FINAL
September 9, 2005
Conditionally Approved by DEQ

Northwest Forest Plan Temperature TMDL Implementation Strategies

Evaluation of the Northwest Forest Plan Aquatic Conservation Strategy and Associated Tools to achieve and maintain stream temperature water quality standards

United States Forest Service and the Bureau of Land Management

July 9, 2002 (revised Dec. 6, 2002; January 2, 2003; January 7, 2003; January 29, 2003; January 31, 2003; February 5, 2003; February 26, 2003; March 3, 2003; April 2, 2003; April 16, 2003; May 19, 2003; Final Draft July 29, 2003; revised September 11, 2003; October 8, 2003; March 2, 2004; March 3, 2004; August13, 2004; October 21, 2004; December 30, 2004; February 9, 2005; April 15, 2005, September 9, 2005

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Executive Summary

Water temperature is a major water quality issue on public lands in the area covered by the Northwest Forest Plan (NWFP). Water Quality Restoration Plans (WQRPs) that are developed according to the U.S. Forest Service (FS) and Bureau of Land Management (BLM) 303(d) protocol[1] and agreements between Oregon DEQ and the FS and BLM[2]are the primary vehicles for conveying the commitment of federal land management agencies to protect and restore water quality. Several WQRPs completed for the NWFP area found that management of designated streamside zones (e.g., Riparian Reserves) can provide sufficient stream shade to protect or recover stream temperature in waters listed as "impaired" on the State's 303(d) list. A primary goal of this document is provide the basis for analyzing stream shade, effects of shade on stream temperature, and management of riparian areas to meet water quality and broader objectives embodied in the NWFP Aquatic Conservation Strategy (ACS).

The approach includes a logic outlining how management of Riparian Reserves contributes to the long term protection and restoration of water quality. The approach recognizes the contribution of Riparian Reserves to passive restoration; and as well proposes active management of Riparian Reserves suggesting that management can also contribute to attainment of restoration objectives. Third, the approach develops and presents shade nomographs as a tool for analyzing and demonstrating how vegetation thinning in of Riparian Reserves can contribute to water quality restoration. Finally, the approach includes a framework for assembling information about watershed condition, identifying areas where passive restoration is occurring and where active management is planned and proposes a monitoring strategy to support TMDL[3] implementation. The intent is to illustrate how the ACS and Riparian Reserves are protective of and provide shade necessary to protect and maintain water quality objectives and meet TMDL targets over time. The document illustrates how management to maintain forest health is not inconsistent with objectives to protect or recover shade. The document provides tools to identify critical shade. The tools allow for analysis of shade, identification of contributing sources of shade, and review of opportunities for management within Riparian Reserves. This document is not a decision document nor does it provide recommendations. The document is multipurpose in that it demonstrates the adequacy of existing direction to protect and maintain stream shade and demonstrates how management within Riparian Reserves can contribute to restoring and maintaining stream shade through time.

Background

The NWFP provides a common approach for administering 25 million acres of public lands that accommodates among other things, the protection and restoration of riparian processes and improved water quality. The NWFP was structured to ensure maintenance and improvement of water quality through a watershed-based approach and attainment of ACS objectives within a network of Riparian Reserves. Recognizing that riparian areas provide other functions in addition to stream shade, the focus of this analysis is on shade. The analysis uses solar physics to illustrate how management of riparian areas, given area width, aspect, and slope can produce conditions

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[1] Forest Service and Bureau of Land Management Protocol for Addressing Clean Water Act Section 303(d) Listed Waters. May 1999.

[2] These MOAs also state that ODEQ/FS/BLM acknowledge the contribution of existing planning processes towards meeting CWA responsibilities.

[3] TMDL is a total maximum daily load and includes the sum of the individual waste load allocations for point sources and load allocations for nonpoint sources of pollution and background.

that protect stream shade and thus water temperature. The analysis illustrates how manipulation of vegetation within riparian areas affects shade, solar loading on streams, and thus stream temperature. The results demonstrate how management of riparian areas can contribute to protection or recovery of stream temperature.[4] This evaluation provides the framework for streamlining development of WQRPs that the states rely on to implement TMDLs on federal lands.

The FS and BLM have legislated responsibilities for managing public forest lands and resources according to a multiple-use mandate. The National Forest Management Act (NFMA) and the Federal Land Policy and Management Act (FLPMA) require the FS and BLM, respectively, to develop comprehensive land management plans to guide this work. BLM Resource Management Plans, FS forest plans, and decisions made under the National Environmental Policy Act (NEPA) are the primary means for implementing activities that restore watershed processes and thus protect water quality on lands administered by the FS and BLM.[5] It is through these legal mandates and cooperative agreements that the FS and BLM support implementation of the Clean Water Act (CWA) on federal lands.

Rationale

The 1993 Forest Ecosystem Management Assessment Team (FEMAT) report that provided the science underlying the NWFP, delivered 10 options for management of public lands with the range of the Northern Spotted Owl. Option 9, which was selected at the time, was a dynamic plan formulated around active management. The clear intent of Option 9 was that buffers of uncut forest along streams would be subject to appropriate silvicultural manipulation. Based on scientific findings in FEMAT, the NWFP designated streamside zones termed Riparian Reserves, to provide protection for aquatic and riparian dependent species. The Riparian Reserve network was also developed to provide connectivity and migration corridors that would benefit terrestrial species, extending buffer areas necessary to accomplish hydrologic, water quality, and aquatic resource management objectives. The NWFP provided for management and adjustment of riparian buffers contingent upon completion of watershed analyses. This management direction was based on FEMAT science, which recommended that the interim riparian reserves should be adjusted and appropriately managed to protect and enhance stream conditions including among others, stream shading.

However, as a result of regulatory requirements to comply with the Endangered Species Act (ESA), objectives to preserve biodiversity, and lack of adequate technical resources to evaluate and adjust buffer widths, a regulatory precedent that recognizes 300-foot riparian buffers along fish bearing streams, was established and has been maintained in most cases. One unintended consequence of this precedent has been FS and BLM reluctance to actively manage Riparian Reserves. A second unintended consequence has resulted in a regulatory requirement to develop

[4] The 1993 Forest Ecosystem Management Assessment Team (FEMAT) report that provided the science underlying the NWFP, delivered 10 options for management public lands within the range of the Northern Spotted Owl. Option 9, which was selected at the time, was a dynamic plan formulated around active management. The clear intent of Option 9 was that buffers of uncut forest along streams (i.e., Riparian Reserves) would be subject to appropriate silvicultural manipulation.

[5] The FS and BLM are designated management agencies (DMAs) responsible for implementing the Clean Water Act (CWA) on federally administered lands. The primary mechanisms for clarifying these responsibilities are memoranda of understanding and agreement with state water quality regulatory agencies.

detailed WQRPs for riparian areas regardless of whether they are being actively managed. This effort is duplicative of other efforts provided by the NWFP ACS.[6]

Whether the FS and BLM are actively managing riparian areas, the regulatory requirements to meet CWA objectives remain the same. By design, full implementation of the NWFP was intended to protect and restore water quality over the long term. The NWFP temperature TMDL implementation strategy provides the tools and assurances necessary to accomplish objectives of compliance reporting, restoration planning, and public disclosure, in order that the agencies can manage riparian areas while continuing to protect water quality. The proposal is not intended to depart from the precautionary principle but is intended to accommodate, with regulatory certainty, active management of riparian areas. The template as proposed should provide information that is both necessary and sufficient for meeting BLM and FS obligations for compliance reporting.

The FS and BLM seek ODEQ concurrence that the NWFP is sufficient for protecting and restoring water quality. The FS and BLM seek ODEQ's agreement that the streamlined approach presented herein will provide the information necessary to support the State's TMDL process and non-point source program objectives and meets ODEQ's expectations for stream temperature compliance under the CWA.

[6] The *Forest Service and Bureau of Land Management Protocol for Addressing Clean Water Act Section 303(d)Listed Waters* is the FS and BLM vehicle for developing water quality restoration plans that are used to guide restoration of waters included on the State of Oregon's 303(d) list. Elements of the protocol were intended to streamline compliance reporting and water quality restoration planning. However, the protocol did not anticipate administrative process that perpetuates the development of often times redundant plans.

Part 1 Sufficiency of the NWFP to meet water quality objectives

Overview

The NWFP Record of Decision (ROD) and Standards and Guidelines include objectives designed to maintain the hydrologic, geomorphic and ecologic processes that affect riparian condition, fish habitat, and standing and flowing water. [7] The ACS[8] outlines a comprehensive framework for protecting and restoring aquatic and riparian systems including Key Watersheds, Riparian Reserves, Watershed Analysis, and Watershed Restoration. In general, Key Watersheds serve as the cornerstones of aquatic species recovery. Watershed Analysis involves an analytic process and is required in Key Watersheds, as well as Riparian Reserves, to determine how activities on federal lands contribute to meeting ACS objectives. Finally, Watershed Restoration that is integral to recovery of fish and riparian habitat becomes a means by which water quality can be recovered to levels necessary to meet state and federal water quality standards and support beneficial uses.

Northwest Forest Plan Riparian Reserves

Riparian Reserves include areas designated to maintain the hydrologic, geomorphic, and ecologic processes that affect riparian condition, fish habitat, and standing and flowing water. Every watershed on federally administered lands under NWFP direction has Riparian Reserves. Riparian Reserves are not reserved from management but rather are "reserved" to protect and restore aquatic and riparian dependent resources. Riparian Reserves vary by stream category according to whether a stream is fish bearing; permanently flowing but non-fish bearing; or intermittent.[9] For permanently flowing streams Riparian Reserves are defined as follows:

> *Fish bearing streams* – Riparian Reserves consist of the stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edge of the Riparian Reserve vegetation, or to a distance equal to two site potential trees, or 300 feet slope distance (600 feet total, including both sides of the stream channel), whichever is greatest).
>
> *Permanently flowing, non-fish bearing streams* – Riparian Reserves consist of the stream and the area on each side of the stream extending from the edge of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance (300 feet total, including both sides of the stream channel), whichever is greatest.

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[7] Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl; Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl

[8] NWFP consists of the Record of Decision and Standards and Guidelines, the Final SEIS, and the Forest Ecosystem Management Assessment Team report; April, 1994 and July, 1993.

[9] Sediment loads from intermittent streams can alter channel shape in receiving perennial streams, causing heating. However, this potential impact is not further assessed in this assessment.

Riparian Reserve widths were based on site potential tree height based on the FEMAT science findings which demonstrated that one site potential tree height provides components necessary to ensure sustainable ecological function of riparian systems. Because "site potential" can vary in relation to many factors and further because the Riparian Reserve network was established for multi-purpose resource management objectives, Standards and Guidelines were developed to regulate activities in Riparian Reserves and as well to accommodate management leading to attainment of ACS objectives in Riparian Reserves.

The Standards and Guidelines developed to ensure that activities in Riparian Reserves are implemented consistent with the ACS include but are not limited to:

LH-1 requires identification of "in-stream flows needed to maintain riparian resources, channel conditions, and fish passage".

WR-1 addresses design and implementation of watershed restoration projects in a manner that promotes long-term ecological integrity of ecosystems, conserves the genetic integrity of native species, and attains ACS objectives.[10]

FW-1 addresses design and implementation of restoration and enhancement activities in a manner that contributes to meeting ACS objectives.

FW-4 identifies cooperation with Federal, Tribal, and state fish management agencies to identify and eliminate impacts associated with habitat manipulation, fish stocking, harvest, and poaching that threaten the continued existence and distribution of native fish stocks.[11]

TM-1 prohibits timber harvest, including fuel wood cutting, in Riparian Reserves, except as described below. Riparian Reserve acres shall not be included in calculation of the timber base.

a. if required to attain Aquatic Conservation Strategy objectives
b. and other ACS objectives are not affected
c. to attain Aquatic Conservation Strategy Objectives

By design, the Riparian Reserve network was intended to maintain and restore hydrologic, water quality and riparian processes. As well, Riparian Reserves were intended as transition zones between upslope and aquatic areas, travel and dispersal corridors, and connectivity corridors within a watershed.[12] Thus, management within these areas was to be based on objectives to protect, maintain, or restore high value riparian zones, terrestrial and aquatic habitats, and water quality. These objectives necessitate an understanding of hydrologic, geomorphic, and ecologic processes, among other processes, in order that active management can be pursued. Of importance to the present analysis is an understanding of the relationship between the function of Riparian Reserves (e.g., riparian vegetation) in protecting or restoring water quality.

