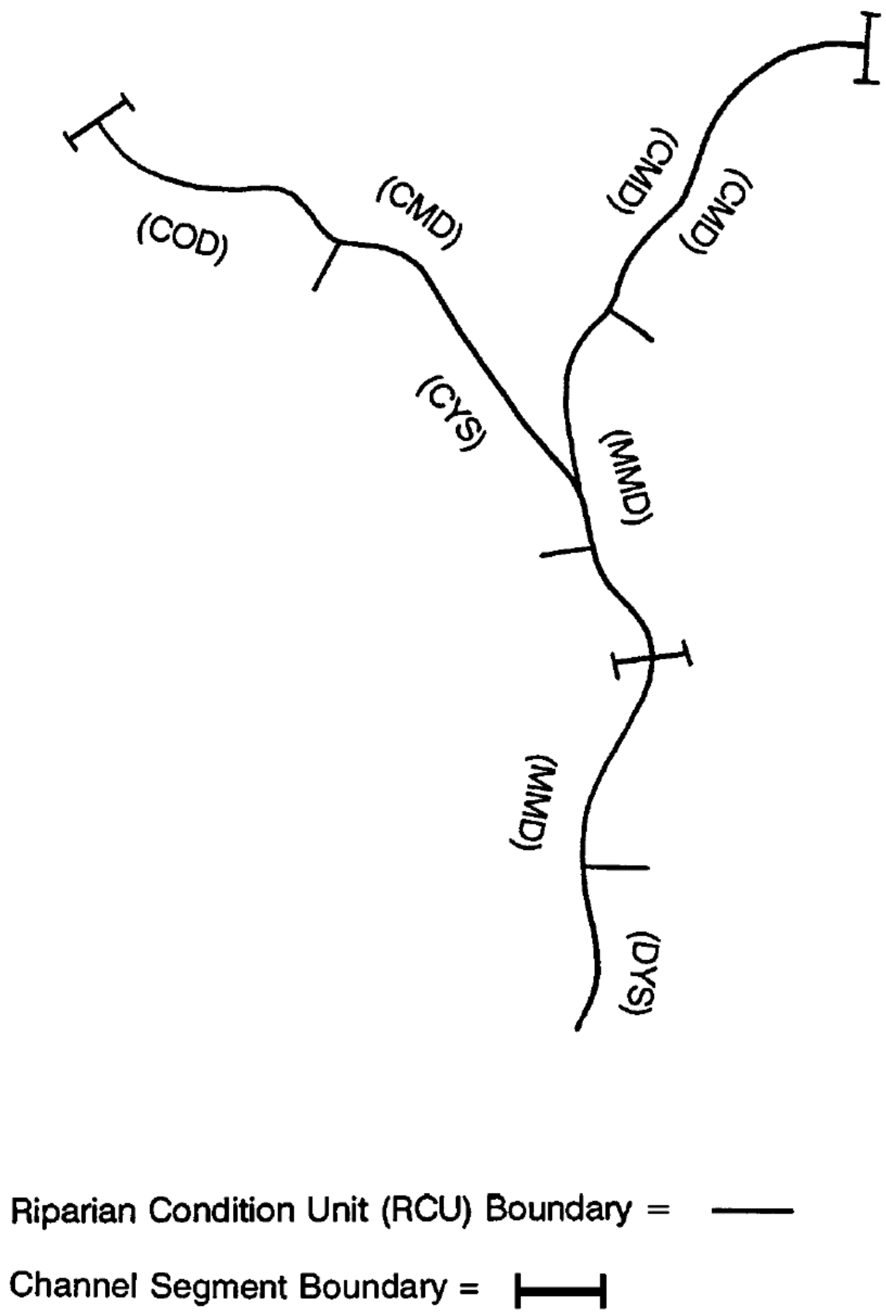


Figure D-1: Example of Map D-1: Riparian Vegetation Condition

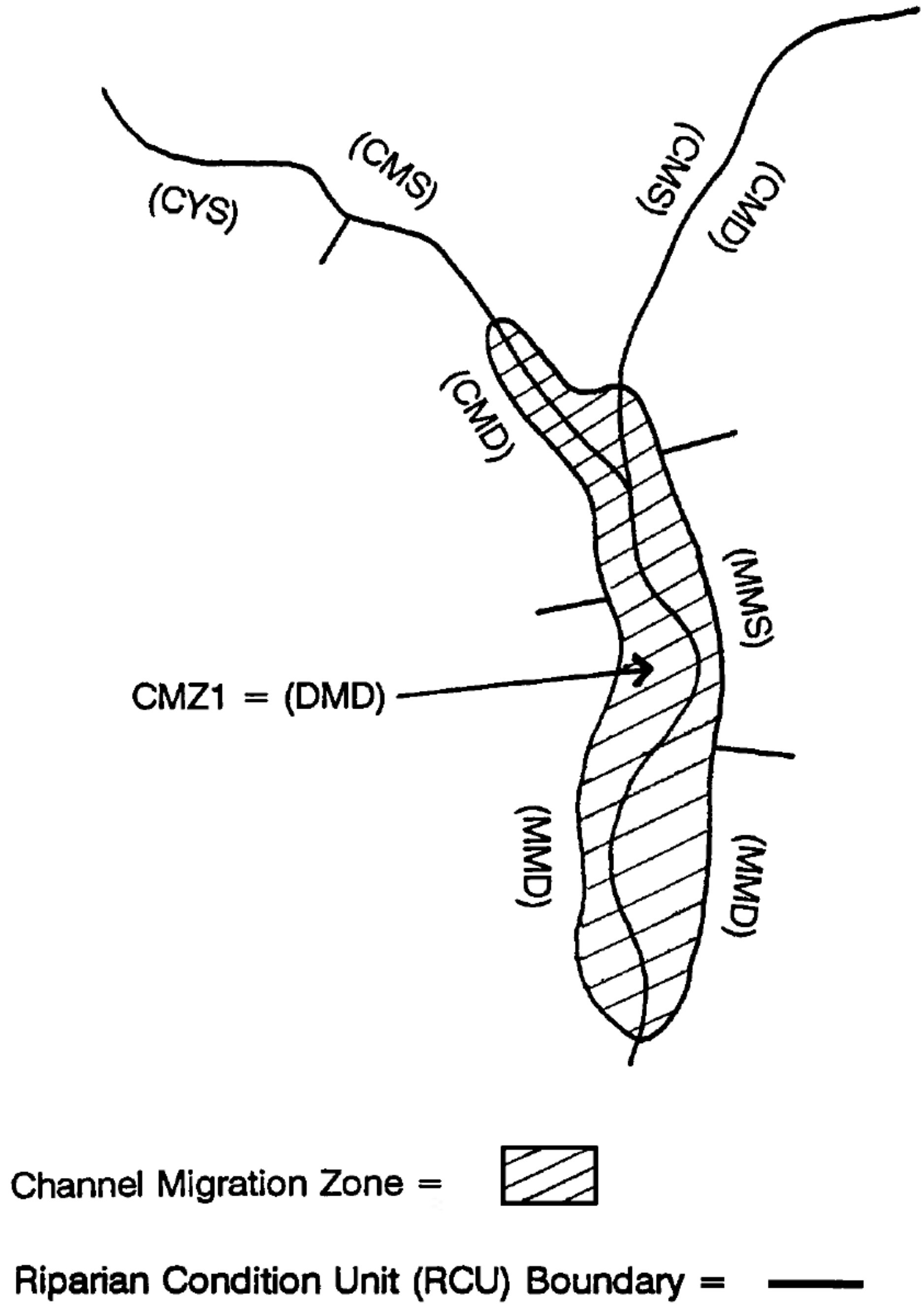


Figure D-2: Example of Map D-1 with Channel Migration Zone

Table D-1: Dominant Vegetation Types

>= 70% Coniferous Species	Conifer Dominated
>= 70% Hardwood Species	Hardwood Dominated
All Other Cases	Mixed

