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2. EVALUATING THE BIOLOGICAL SIGNIFICANCE OF INTERMITTENT STREAMS

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Abstract

Intermittent channels comprise a large proportion of the drainage network in many parts of the Pacific Northwest, and recent policy changes now afford them an unprecedented level of protection. If, during watershed analysis, these sites are found to be relatively unimportant in maintaining the overall ecosystem, then their level of protection is likely to be decreased. An important function of watershed analysis on Federal lands of the Pacific Northwest is thus to evaluate the roles these landscape features play in maintaining ecosystems on adjacent slopes, in riparian areas, and in downstream aquatic environments. Intermittent channels which support distinctive riparian vegetation are most important biologically; the major biological role of smaller channels is likely to be their influence on the supply of sediment, water, and organic materials to downstream channels. Neither the physical nor biological role of intermittent channels can be evaluated without evaluation of their interactions with hillslope ecosystems and physical processes. Watershed analysis can provide information in different parts of a watershed about the extent of the intermittent channel network, what types of interactions are important for ecosystems at those sites and downstream, what types of management activities influence those interactions, and the types of information that will be useful to gather before or during project-level assessments. Watershed analysis cannot define Riparian Reserve boundaries, and collection of new inventory information is not intended as a part of watershed analysis.

Introduction

Intermittent streams are those with discernible channels which show evidence of annual deposition or scour, but which do not carry flow yearround (USDA and USDI 1994). Intermittent streams were not consistently protected from landuse disturbance in the past. Tractors occasionally used them as skid roads, and trees were commonly yarded across them. These sites frequently accumulated large volumes of logging debris and so were likely to support intense fires when units were burned.

Now, however, the Standards and Guidelines for Management of Habitat for LateSuccessional and OldGrowth Forest Related Species Within the Range of the Northern Spotted Owl (USDA and USDI 1994; the combined Record of Decision and Standards and Guidelines are here referred to as the "ROD") direct that intermittent channels will be protected with interim Riparian Reserves unless watershed analysis and projectlevel site analysis demonstrate that this protection is unnecessary. Casual observations suggest that intermittent streams account for more than half the channel length in many watersheds of the Pacific Northwest (Reid, unpublished data), so Riparian Reserves associated with these channels can make up a high proportion of the reserve area in a watershed. Thus there is considerable economic incentive to decrease reserve widths around intermittent channels. However, activities will not be permitted at these sites unless they can be demonstrated to enhance ecosystem values, or at least not to harm them. In the past, activities would have been permitted unless they were shown to be harmful, so this requirement represents an important shift in the burden of proof.

Federal land management agencies now must be able to tailor landuse prescriptions to address sitespecific needs. To design appropriate reserves along intermittent channels, we must understand what makes these streams important to terrestrial and aquatic ecosystems throughout a watershed. The task of designing reserves is complicated because of the variety of roles that Riparian Reserves are now intended to fill. The standards and guidelines for interim Riparian Reserves were originally designed by the Scientific Analysis Team (Thomas et al. 1993) to protect aquatic ecosystem values. The needs of other ecosystem components were not considered in as much detail during development of the Scientific Analysis Team plan, so the reserves are not necessarily appropriate for protecting the other components they now serve. In addition, the interim reserves were planned with the assumption that worstcase management practices would extend to the reserve margins, and a recognition that past management practices have severely modified riparian ecosystem function in many areas. As further developments (e.g. FEMAT 1993) have guided matrix management to a lessthanworst case, interim reserves may now be wider than necessary to fulfill their goal: a buffer zone for a light selection cut may not need to be as wide as for a clearcut. Unfortunately, there is little information available to guide reserve design, and the recommendations for interim reserve widths in the ROD were based more on professional judgment than on data.

Biological roles of the intermittent stream environment

Considerable work is now needed to develop our understanding of what various ecosystems require from riparian zones, and of how riparian zones respond to different management activities. However, it is possible to identify some important biological functions of intermittent channels and their riparian zones by examining the needs of particular organisms.