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[10] *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl.* WR-1 included on page C-37.
[11] *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl.* FW-1 and FW-4 included on pages C-37 and 3-38, respectively.
[12] ROD, B-12; FEMAT V-26-28,34

The Structure of Riparian Vegetation and Influence on Stream Shading

The effect of riparian vegetation on stream shading decreases with increasing distance from the stream bank, the degree of channel constraint and floodplain development.[13] Effectiveness of streamside vegetation to provide shade varies with geomorphology, topography, orientation, extent of canopy opening above the channel, and forest structure. ODEQ has established site potential shade as a "target" which, if achieved, should accommodate stream shading to the degree necessary to protection stream temperature. Recognizing that the width of Riparian Reserves necessary to meet the shade target and thus protect water quality can vary, it must also be recognized that effective shade diminishes beyond some point where the incremental benefit of a wider riparian buffer is either negligible or immeasurable. The point herein is that significant shade is derived from near stream riparian vegetation (FEMAT 1993).[14]

The Physics of Stream Temperature

Stream temperature is driven by the interaction of site conditions, weather, riparian vegetation, and the input of radiant energy to a stream system. Energy exchange that effects a change in water temperature may involve solar radiation, long wave radiation, evaporative heat transfer, convective heat transfer, conduction, and advection (Lee 1980; Beschta 1984) (Figure 1). Solar radiation is the most important source of radiant energy affecting stream temperature (Brown, 1969; Beschta, 1997). With the exception of solar radiation that only delivers heat energy, all the other processes are capable of both introducing and removing heat from a stream. While the process of introducing and removing heat from a stream is complex, certain processes are more important than others in determining how stream temperature is affected by solar inputs (Beschta, 1987). If it is agreed that solar radiation is the most important source of radiant energy affecting stream temperature, given constant surface area and stream flow, any increase in heat entering a stream from solar radiation will result in a proportional increase in stream temperature (Brown, 1972).[15]

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[13] Many effects of riparian vegetation on streams decrease with increasing distance from the streambank; among these are root strength, large wood delivery, inputs of particulate and organic matter to streams, shade, riparian microclimate, water quality and habitat. FEMAT (1993) reviewed variations in buffer widths to support these riparian functions. Of focus in this analysis is the relationship of riparian vegetation to stream shade and water quality.

[14] Although the width of riparian areas necessary to protect water quality are highly variable, shading potential of riparian vegetation is the most effective within widths less than one-half of the average height of the tallest trees on a site, or half a site potential tree height.

[15] Stream temperature is an expression of heat energy per unit volume, which in turn is an indication of the rate of heat exchange between a stream and its environment.

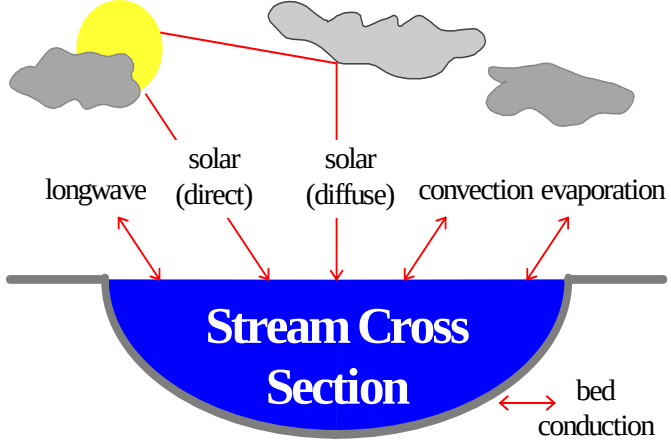


Figure 1. Heat exchange between a stream and its environment.

While a stream exposed to solar radiation absorbs a certain amount of heat, some heat is reflected off the stream surface, depending on the sun's elevation (Brown 1969, Beschta et al. 1987). The solar radiation that is absorbed as heat occurs outside the visible spectrum (0.36μ to 0.76μ) and is absorbed within the first meter of stream depth. Only visible light penetrates below one meter (Wunderlich, 1972). Conversely, when a stream is shaded far less heat energy is absorbed, demonstrating the affect which riparian vegetation can have on stream shading and thus water temperature (Rishel et al., 1982; Brown, 1983; Beschta et al., 1987). Of course, the influence of riparian vegetation on stream shading varies with vegetation height, location, and density; and stream width, orientation, and steepness of adjacent uplands; all which must be considered when drawing conclusions regarding the affect of riparian vegetation on stream shade. .

Existing Shade and Site Potential Shade

In order to determine the sufficiency of Riparian Reserves for producing or maintaining riparian vegetation necessary to achieve temperature standards or meet TMDL shade targets, existing shade and the shade necessary to prevent solar loading must be analyzed. Such an analysis accommodates a more rigorous examination of existing shade and the effect that manipulation of riparian vegetation could have on shade. Existing shade refers to the amount of shade provided by the existing riparian vegetation. Existing shade may or may not be the same as "site potential shade" which is the optimum shade that can be expected at a given site given specific channel widths and site specific characters.

Anthropogenic factors influence both existing and site potential shade. For example, in riparian areas that have been harvested and have succeeded to dense early-seral vegetation site potential shade may be diminished until stands are thinned and individual trees are released for recruitment into the forest canopy. In such cases thinning that reduces stream shade and may affect stream temperature in the short term may ultimately result in a long-term benefits to shade production.

Effective Shade

Effective shade is the total solar radiation blocked from reaching the stream over a twenty-four hour period. Effective shade is defined as:

$$\frac{\text{Total Solar Radiation - Total Solar Radiation Reaching the Stream}}{\text{Total Solar Radiation}}$$

Effective shade is influenced by slope steepness, vegetation species composition, tree height, vegetation density, tree distance from the stream bank, and stream width. Thus, although riparian vegetation is a physical barrier between the stream and incoming solar radiation, only a portion of the riparian canopy contributes to effective shade. The relationship and interplay of variables affecting effective shade can be simplified, to some degree, using geometry and computer models that simulate shade (Boyd 1996, Park 1993). Because, in many cases, a modeling approach has been used to develop temperature TMDLs, such an approach was developed to support the temperature strategy discussed herein.

Figure 2 illustrates the results of modeling to represent the downstream change in water temperature relative to effective shade. The Figure illustrates that as effective shade increases beyond 40% there is a corresponding reduction in stream temperature to a point (e.g., approximately 80%) beyond which further reduction in stream temperature as a function of shade is not measurable (Boyd 1999). Eighty percent does not represent a minimum threshold, standard, or load allocation but simply that point beyond which a reduction in stream temperature as a function of shade may not be measurable.[16]

[16] It should be noted that several TMDLs approved in the late 1990s refer to 80% stream shade as an optimum threshold for shading based on the relationship of shade to stream temperature. The relationship is discussed in terms of temperature, percent shade, and stream flow that are the primary variables quantified in the TMDL modeling process.

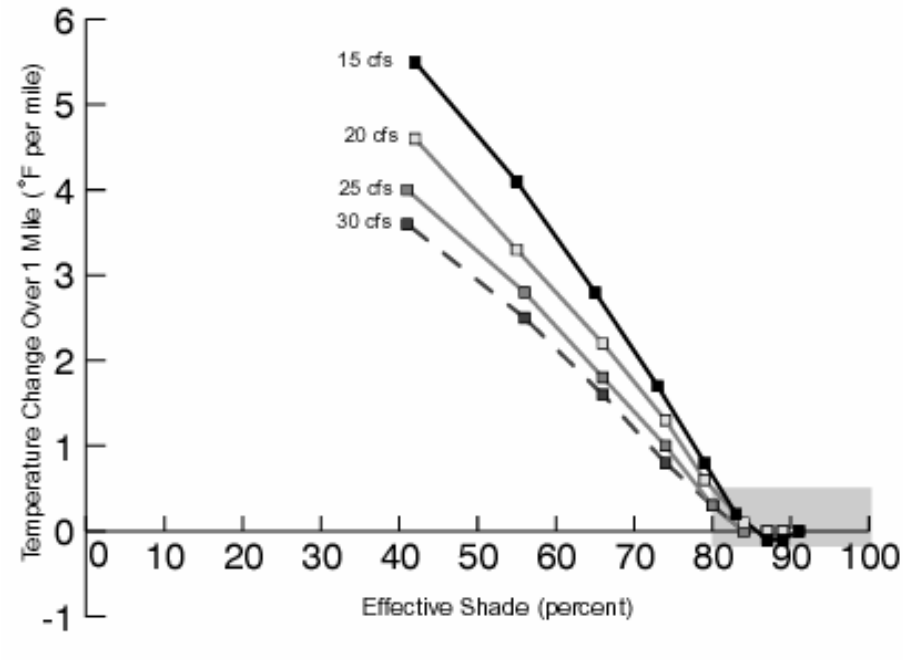


Figure 2. Stream shade and change in water temperature

Figure 3 illustrates the relationship between shade and stream width.[17] As stream width increases beyond the point where site potential vegetation is not tall enough to cast a shadow across the stream channel, shade values may be less than 80%.[18] Figure 3 also illustrates that, given 150-foot tall trees (e.g., site potential tree height) stream shade decreases below 80% for channels wider than 40 feet. Thus, where site potential vegetation is less than 150 feet, optimum shade may not be reached for channels less than 40 feet.

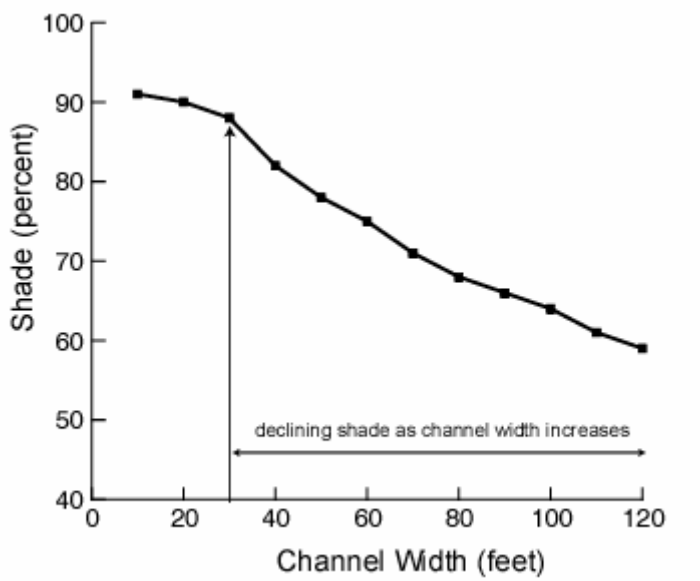


Figure 3. Shade provided by 150 foot tall conifers

[17] Shade represents that provided by a site potential tree as defined by FEMAT (1993).
[18] The model analysis is based on the shadow cast by shade producing vegetation.

Determining Shading Vegetation within the Riparian Area

Because, in many cases, a modeling approach was used to develop temperature TMDLs, such an approach was used to support the temperature strategy discussed herein. For purposes of this analysis, the SHADOW model was used to calculate effective shade. SHADOW is a physical model that is used to estimate stream shade and the width of areas providing shading vegetation. Although the accuracy of SHADOW has been demonstrated (Figure 14) it must be recognized that temperature responds to many variables, all which may not be included as components of the SHADOW model.

SHADOW accounts for solar position, vegetation height, stream orientation, and side slope (Figure 4) that effect stream shade variability throughout the day. As the sun changes its vertical (zenith angle) and horizontal (azimuth) positions the shading provided by vegetation changes. Thus, knowing the sun's position at a given time of day, the height of the riparian vegetation and the location or distance from the stream's edge, effective shade can be calculated.

When the sun's zenith angle is at its smallest and the sun is in its highest position in the sky, vegetation closest to the stream is providing maximum shade. As the zenith angle increases and the sun's position in the sky is lower vegetation farther from the stream begins to provide shade. Knowing the sun's position throughout the day and the physical characteristics of riparian vegetation (e.g., vegetation height or distance from stream edge) accommodates modeling of the area width necessary to provide effective shade. (Park, 1991).

For purposes of analysis, the sun's zenith and azimuth angle must be derived and can be calculated using the following equations.

Zenith angle (Z)

Cos(Z) = (sin latitude)(sin solar declination) + (cos latitude)(cos solar declination) x (cos hour angle)

Azimuth angle (A)

Sin(A) = (cos declination) x (sin hour angle)/sin zenith angle)

For the present analysis it was assumed that peak stream temperatures occur during July and August. Based on this the sun's zenith and azimuth angel on August 1st were used to represent "the period during which peak stream temperatures would be recorded" and were used, among other variables, to calculate the width of the riparian area necessary to provide effective shade. This assumption can be validated in the field using an instrument such as the Solar Pathfinder.[19]

[19] The Solar Pathfinder is an instrument developed to determine heating in solar collectors but which is also used to measure effective shade. The Solar Pathfinder measures the percent solar radiation available each hour of the day, for each month of the year. Mention of a product name does not imply endorsement of the instrument by the USFS or BLM.

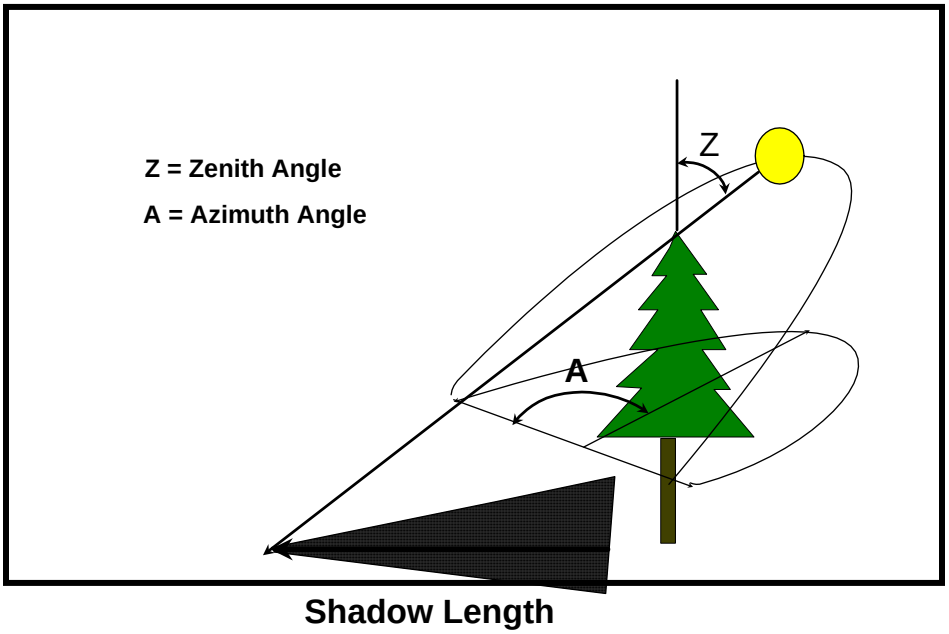


Figure 4. Solar Zenith and Azimuth Angles Used to Estimate Shadow Length and Riparian Area Width

$$\text{Riparian width} = \frac{T\,[(\tan Z)\cos(\tan S^{-1})]}{[\sin(\tan S) + Z - 90\,]}\,[\sin(A-R]$$

T = average tree height
Z = zenith angle
S = bank slope
A = azimuth
R = stream orientation

As stated earlier, the width of riparian vegetation providing effective shade is a function of vegetation height. Figure 5 displays the shade producing riparian buffer for various tree heights.