Table D-2: Average Tree Size Classes[1]

Small	<12 inches DBH
Medium	>=12 and < 20 inches DBH
Large	>=20 inches DBH

[1]Under certain circumstances, age may be a reliable indicator of tree diameter; if this is the case, the analyst may obtain forest age class data from landowners and use the information to correlate age and diameter.

Table D-3: Stand Density Classes

Western WA	Density is sparse if more than 1/3 of the ground is exposed. Otherwise, it is dense.
Eastern WA	Density is sparse if more than 1/2 of the ground is exposed. Otherwise, it is dense.

For example, a riparian zone dominated by conifers of medium size and dense spacing would be coded as (CMD). Record the riparian condition codes on the overlay map (Map D-1) and place them off to the side of each RCU and CMZ (Figure D-2).

In some instances, the analyst may discover riparian areas where soil conditions have limited vegetation growth needed to supply LWD. These include talus slopes, bedrock outcrops, wetlands, beaver ponds, and annual floodplains. These areas may be distinguished from those impacted by land use activities by use of historic aerial photos to establish baseline conditions. Other situations unrelated to forest management include road and/or powerline rights-of-way where vegetation is cleared on a regular basis. All of these conditions should be noted and recorded on Worksheet D-2 and Map D-2: Near-Term LWD Recruitment Hazard.

The accuracy of this method is dependent on the analyst's ability to interpret riparian conditions from aerial photography. Confidence in the assessment can be increased by performing field checks of the preliminary photo estimates of riparian conditions. Survey RCUs that represent a range of riparian conditions found in the WAU (i.e., combinations of tree type, size, and density). An easy way to perform the field checks is to transfer the riparian condition code for each RCU and CMZ to a mylar overlay attached to the most recent aerial photograph of the area. This way, photographs can be taken to the field and corrections or comments can be made on the mylar overlay. The analyst should be sure to keep a record of where field checks were made for later evaluation of confidence in the assessment.

Field checks can be expanded by asking members of the fish and channel assessment teams to note riparian conditions while performing their own field work. Provide each assessment team with a smaller scale version of Map D-1 or a marked photocopy of an aerial photo that they can take to the field to record their observations.

- Finalize the riparian condition codes on Map D-1: Riparian Vegetation Condition by making any necessary corrections or adjustments based on the information gained via field checks. Including the RCU and CMZ boundaries and corresponding riparian condition codes will finalize Map D-1.

Tally Information By Channel Segment

Once the riparian condition base map has been finalized, summarize the information by channel segment. By now, the channel assessment team has developed Map E-1: Channel Segment Map (preliminary or field-verified final). Use Map E-1 to transfer channel segment boundaries to the riparian condition base map (Map D-1) or to another overlay.

- With a map wheel, measure the length of each RCU in a given channel segment and record this information on Worksheet D-1. (Partitioning RCU information by channel segment is necessary because LWD recruitment hazard calls will be based on channel segment, not by RCU.)

In some cases, a single channel segment may include several RCUs. When this happens, maintain the channel numbering system established by the channel analyst by dividing the segment into sub-segments. For example, channel segment 37 may contain three RCUs which can be numbered as 37a, 37b, and 37c. By doing this, cross-referencing between RCUs and channel segments is made much easier.

The map wheel measurements will be in centimeters or inches, depending on the type of instrument. At this point it is not necessary to convert the raw data (unit lengths) into kilometers or miles. (This will be done later when the data is summarized for the assessment report.)

- Sum the lengths recorded for each channel segment to obtain a total stream length by channel segment (Worksheet D-1). This number should actually be twice the channel segment length because the riparian zone has been measured on both sides of the stream. Continue completing the worksheet for assessed channels in the WAU.

The next step is to classify each riparian vegetation condition according to its LWD recruitment potential. The recruitment potential rating describes the likelihood that the riparian zone will provide functional LWD to the stream in the near term (e.g., a conifer-dominated riparian zone that contains medium-sized trees and is densely stocked (CMD), will have a HIGH likelihood of providing functional LWD to the stream in the near term).

- Assign a recruitment potential rating to each channel segment based on the segment's riparian condition code and record this information on Worksheet D-2. (See Table D-4.)

Table D-4: Recruitment Potential Ratings

Low	HSS, HSD, MSS, MSD, CSS, CSD, HMS, HLS
Moderate	HMD, MSS, CMS, CLS, HLD, MLS
High	CMD, MMD, MLD, CLD

Incorporate Channel Sensitivity, In-channel LWD Information

The recruitment potential rating is one of three elements used to establish the LWD recruitment hazard call. The other two include (1) the sensitivity of the channel to inputs of LWD and (2) the existing level of LWD in the channel.

Channel Sensitivity Rating—As part of the channel assessment, each geomorphic unit (a group of geomorphically similar channel segments) will be assigned a sensitivity rating for each of five input factors: water (peak flows), coarse sediment, fine sediment, temperature, and LWD. The sensitivity to LWD characterizes the degree to which LWD influences channel form and fluvial processes. LWD tends to function differently in low gradient, unconfined stream reaches as compared to high gradient, confined channels. In general, the capability of LWD to influence flow and channel complexity increases as channel gradient and confinement decrease. Therefore, the sensitivity of a particular channel segment to inputs of LWD is considered when assigning a recruitment hazard. Obtain the LWD channel sensitivity ratings for each channel segment from the channel analyst and record this information on Worksheet D-2.

In-channel LWD Rating—Prior to field checking the riparian condition photo calls, work with the channel and fish analysts to identify channel segments to be inventoried for in-channel LWD. Those channel segments included in the inventory should be representative of the various geomorphic units found within the WAU. Although the channel and/or fish analysts will be collecting most of the in-channel LWD data, the riparian analyst can expand the number of channel segments inventoried by collecting his/her own information. Be sure to work with the channel and fish analysts to establish a standard inventory methodology so that the data is comparable regardless of who collects the information. This may include characteristics such as minimum piece size, influence zone (Robison and Beschta 1990b), and wood type (hardwood or conifer). If a decision is made to inventory LWD, it may be easiest for the analyst to do this in conjunction with field checks of riparian vegetation condition.