Onsite influence on ecosystem components

Riparian vegetation communities are recognized by a change in species composition or age structure associated with the presence of open or nearsurface water. Riparian vegetation is influenced primarily by four aspects of the setting: occasional high flows, seasonally saturated conditions, readily available moisture, and substrate. Physical effects of high flows include erosion, battering, and floodplain deposition. These impacts largely control the riparian disturbance regime and so influence the age distribution of stands, the patchiness of riparian communities, and the plant species that can survive and reproduce there. Saturated conditions also influence which plants can survive at these sites, and often prevent conifers from becoming established. The moist conditions benefit many other species, however, and many riparian plants have high water demands. Interim Riparian Reserves include the entire floodplain likely to be inundated during a 100year storm, so they are likely to maintain adequately the role of physical disturbance in the riparian community. Their adequacy for maintaining the other influences on riparian vegetation must be evaluated for each type of site. Few problems are expected where reserves extend beyond the margin of riparian vegetation. However, where reserves are defined by the extent of riparian vegetation, microclimatic changes may affect vegetation (Chen et al. 1992). Riparian vegetation can also be modified by changes in flow and channel morphology that occur because of inadequate protection of the environment upstream or upslope.

Forest mammals use riparian areas for food sources and denning, and they may also use them as travel corridors within and between watersheds. A forest canopy is advantageous along migration routes to protect animals from raptors and, in some cases, to provide arboreal escape from terrestrial predators, so riparian leave strips may be particularly important along intermittent channels because they extend close to the ridgetop. Intermittent riparian areas remain cooler than surrounding hillslopes, so they may act as thermal refuges for fishers (*Martes pennanti*), martens (*Martes americana*), and other boreal species. Studies suggest that martens and fishers may preferentially select resting sites in riparian areas (Spencer et al. 1983, Seglund 1995). Bats are even more closely associated with riparian areas because they require pools of water to drink from, they eat insects associated with aquatic and riparian environments, and they usually roost near their foraging sites. Bats are expected to use riparian habitat along perennial channels more heavily than along small intermittent streams because they drink "on the wing" and thus prefer relatively long pools.

A few birds, such as dippers (*Cinclus mexicanus*) and willow flycatchers (*Empidonax traillii*), are aquatic or riparian specialists. Others use the riparian zone primarily during the breeding season or immediately after. Riparian areas along both perennial and intermittent channels are particularly rich in insects and fruit, so these areas are important food sources. Many species thus include a patch of riparian vegetation as a part of their territory, even if they do not depend fully upon it.

Most amphibians require open water to breed, and some need open water throughout the year. Intermittent streams may be particularly important as nursery areas for amphibians because these sites support fewer predators than perennial channels. Young salamanders may rear in the intermittent channels and then move downstream when they grow large enough to protect themselves (H. Welsh, USDA Forest Service Pacific Southwest Research Station, unpublished data). Some amphibians, such as the Pacific tree frog (*Hyla regilla*), may rear in ephemeral pools and then move away from the channels when pools dry up. Juvenile black salamanders (*Aneides flavipunctatus*) may remain for several years in moist sites, such as those commonly found near intermittent channels, moving away to the forest floor only as they mature.

Intermittent channels have usually been considered important to fish resources primarily as seasonal sources of water, sediment, and wood delivered downstream to more important habitats. Because intermittent channels form a high proportion of the channel system, they contribute a lot of nutrients to downstream reaches from primary production and litterfall. Productivity of perennial channels depends on delivery of materials from intermittent channels during at least part of the season. Some intermittent channels are also important as fish habitat. Onethird to half the trout production in some Sierra systems is from intermittent channels (Erman and Hawthorne 1976), and intermittent channels are an important winter refuge for juvenile coho (*Oncorhynchus kisutch*) and steelhead (*Salmo gairdneri*) (Peterson and Reid 1984).

Biological uses of intermittent channels depend primarily on the presence of water and distinctive riparian vegetation. The most ephemeral channels may contain water for only a few days of the year and may not support riparian vegetation, so they are unlikely to have much onsite biological significance. Their major biological role is likely to be their influence on downstream channels through the supply of sediment, water, and organic materials, and management to maintain their physical role may be adequate to preserve their biological function. For example, in an area of high winds and stable slopes it might be physically less damaging to log these sites than to leave stringers of standing trees that are susceptible to catastrophic blowdown. The most ephemeral channels are likely to require special biological analyses and modified protection for biological resources only if there are biological considerations at these sites-such as their potential use as migration corridors-that are not captured by an analysis of sediment, water, and organic materials.

