RIPARIAN AREA MANAGEMENT

Management Techniques in Riparian Areas

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I. Introduction

A large number of techniques have been developed to assist in managing riparian areas. These management (treatment) techniques can be as varied as the multiple uses that occur within riparian zones. *Even though these techniques are discussed in relationship to riparian zones, some can be applied to other forms of wetlands*. The following management techniques and their associated concepts are discussed in this document:

1. Fencing
2. Prescribed Burns
3. Forestry Practices
4. Vegetation Plantings
5. Opportunities from Mineral Activities
6. Structures
7. Beaver
8. Bank Stabilization
9. Recreation Planning
10. Road Construction and Maintenance

More detailed and comprehensive information (e.g., structure design and construction, costs, etc.) can be found in documents listed in the reference section under each technique.

Technical Reference 1737-4 "Riparian Area Management: Grazing Management in Riparian Areas" (Kinch, 1989) and "Livestock Grazing on Western Riparian Areas" (Chaney et al., 1990) are two documents that provide detailed information on livestock grazing and management in riparian areas. Therefore grazing management is not addressed in this manual.

II. Purpose

The purpose of managing riparian areas is to achieve specific goals and objectives. For riparian areas specific goals and objectives typically fall into one of four general management strategies:

1. Maintenance of existing riparian conditions
2. Improvement of degraded riparian conditions
3. Recovery of lost riparian areas
4. Development of new riparian areas

When developing these goals and objectives they should be simply defined, quantified, and incorporated into specific program and project case files as part of the management record. These records provide the basis for future *results-oriented* management assessments.

For example, a treatment should not be evaluated on the basis of vegetation species composition if the initial objectives were to reduce bank erosion or soil compaction and improve ground cover. *Regardless of the technique applied, the intent should be the same in all cases: achievement of the management objective.*

This document is not a cookbook for riparian treatments, but rather a general technical overview to assist individuals in developing original solutions to their own, unique management requirements. The references listed in the text and appendices provide detailed information on techniques and ecosystem management.

III. Biological Considerations or Aspects of Riparian Ecosystem Management

In ecosystem-oriented management, the basis for riparian treatments lies with the relationships between biotic and abiotic components. Ideally, the basic unit for management is a watershed. Using the watershed as a management unit provides a focus toward the entire stream system, as well as its individual streams, as opposed to isolated, site-specific treatments. Key components for consideration are overall watershed geomorphology; hydrology; existing, historic, and potential vegetation; and animal community dynamics. Human activities can also significantly influence riparian ecosystems and should be considered as well. They are usually the most impacting, and yet the most readily controllable factors.

Riparian ecosystems tend toward some form of succession and the development of ecosystem order and dynamic equilibrium. The processes and products of geologic (natural) erosion on steeper, less stable upland mineral soils have historically provided materials for the development of ecologically more productive and complex vegetative and animal communities in floodplains throughout the watershed.

The most common biological features establishing or affecting the relationships of channel and valley slope have been native pioneer species of vegetation (willow, aspen, and alder) and long-term beaver activity. In both cases, high energy runoff and its associated transported sediment have been moderated by dissipation, through spreading across floodplains, vegetative entrapment, development of sinuous meander patterns, and seasonal recharge of ground-water aquifers and riparian bank storage.

The historic use of natural resources has caused major alterations in the dynamic equilibrium in riparian areas. This use has led to extensive destabilization, accelerated erosion, and the ultimate loss of many historic riparian ecosystems and their associated values. By reemploying *the basic principles and processes* that were present in the original formation of riparian ecosystems, it is possible to manage for the improvement and recovery of historic riparian resource values.

Watersheds are most effectively restored through a team approach, by integrating the interdisciplinary technical skills and abilities of a variety of resource specialists. This process should also include seeking assistance, expertise, and cooperation from other agency personnel, academia, and public resource users. The interdisciplinary approach applies to all forms of activity plans, such as Habitat Management Plans, Allotment Management Plans, and Mining Plans.

Numerous inoperative physical “watershed treatments” of the 1950’s and 1960’s today stand as mute testimony to the fact that the mere *application of money-intensive solutions (without associated long-term commitments to improved land management programs) provides only a brief respite to riparian productivity losses.*

Appendix A contains additional references pertaining to biological considerations.

IV. Consideration of Natural Vectors for Riparian Improvement

Isolated stands of riparian vegetation can serve as ecological seeds within a watershed to help speed recovery of riparian species diversity throughout the system. Air, water, and animal distribution of seeds or plant material can be important recovery vectors, if suitable seed sites are available. Up to a 35 percent increase in species richness of birds has been observed in improved riparian habitats and is indicative of the latent natural potential for utilizing birds to stimulate recovery as they transport seeds, plants, spores, etc., from outside areas.