The channel and/or fish teams will determine target LWD loadings for channel segments in the WAU. Use this information to determine if existing levels of in-channel LWD meet these target levels (i.e., ON or OFF target) and record this information on Worksheet D-2.

Establish Near-term LWD Recruitment Hazard Calls

Using the matrix illustrated in Table D-5, determine the near-term LWD recruitment hazard call for each channel segment using (1) the LWD recruitment potential rating (Low, Moderate, or High); (2) the channel sensitivity rating (Low, Moderate, or High); and (3) the in-channel LWD rating (On/Off Target) from Worksheet D-2. Record the hazard call for each channel segment (Low, Moderate, or High) on Worksheet D-2.

Transfer the LWD recruitment hazard calls to Map D-2: Near-term LWD Recruitment Hazard using the labeling system described in Table D-6. Remember, each channel segment receives a hazard call so each side of the stream should be coded. Be sure to include areas that are naturally low in LWD recruitment or low due to non-forest land uses such as residential development or agriculture.

Table D-5: LWD Recruitment Hazard Call Channel Sensitivity Rating

Recruitment Potential Rating	LWD On LWD Off	Low	Mod	High
Low		Low	Mod	High
		Low	High	High
Mod		Low	Mod	Mod
		Low	High	High
High		Low	Mod	Mod
		Low	High	High

Table D-6: Map Labeling Guidelines for LWD Recruitment Potential

Solid Red Line	High Hazard
Solid Blue Line	Moderate Hazard
Solid Green Line	Low Hazard
Solid Black Line	Naturally Low Recruitment
Dotted Black Line	Non-forest Land Use Low Recruitment

Long-Term LWD Recruitment

At this stage in the riparian assessment, there should be a reasonable understanding of the current condition of the riparian zones relative to their ability to supply LWD in the near term. Also, the general distribution of in-channel LWD and the adequacy of in-channel LWD levels have been identified. All this information has been gained through the standard assessment of near-term LWD recruitment potential.

The riparian assessment may be continued by estimating the long-term LWD recruitment potential. This will require a more detailed examination of the age, size, species composition, and density of riparian vegetation. In contrast to the standard assessment which relies on the interpretation of riparian vegetation conditions from aerial photos, the assessment of long-term LWD recruitment is a field-level analysis where both overstory and understory riparian vegetation is inventoried. One use of the long-term assessment information would be to provide managers with information that may be used to guide voluntary active management where the landowner wishes to implement riparian restoration and/or enhancement. This assessment does not result in any hazard calls, but a map is produced showing what the dominant vegetation in the long-term riparian forest will likely be in the absence of disturbance.

There is no sampling protocol for this portion of the assessment. As a result, the analyst must be familiar with standard forest inventory methods and should be able to devise his/her own sampling scheme. In western Washington, the field inventory data will be used in conjunction with the successional charts illustrated in Figure D-3 to predict future riparian vegetation condition, and as a result, LWD recruitment potential. Riparian forest succession is strongly influenced by the composition of the early successional forest. The relative proportions of shade-tolerant to shade-intolerant species within a given stand may strongly influence the composition of the future forest. An underlying assumption associated with these charts is that outside influences such as wind, fire, disease, or logging will not disrupt the successional pathway.

Unless there has been severe disturbance, the tree species mix found in a late-successional riparian forest is likely to be determined by the tree species mix present when the forest was established. The successional charts (Figure D-3) illustrate this for different forest types in western Washington. To use these charts, field observations must be made of the relative proportions of shade-tolerant to shade-intolerant species within each RCU. For example, if shade-intolerant species such as red alder or big-leaf maple comprise 80% of the stems within a given RCU while the remaining 20% consists of shade-tolerant species such as western red cedar, the analyst is able to estimate that the stand will likely persist as a hardwood/conifer mix until it reaches 100 years of age when the hardwood species begin to die off and give way to conifers. Eventually (140+ years), the stand will become conifer dominated even though the early stage successional forest contained only 20% conifer.

Based on predictions of late-successional stage riparian forest conditions, create Map D-3: Long-term LWD Recruitment Potential. Label the segments as hardwood dominated, mixed stand, or conifer dominated. Also include areas that are naturally low in LWD recruitment or low due to non-forest land uses such as residential development or agriculture.

1. STARTING POINT = Pure Hardwood

Height Above Ground (ft)	Column A < 40 years	Column B 40-70 years	Column C 70-100 years	Column D 100-140 years	Column E 140-200 years	Column F 200-250 years
200+						
150-200						
100-150				Occasional Hardwood	Occasional Hardwood	
50-100	Hardwood	Hardwood	Hardwood	Less	Occasional Hardwood	
15-50	Hardwood	Vine Maple	Vine Maple	Vine Maple	Vine Maple	Vine Maple
6-15 (all shrub)	Hardwood Vine Maple Devil's Club	Vine Maple Devil's Club	Vine Maple Devil's Club	Vine Maple Devil's Club	Vine Maple Devil's Club	Vine Maple Devil's Club
3-6 (small shrub)	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry
<3 (ground cover)	Grasses, Sedges, Forbes	Sedges, Forbes	Forbes	Less	Less	Less

2. STARTING POINT = Hardwood + Shade Intolerant Species (Douglas-fir)

Height Above Ground (ft)	Column A < 40 years	Column B 40-70 years	Column C 70-100 years	Column D 100-140 years	Column E 140-200 years	Column F 200-250 years
200+					Douglas-fir	Douglas-fir
150-200				Douglas-fir	Douglas-fir	Douglas-fir
100-150		Douglas-fir	Douglas-fir	Douglas-fir	Douglas-fir	Shade Tolerant Species
50-100	Douglas-fir Hardwood	Douglas-fir Hardwood	Douglas-fir Hardwood	Hardwood	Shade Tolerant Species	Shade Tolerant Species
15-50	Vine Maple Hardwood Douglas-fir	Hardwood Vine Maple	Vine Maple		Shade Tolerant Species	Shade Tolerant Species
6-15 (all shrub)	Vine Maple Devil's Club	Vine Maple Devil's Club	Vine Maple Devil's Club	Less Vine Maple LessDevil's Club STS	Shade Tolerant Species	Shade Tolerant Species
3-6 (small shrub)	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Less Salmonberry LessThimbleberry STS	Less Salmonberry LessThimbleberry STS	Shade Tolerant Species	Shade Tolerant Species
<3 (ground cover)	Grasses, Sedges, Forbes	Grasses, Sedges, Forbes	Grasses, Sedges, Forbes STS	Forbs, Ferns, STS	Shade Tolerant Species	Shade Tolerant Species