Interactions between terrestrial and riparian environments

Because watershed analysis was originally introduced as a tool for understanding aquatic ecosystems, there has been a tendency to evaluate riparian areas primarily in relation to aquatic concerns. In practice, terrestrial ecosystem analysis remains largely decoupled from aquatic and riparian analyses. This is unfortunate, because interactions between hillslope and riparian environments are so interwoven that neither can be evaluated without an understanding of the other.

Communities associated with intermittent channels are an integral part of the interlocking mosaic of contrasting habitats that together form the terrestrial ecosystem. Intermittent channels and associated riparian zones provide an important source of food and water for hillslope ecosystems, they may function as travel corridors, and they provide a microclimatic refuge for hillslope animals during times of moisture and temperature stress. The distinctive vegetation and higher moisture content of these sites can modify fire behavior, so their distribution might affect the patchiness of large burns. In addition, microclimatic differences provided by intermittent channels may contribute to genetic diversity by maintaining a variety of site types. For example, Campbell (1979) demonstrates genetic differences between Douglasfirs growing in different microhabitats near to one another. Intermittent channels also influence the physical environment on hillslopes by modifying microclimates and controlling geomorphic processes. Debris flows, landslides, and incision in intermittent channels can undercut hillslopes and cause landslides and surface erosion. Subsurface soil pipes extend upslope from many intermittent channels, and disturbance of the pipe network may allow intermittent channels to grow rapidly headward as pipes collapse.

Hillslope environments also strongly influence intermittent channels. Hillslope processes and conditions control the quality and quantity of wood, sediment, water, and nutrients entering the channel system, and affect the frequency and intensity of fires in riparian zones. Hillslope vegetation influences the amount of light reaching the channels, the windiness, and the temperature there. Raccoons, snakes, songbirds, raptors, and many other predators on aquatic and riparian species also extensively use hillslope ecosystems, so a change in hillslope conditions will alter the predation regime in and near the channels. Vegetation changes on hillslopes can strongly affect the duration and seasonality of flow in intermittent channels through changes in evapotranspiration, overland flow, and snowmelt rates. In addition, the condition of the hillslope environment influences the ecological role of intermittent channels. For example, leave areas along intermittent streams can provide refugia for the species that will eventually recolonize hillslopes that have been logged or burned.

The downstream biological influence of intermittent streams

Intermittent channels strongly influence downstream ecosystems by controlling the input of sediment, water, woody debris, and nutrients to the rest of the channel system. Not only are a high proportion of watershed products produced from intermittent channels, but these channels also store large volumes of hillslope materials and release them over long periods. For example, much of the sediment eroded from hillslopes during a major storm may be stored in the smallest channels, allowing it to be released gradually at levels that may not harm downstream environments. These sites can be particularly important as potential sediment sources because many are susceptible to gully formation and debris flow erosion. Intermittent channels and the unchannelled swales associated with them may represent areas of considerable potential instability (e.g. Benda and Dunne 1987).

Intermittent channels are also important contributors to downstream fauna and flora. Many riparian plants recolonize from upstream seed stocks after disturbance, and intermittent channels provide nursery environments for some amphibians and fish that later move downstream to perennial channels. The channel system may also be a dispersal pathway for pathogens, as is the case for the rootrot fungus (*Phytophthora lateralis*) that has proved devastating to stands of Port-Orford-cedar (*Chamaecyparis lawsoniana*) (Zobel et al. 1985). These roles must all be considered when designing management strategies for the smallest streams.

Management policy for intermittent streams

The ROD outlines a new approach to managing intermittent channels. It specifies a set of interim reserve widths to be used for these sites, but it also allows the Riparian Reserve boundaries to be modified on the basis of information compiled during watershed analysis: "The prescribed widths of Riparian Reserves apply to all watersheds until watershed analysis is completed, a sitespecific analysis is conducted and described, and the rationale for final Riparian Reserve boundaries is presented through the appropriate NEPA decisionmaking process" (ROD, p. B13, par. 4).