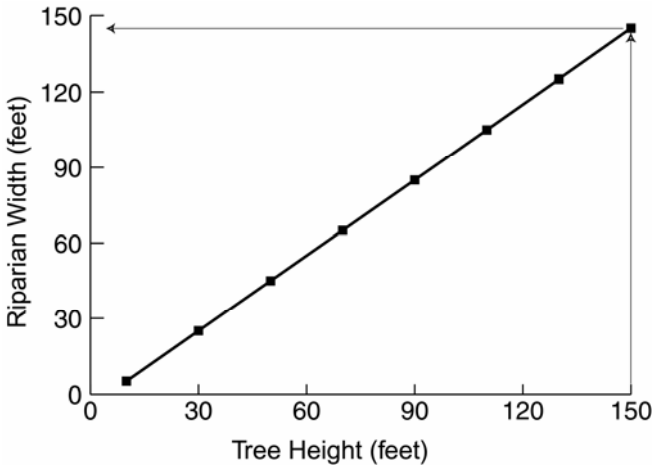


Figure 5. Riparian width contributing shade based on tree height and 70 percent slopes

Sufficiency of Riparian Reserves for Protecting and Maintaining Effective Shade and Water Temperature

SHADOW incorporates slope and vegetation height to calculate the width of the riparian area necessary to maintain some threshold of effective shade. For example, given a 150-ft tall tree on a 70% slope (Figure 5) the greatest distance a tree that can produce one unit of stream shade (1%) can be from the stream is 145 feet.[20]

Slope steepness can affect the width of the area that provides effective shade. As slope steepness decreases the width of the area providing effective shade will be narrower; as slope steepness increase, the width of the area producing effective shade will increase.

Based on the preceding logic and given interim buffer widths of Riparian Reserves (e.g., minimum 150 ft or one (1) site potential tree for perennial streams) that are required under the ACS, the NWFP is adequate to achieve riparian conditions necessary to protect effective shade and maintain or restore water temperature.

[20] This estimate accounts for the tip of the farthest tree that as some time of the day could potentially cast a shadow that will touch the edge of the stream. It therefore overestimates the width of trees in the riparian area that could potentially provide meaningful shade to the stream.

Part 2 Thinning within Riparian Reserves to Restore Ecological Health and obtain ACS objectives

Effects of Thinning

The ACS objectives did not intend that active management in Riparian Reserves would cease as function of NWFP implementation. In fact, vegetation treatment may be necessary to restore the ecological health of sites that were harvested previously or have been degraded due to lack of disturbance. Many Riparian Reserves are over dense or lack the species composition and age class of vegetation necessary to restore riparian condition. Treatment of these sites to reduce vegetation density in order to limit the risk of fire and disease; restore species composition and structural diversity of riparian vegetation; restore habitat for wildlife; and enhance large wood recruitment potential; could have short-term effects on water quality but would ultimately translate to enhanced sustainability of riparian and aquatic resource conditions.

Riparian Reserves act as buffers moderating water temperature by intercepting incoming solar radiation (Brazier and Brown, 1973). However, the only vegetation providing shade to the stream channel is limited to that vegetation between the stream and the sun. Therefore, vegetation in Riparian Reserves could be thinned and continue to provide shade to the stream if the critical shading vegetation is protected. Thus although vegetation removal (e.g., thinning) could affect existing shade as long as the critical shading vegetation is protected effects to water quality should be either negligible or of short duration. It should be noted that thinning affects other watershed processes that affect water quality (e.g., sediment delivery, bank stability, wood recruitment) however the effects of thinning on these processes is beyond the scope of this analysis.

Since thinning may be necessary in some cases to accomplish ACS objectives, identifying critical stream shade will also be necessary in areas proposed for thinning in order to protect stream temperature. Based on an understanding of riparian characteristics and given solar physics, it is possible to define the area in which vegetation that provides critical stream shade must be retained. This analysis will accommodate development of recommendations for thinning in areas that do not providing critical stream shade.

Figure 6 illustrates the effects of riparian thinning on stream temperature. Although the example illustrates the relationship between shade loss, temperature, and basal area rather than canopy closure it is noteworthy to point out that as effective shade decreases below 80% water temperature increases.

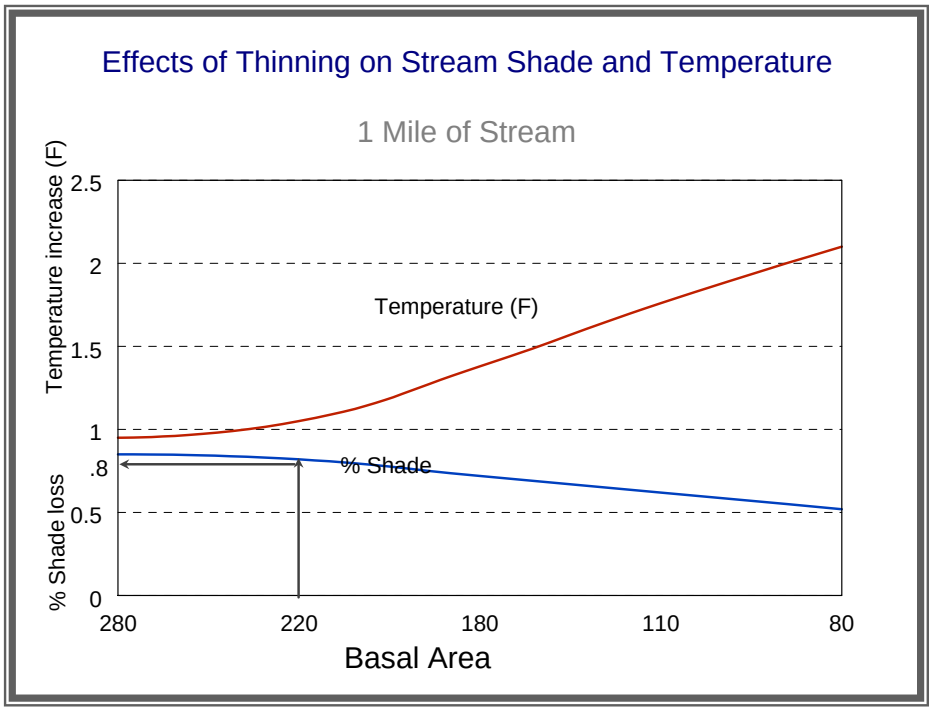


Figure 6. Modeled effects of thinning on stream temperature (SHADOW)

Angular Canopy Density

As described previously, as the sun's zenith and azimuth angle change throughout the day, so does the function of vegetation in affecting shade density (Figure 7). When the sun is at the highest point in it's' arc (e.g., solar noon) vegetation closest to the stream provides the greatest shade. As the sun's position lowers, vegetation farther from the stream intercepts radiation and increases the function of vegetation in providing stream shade.

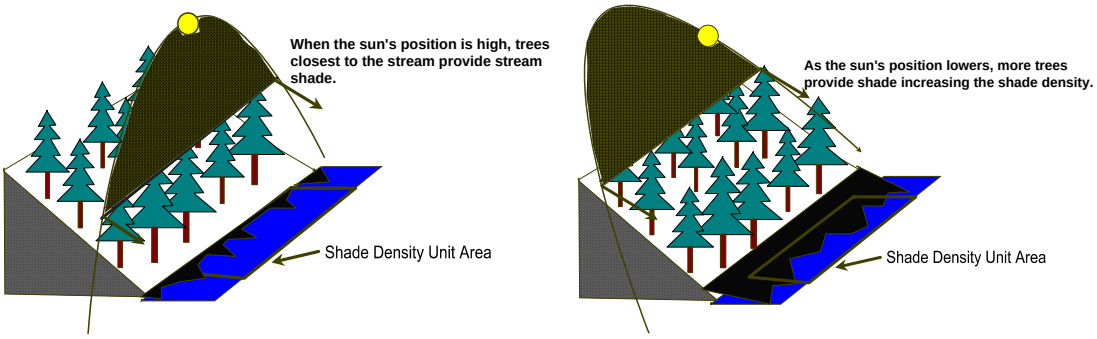


Figure 7. Shade density and the location of vegetation intercepting solar radiation.

What we are describing and what changes with the position of the sun in it's' arc is the angular canopy density. Angular canopy density (ACD) is the measure of canopy closure as projected in a straight line from the stream surface to the sun. ACD measures the quality of the shadow the canopy provides as the angle of the sun changes throughout the day. ACD is a proxy, if you will, for the quality of the shadow cast. ACD is expressed as a percent where "100%" is complete canopy closure blocking all direct solar radiation from reaching the stream surface. Realistically 100% canopy closure is never achieved. However, factors that increase ACD include 1) high tree densities; and 2) low solar angle. As the sun's position in its arc lowers the greater number of trees and thus a wider riparian buffer become necessary to block solar radiation. This relationship is not so clearcut and will vary according to site condition and vegetation type.

A study on the Umpqua and Siuslaw National Forests measured the changes in ACD with varying riparian buffer widths (Brazier and Brown, 1972). The sites, located adjacent to clearcut harvest units had variable buffer widths. Steinblums et al. (1984) conducted a similar study on the Willamette and Mt Hood National Forests and in the North Umpqua Resource Area of BLM. Results of the two studies illustrated lower ACD for the Willamette, Mt Hood, and North Umpqua than for sites with similar buffer widths in the Umpqua and Siuslaw National Forests. Steinblums et al. (1984) focused on the effects of windthrow in riparian areas adjacent to clear-cut harvest units. Of the 22 study sites, 13 sites contained 50 to 88% of the original buffer volume still standing at the time ACD measurements were recorded. This could account for the lower ACD measurement results from that study.

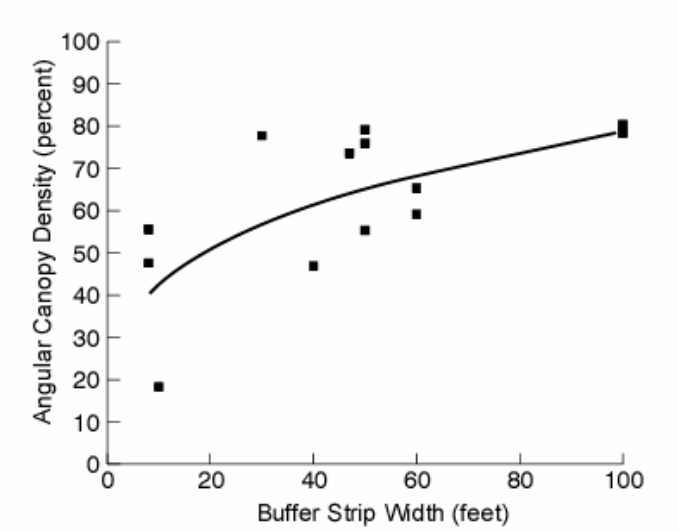


Figure 8. Angular canopy density (ACD) and buffer widths for small streams in western Oregon (Brazier and Brown, 1972)

Study results illustrated that as riparian area widths increased from 10 to 60 feet, ACD increases (Figure 8). The results also illustrated that increases in ACD decrease beyond buffer widths of 60 feet. It is important to note that the ACD value for a given buffer depends on vegetation density; thus, the results from Steinblums et als. work. In more open stands wider buffers become necessary to achieve the same ACD as would be achieved given similar vegetation with a closer spacing (Brazier and Brown 1972).

Table 1. Buffer Width and ACD in Relation to Vegetation Density

STREAM NAME	BUFFER WIDTH	VOLUME PER ACRE[21]	ACD PERCENT
Lower Francis	50	28,279 bd-ft	55.3
Little Rock	47	46,296 bd-ft	73.6
Upper Francis	50	68,322 bd-ft	75.9
Griffith	50	120,134 bd –ft	79.1

Table 1 illustrates that given similar buffer width, ACD increases with higher vegetation densities. Immature or smaller vegetation can be more tightly spaced and achieve the same ACD with a relatively small buffer width as compared to the buffer width required by mature vegetation.

Table 2. Buffer Width and ACD in Planted Stands

STREAM NAME	BUFFER WIDTH	VOLUME PER ACRE	ACD PERCENT
Needle Branch Upper	8	N/A	55.6
Needle Branch Lower	8	N/A	47.6

Table 2 illustrates buffer width and ACD for two streams planted for regrowth after logging (Brazier and Brown study). Essentially the same ACD is achieved given an 8-ft buffer as for the 50-ft buffers required in more open stands.