Figure D-3: Forest Successional Pathways, Western Washington

3. STARTING POINT = 50% Hardwood, 50% Shade Tolerant Species (STS)

Height Above Ground (ft)	Column A < 40 years	Column B 40-70 years	Column C 70-100 years	Column D 100-140 years	Column E 140-200 years	Column F 200-250 years
200+						Shade Tolerant Species
150-200				Shade Tolerant Species	Shade Tolerant Species	Shade Tolerant Species
100-150		Shade Tolerant Species	STS Hardwood	Hardwood		
50-100	STS Hardwood	Hardwood STS	Hardwood STS			Shade Tolerant Species
15-50	STS Hardwood	Hardwood	Less		Shade Tolerant Species	
6-15 (all shrub)	Vine Maple Devil's Club	Vine Maple Devil's Club	Vine Maple Devil's Club STS	Shade Tolerant Species		Shade Tolerant Species
3-6 (small shrub)	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Less	Less Shade Tolerant Species	Less
<3 (ground cover)	Grasses, Sedges, Forbes	Grasses, Sedges, Forbes	Forbes	Forbs, Shade Tolerant Species	Forbs	Less

4. STARTING POINT = Hardwood with a few Shade Tolerant Species

Height Above Ground (ft)	Column A < 40 years	Column B 40-70 years	Column C 70-100 years	Column D 100-140 years	Column E 140-200 years	Column F 200-250 years
200+						Shade Tolerant Species
150-200					Shade Tolerant Species	Shade Tolerant Species
100-150				Shade Tolerant Species	Shade Tolerant Species	Shade Tolerant Species
50-100	Hardwood	Hardwood STS	Hardwood STS	STS Hardwood	Shade Tolerant Species	Shade Tolerant Species
15-50	Hardwood STS	Vine Maple	Vine Maple	Vine Maple	Vine Maple	STS Vine Maple
6-15 (all shrub)	Devil's Club Vine Maple STS	Devil's Club Vine Maple STS	Devil's Club Vine Maple STS	Devil's Club Vine Maple STS	Devil's Club Vine Maple STS	Devil's Club Vine Maple STS
3-6 (small shrub)	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry	Salmonberry Thimbleberry STS	Salmonberry Thimbleberry STS	Salmonberry Thimbleberry STS
<3 (ground cover)	Grasses, Sedges, Forbs	Grasses, Sedges, Forbs	Grasses, Sedges, Forbs, STS	Grasses, Sedges, Forbs, STS	Grasses, Sedges, Forbs, STS	Grasses, Sedges, Forbs, STS

Figure D-3: Forest Successional Pathways, Western Washington (Continued)

5. STARTING POINT = Shade Intolerant Species, fully stocked

Height Above Ground (ft)	Column A < 40 years	Column B 40-70 years	Column C 70-100 years	Column D 100-140 years	Column E 140-200 years	Column F 200-250 years
200+					Douglas-fir	Douglas-fir
150-200				Douglas-fir	Douglas-fir	Douglas-fir
100-150		Douglas-fir	Douglas-fir	Douglas-fir		
50-100	Douglas-fir	Douglas-fir	Douglas-fir	Douglas-fir		Shade Tolerant Species
15-50	Douglas-fir	Douglas-fir	Douglas-fir Vine Maple		Shade Tolerant Species	Shade Tolerant Species
6-15 (all shrub)	Vine Maple Devil's Club	Less	Less	Less STS	Shade Tolerant Species	Shade Tolerant Species
3-6 (small shrub)	Salmonberry Thimbleberry	Less	LessSalmonberry LessThimbleberry Huckleberry	Huckleberry STS	Shade Tolerant Species	Shade Tolerant Species
<3 (ground cover)	Grasses, Sedges, Forbs	Less Grasses, Less Sedges, More Forbs	Forbs, STS	Forbs, Ferns, STS	STS, Forbs, Ferns	Shade Tolerant Species

6. STARTING POINT = Shade Tolerant Species (STS), fully stocked

Height Above Ground (ft)	Column A < 40 years	Column B 40-70 years	Column C 70-100 years	Column D 100-140 years	Column E 140-200 years	Column F 200-250 years
200+						Shade Tolerant Species
150-200				Shade Tolerant Species	Shade Tolerant Species	Shade Tolerant Species
100-150			Shade Tolerant Species	Shade Tolerant Species	Shade Tolerant Species	Less
50-100	Shade Tolerant Species	Shade Tolerant Species	Shade Tolerant Species	Less		
15-50	Shade Tolerant Species	Shade Tolerant Species	Less			
6-15 (all shrub)	Vine Maple STS	Vine Maple	Less	Less		Shade Tolerant Species
3-6 (small shrub)	Vine Maple Salmonberry	Less	Less	Less	Shade Tolerant Species	Shade Tolerant Species
<3 (ground cover)	Grasses, Sedges, Forbs	Less	Less	Shade Tolerant Species	Shade Tolerant Species	Shade Tolerant Species

Figure D-3: Forest Successional Pathways, Western Washington (Continued)

Riparian LWD Recruitment Assessment Report

The assessment report is intended to convey the riparian analyst's results to other members of the assessment team, to the prescription team, and to those who may be interested in a concise, written description of the analysis. It should describe the results of the analysis and any conclusions reached relative to the critical questions. The assessment report should include the following:

- Documentation of all information used in the assessment of both the early and current conditions of the riparian zones in the WAU. This includes aerial photos, maps, anecdotal information, timber stand inventory data, aerial flights made, and any other information used to characterize riparian conditions.
- A discussion of early land use practices that may explain the current condition of the riparian zone. Areas that were historically hardwood-dominated such as river or large stream floodplains, and areas that were historically low in LWD recruitment such as wetlands, beaver ponds, rock outcrops, etc. should be identified where possible. Land use practices may include splash damming, log jam removal, stream "cleaning", harvest of riparian vegetation, large scale disturbances such as debris flows or dam-break floods, conversion from forest land, agricultural practices, or development.
- A summary of the riparian vegetation conditions, in-channel LWD levels, and hazard calls for the WAU. The information should be presented in tabular format so the reader can quickly assess the current riparian condition relative to LWD recruitment. The summaries should provide answers to questions such as, "What percent of the WAU's riparian zones are in a CMD timber condition?", and "What percent of the assessed riparian zones received HIGH hazard calls?"
- A description of any deviations from the standard methods and why the changes were necessary.
- A description of the sampling methodology used in the long-term assessment of LWD recruitment potential (if this assessment was performed). A discussion of the analyst's confidence in the work products. Consider factors such as skill level, variability of riparian conditions, extent of field-checking photo calls, accessibility of the WAU, quality of aerial photos used, quality and quantity of additional information and any additions or deviations from the standard methods.
- Answers to the **critical questions** presented at the beginning of the section. While it is not necessary to include this as a separate section, be sure that the critical questions are addressed somewhere in the body of the report.