Table 2-1. Criteria for defining interim Riparian Reserve margins (ROD, p. C30)

Attribute	**channels**	**Usual relative size on intermittent margin**	**Difficulty of delineating**
Fishbearing intermittent streams, choose the larger of:			
	Edge of 100year floodplain	small	moderate
	Top of the inner gorge	small	easy
	Extent of riparian vegetation	small	moderate
	Two sitepotential tree heights	large	easy
	300 feet slope distance from bank	large	easy
Nonfishbearing			

intermittent streams and unstable areas, choose the larger of:			
	Top of the inner gorge	small	easy
	Extent of riparian vegetation	small	moderate
	One sitepotential tree height	large	easy
	100 feet slope distance from bank	large	easy
	Extent of unstable or potentially unstable land	large	difficult

Interim Riparian Reserves for intermittent streams

The ROD specifies the widths required for interim Riparian Reserves (Table 2-1), and further specifies the types of activities that can be carried out in these areas. These interim reserve widths are expected to be appropriate in most cases, and are considered sufficient in areas that do not require watershed analysis. Watershed analysis will identify factors that may influence the design of appropriate Riparian Reserves, and project site analyses will use that information to delineate boundaries that fit the ecological and physical requirements of the watershed: "Watershed analysis and appropriate NEPA compliance is required to change Riparian Reserve boundaries in all watersheds" (ROD, p. C31). Where interim reserves are considered to be more than adequate to attain aquatic objectives and ecosystem requirements, watershed analysis will provide the information necessary to evaluate actual riparian needs. Interim boundaries are not expected to be significantly changed along perennial channels after watershed analysis, but "postwatershed analysis Riparian Reserve boundaries for intermittent streams may be different from the [interim] boundaries" (B13, par. 3).

"Standards and guidelines for Riparian Reserves prohibit or regulate activities in Riparian Reserves that retard or prevent attainment of the Aquatic Conservation Strategy objectives" (ROD, p. C31, par. 7). These objectives include maintaining and restoring spatial connectivity within and between watersheds, the physical integrity of the aquatic system, water quality, the natural sediment and flow regime, and riparian plant communities (p. B11). For example, logging is allowed only if it is necessary to attain the objectives; roads can be built only if they do not conflict with the objectives; and grazing, recreational use, habitat restoration, mining, and fire management are similarly restricted. In particular, roads cannot be constructed through interim Riparian Reserves unless a watershed analysis has been carried out (Standards and Guidelines RF2b, p. C32). In many cases, watershed analysis is likely to be the easiest way to demonstrate that desired management options promote the Aquatic Conservation Strategy objectives, whether or not analysis is a mandated prerequisite for the activity.

Interim reserve boundaries are delineated at the project scale by those carrying out site analysis for particular projects. Considerable expertise may be required to identify the upstream extent of the intermittent channels at these sites, and to identify potentially unstable lands. Once the interim boundaries are mapped, however, they will not be modified unless a watershed analysis is carried out. Activities within the interim reserves are closely regulated by the riparian standards and guidelines.

The role of watershed analysis in designing Riparian Reserves

No interim reserve boundaries can be changed without watershed analysis (p. C31, par. 7), so analyses will be carried out in all watersheds where managers want to modify the boundaries. A watershed analysis does not actually delineate the reserves for several reasons: 1) a watershed analysis is not a NEPA document so it cannot allocate land (p. E20, par. 4); 2) the sitespecific information necessary to design reserve boundaries cannot be collected at the scale of watershed analysis; and 3) most projects in a watershed are not yet planned, so reserves could not be designed to account for their likely effects. Instead, Riparian Reserves are designed for particular projects when the projects are planned.

However, it is necessary to know the approximate extent, distribution, and characteristics of Riparian Reserves during watershed analysis so that watershedscale issues of habitat availability and connectivity can be addressed. This information is also essential for later development of management strategies for the watershed as a whole. Where information on the distribution of unstable lands and sitepotential vegetation characteristics exists and the channel network has been well mapped, it may be possible to construct reasonably accurate maps of the likely distribution of interim Riparian Reserves. Often, however, such information is not available, and it is necessary to use observations of slope stability and vegetation characteristics at representative sites to characterize Riparian Reserves over a broader area. This approach will provide a description of the interim reserves and their general distribution, but will not necessarily produce an accurate map.