ACD and Effective Shade

As discussed in Part 1 of this document, effective shade is the total solar radiation blocked from reaching the stream over a 24-hour period. It is defined as:

$$\frac{\text{Total Solar Radiation - Total Solar Radiation Reaching the Stream}}{\text{Total Solar Radiation}}$$

As ACD increases, more solar radiation is blocked, thus increasing effective shade. However, at some point, increases in ACD provide negligible increases in stream shading. This is because a “tree behind a tree” does not provide additional shade where the trees in front (close to streams) are already providing critical stream shade. This concept is illustrated in Figures 9 (a) and (b). For 60 foot trees on a 50% slope, increasing the riparian width from 15 to 33 feet results in a change in ACD from 45 to 70%. Increasing the riparian width from 33 to 55 feet, puts a “tree behind a tree” and results in no further increases in ACD (Figure 9 [b] and [c]).

[21] Volume is measured in board-feet (bd-ft) per acre removed.

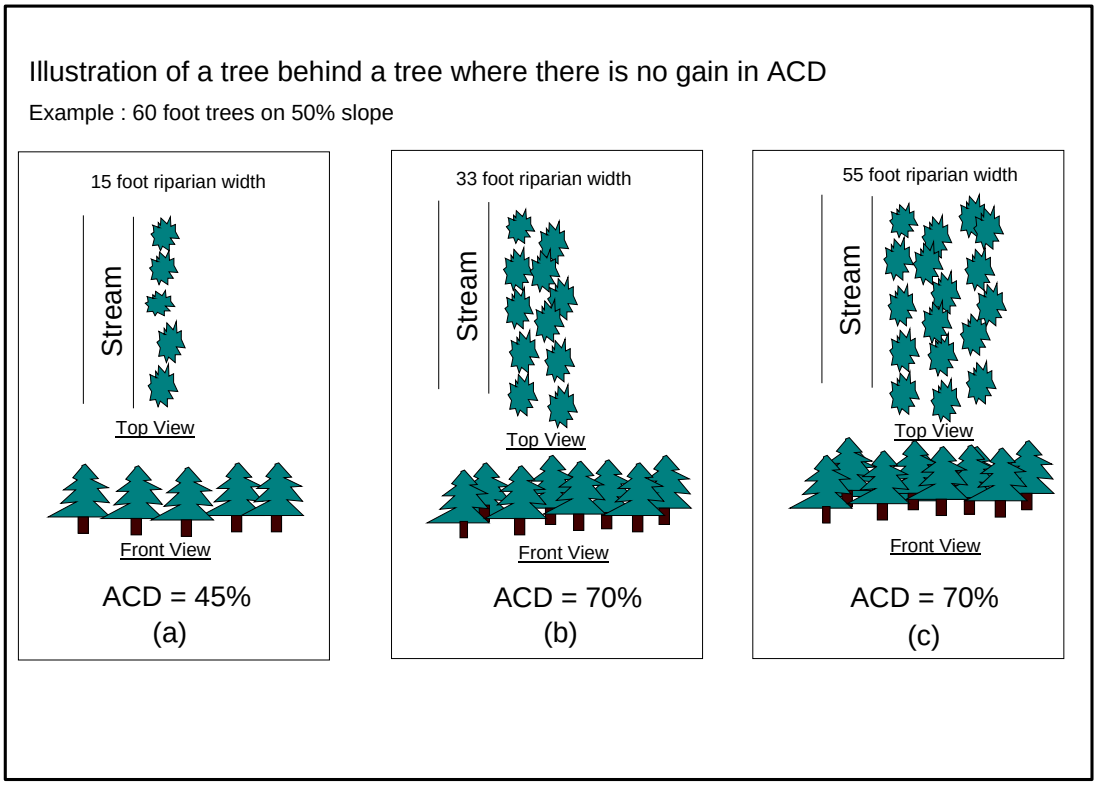


Figure 9. Angular Canopy Density and Buffer Width

Figure 10 illustrates the relationship between ACD and effective shade. The graph shows that effective shade of 80% corresponds to an ACD of 65%. The graph illustrates further that only a 3% gain in effective shade results as ACD is increased from 65 to 80%. When effective shade increases beyond 80%, the trees behind the trees that block solar radiation provide minimal additional shade. Thus, it is assumed that an insignificant change in temperature would result as a function of increasing effective shade beyond 80% (Figure 2).

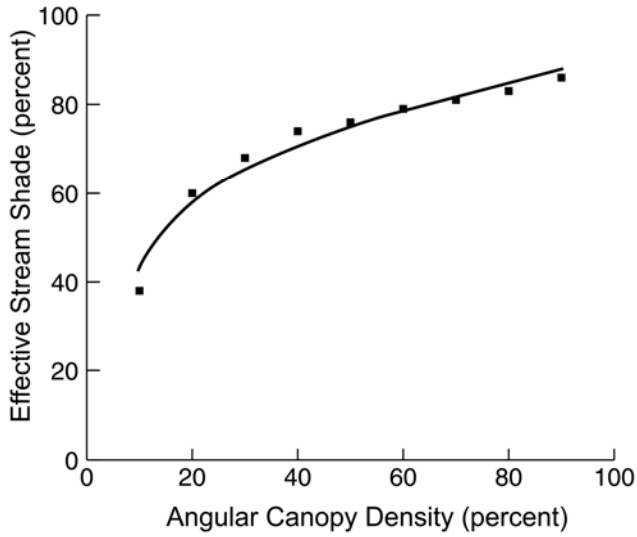


Figure 10. Angular canopy density (ACD) and stream shade (Park, 1991).

Primary and Secondary Shade Zones

The period of greatest solar loading occurs between 1000 and 1400 hours (Figure 11) that includes the period during which 58% of the total daily solar radiation is cast. Vegetation that intercepts solar radiation between 1000 and 1400 hours is critical for providing stream shade and maintaining stream temperature. This vegetation constitutes the primary shade zone. Although the primary shade zone provides stream shade throughout the entire day, by definition the primary shade zone is that area which provides shade between 1000 and 1400 hours. During the morning and afternoon hours (e.g., 0600 to 1000 hours and 1400 to 1800 hours, respectively) trees outside of the primary shade zone can also provide stream shade. This area is referred to as the secondary shade zone.

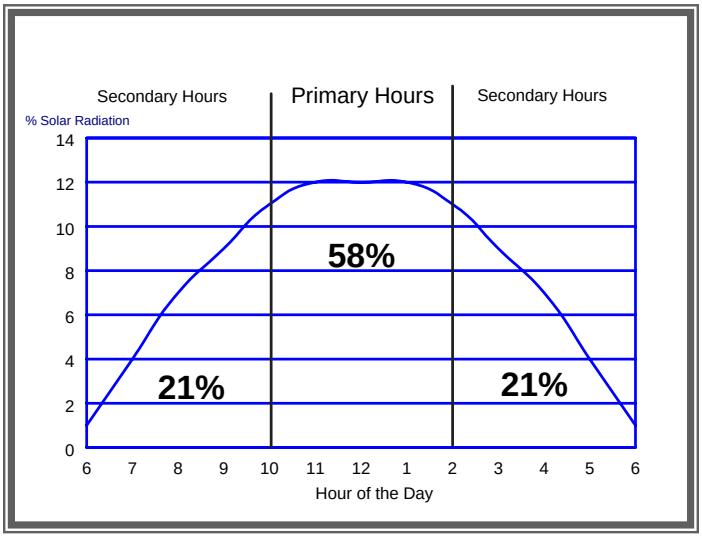


Figure 11. Percent total solar radiation available for each hour of the day, August 1 (source: Solar Pathfinder (43° to 49° N Lat.)

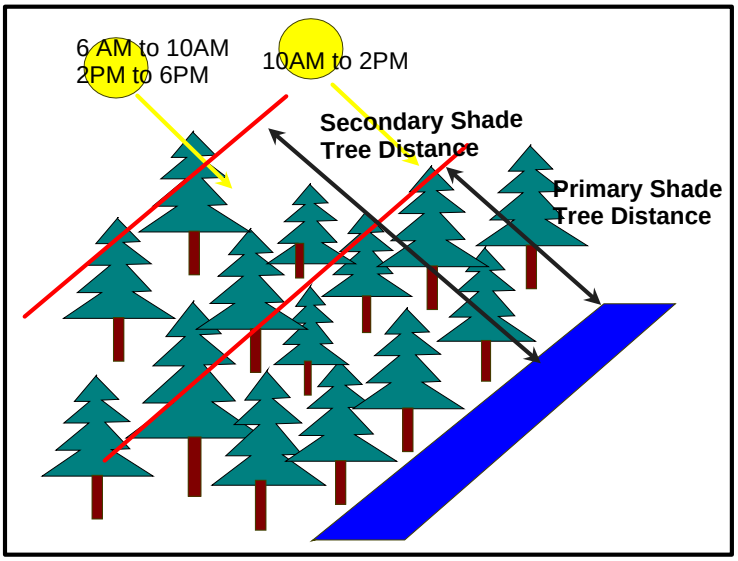


Figure 12. Relationship of primary and secondary shade zone

The width of the primary shade zone can be calculated using models like SHADOW to generate the width of the primary shade zone based on tree height, terrain slope, and the sun's position between 1000 and 1400 hours. For example, the primary shade zone for a stream buffered by 120-ft conifers on a 30 degree slope would be 60 feet. The primary shade zone for a 20-ft conifer stand on a 30 degree slope would be 12 ft. Figure 13 illustrates the relationship between the primary shade zone and slope based on an example using 120-ft tall trees. The example illustrates how the width of the primary shade zone changes depending on slope (Figure 13).

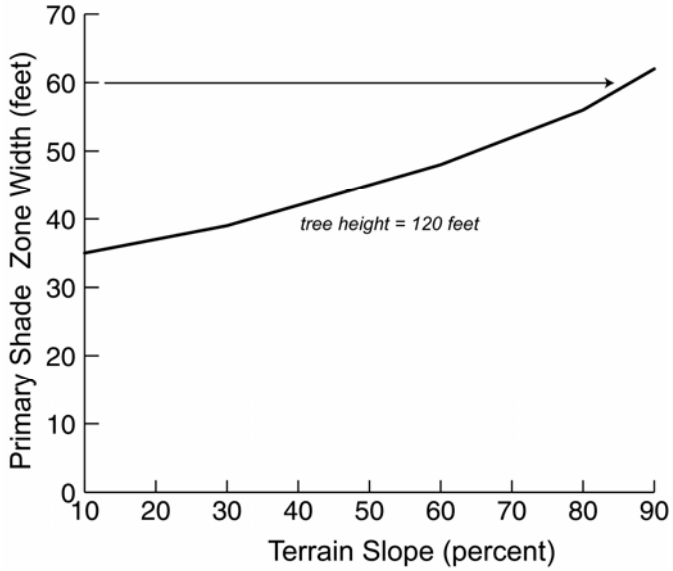


Figure 13. Modeled primary shade zone widths for various slopes

Table 3 illustrates further how tree height, slope, and the angle of the sun can be used to calculate the width of the primary shade zone. Table 3 was developed to illustrate how the width of the primary shade zone can vary based on varying slope and tree height. Table 3 does not illustrate however, how the width of the primary shade zone may be over- or underestimated because the calculation does not account for such parameters as stream orientation or sinuosity. Thus, if for example, a stream is east-west oriented vegetation on the south bank will be more critical for stream shade than vegetation on the north bank. The calculation does not account for this. To obtain a more accurate estimate of the width of the primary shade zone analysis using the SHADOW model and not the hand calculation can be conducted.

Table 3. Minimum Width of Primary Shade Zone (feet) based on Slope and Tree Height[22]

HEIGHT OF TREE	HILL SLOPE <30	HILL SLOPE 30 TO 60	HILL SLOPE >60
Trees < 20 feet	12	14	15
Trees 20 to 60 feet	28	33	55
Trees >60 to 100 feet	50	55	60

Minimizing Loss of Effective Shade

As stated previously, effective shade is that vegetation which blocks solar radiation from reaching a stream over a 24-hour period. Side slope steepness, vegetation species composition, vegetation height and density, distance of trees from the stream bank, and stream width all affect effective shade. Effective shade increases as ACD increases but only to point. Thus, by ensuring that ACD is maintained in a stand that is being treated, the risk of reducing effective shade can be minimized. To illustrate this point consider an example, wherein vegetation density is low. In these circumstances, trees in the primary shade zone as well as the secondary shade zone affect the ACD. In these circumstances, trees in the secondary shade zone increase ACD when the sun is lower in its arc (Figure 12).

Conversely, in over-dense riparian areas optimum ACD can be provided by the primary shade zone alone and the secondary shade zone may contribute little to shade since trees in the primary shade zone are already blocking the sun's solar radiation. The correlation between optimum ACD and the width of the primary shade zone can be illustrated based on an example for a well-stocked mature stand wherein the primary shade zone of 60 feet provides canopy closure greater than 65% (Brazier and Brown) and approaches optimum ACD. Conversely, in a stand dominated by shorter trees with a tighter spacing ACD may reach optimum (65%) given a narrower riparian buffer.

This distinction is important for two reasons. First, it refutes an assumption that simply because a stand is dominated by shorter trees, optimum ACD cannot be achieved.