Maps

- D-1: Riparian Vegetation Condition (including Water Types)
- D-2: Near-term LWD Recruitment Hazard Calls
- D-3: Long-term LWD Recruitment Potential (if additional analysis was performed)

Summary Data

- Worksheet D-1, Stream Length by Riparian Vegetation Condition
- Worksheet D-2, LWD Recruitment Hazard Call by Channel Segment
- Any additional worksheets or field data used in the analysis

An important reminder: The steps outlined in this module are meant to provide guidance to the analyst and aid in answering the critical questions as thoroughly and efficiently as possible. The evidence obtained through these steps should lead to and satisfactorily support answers to the critical questions. However, each WAU will present its own interpretive challenges and the analyst is encouraged to do what is necessary to focus on the critical questions, not merely the step-by-step instructions. Where deviations from these methods are made, the analyst is expected to supply supporting rationale and documentation.

Part 2. Canopy Closure/Stream Temperature

Introduction

Timber harvest within riparian zones can have a significant effect on canopy closure, which affects stream temperature. Canopy cover is an important factor governing stream heating and cooling. Fish require relatively cool, stable stream temperatures.

The purpose of this assessment is to evaluate the current degree of the canopy closure on fish-bearing and selected non-fish-bearing streams in the WAU. The standard assessment procedure relies on topographic maps and the TFW temperature screen (Sullivan et al. 1990) to identify the approximate minimum shading values needed to meet state water quality criteria for maximum stream temperatures. By analyzing aerial photographs and making field checks, this method estimates whether current conditions meet target shade values. More detailed procedures to determine current conditions and boost confidence in the results of the standard assessment may be needed. If the TFW temperature screen is not sufficient because of unusual conditions, additional analysis may justify the use of a temperature prediction model.

Critical Questions

What was the early condition of the riparian zone relative to its ability to provide shade?

What is the current condition of the riparian zone relative to its ability to provide shade necessary to maintain desirable summer stream temperatures?

Assumptions

- Forest practices may influence stream temperature regimes directly by reducing riparian shade through harvest or indirectly through mass wasting processes.

  (Unless otherwise noted, the following assumptions are based on information obtained from the TFW temperature report (Sullivan et al. 1990).

- Stream temperature can both warm up and cool down along its course due to the amount of shade provided by riparian vegetation.
- By the time a free-flowing stream has traveled 1000 feet (300 meters) or more under relatively uniform canopy closure, water temperatures will be in equilibrium with local environmental conditions.
- Non-fish-bearing Type 4 tributaries contributing 20% of the flow to a fish-bearing Type 1-3 waters will significantly influence water temperature (Caldwell, Doughty, and Sullivan 1991).
- At elevations above 3,600 feet (1,100 meters) in western Washington and 4,450 feet (1,370 meters) in eastern Washington, environmental conditions are such that streams are not likely to exceed water quality standards for maximum temperature.
- The target shade requirements differ depending on whether the stream of interest is rated by the DOE as Class A, AA, or B.
- Riparian shade is unlikely to have a significant influence on stream temperatures where the natural low flow wetted stream width exceeds 100 feet (33 meters).
- When riparian shade levels are below target levels, maximum water temperature standards may be exceeded.

General Approach and Products

In this part of the riparian assessment, the analyst again uses aerial photos to assess the level of canopy closure on all fish-bearing and selected non-fish-bearing waters in the basin. Some field work is involved in ground truthing interpretations from the standard assessment. Additional field work is required to complete more detailed, non-standard assessments. Stream temperature data or stream temperature models should be considered to complement canopy closure estimates where such information is available. As with LWD recruitment, some locations may be shade-limited due to natural conditions. These special situations are identified during the assessment.

Confidence in Work Products

The most reliable results will be achieved when the analyst has validated the remote assessment abilities through ground-truthing shade estimates with a densiometer. The analyst's confidence in their ability to answer the critical question with the methods used should be evaluated.

Qualifications

Same as for LWD Recruitment, in addition to:

- Ability to estimate canopy closure from aerial photographs

For additional analysis, it is recommended the analyst have experience using stream temperature monitoring equipment, and experience using the TFW temperature model or similar models.

Startup Materials

Maps and Photographs

- Use the base map from the LWD assessment to define the assessment area.
- Use the same photographs that were used in the LWD assessment.
- Use the forest practices temperature standards map. (Contact DNR or DOE.)

Field Data

- Average canopy closure estimates for selected riparian areas (obtained using a densiometer). Check with the TFW Ambient Monitoring Program, Northwest Indian Fisheries Commission (360) 438-1180, for existing data.

Analysis Procedure

Standard Analysis

- To evaluate the degree to which fish-bearing waters and selected non-fish-bearing waters of the WAU are adequately shaded, follow these general guidelines:

Define Assessment Area

Prepare an overlay map labeled Map D-4: Stream Type Overlay for Target Shade (mylar or other material). Mark the boundaries of the Class AA, A, and B target shade zones illustrated in the forest practices temperature standards map. The assessment area will encompass Type 1-3 waters and selected Type 4 waters. Use the following criteria to delineate the stream network to be assessed:

- Include all streams that contribute at least 20% of the flow to a Type 1-3 water. This 20% criterion can be estimated by evaluating either: (a) the proportion of lineal stream length of the mainstem and all tributaries upstream from the Type 4 confluence (determined with a map wheel); or (b) the proportion of total basin area above the confluence contributed by the Type 4 tributary (determined with a planimeter).

- Do not include Type 4 waters above 3,600 feet in elevation for western Washington or 4,450 feet in elevation for eastern Washington.

- Do not include any water bodies with a low flow width greater than 100 feet. Include streams that have been widened due to mass wasting events (consult with Mass Wasting Analyst).

- Do not include Class B streams as defined on the forest practices temperature standards map. A temperature study of small (i.e., Type 4) streams showed that where harvesting within riparian zones had occurred, logging debris and understory brush provided substantial shade to maintain water temperatures below state water quality standards (Caldwell et al. 1991). These streams often occur at higher elevations and were easily shaded with residual streamside vegetation. Therefore, Type 4 waters not typically vulnerable to temperature increases are not included in the assessment.

Determine Target Shade Levels

Use Tables D-7 and D-8 to identify target shade values for sections of Class AA and A streams (1,000 feet minimum length), then mark the boundaries on the base map. Note that the eastern Washington target values presented in Table D-8 are applicable to a geographic area different from the standard TFW minimum shade guidelines (Figure D-4). Also note that in some stream segments, state water quality classifications may conflict with predicted AA and A zones because riparian shade is naturally unlikely to maintain stream temperatures within Class AA standards in streams greater than 13 miles (21 km) from the WAU divide. Record the target shade value next to the boundary (Figure D-5).

Table D-7: Riparian target shade (canopy closure) values for non-glacial streams in western Washington.

Minimum Shade Category (%)	Elevation Zones (feet)	
	Class AA DOE Standard -16°	Class A DOE Standard -18°
<10	>3600	>2320
10	3280-3600	1960-2320
20	2960-3280	1640-1960
30	2400-2960	1320-1640
40	1960-2400	1000-1320
50	1640-1960	680-1000
60	1160-1640	440-680
70	680-1160	120-440
80	320-680	<120
90	<320	N/A
(**Note** that glacier fed streams tend to be naturally cooler than other forested streams for some distance downstream of their sources; these and other anomalous basin conditions may warrant special consideration.)		