Reserves are designed to preserve the function or role of the riparian areas within the watershed and ecosystems (B13, par. 4). Watershed analysis is the means for defining what those functions are in different parts of the watershed. An analysis may highlight the portions of the channel system that have particularly high biological or physical significance; it may characterize the general patterns of riparian dependence in different parts of the watershed; it may identify the types of sensitive species that would need to be considered in different parts of the watershed; it may indicate the types of concerns that must be addressed at a project level; and it may suggest types of sitespecific fieldwork that need to be done in an area to provide information necessary before projects can be designed. The ROD also specifies that watershed analysis "will be used in developing monitoring strategies and objectives" (E4, par. 2).

The role of monitoring and inventory in Riparian Reserve design

Nowhere has all the necessary information been gathered to completely understand a riparian system. Watershed analysis will identify the most important data gaps, and it may suggest ways of filling those through monitoring, surveys, or inventories. In particular, the ROD specifies some biological inventories that must be carried out before any grounddisturbing activities (p. C49). This type of information can be collected after a watershed analysis is completed and before particular projects are planned. In many respects, this phase is a continuation of the monitoring and inventory work that has long been carried out on federal lands. However, the guidance provided by watershed analysis can ensure that the most useful types of data are prioritized for collection, that data standards allow comparisons between areas, and that appropriate ancillary data are collected to allow the information to be used for multiple purposes. Watershed analysis can also disclose functional relations between different ecosystem components, and this information may lead to more efficient strategies for monitoring and inventory.

Because many of the species for which the ROD requires surveys are associated with riparian areas, biological inventories will usually be necessary at each site before even interim reserves are designed. If the target species are found, both interim and modified Riparian Reserves will be adjusted according to the reserve requirements for those species (p. C4 to C6). Inventories thus are necessary whether or not watershed analysis has occurred, and are not a part of the analysis. Watershed analysis itself is intended to be "...an informationgathering and analysis process, but will not be a comprehensive inventory process" (p. E20, par. 6). However, other types of information may be identified that are critical components of the watershed analysis, and "...in those instances, the additional information will be collected before completing the watershed analysis" (E21, par. 1).

Modification of reserve designs and activity guidelines

In watersheds lacking a watershed analysis and for which analysis is not required, boundaries on intermittent streams will be established according to the guidelines listed in Table 2-1. Once established, they will not be modified without watershed analysis, and activities will proceed according to the standards and guidelines specified by the ROD.

Where watershed analysis has been carried out, project analyses can recommend changes in reserve boundaries for individual projects. Projectlevel analysis and accompanying NEPA documents will identify the interim reserve boundaries and then use information from the watershed analysis to design boundaries that better suit the needs of the area. If watershed analysis suggests that some types of sites are particularly important or particularly unimportant, or if a planned project will not affect the riparian functions identified as important by the watershed analysis, then project analysis may suggest reserve modifications to account for these characteristics.

Projectlevel recommendations for altered reserve boundaries will be incorporated into Forest Service project plans or BLM activity plans, which are then subject to the existing regulatory and review process. "Decisions to change land allocations, or standards and guidelines will be made only through the adoption, revision, or amendment of [the planning] documents following appropriate public participation, NEPA procedures, and coordination with the RIEC" (E18 par. 2). In other words, alterations to the interim reserves will receive considerable interagency and public oversight to ensure consistency with the Standards and Guidelines (p. E15), and are not simply made at the discretion of agency line officers. Since so little is known about the habitat requirements of so many species, it seems unlikely that boundaries smaller than the interim ones will be accepted following rigorous interagency and public technical review. It may be difficult to demonstrate that shrinking a reserve will be both consistent with the Aquatic Conservation Strategy and will not harm any of the species specified for protection by the ROD. The process for redesigning Riparian Reserves will require development and clarification and may best be done in the context of specific proposals.

Activities allowed in Riparian Reserves are closely controlled by the Standards and Guidelines that accompany the ROD (p. C31). Recommended modifications to the standards and guidelines for Riparian Reserves will undergo the same procedure as proposed changes in reserve design. In both cases, the burden of proof is to show that a change in interim design or management is necessary to meet the Aquatic Conservation Strategy objectives and ecosystem needs, or that it will not retard or prevent attainment of those goals.

Watershed analysis and intermittent streams

Watershed analysis is a prerequisite for any modification of interim reserve boundaries, so analysis is likely to be in high demand where managers want to alter interim boundaries. Since much of the reserve system is associated with intermittent channels, and since the ROD specifies that these are the sites at which changes are most likely to be allowed (p. B13 par. 3), defining the role of intermittent riparian zones is likely to be a major component of most watershed analyses.