[22]The approximate width of the primary shade zone and thus any treatment thereof should consider stream orientation, sinuosity, aspect, bank and channel stability, channel migration, channel width and potential for sediment loading.

Second, based in the conclusion that optimum ACD can be achieved in stands dominated by shorter trees, these stands can also be considered for treatment.

Vegetation Treatment Within the Secondary Shade Zone

Figure 14 distinguishes increases in stream temperature given treatment of both the primary and secondary shade zones versus treatment of just the secondary shade zone. The modeled values represent what is typically found in an overstocked riparian area with 80-foot tall conifers and a 20-foot wide perennial stream. Thinning both the primary and secondary shade zones along a six-mile segment affects a measurable increase in stream temperature while thinning in the secondary shade zone along the same six-mile segment affects no measurable increase in stream temperature.

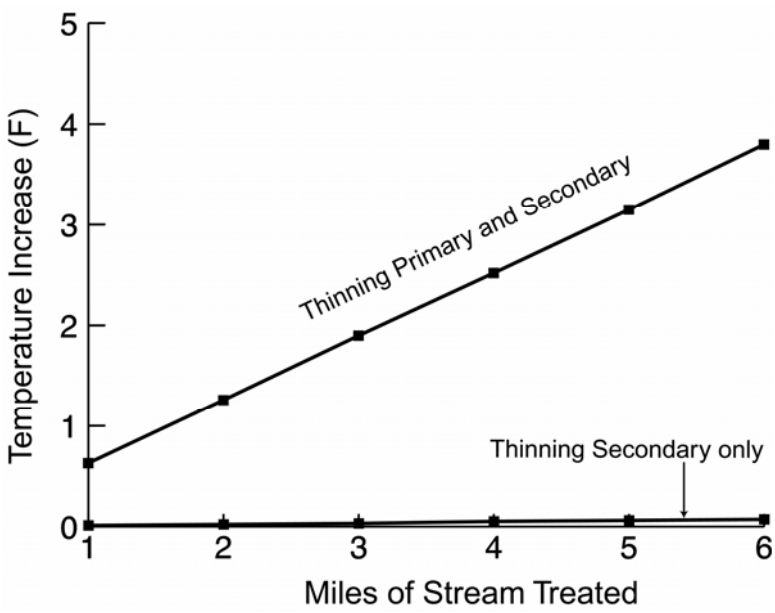


Figure 14. Comparison of thinning treatments and their affects on increasing stream temperature

Implementation of the NWFP accommodates vegetation treatment necessary or desirable to restore ecological health in Riparian Reserves that have been harvested previously or affected by fire exclusion or other disturbance. The NWFP also provides for long-term maintenance of water quality. Thinning that is protective of vegetation which produces shade during the period of greatest solar radiation and which limits the loss of vegetation that produces shade during the rest of the day will ensure benefits for effective shade over the long term. Thus, short-term impacts that lead to long term benefits as a function of vegetation treatment should not be dismissed. The practice of limiting thinning to the secondary shade zone and identifying the “trees behind the shade trees” will aid in accomplishing this objective.

If it is agreed that there are benefits to shade from the tree behind the tree and that thinning in the secondary shade zone can benefit effective shade over the long term, recommendations for thinning in Riparian Reserves should be considered as long as they meet the following conditions:

1. Vegetation density is high and will benefit from thinning.
2. Vegetation thinning will not occur in the primary shade zone. Vegetation thinning in the secondary shade zone will not result in less than 50% canopy closure post harvest.
3. NWFP Standards and Guidelines and BMPs still apply.
4. Table 3 will be used to determine the width of the primary shade zone, unless a shade model is used for site specific analysis.

In all cases, care must be taken to determine what treatments are appropriate for a site. For example, a detailed analysis that considers parameters in addition to slope and tree height (e.g., stream orientation, sinuosity, aspect, bank and channel stability, channel migration, potential for sediment loading) and addresses cumulative effects may inform a conclusion that the primary shade zone for a specific location may need to be wider than a no touch buffer. Conversely, the primary shade zone identified to protect effective shade at a specific location may be narrower than the Riparian Reserve width necessary to protect or restore other aquatic and riparian processes. The point herein is that in all cases, an appropriate level of analysis should be the basis for determining what treatments are appropriate for a site. An example from microclimate studies of riparian areas provides a good example for illustrating the importance of this point.

Emmingham et. al. (2000) measured the change in air temperature and humidity for various levels of thinning in riparian areas in the Oregon Coast range. Air temperatures for the control and normal thin were generally the same whereas a 3 to 5 degree Celsius increase in temperature was recorded for heavier treatments. A normal thin might reduce canopy closure by 50%. Temperatures for all the thinnings were within one degree Celsius during the evening and into mid morning. Differences in relative humidity between treatments were small and in some cases within the error range of the instruments (+/- 3% RH) (Emmingham et. al, 2002). This example illustrates the importance of establishing the appropriate level of analysis necessary for evaluating the effects of treatment on aquatic and other riparian processes.

To Thin or Not to Thin: Risk and Benefits of Thinning in Riparian Areas

Natural disturbance is a normal process in ecosystems. Among other events, natural disturbance includes forest fires, windstorms, landslides, floods, and insect and disease outbreaks. The question of treatment where treatment has been limited must be considered in terms of both what is to be lost and what is to be gained as a consequence of treating or not treating a stand. Treatment may or may not minimize the risk of occurrence of catastrophic events.

Treatment in the primary and secondary shade zones may increase stand resiliency, improving sustainability of the riparian ecosystem. Treatment can maintain and restore species and structural diversity of forest stands, shift vegetation growth to more open stands consisting of evenly mixed age classes, provide for recruitment of large wood, and enhance habitat diversity and connectivity. From the standpoint of shade, treatment that increases vegetative growth, can reduce the time for shade recovery and ultimately may enhance growth of residual trees and regeneration in the understory. It must be recognized that any treatment could exacerbate loss of stream shade that results from natural disturbance and conversely that treatment could increase resiliency and improve overall sustainability of the riparian ecosystem. Without treatment, some

riparian vegetation types may become overly dense and or evolve toward single canopy stands lacking in species composition and age class distribution.

Part 3 Tools for Treating Riparian Reserves and Protecting Water Quality

Monitoring

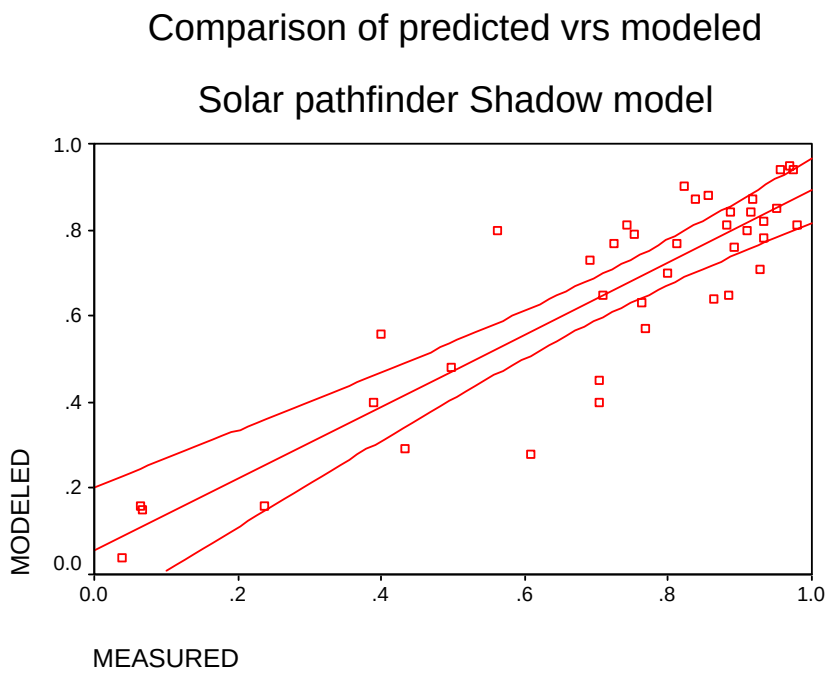
Monitoring is necessary for determining (1) whether Best Management Practices (BMPs) have been implemented; (2) the effectiveness of management practices; and (3) whether predictions regarding ecosystem functions and processes are valid. In addition to BMP monitoring and implementation and effectiveness monitoring, monitoring according to the Aquatic and Riparian Effectiveness Monitoring Program (AREMP) is recommended for evaluating the long-term effects of treatment in Riparian Reserves on water quality. The AREMP process accommodates determination of present watershed conditions, tracking trends in watershed condition over time, and reporting on NWFP effectiveness. Although the focus of AREMP options and guidelines is on characterizing ecosystem status and trend, AREMP monitoring will yield information useful for developing correlations regarding certain trends over time. Finally, the U.S. EPA has analyzed the utility of physical aquatic habitat indictors as a means for evaluating whether water quality objectives under the Clean Water Act are being met (Bauer and Ralph 1999). Although the EPA indicators do not accommodate use of numeric values of physical habitat condition to monitor compliance, habitat variables such as large wood, pool frequency, and pool depth are considered useful as diagnostic indicators of attainment of "beneficial use." Like reference sites developed to support AREMP, the EPA indicators can be calibrated to reflect local or ecoregional conditions and will accommodate stratified sampling to reflect variability in landscape or stream channel characteristics.

Oregon Shade Nomographs

Calculating effective shade can be difficult. Although models can simplify the task, models require time to master and a basic knowledge of the calculations being performed by the model to assure the accuracy of estimates. Further models do not account for the policy or regulatory context in which decisions regarding natural resource administration are going to be reconciled.

The Oregon Shade Nomographs were developed to create efficiencies in analyzing the effects of vegetation treatments on effective shade. The nomographs can be used to characterize existing shade conditions and identify site potential shade. With the nomographs and a Solar Pathfinder,[23] conclusions about stream shade recovery can be easily monitored and the accuracy of stream shade estimates evaluated. The nomographs provide an alternative to applying the SHADOW model; thus streamlining the compliance process.

[23] Reference to the Solar Pathfinder does not constitute an endorsement of this product.



Correlations

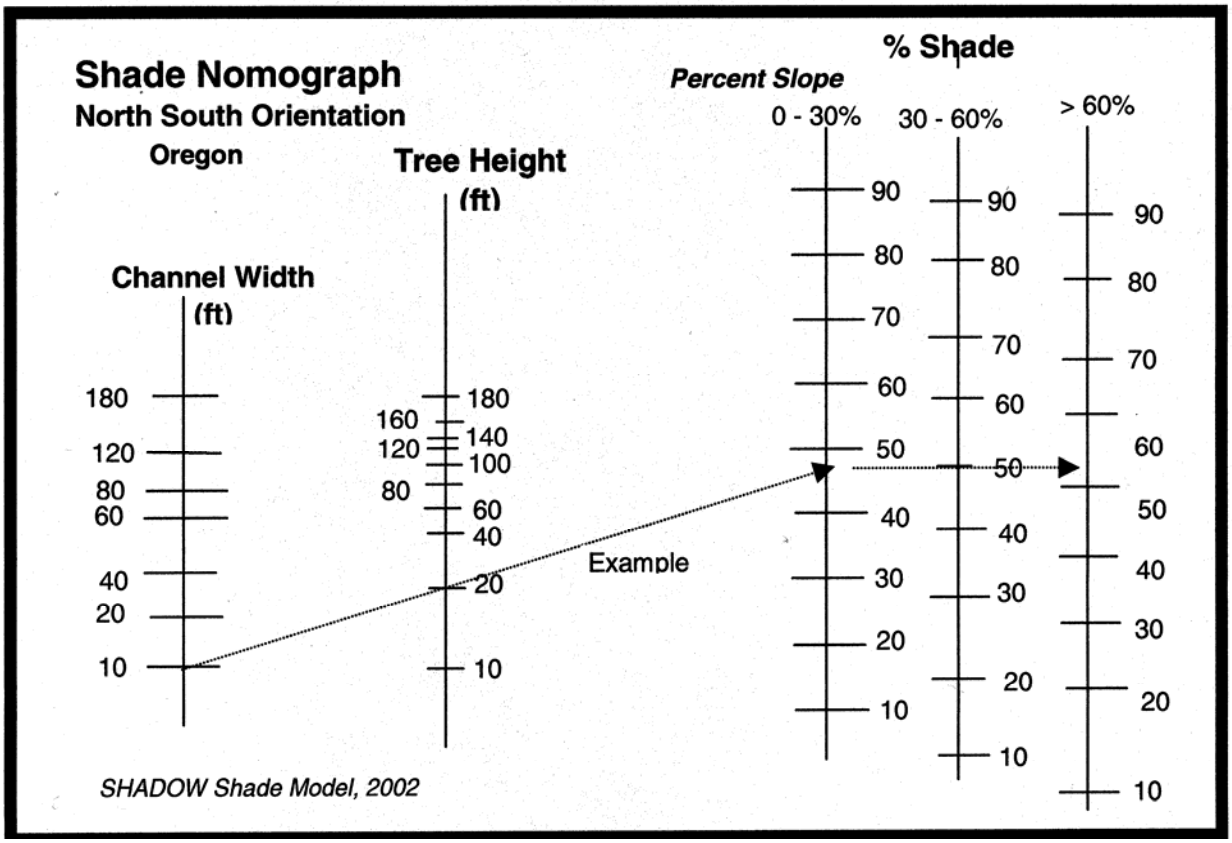
		Measured	Modeled
Measured	*Pearson Correlation* *Sig. (2-tailed)* *N*	1 40	.884(**) .000 40
Modeled	*Pearson Correlation* *Sig. (2-tailed)* *N*	.884(**) .000 40	