Table D-8: Riparian target shade (canopy closure) values for non-glacial streams in eastern Washington.

Minimum Shade Category (%)	Elevation Zones (feet)	
	Class AA DOE Standard -16°	Class A DOE Standard -18°
<10	>4450	>3900
10	4200-4450	3700-3900
20	4000-4200	3450-3700
30	3800-4000	3250-3450
40	3600-3800	3050-3250
50	3350-3600	2850-3050
60	3200-3350	2600-2850
70	2900-3200	2450-2600
80	2750-2900	2200-2450
90	<2750	<2200
(**Note** that glacier fed streams tend to be naturally cooler than other forested streams for some distance downstream of their sources; these and other anomalous basin conditions may warrant special consideration.)		

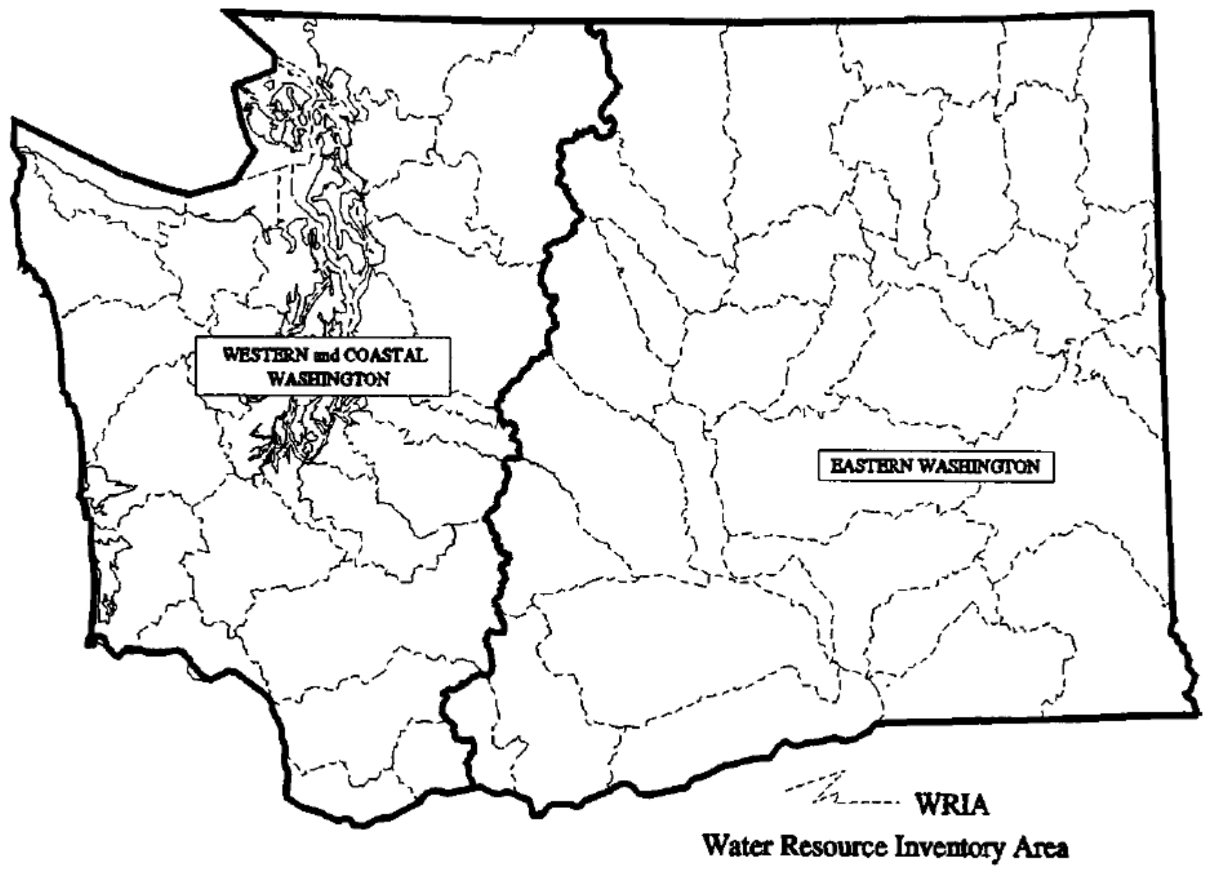


Figure D-4: Stream Temperature Regions of Washington For Applying TFW Temperature Screens