Characterizing intermittent channels

An intermittent channel is defined by the ROD as "any nonpermanent flowing drainage feature having a definable channel and evidence of annual scour or deposition" (B14 par. 2). This definition includes both channels that flow only in response to heavy rains ("ephemeral channels") and those supported seasonally by groundwater inputs. In general, the distinction between intermittent and perennial flow is not as important as that between intermittent channels and swales without channels, and between fishbearing and nonfishbearing channels; these are the distinctions to which management prescriptions are tied (Table 2-1).

The first problem is to identify what is and is not a channel. This distinction can be made only in the field at the precision required for sitelevel planning, but watershed analysis can indicate the likely extent of intermittent channels in different parts of a watershed. One useful approach is to fieldcheck a few locations to define the drainage area needed to support a channel in different parts of the watershed (Montgomery and Dietrich 1989). This area will depend on geology, topography, prior land use, and climate, so the watershed can be stratified according to these variables to allow patterns to be recognized. The resulting estimates of drainage density for each stratum might then be used to estimate the extent of channel systems throughout a watershed. Areas included in Riparian Reserves and the reserves' characteristics can then be estimated even though their precise location is not known. USGS topographic maps alone are not adequate for defining the extent of the channel network because they have not been field checked, and contour crenulations cannot be used reliably unless their relationship to the actual channel network has been defined through field observations.

The upstream extent of intermittent channels is recognized in the field by physical evidence of scour or deposition, with the understanding that evidence may be hard to see after several years of drought. In some cases, vegetation may indicate the extent of intermittent flows, but the relation between vegetation and flow must be identified for each area if vegetation is to be used as an indicator. There may be no riparian vegetation indicators at all in the most ephemeral channels. As individual channels are increasingly mapped and evaluated during project planning, this sitespecific information can feed back into the watershed analysis to better define the relations between drainage area and the hydrologic characteristics of streams.

The downstream extent of intermittency varies considerably from year to year, and thus is not a particularly useful parameter except as a general indicator of biological and hydrological characteristics. The relative extent of intermittency may be compared in different locations by determining the upstream extent of perennial flow in characteristic channels at the end of the dry season. Approximate limits of intermittency might be recognized by the presence of sessile aquatic biota that require perennial flow.

More important than the extent of intermittency is the type or intensity of intermittency. The biological and physical functions of intermittent channels are strongly influenced by how often the channels carry water, and these functions form the basis for Riparian Reserve design. An important element of watershed analysis will thus be to characterize the type of intermittency for different types of channels, and to evaluate the biological and physical roles of riparian environments along those channel types. An approach to this task might be first to classify channels in a watershed according to how frequently they flow, and then for an interdisciplinary team to examine representatives of each channel type in the field to determine what function they play. Results could describe diagnostics for each channel type, identify the features that should be considered during projectlevel analyses, and define the types of biological communities that need protection.

Landuse activities may alter the headward extent of the channel network by promoting gully growth, altering evapotranspiration rates, and adding road runoff to drainages. Unchannelled swales upstream of the channel head thus might be included in the Riparian Reserve as potentially unstable lands if they are susceptible to gullying. Watershed analyses will need to include a description of the stability of these sites with respect to altered land use.

Using watershed analysis to evaluate habitat needs associated with intermittent channels

A procedure for evaluating habitat needs along intermittent streams might be first to stratify the channel network by seasonal flow duration and by biological differences. Next, beneficial uses, sensitive communities or species, and special concerns could be evaluated to determine what functions they require of the intermittent channels. The importance of each channel class in carrying out these functions could then be identified and the characteristics required to maintain each functional role evaluated. This information would be useful for planning management strategies, and would indicate what types of information would need to be gathered before or during projectlevel analysis.

In some areas, perennial reaches may become intermittent downstream. How these channels are evaluated and managed will depend on their physical and biological role in the watershed. Hillslope springs fall into a similar category. Even if they do not connect directly with the channel system, it may be useful to leave a vegetated corridor between channels and springs to facilitate movement of animals between the two. In many areas, roads have themselves created wetlands by blocking drainage or simply by contributing flow to a roadside ditch. In this case, too, the role of the ersatz wetland and its relation to the rest of the watershed must be determined before management strategies are designed. Watershed analysis will provide general information on the likely importance and functions of these habitat elements, while project analysis will evaluate their distribution and characteristics at a project site.