** Correlation is significant at the 0.01 level (2-tailed).

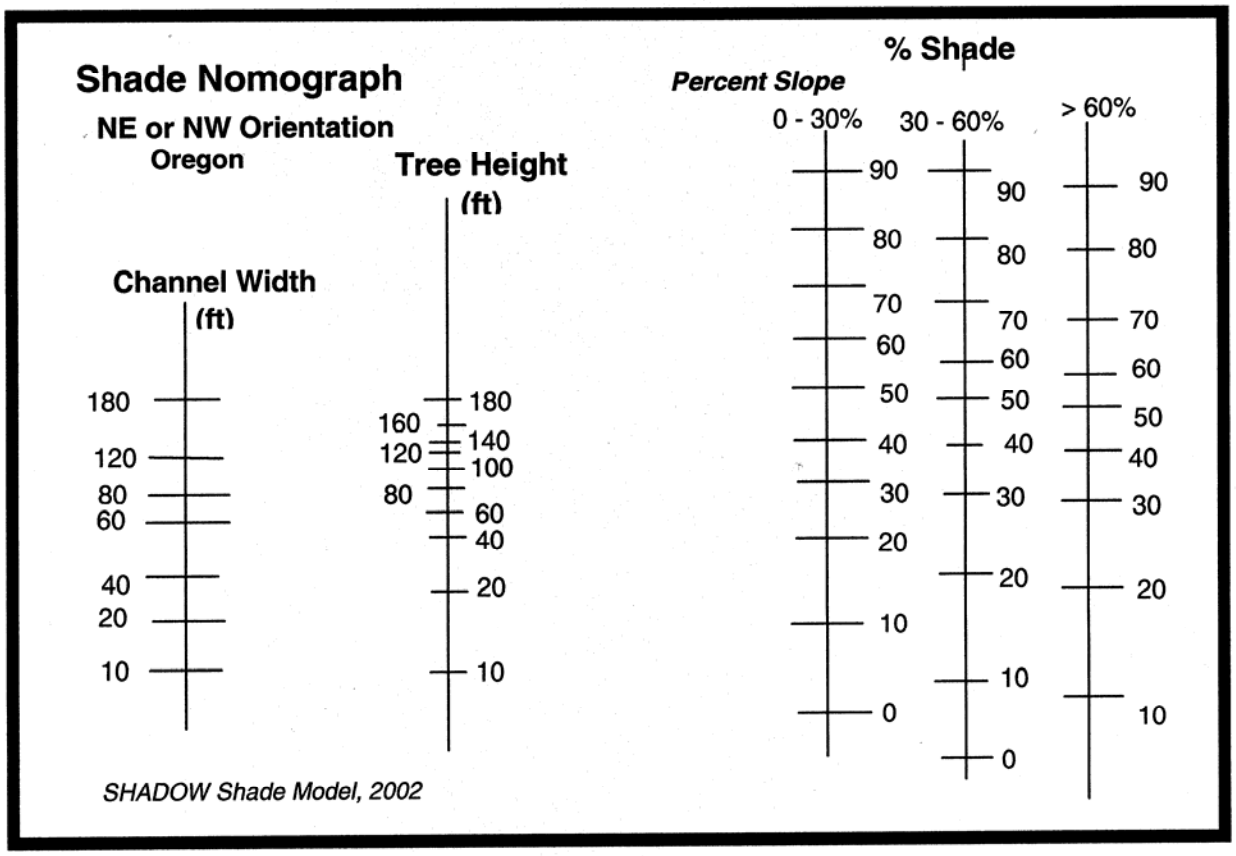
Figure 15. Correlation of shade measured with a Solar Pathfinder and shade estimated with SHADOW shade model for 41 sites. (Source: Cindy Ricks South Coast Coordination Council and Lower Rogue Watershed Council).

Three Shade Nomographs are provided for one of three general stream orientations, north-south, northeast-northwest, and east-west. Information necessary for estimating stream shade includes active channel width (ft), tree height (ft) and percent side slope. All nomographs assume a canopy closure of 65% or greater. If the canopy closure is less, the value from the nomograph will need to be adjusted using the Canopy Closure Adjustment Graph.

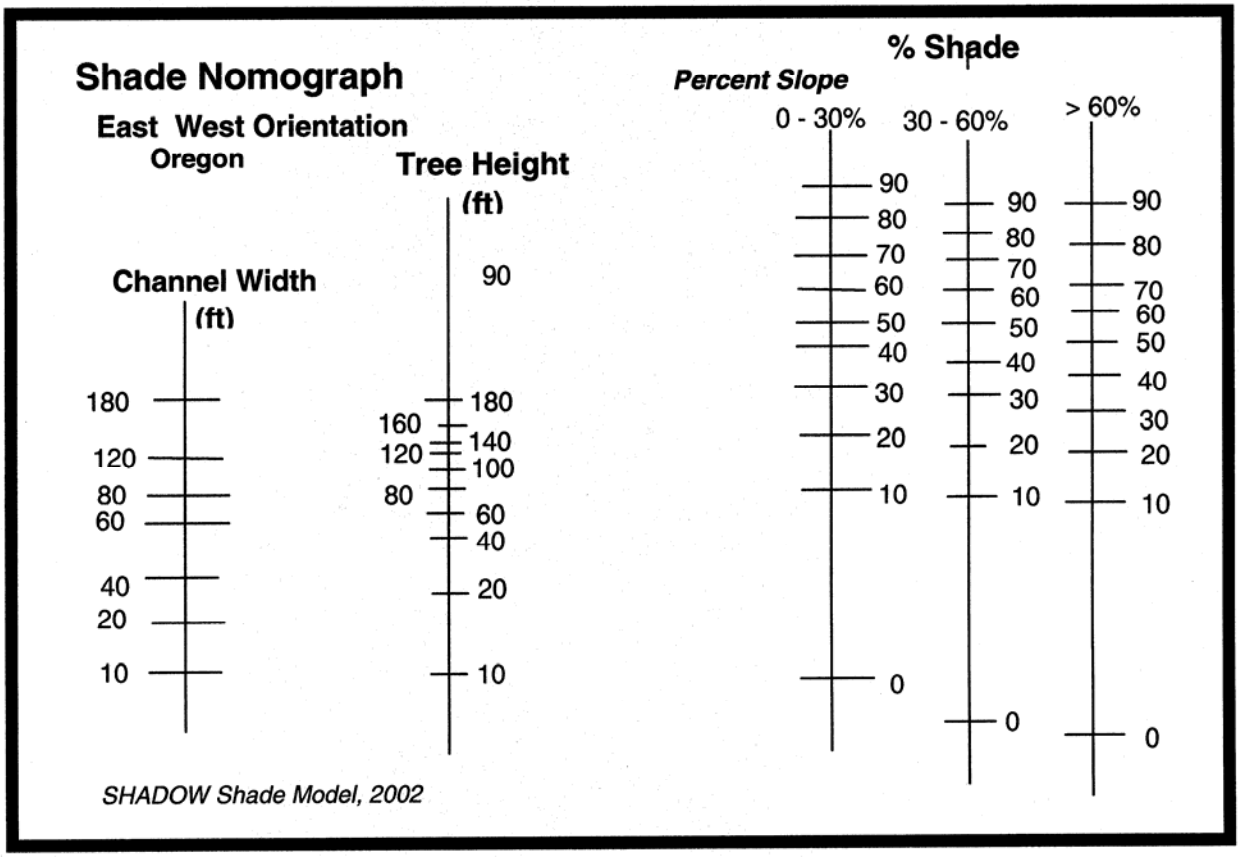
North South Stream Orientation



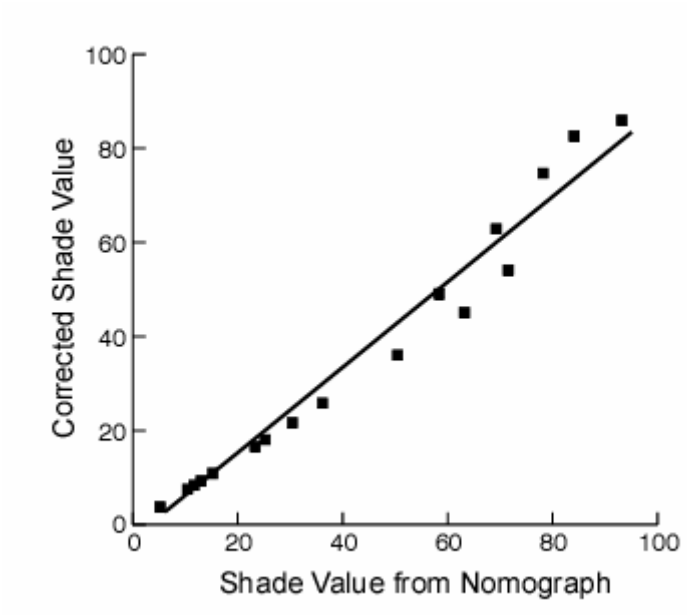
Northeast or Northwest Stream Orientation



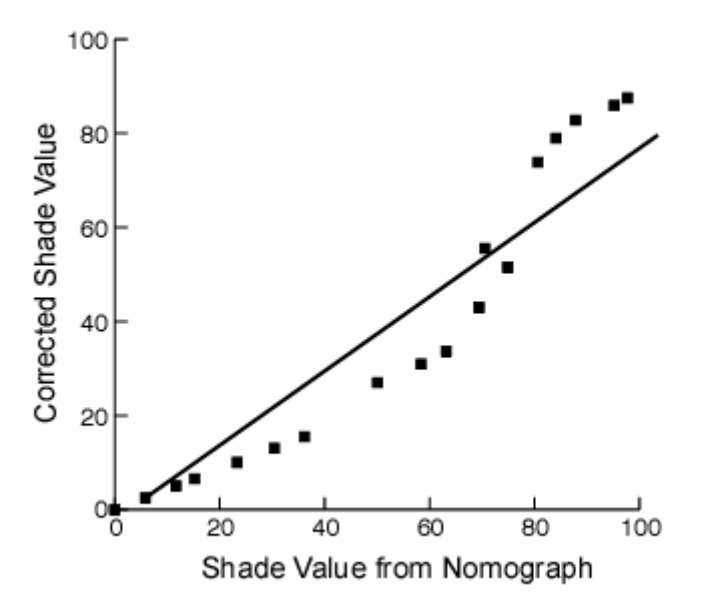
East West Stream Orientation



Canopy Closure Correction Graphs



40% to 60% Canopy Closure Correction



<40% Canopy Closure Correction

Example Application:

Estimating Shade Conditions and Identifying Potential Restoration Sites Using the Shade Nomographs and Interagency Mapping Project Database

Shade nomographs can be used to characterize the shade condition of the watershed and estimate target or potential shade for riparian areas which have been harvested previously. Input for the nomographs can be obtained from either aerial photographs or other sources such as the Forest Service/BLM Integrated Vegetation Mapping Project (IVMP). IVMP can be downloaded from:

www.or.blm.gov/gis/projects/vegetation/ivmp/index.asp

For this example, shade estimates from aerial photographs and use of the SHADOW model were compared to estimates from the nomographs and IVMP data. The two IVMP data sets used are vegetation DBH and canopy closure. The IVMP data for DBH is displayed in six ranges that need to be converted into tree height in order to apply the nomographs. An experienced silviculturist familiar with an area can do this conversion.

The following is a sample of the relationship between DBH and tree height for conifers for the Little River Watershed in the Umpqua National Forest.

DBH (in)	Height
0-4.9	25
5-9.9	50
10-19.9	100
20-29.9	130
30-49.9	150
50+	180

Source: North Umpqua Ranger District. Field reconnaissance and stand exams.

Steps used to characterize stream shade.

Step 1. What is the average shade value?

Establish a crosswalk between the IVMP DBH and tree heights. The weighted average tree height and conifer canopy closure can be estimated using IVMP because conifers are the dominate vegetation along this stream section. Note a broadleaf IVMP canopy closure layer is also available.

To read the percent shade from the nomographs, estimate average active stream width from the mid-point of the mainstem and average of the side slopes.

Nomographs and IVMP data at 0-30 percent slope: 88% shade

For photo interpretation and use of the SHADOW model given a 30% slope the average shade value was 89% for the area in the example.