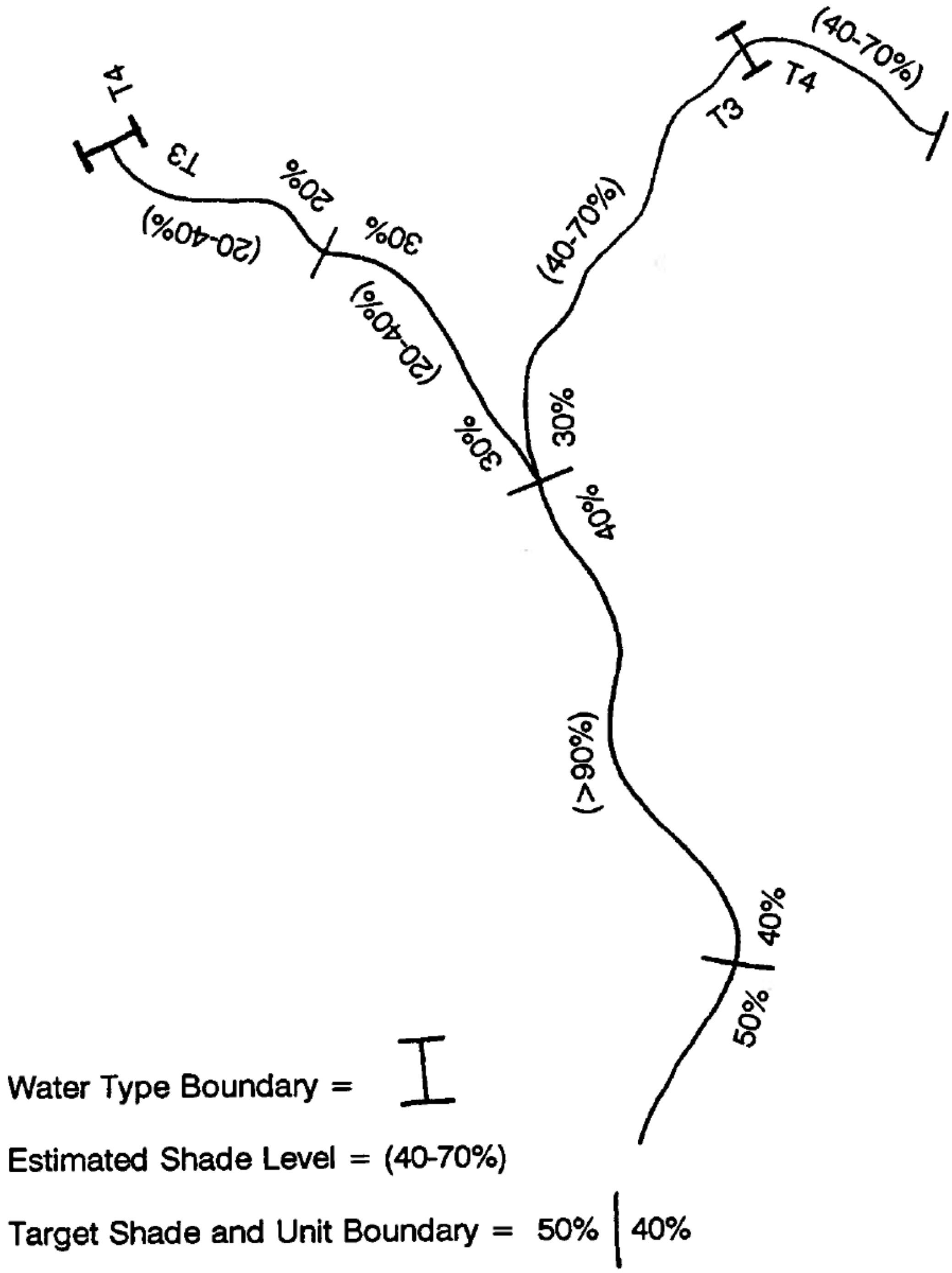


Figure D-5: Example of Map D-4: Target and Estimated Shade Levels

Also, use aerial photographs to identify stream segments that may be unusually wide relative to their position within the drainage (distance from WAU divide). These areas are candidates for additional assessment to verify low flow widths and to estimate shading and its influence on downstream temperatures.

Target values for Class B streams are not shown because the elevations of these streams are relatively low and shade does not ensure stream temperatures will meet state water quality standards.

Determine Existing Shade Levels
Existing shade levels are determined from an analysis of aerial photographs. If available, this analysis may be supplemented with ambient monitoring (canopy closure inventory data). For the photograph analysis, select stereo pairs of the most recent photographs that cover the Type 1-4 waters delineated earlier. Using a stereoscope with a 1x or 2x magnification, examine the riparian canopy cover and estimate the percentage of canopy shading to the nearest 10%. A general guide for shade estimates is contained in Table D-9.

Table D-9 Estimated Levels of Canopy Closure from Aerial Photos

Stream surface not visible	>90% shade
Stream surface slightly visible or visible in patches	70-90% shade
Stream surface visible but banks are not visible	40-70% shade
Stream surface visible and banks visible at times	20-40% shade
Stream surface and banks visible	0-20% shade

Record the shade estimates on the overlay (in brackets) next to the target shade values (Figure D-5).

The units should be coded on the map as follows:

20+ (40)

where 20+ denotes the percent target shade for the given elevation (i.e., 20% shade required), and (40) is the estimated percentage shade level for the reach (Table D-9).

The accuracy of this method is strongly dependent on ground-truthing of photograph interpretations and review of any supplemental information that may be available. First, preliminary estimates of riparian conditions are made in the office using the photographs and supplemental information. These estimates are coded on a mylar attached to representative photographs of the WAU. Second, field surveys are conducted as needed to check the accuracy of estimates for the representative areas selected. The analyst should focus on those stream reaches where their confidence in the photo calls was low. Use a canopy densiometer to make shade measurements at 50-foot intervals within the representative area. (See TFW Ambient Monitoring methods manual for detailed procedures.) Determine the average shade from the densiometer measurements. Finally, record the existing and target shade codes on Map D-4.

Identify Riparian Shade Hazard

Hazard calls for shade are determined by comparing estimates of existing shade levels with target shade levels. High hazard calls apply where existing shade, estimated from photographs or field measurements, is less than the target value for that stream reach. Low hazard calls apply to those stream reaches where existing shade meets or exceeds target shade levels. Because estimates of existing shade levels either fall short of target levels (High hazard) or meet/exceed target levels (Low hazard), no moderate hazard calls are assigned. Reaches needing field verification receive an indeterminate hazard call until canopy measurements can be completed.

An example of a field verified indeterminate hazard riparian zone may be as follows: A stream appears on aerial photography to be unusually wide for its position in the basin. Actual channel width and thus shading and target shade requirements must be established on the ground. Field examination finds large gravel bars derived from mass wasting inputs and a poorly shaded channel below target shade for its actual size. The indeterminate call is then reassessed to a high hazard call.

There are also some areas where water quality classifications and predicted natural maximum temperatures conflict, such as in eastern Washington where vegetation types may be inadequate to provide shade. These are often referred to as anomalous reaches and may include such things as beaver ponds, wetlands, or unnaturally wide channels. Field verification to determine if additional analysis is needed may be necessary. These naturally low shade reaches are identified separately. (See Table D-10: Map Labeling Guidelines for Shade Impact.) Record riparian shade hazard calls on Map D-5: Riparian Shade Hazard using a colored line code as defined in Table D-10.

Table D-10: Map Labeling Guidelines for Shade Impact

Solid Red Line	High Shade Hazard
Solid Green Line	Low Shade Hazard
Dotted Black Line	Naturally Low Shade Level
Dashed Blue Line	Indeterminate Shade Hazard

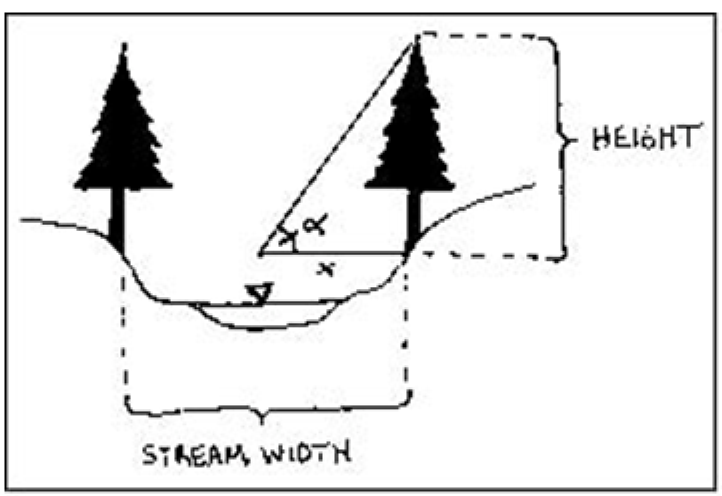
Identify Potential Contributing Activities

For those channel segments where existing shade does not meet the established target, identify the contributing activities that produced a high riparian shade hazard. Using the aerial photographs and supplemental information (talk with other analysts), determine if the reduction in shade is due to land use practices (e.g., logging, road construction, grazing, residential development) or natural influences. This information should be recorded in tabular format and included in the assessment report.