Watershed analysis is expected to include a component of fieldwork, but the fieldwork will be directed primarily toward defining interdisciplinary relationships. Only rarely will fieldwork relevant only to a single discipline be carried out during analysis. The major emphasis of both officebased and fieldbased analysis will be to identify and evaluate processes and functions across disciplines and scales. The interdisciplinary team will identify how processes and components of the physical and biological environment interact, and together the team will consider the implications of past, present, and future management activities. Monitoring and inventory data will be useful for watershed analyses, but such information is not a prerequisite for analysis, and analysis will not supply it (E20, par. 6). The watershed analysis will instead identify the types of monitoring and inventories most useful in an area. Because watershed analysis is iterative (E20, par. 6), later monitoring and inventory data can be incorporated into future analyses.

Information provided by watershed analysis for Riparian Reserve design

The ROD specifies the types of information that watershed analysis will provide in support of Riparian Reserve design (Table 2-2), and the pilot watershed analysis manual (Furniss and McCammon 1993) describes the part of the analysis report dealing with Riparian Reserves. The manual specifies that the report "...lists the types of concerns at each site type, and for each concern, describes the types of information needed to evaluate riparian characteristics needed to maintain the functional role of the Riparian Reserve" (Furniss and McCammon 1993, p. 43). It is important to recognize that any manual will never be complete enough to address all types of issues in all types of areas. Watershed analysts must have a strong enough background to tailor the manual's recommendations to the needs of particular watersheds, and to tailor the "look and feel" of the product to the needs at hand. In particular, areas under different management constraints will have different needs. BLM land in the Mattole watershed is to be managed primarily for wildlife habitat and recreational use, and Redwood National Park lands are to be restored to natural vegetation; timber is not an issue at these sites. Riparian Reserves in these areas will have a very different role than reserves adjacent to logged sites, and the corresponding watershed analyses will consider different types of issues and provide different types of information.

In most cases, Riparian Reserves along intermittent channels will include large areas of unnaturally disturbed lands, where trees have already been cut, riparian zones grazed, channels mined, and flows diverted. An important component of watershed analysis in these areas will be to evaluate the extent of changes and their likely persistence. Opportunities can be identified to hasten their return to a natural state, but the decision to take such actions will require decisions to be made about what the desired future state will be. Altered habitats may benefit some sensitive species while harming others, so a return to "natural" may entail damage to a sensitive population. Watershed analysis should identify the types of tradeoffs that might be encountered during management (E20, par. 5). In addition, "natural" is rarely achievable, and information will be needed about what functions of the environment are in most need of restoration to meet today's needs in the context of the extensive environmental changes that have occurred in surrounding areas. What actions will be taken will be decided at a later stage, using the results of watershed analysis as background for making the value judgments that will be required during project planning.

Table 2-2. Goals of watershed analysis. According to the ROD Standards and Guidelines, a watershed analysis:

Has the purpose of developing and documenting a scientificallybased understanding of the ecological structures, functions, processes and interactions occurring within a watershed (E21/1)

Collects and compiles information within the watershed that is essential for making sound management decisions (E20/4). It generally will organize, collate, and describe existing information (E21/1).

Identifies processes that are active within a watershed and how those processes are distributed in time and space (B21/4)

Describes the current upland conditions of the watershed (B21/4)

Describes how processes and upland conditions influence riparian habitat and other beneficial uses (B21/4)

Describes the location and abundance of key species (B23/1), although it is not a comprehensive inventory process (E20/6)

Identifies potentially disjunct approaches and conflicting objectives within watersheds (E20/5)

May define important information needs that should be met for subsequent analyses, planning, or decisions (E-21/1), and serves as a basis for determining monitoring and restoration needs (E20/4)