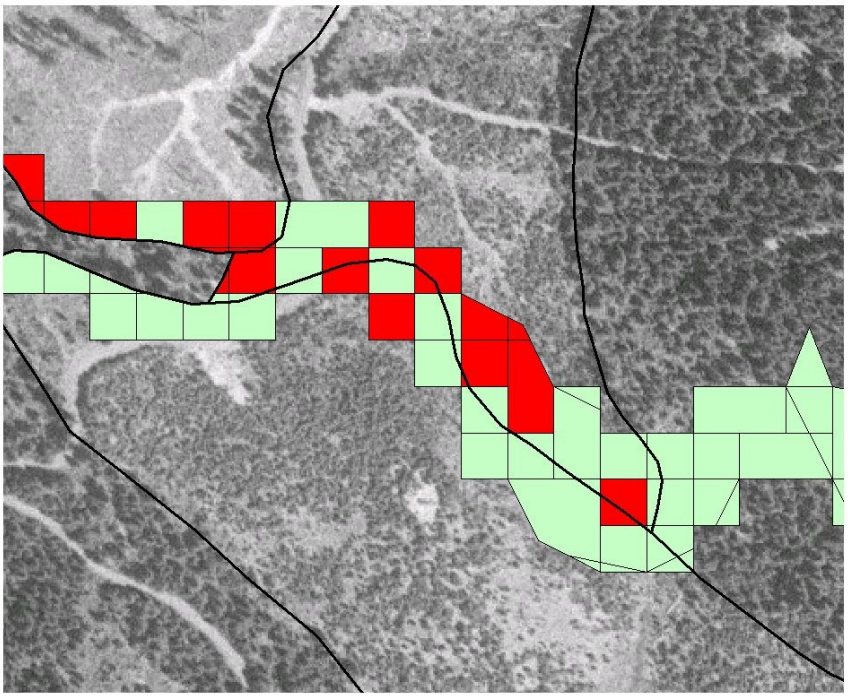
Step 2. How much of the total riparian area is within vegetation treatment units? Identify the potential influence management has on stream shade.

Calculate the total riparian area in harvest units and divide by the total riparian area. For this example the value is16%

Step 3. Identify sites proposed for riparian thinning.

Identify areas in riparian harvest units with less than 50% canopy closure. Display the IVMP cover layer by color-coding the pixels with <50% canopy closure in red. Overlay the riparian harvest layer developed in Step 2. Harvest areas with low canopy closure should be identified. Overlay these layers on the 1994 orthophoto quads to verify canopy closure.

Document the existing condition, past treatments and restoration opportunities. Refer to the Watershed Analysis to see if any riparian treatments are recommended. Include sites proposed for riparian thinning as active restoration sites and areas that will not be thinned as passive restoration sites.



Step 4. Calculate average shade value in harvest units? Identify the existing shade condition in past managed areas.

Nomographs and IVMP data at 0-30 percent slope:	58% shade
Photo interpretation and SHADOW at 30% slope:	60% shade

Step 5. Estimate recovery time?

Estimate average stream width using the shade nomographs to determine tree height needed to produce 80% stream shade. For this example, 95-foot tall trees are necessary to produce 80% stream shade. Locate the smallest trees in managed riparian areas and determine the time necessary for them to achieve 95 feet. This should be the total shade recovery time. Estimated recovery time for this example is 50 years.

Step 6. Identify long term monitoring sites and needs.

Use IVMP data and shade nomopraphs to estimate existing shade. Use nomographs to estimate site potential shade. Measure shade in the field with Solar Pathfinder and document. Use these estimates to track long term recovery. Repeat measurements every 5 or 10 years.

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Part 4 Water Quality Restoration Plan Framework and Master Template

Introduction

Achieving water quality, in accordance with the Clean Water Act (CWA), is the foundation of the Oregon Department of Environmental Quality's (DEQ) water quality program. The Total Maximum Daily Load (TMDL) process is one of the mechanisms used to achieve this goal. The US Forest Service (FS) and Bureau of Land Management (BLM) are designated management agencies (DMAs), through mutual signed agreements, and therefore play an essential role in TMDL development and implementation. The development and implementation of Water Quality Restoration Plans (WQRPs) by the FS and BLM supports DEQ's TMDL process for addressing impaired waters on federally administered lands. In addition FS and BLM policy requires consistent evaluation of impaired or 303(d) listed waters where activities have the potential to affect such waters and where TMDLs are completed. WQRPs are purposefully designed to produce compatible information for water quality management plans (WQMPs) and/or TMDL implementation planning and to contribute to meeting TMDL load allocations. Common elements of a WQRP include:[24]

1. Condition assessment – (streamlining options discussed below)
2. Goals and objectives
3. Proposed Management Measures
4. Timeline for implementation
5. Monitoring, evaluation, and adaptive management plan (i.e., clear benchmarks that are measurable through time)
6. Public involvement plan (coordinated with DEQ's public involvement process where feasible)

In addition, WQRPs should include a discussion of reasonable assurance of implementation as well as costs and funding.

If a WQRP is submitted before or during the development of a TMDL, it should contain information to support development of the TMDL. Once the TMDL is approved by the EPA, the completed WQRP may need adjustment to satisfy the requirements of a TMDL implementation plan.[25] TMDL implementation plans (and subsequent implementation of these plans) are required of Designated Management Agencies (DMAs), by state law, approximately 18 months following approval of the TMDL.[26]

[24] Forest Service and Bureau of Land Management Protocol for Addressing Clean Water Act Section 303(d) Listed Waters (May 1999)
[25] See the MOAs between the FS/BLM/DEQ. WQRPs may need to be adjusted once the TMDL is complete if they are completed prior to the TMDL or if information has changed prior to development of the TMDL implementation plan.
[26] OAR Chapter 340, Division 042 – Department of Environmental Quality

Overview

Part 4 of the Sufficiency Analysis outlines the information necessary to develop WQRPs for temperature TMDLs where shade is the driver and waters on the State's 303(d) list of impaired waters are administered under the direction of the NWFP. The information and data contained in these WQRPs is specific to lands administered by the FS or BLM and do not apply to state or private lands. WQRP's developed using Part 4 will provide the input to DEQ's TMDL assessment and TMDL implementation planning for lands managed by the FS and BLM. Part 4 is to be used together with Parts 2 and 3 of the temperature strategy where active vegetation management is planned or proposed.

The framework is based on information contained in the NWFP for each element common to temperature WQRPs and relies heavily on the ACS. The master template will be completed for each project or TMDL where waters are temperature impaired. Completed templates will contain the information necessary to support development and implementation of individual temperature TMDLs. Completion of the template provides a consistent approach for developing detailed restoration and monitoring plans. The information provided in the template for specific TMDLs is intended to be obtained from existing information, such as watershed analyses and other plans. The template is also intended to allow for the flexibility and creativity of the local FS, BLM and DEQ units to develop TMDLs. The BLM and FS should work with DEQ basin coordinators to ensure that WQRPs being developed contain sufficient information. The template provides useful framework but is not intended to replace collaboration between DEQ and the federal field staff.

The template is intended for use in two ways:

1) The completed template will provide the minimum acceptable condition and source information necessary for DEQ to complete a TMDL assessment of current and potential future vegetation conditions, and the expected timeframe for achieving future vegetation condition.

2) The completed template will serve as the WQRP where vegetation management is the sole restoration component planned in Riparian Reserves. Where road restoration, in channel work or other management activities are planned in Riparian Reserves, the WQRP will be supplemented to cover these activities. The WQRP template may also need to be updated if conditions or information change prior to implementation of the WQRP, or once the TMDL is completed.[27]

Part 2 (tree height and slope steepness) will be used to determine where and how much vegetation in Riparian Reserves can be actively managed while still protecting stream shade. Part 3 (the nomographs and satellite imagery tools) will be used to identify priorities for active and passive vegetation management within the watershed. The template can be used at multiple scales, and encourages development of WQRPs at a scale that adequately reflects the level of understanding of the system and proposed management. Completed templates should include a current and site potential condition assessment of riparian and channel conditions, using existing information, at a level of rigor equivalent to the existing condition and degree of proposed management. [28]

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[27] See the MOAs between the FS/BLM/DEQ. WQRPs may need to be adjusted once the TMDL is complete if they are completed prior to the TMDL.

[28] Site potential may not be equivalent to maximum shade. There may be situations where maximum shade conditions will be produced at vegetation conditions less than site potential vegetation conditions. For example small streams may achieve full shading without site potential. In addition, site potential may not

Completed templates should also propose restoration and monitoring that corresponds with the degree of past and proposed land management and is based on gaps in our understanding of how the system will respond to and recover from disturbance. Proposed restoration and monitoring should be commensurate with current budget and workforce constraints, both within the FS and BLM, but also within DEQ. The template is designed to yield products that are useful to DEQ, and the land management agencies, and for the overall TMDL process.

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be the maximum shade needed by the stream, for example riparian areas on serpentine soils. In addition, natural disturbance regimes need to be taken into account when determining site potential.

Template: Background information for elements common to all temperature WQRPs within the NWFP area and information to be completed for individual temperature TMDL/ WQRP

The text in regular font provides general information applicable to most areas covered by NWFP. Each WQRP should include information relevant to the area covered by the document.

The boxed text gives general approach to attaining information.

Provide applicable information per instructions in italics.

Cover Page

Title (Subbasin, Watershed name) Water Quality Restoration Plan

BLM/FS Regional District

Date

Watershed at a Glance	
Watershed	*name of watershed (acres)*
Stream Miles	*total, perennial, ownership (miles)*
Watershed Identifier	*HUC*
303(d) Listed Parameters	*Temperature*
Key Resources and Uses	*salmonids, domestic, recreation, etc.*
Known Impacts	*timber harvest, roads, water withdrawals, etc.*

List of Preparers
Name, title, district

Contributors
Name, title, district

Statement of Purpose

This Water Quality Restoration Plan is prepared to meet the requirements of Section 303(d) of the 1972 Federal Clean Water Act.

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1. Condition Assessment and Problem Description

Chapter V of the Forest Ecosystem Management Assessment Team (FEMAT)[29] (e.g., the Aquatic Ecosystem Assessment) and the Environmental Impact Statement for the NWFP includes a description of aquatic, riparian, and watershed conditions across the NWFP area. These conditions are the foundation for the delineation of management areas, and Standards and Guidelines directing specific management within these areas. These conditions provide the context for information supplied in the templates. Supplemental information for the template will therefore only address riparian condition unless site specific information is needed to describe the situation.

Vegetation information may be assessed and provided in a variety of ways. The preferred approach is to use maps and a series of layered information to describe the past, current, and future condition of riparian conditions within the watershed. Information used in this analysis can be obtained from aerial photos, satellite imagery, and stand age class records. In some cases field verification using a Solar Path Finder may be needed. This information is then put into the SHADOW model.

The level of rigor should be consistent with the existing situation and the pertinent components of a temperature TMDL including a Margin of Safety (MOS) and Reasonable Assurances (RA). Unmanaged landscapes reflect the highest MOS and RA. A general overview of the approach is:

- Provide condition data to DEQ for % shade modeling of the mainstems, or provide DEQ with SHADOW modeled inputs. Headwater streams will either be modeled by the FS/BLM or not included in the assessment. This information would be returned to the FS/BLM for integration into the WQRP. This approach should provide usable % shade information and allow the FS/BLM to focus on vegetative and channel features. No aspect delineation or SHADOW modeling would be required. Information still required would include channel width, vegetative composition, and tree height, meters stem overhang, and tree to channel set back.

- The FS and BLM have multiple tools to derive the required assessment information. Where contiguous riparian conditions exist, this type of general information might be derived from aerial photos, satellite coverage, and/or stand age class information.

- Conduct low resolution assessments (e.g., [field data]) on ownerships where riparian conditions are currently at or near site potential and thinning is not predicted to occur in the near future. This might include late successional reserves, riparian reserves, and wilderness areas.

- Conduct detailed assessments where measurable riparian thinning may be expected over time (i.e., matrix lands, legacy impacts). This category might include areas where upland harvest is likely to be proposed in conjunction with riparian thinning.

[29] The FEMAT report is the science-based ecological, economic, and social assessment completed by an interagency team of scientists and technical experts that forms the foundation for the Environmental Impact Statement and Record of Decision for the Northwest Forest Plan.

1. *Provide information that contributes to a general understanding of the 303(d) listing and the area such as geology, seasonal flow, and gradient, and stream order make up. If available and applicable, include Watershed Vicinity Map and ownership map. Include the location of the management area and extent of key watersheds.*

2. *Describe 303(d) listed water bodies for the area of interest. (Provide a summary table if it is effective)*

3. *Summarize waters meeting or surpassing temperature standards and their juxtaposition relative to the listed water.*

4. *Describe the status of temperature and other pollutants TMDL (schedule for completion, date completed, date implementation initiated, etc).*

5. *Provide a discussion of known and hypothesized sources of the water quality problem.*

6. *Provide information in the tables below.*

Federal Land Summary Current Shade Conditions and Recovery

Drainage	% Flow of main stem	% Existing Shade	% Probable Target Shade	% Shade Loss/ Gain	Type of Disturbance	Years to Shade Recovery

Total Shade Values on Federal Lands within Watershed

Type of Disturbance	% Existing Shade	% Shade Loss/Gain	% Probable Target Shade	Years to Full Site Potential Recovery	Proposed Treatment
Summary Harvest					Follow ACS for all management activities within the riparian zone of all perennial streams

Target Solar Loading or TMDL (if available)

Existing Solar Loading	Target Solar Loading or Temperature TMDL	Reduction Needed

The guidance and tools provided in parts 2 and 3 of the temperature strategy should be used to determine where and how much vegetation can be managed in Riparian Reserves with low risk to water quality. Include a discussion of how these tools were used to obtain the information provided below.

Riparian Reserves include areas designated to maintain the hydrologic, geomorphic, and ecologic processes that affect riparian condition, fish habitat, and standing and flowing water. Every watershed on federally administered lands under NWFP direction has Riparian Reserves. Riparian Reserves are not reserved from management but rather are "reserved" to protect and restore aquatic and riparian dependent resources.