Additional Assessment for Wide Streams

Determine Potential Shade Levels

Using geometric parameters, the analyst can estimate the potential shade for a stream assuming a mature riparian tree height typical of the site. The following geometric configuration should be used as a general guide to estimate the effective tree height as a function of stream width. Assuming a solar angle, the height of riparian vegetation needed to provide shade to the middle of the stream channel can be calculated as:



where: HEIGHT = $(\tan \alpha)X$
X = ½ STREAM WIDTH

Given a solar angle of 60° (as in mid-summer, June-August), the HEIGHT of vegetation required to provide shade to the middle of the stream nearly equals the STREAM WIDTH. For example, a stream that is 50 feet wide requires vegetation nearly 50 feet in height for one-half of the stream to be shaded, or nearly 90 feet for the entire stream to be shaded.

If a constant solar angle of 60° is assumed, the equations can be simplified as follows:

HEIGHT = 1.73(½ STREAM WIDTH) or,

STREAM WIDTH = 2(HEIGHT/1.73)

For example, given a HEIGHT of 140 and 90 feet for effectively mature Douglas-fir and ponderosa pine, respectively, the maximum stream width measured from the vegetation edge that provides shade to one-half of the stream are 162 and 104 feet, respectively. It should be noted that topographic relief can reduce the necessary height. For an example of how this methodology has been applied in the past, the analyst should refer to the Griffin/Tokul Watershed Analysis (Weyerhaeuser Co. 1995).

Canopy Closure/Stream Temperature Assessment Report

The assessment report is intended to convey the analyst's results to other members of the assessment team, to the prescription team, and to those who may be interested in a concise, written description of the work. It should describe the results of the analysis and any conclusions reached relative to the critical questions. The assessment report should include the following:

- Documentation of all information used in the assessment of both the early and current conditions of the riparian zones in the WAU. This includes aerial photos, maps, anecdotal information, aerial flights made, and any other information used to characterize riparian conditions.
- A discussion of the riparian history land use practices that may explain the current condition of the existing riparian vegetation. Shade-limited areas such as floodplains, wetlands, beaver ponds, rock outcrops, etc. should be identified where possible. Land use practices may include harvesting within riparian areas or large scale disturbances such as debris flows or dam-break floods.
- A summary of the current shade levels, target shade levels, and hazard calls for the WAU. The information should be presented in tabular format so the reader can quickly assess the current riparian condition relative to target conditions. The summaries should provide answers to questions such as "What percent of the WAU's riparian zones are currently meeting target shade levels?", and "What percent of the assessed riparian zones received HIGH hazard calls?".
- A description of any deviations from the standard methods and why the changes were necessary.
- A description of any additional analysis that was performed.
- A discussion of the analyst's confidence in the work products. Consider factors such as skill level, variability of riparian conditions, extent of field-checking photo calls, accessibility of the WAU, quality of aerial photos used, quality and quantity of additional information, and any additions or deviations from the standard methods.

- Answers to the critical questions presented at the beginning of the section. While it is not necessary to include this as a separate section, be sure that the critical questions are addressed somewhere in the report.

Maps

- D-4: Target and Estimated Canopy Closure Levels
- D-5: Riparian Shade Hazard

Summary Data

- Worksheet D-3, Estimated Canopy Closure By Channel Segment.
- Contributing Activities Table
- Any additional worksheets or field data used in the analysis.

Riparian Function Assessment Report

I. **Title page** with name of watershed analysis, name of module, level of analysis, signature of qualified analyst(s), and date

II. **Table of contents**

III. **Maps**
- Riparian stand conditions and water type map (map D-1)
- Near-term large woody debris recruitment potential map (map D-2
- Long-term large woody debris recruitment potential map (map D-3) -- if assessment of long-term potential was performed
- Target riparian shade conditions map (map D-4)
- Riparian shade potential map (map D-5)

IV. **Summary Data**
- Stream length by riparian vegetation condition (form D-1) or equivalent
- LWD recruitment impact call by channel segment (form D-2)
- Estimated canopy closure by channel segment (form D-3)

V. **Summary Text**
- Summary of all information used to document historic and current riparian conditions
- Summary of historic land use practices in riparian zones
- Summary of riparian vegetation conditions, in-channel LWD levels, and hazard calls
- Summary of current shade levels, target shade levels, and hazard calls
- Study methods, including description of sampling methods and any deviations from standard methods
- Statement of the author's confidence level in the analysis and results
- Recommendations for Level 2 (at Level 1 only)
- Does module report address all critical questions?

VI. **Aerial Photos**
- List and resolution of aerial photos
- Photo series (flight line photo number, etc.) and where stored

VII. **VII. Other Information (optional)**
- Monitoring strategies and design and implementation suggestions
- Learning resources (a.k.a., references, bibliography) section
- Acknowledgments section

Acknowledgments

This module represents the work of many people over the course of several years. The current version was revised by Jeff Grizzel, Jeff Light, Steve Toth, Curt Veldhuisen, and Chris Earle. Bob Gustavson, Jerry Gorsline, and Mark Hunter reviewed the final draft and provided valuable comments. Judith Holter edited the final version in preparation for its presentation to the Forest Practices Board. The Board approved this revised module in February 1996.

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Worksheet D-1: Stream Length by Riparian Vegetation Condition and Channel Segment

Worksheet D-1: Stream Length by Riparian Vegetation Condition and Channel Segment

Riparian Condition Code	**Stream Channel Segment***																	
Hardwood/Small/Sparse																		
Hardwood/Small/Dense																		
Mixed/Small/Sparse																		
Mixed/Small/Dense																		
Conifer/Small/Sparse																		
Conifer/Small/Dense																		
Hardwood/Medium/Sparse																		
Hardwood/Medium/Dense																		
Mixed/Medium/Sparse																		
Mixed/Medium/Dense																		
Conifer/Medium/Sparse																		
Conifer/Medium/Dense																		
Hardwood/Large/Sparse																		
Hardwood/Large/Dense																		
Mixed/Large/Sparse																		
Mixed/Large/Dense																		
Conifer/Large/Sparse																		
Conifer/Large/Dense																		
Segment TOTAL**																		

*** Lengths measured using a map wheel (record in centimeters or inches)**

****Segment TOTAL = 2 X Actual Segment Length because both sides are measured**

Worksheet D-2: LWD Recruitment Impact Call by Channel Segment

Worksheet D-2: LWD Recruitment Impact Call by Channel Segment

Riparian Condition Unit	Channel Segment Number	Riparian Condition Code	Recruitment Potential Rating	Channel Sensitivity Rating	In-channel LWD Rating	LWD Recruitment Impact Call	Comments

Worksheet D-3: Stream Length by Estimated Canopy Closure and Channel Segment

Worksheet D-3: Stream Length by Estimated Canopy Closure and Channel Segment

Canopy Closure Estimate From Photo Interpretation	**Stream Channel Segment***																	
>90%																		
80-89%																		
70-79%																		
60-69%																		
50-59%																		
40-49%																		
30-39%																		
20-29%																		
10-19%																		
<10%																		
From Field Measurements																		
Number of Plots -->																		
Plot Average (% Cover) >																		
Segment TOTAL																		

*** Lengths measured using a map wheel (record in centimeters or inches)**