The goal of Riparian Reserve management is to preserve the processes and functions of the riparian zone. The ROD specifies that activities can take place in Riparian Reserves if they are needed to accomplish the aquatic conservation strategy (e.g. Standards and Guidelines TM1c and WR1), and this approach is the basis for restoration activities. The ROD specifies that watershed analysis will identify restoration opportunities (p. 56, par. 1). Watershed analysis will indicate what types of changes have occurred in channel and riparian systems, and this information might be used to design a strategy for Riparian Reserve management that promotes the reestablishment of natural conditions. In general, it will be much easier to demonstrate the benefits of a Riparian Reserve restoration activity than it would to demonstrate that a nonrestorationrelated activity would have no negative effects, particularly since the ROD implies that any risk is too great. It is important to note that the goal of management is not to prevent instability or change along intermittent channels, but to maintain a natural disturbance regime there. The biological and physical integrity of downstream channels can be maintained only if the full complement of natural "freight" is supplied from the uppermost reaches of the channel network.

Because there is never quite enough information, interim Riparian Reserves have been designed to be conservative. In essence, they are places to save until we know enough to manage them properly, and they are places in which research on management effects can take place (C38, par. 4). Reserves might become smaller in the future as we learn more about what the system actually needs, and options for commodity extraction within reserves might be developed. However, there are also grave risks associated with doing nothing in an area: vegetation may change due to changes in fire frequency, for example. It thus may be necessary to actively manage the Riparian Reserves to maintain their physical and biological functions. In addition, "restoration" projects may actually damage the system unless their likely effects are very well understood. Such projects often have been carried out for the benefit of a single species while ignoring the impact of the changes on other components of the ecosystem. Only by understanding a project's effects on the function of the riparian zone can its impacts be predicted, and only by understanding those functions can useful restoration projects be designed. Thus, low thinning is not the same as underburning, and we need to know the effects of each on riparian function before we can prescribe a treatment for maintaining the riparian zone's full complement of functions.

Relation to other analysis scales

While watershed analysis concentrates on describing functions, relationships, and trends, project analysis evaluates the importance of the functions, relationships, and trends at particular sites. Both of these analyses are done in the context of a basin assessment, which defines the importance of trends at a larger scale. At each level of analysis, there will not be enough information, and each level will define the types of information that are most important to gather in the future.

The most important stage in carrying out ecologically sensitive land management is that of actually putting the project on the ground. The finest watershed analysis will be useless if the sitespecific planning and implementation is delegated to people who are not capable of interpreting and applying watershed analysis results. Project analysis will require interdisciplinary evaluations of riparian zone functions at particular sites, and thus will require a level of expertise equivalent to that needed for watershed analysis. Because site conditions vary so much throughout a watershed, watershed analysis cannot simply provide a cookbook for project design.

Some types of planning that involve intermittent streams must be done at a watershed scale or larger. For example, evaluation of the importance of dispersal or migration corridors must take into account the distribution of habitat over a scale broader than a watershed, and certainly cannot be done at the scale of individual sites. Similarly, guidance for the design of the road system must incorporate information on resource distribution, sensitive habitats, and landuse patterns throughout the watershed and adjacent watersheds; and the effects of altered evapotranspiration or runoff are easiest to recognize and evaluate at a watershed scale. Watershed analysis will identify opportunities to affect conditions at the watershed scale.

Adequacy and consistency of watershed analysis

The ultimate test of whether the watershed analysis is "good enough" is whether the information it supplies is useful to projectlevel analyses, and whether the resulting projects are approved. Changes that are agreed on by the interagency team of experts involved in watershed analysis are expected to have a high probability of approval. Watershed analyses are intended to be iterative (E20, par. 6), and the first ones are unlikely to be adequate. As more analyses are completed and projects planned, we will learn which analysis approaches are most effective and what types of information are most useful.

It is important that definitions and methods not be narrowed. Intermittent channels show an extremely wide variety of functions and characteristics in different parts of the western United States. These differences can only be addressed using a variety of approaches, and no single management plan could adequately maintain their various roles.

The ROD is a statement of policy that "amends current land and resource management plans with additional land allocations and standards and guidelines" (ROD, p. 11); it "supersedes other direction except treaties, laws, and regulations unless that direction is more restrictive or provides greater benefits to latesuccessional forest related species" (C1, par. 3). The ROD occasionally seems to contradict itself; its broad language allows several interpretations for some requirements; and some requirements seem impractical. As with watershed analysis, inconsistencies and impracticalities will be resolved primarily by seeing what works and what does not, and by establishing precedents on the ground.

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