Riparian Reserve widths were based on site potential tree height based on the FEMAT science findings which demonstrated that one site potential tree height provides components necessary to ensure sustainable ecological function of riparian systems. Because "site potential" can vary in relation to many factors and further because the Riparian Reserve network was established for multi-purpose resource management objectives, Standards and Guidelines were developed to regulate activities in Riparian Reserves and as well to accommodate management leading to attainment of ACS objectives in Riparian Reserves.

7. *Describe Riparian Reserves for the streams that are listed, including a description of buffer widths and past or planned silvicultural treatments. Include a discussion of minimum, no-cut buffers, and the primary shade zone as they relate to the temperature strategy.*

8. *If varying from the minimum buffers described in the temperature strategy, provide further information showing how they meet the water quality standard for temperature.*

9. *Summarize past management activities and timing (i.e., description of legacy management and resulting conditions).*

10. *Summarize relevant watershed analyses and reference. Include a discussion of water quality, water quantity, soils, hydrology, vegetation condition, climate, and any proposed changes to interim riparian reserves including the rationale for these proposals.*

11. *Include any applicable information resultant of cumulative effects analyses.*

12. *Include an update on the status of restoration planning and implementation.*

2. Goals and Objectives

The protection and recovery of water quality will depend on implementation of the Resource Management Plans and Forest Plans as amended by the NWFP. Paramount to recovery is adherence to the Standards and Guidelines of the NWFP to meet ACS objectives including protection, restoration, and active management of riparian areas.

The ACS was developed to prevent further degradation and restore the ecological health of watersheds over broad landscapes across FS and BLM administered lands within the range of the northern spotted owl and the range of Pacific Ocean anadromy. The ACS contains nine objectives that guide maintenance and restoration of watershed processes and water quality:

1. Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted.

2. Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.

3. Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.

4. Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

5. Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.

6. Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.

7. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.

8. Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.

9. Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.

Together these objectives are intended to enhance biodiversity and ecosystem function for fish, wildlife, and vegetation, enhance soil productivity and water quality, and reduce hazardous fuel loads and risk to uncharacteristic disturbance.

1. *Specify which ACS objective(s) are relevant to planned management strategies if appropriate. Otherwise all ACS objectives will be assumed to apply.*

2. *Identify the specific goals and objectives by vegetation condition categories/overlay or watersheds where information is to be used to support TMDL and WQRP development.*

3. *List other pertinent goals and objectives from forest and land management plans.*

4. *Include a table of recovery goals as follows.*

Recovery Goals

Element	Goals	Passive Restoration	Active Restoration
Temperature Shade Component			
Flow Modifications			

5. *Complete the following table of temperature TMDL Organization.*

Temperature TMDL Organization

Element	Assessed Factors	Loading Capacity	Sources	Load Allocation	Mgmt measures
Temperature Lack of shade	*Shade*	*Solar loading*	*Harvest, etc.*		
Temperature Flow – channel morphology					

3. Management Actions to Achieve Objectives

A. Past, Current, and Future Planned Activities

The NWFP ACS describes general guidance for managing Riparian Reserves. The BLM and FS manage Riparian Reserves for the nine objectives. Riparian Reserves, Key Watersheds, Watershed Analysis, and Watershed Restoration components of the ACS are designed to operate together to maintain and restore the productivity and resiliency of riparian and aquatic ecosystems. Specific Standards and Guidelines direct the types of activities and how they will be accomplished within these land allocations. These Standards and Guidelines effectively serve as general BMPs to prevent or reduce water pollution further contributing to goals of CWA compliance.[1] Although management to attain ACS objectives is occurring throughout Riparian Reserves, much of the Riparian Reserve network has not had active management since 1994. In many cases proposed active management is related to the degree of past management and the type of management that occurred (e.g., removal of large trees and return of hardwood vegetation may require one type of management, the encroachment of conifers at the exclusion of hardwoods may require another type of action).

Parts 2 and 3 of the temperature strategy provide specific guidance and tools for active vegetation management within Riparian Reserves. Shade curves that were generated using the SHADOW model, based on stream width, orientation, and topography factors show the required minimum no-cut buffers necessary to maintain and restore site-potential riparian shade.

B. Best Management Practices

The NWFP describes Standards Guidelines that serve as BMPs to prevent or reduce water pollution in order to meet the goals of the CWA.[30] BLM Resource Management Plans and FS include provisions to ensure attainment of ACS objectives. Often, these plans contain BMPs that are important for preventing and controlling to the "maximum extent practicable" non-point source pollution. BMPs are developed on a site-specific basis and are presented for public comment during the National Environmental Policy Act (NEPA) process. One element of BMP implementation includes effectiveness monitoring and modification of BMPs when water quality goals are not being achieved.

If the FS, BLM, and DEQ agree that existing BMPs contribute to attainment or are inadequate for achieving TMDL load allocations, the FS and BLM will develop additional watershed specific BMPs. If the FS, BLM, or DEQ do not agree that BMPs will achieve the forestry load allocation in an applicable TMDL, these BMPs will serve as interim BMPs. However, the FS and BLM in coordination with DEQ will design and implement a mutually agreeable monitoring program to gain information sufficient to determine whether or not existing BMPs will achieve the forestry load allocation. This monitoring program will become a component of the WQRP. If monitoring demonstrates that existing BMPs will not achieve the forestry load allocation, then the FS and BLM will create additional watershed specific BMPs to implement the load allocations to assure attainment of water quality standards.

[30] In all allocations, standards and guides in current plan and draft plan preferred alternatives apply where they are more restrictive or provide greater benefits to late-successional forest-related species. (Record of Decision and Standards and Guidelines, page C-1).

1. *Describe, and locate spatially, management actions and projects implemented since the water was included on the state's 303(d) list, and discuss their potential affect to the listed water.*

2. *Describe current and future management activities that protect and restore water quality and watershed processes, specifically riparian shade and stream temperature. Refer to table Recovery goals - Active and Passive Restoration also SA tools.*

3. *Include situations in which silvicultural practices are necessary to control stocking, reestablish and manage stands, and acquire vegetation characteristics needed to attain ACS objectives.*

4. *Include potential for enhancement of coarse woody debris where the watershed analysis determines this resource is limiting.*

5. *Describe current and future management activities that would retard or prevent attainment of the ACS objectives or attainment of state water quality standards.*

6. *Include a description of the potential for catastrophic events (e.g., fire, infestation) that would further degrade riparian condition below that required to attain ACS objectives.*

7. *Include reference to any relevant Standards and Guidelines, BMPs, and mitigations.*

8. *Where TMDL targets have been established, describe management actions designed to meet load and wasteload allocations.*

9. *Include or provide a reference to project specific BMPs that will be used to achieve water quality standards in the area.*

4. Timeline for implementation

The NWFP was implemented with the signing of the Record of Decision , April 13, 1994. Inherent in the implementation is the passive restoration of riparian areas that ensued as a result of the Riparian Reserve buffers/allocation. Implementation of active restoration activities beyond the inherent passive riparian restoration occurs in the context of watershed analyses and through site-specific projects.

1. *Include an implementation schedule for planned and proposed activities. Display using a map and/or spreadsheet.*

2. *List watershed analyses have been completed and which recommendations have been implemented and date or proposed date.*

3. *Specify the expected timeframe for achievement of water quality objectives and/or TMDL targets (e.g., in the Sucker-Grayback TMDL, timeframes for shade recovery corresponded to the estimated 80 years required for conifer growth to provide long-term stream shade).*

5. Monitoring , Evaluation, and Adaptive Management

Monitoring to meet water quality objectives will focus on implementation and effectiveness monitoring and when feasible will be coordinated with AREMP monitoring. Monitoring will be used to address areas where information is lacking or where data gaps have been identified, and this information is necessary to adequately understand the implementation or effectiveness of management, or will help evaluate the range of natural conditions, natural disturbance regimes and patterns, distribution of water quality parameters, and definition of dominant watershed processes. Data gaps may include identification of pollution sources, intact riparian and aquatic habitat, and causal factors for water quality and watershed condition. Monitoring will be accomplished in an integrated, coordinated fashion. Existing monitoring, such as monitoring accomplished for planning, watershed condition, consultation agreements and BMPs, will be utilized to the extent possible to evaluate progress towards TMDL targets and watershed protection and restoration.

Monitoring will be used to ensure that decisions and priorities conveyed by FS and BLM plans are being implemented, to document progress toward attainment of state water quality standards, to identify whether resource management objectives are being attained, and to document whether mitigating measures and other management direction are effective.

The NWFP provides the framework[31] to accommodate a nested analysis, based on scale (region, province, subbasin, watershed, and site) of monitoring information in order to assess the overall effects of management activities. The NWFP monitoring framework requires implementation, effectiveness, and validation monitoring to meet objectives and evaluate the efficacy of management practices. At a minimum, monitoring should contribute to:

- Validating key assumptions in models used to develop TMDL targets for specific watersheds
- Address hypotheses developed in watershed analyses and assessments
- Provide a basis for natural resource policy decisions
- Developing standardized data
- Linking data to management results
- Ensure incorporation of data in the adaptive management process

The NWFP requires that if results of monitoring indicate management is not achieving ACS objectives, among them water quality, plan amendments may be required. These plan amendments could, in part, redirect management toward attainment of state water quality standards.

DEQ will evaluate progress of actions to attain water quality standards after TMDLs are developed and implemented. If, for any particular TMDL, DEQ determines that implementation is not proceeding or if implementation measures are in place, but water quality standards or waste load allocations are not or will not be attained, then DEQ will work with FS and BLM to assess the situation and to take appropriate action. Such action may include additional implementation measures, modifications to the TMDL, and/or placing the water body on the 303(d) list when the list is next submitted to EPA.

[31] Final Supplemental Environmental Impact Statement, Appendix I)

1. *Assess potential for recovery and monitoring that will lend to conclusions regarding attainment of water quality standards as well as land management objectives. Describe existing, planned, and proposed monitoring locations; frequency or interval of monitoring, and methods for maintaining and managing data. Include a discussion of cooperative efforts to monitoring and manage data.*

2. *Discuss data and collection methods to be used in relation to the TMDL process and schedule.*

3. *Discuss interim benchmarks for monitoring in terms of management measures, benchmarks, monitoring parameter, and monitoring interval. Complete the following table,*

Interim Benchmarks and Monitoring Frequencies

Element	Site Identification	Management Measure	Interim Benchmarks	Monitoring Parameter	Monitoring Frequency
Temperature Shade					
Temperature Lack of flow					

4. *Specify how monitoring data will foster changes in management activities. (i.e. iterative watershed analysis, revision of resource management plans, or independent issues raised.)*

5. *Maintenance of effort over time*

6. Public Involvement

The National Forest Management Act (NFMA), the Federal Land Policy Management Act (FLPMA), and the NEPA require public participation for any activities proposed for federal lands. The NWFP had an extensive public involvement process. Activities where NEPA requirements have been fulfilled may be adequate for public involvement. In addition to any actions undertaken pursuant to NEPA, the FS and BLM will assist DEQ in public involvement activities as required as part of TMDL development.

1. *Describe planned or accomplished public participation efforts (FS, BLM and/or DEQ) at the local level pertaining to water quality issues. These may include public meetings for NEPA projects, public meetings for TMDL development, meetings performed by watershed councils that include FS/BLM/DEQ involvement relative to the TMDL.*

- **Reasonable Assurance**

Implementation and monitoring of projects designed to meet ACS objectives and use of the temperature strategy logic and tools provide reasonable assurance that watersheds under the direction of the NWFP will move towards attainment of water quality standards and support beneficial uses. Information obtained from monitoring will ascertain whether management actions need to be changed.

If changes are required specialist will present the problem to management for determination of appropriate actions. The monitoring plan itself will not remain static, but will be evaluated periodically to assure the monitoring remains relevant, and will be adjusted as appropriate.

Implementation and adaptation of the Memoranda of Agreement (MOAs) also provide assurances that water quality protection and restoration on lands administered by the FS and BLM will progress in an effective and non-duplicative manner on priorities waters.

1. *Specify how monitoring data will foster changes in management activities. (i.e. iterative watershed analysis, revision of resource management plans, or independent issues raised.)*

2. *Periodic review of the template- WQRP and TMDL is necessary to provide the assurance that goals and objectives are being met*[32]*. Describe the review timeline, relationship to NEPA, and estimated implementation timeframe.*

3. *Describe strategy for implementing the WQRP and improving water quality over the long term.*

[32] *For nonpoint source temperature TMDLs, an appropriate timeframe may be every 5 to 10 years. This timeframe should be coordinated with DEQ and consistent with the state/EPA TMDL review and adaptive schedule*

- **Costs and Funding**

Funding for project implementation, monitoring, and watershed planning is derived from a number of sources. Implementation of the proposed actions discussed in this document will be contingent on securing adequate funding.

Funds for project implementation originate from grants, cost-share projects, specific budget requests or other sources. Potential sources of funding to implement projects include the Oregon Watershed Enhancement Board, the BLM Clean Water and Watershed Restoration Funds, the BLM Range Betterment Program, the FS.

1. *Summarize fund allocation process for restoration funds distributed. (i.e. The amount of restoration funds distributed to the District depends on the amount of money appropriated each year. BLM's Oregon State Office (OSO) receives a budget for watershed restoration and prioritizes projects for funding.*

2. *Describe funding plan including potential sources and purpose. Include expected shortfalls and funding needs. (State the priority of the restoration plans within watersheds covered in the WQRP.)*

Bibliography

Suggested resources and references

Appendices