Rodent activity can also be an important factor when, in response to increasing cover, their populations function to accelerate relocation of seeds and plant material, nutrient recycling processes, or sprouting of pruned riparian vegetation. Beaver and muskrat can be active agents in redistribution and regeneration of aquatic and terrestrial vegetation through cyclic cutting. Ungulate browsing of vegetation can also be beneficial in stimulating the sprouting or regrowth of woody plants, such as willows.

Management objectives, in most cases, should be to improve the riparian condition throughout the drainage, rather than create an oasis effect in specific project areas. Managing the drainage helps avoid excessive utilization by livestock or wildlife, which may override recovery gained through intensive site management practices.

Appendix B contains additional references pertaining to natural vectors.

V. Physical Factors of Consideration

Physical factors to consider in riparian ecosystem management commonly include elements of hydrology related to natural (versus accelerated) erosional processes such as:

1. Valley slope versus channel slope.
2. Runoff quantity timing.
3. Ice flows and aufeis.
4. Degree of riparian soil compaction and infiltration.
5. Types of erosion occurring within the watershed and the degree to which they are related to human activity.
6. Permafrost.
7. Water quality (chemical and physical parameters).
8. Gully volume determinations to determine past soil losses and present storage capacities.
9. Flow velocities and site potentials for water spreading to reduce velocities.
10. Potential areas for sediment deposition or accumulation and their storage capacities.

These factors and their relationships to the management situation should be considered and incorporated into strategies for riparian area maintenance, improvement, or recovery.

Appendix C contains additional references pertaining to physical factors.

VI. Technique(s) Format

Each riparian area management (treatment) technique included in this technical reference is described and discussed using the following standard format:

Name: States the name or category of the treatment technique(s).

Reference(s): Lists documents that explain the technique(s) in detail, as well as additional sources of information.

Objective(s): Describes the major objective(s) or purpose(s) of the technique(s).

Areas of Applicability: Describes the region, state, or locality where the technique(s) has been proven to work.

Technique(s): Gives a general description of how the technique(s) are applied.

Ease of Application: Provides an estimate of how easily the technique can be applied by professional land resource specialists and users.

Expected Response(s): Identifies environmental changes that can be expected to take place in the riparian system.

Limitation(s): Describes known limitations in the application of the technique.

VII. Riparian Management Techniques

1. Name: Fencing

References:

Electric Fencing - Do’s and Don’ts No. 4. Gallagher Electronics Ltd. P.O. Box 5324. Frankton, Hamilton, New Zealand.

Max-Ten 200 - High Tensile Wire Fence Construction Handbook. United States Steel Co., 600 Grant St. Pittsburgh, PA, 15230, No. 412:433-3285.

Snell Power Fencing Systems Handbook. P.O. Box 17769. San Antonio, TX, 78217, No. 512:657-1140.

U.S. Army Corps of Engineers. 1986. Special Wire Fences. Wildlife Resources Management Manual, L.E. Marcy, Dept. of the Army Waterways Experiment Station, Corps of Engineers, Tech. Rep. EL-86-16 Sec. 5.2.2., Vicksburg, MS.

U.S. Department of Agriculture. 1984. Application of the New Zealand Type Electric Fences. Forest Service Intermountain Region, Habitat Express No. 83-12, Jan. 1984. Ogden, UT.

_________. 1986. Range Structural Improvement Handbook - Part 1 - Fences. Forest Service Equipment Development Center, Missoula, MT.

United States Department of the Interior. 1989. Fencing Manual Handbook H-1741-1. Bureau of Land Management, Washington, DC.

_________ and USDA. 1988. Fences. BLM and FS. July 1988.

Objectives: The reasons for using fencing in riparian zones are quite varied. One reason is to provide exclosures so that response to grazing management systems can be evaluated or site potential can be determined. Exclosures from a few square feet to a few acres may be necessary. To measure watershedwide objectives, special exclosures of several acres to several hundred acres may be necessary.

Sometimes it is more expedient, practical, and cost-effective to isolate a degraded riparian system or special project area in order to enhance its recovery and management. Fencing the system may cause less impact to the entire allotment than initiating large-scale planning and/or changes in grazing prescriptions. Use of fencing, for whatever reasons, should be evaluated for the most practical mix of multiple-use purposes.

Areas of Applicability: Each individual area needs to be scrutinized as to what type of fence will work best, but in general, there is universal application.

Techniques: Deciding what type of fence to use requires an analysis of the terrain, climate, type of riparian system, wildlife, livestock, and human activities. Depending on the mix of requirements, fencing may be made from hardware cloth; chicken wire; rodeo or net sheep wire; barbed or smooth wire on steel; wood or fiberglass posts; pole top; post and rail; buck and pole; or high-voltage (5,000-volt) electric fencing. Natural materials, such as downed timber, and physical features, such as gullies, canyons, and cliffs, can be used to manage access.

Criteria to be considered in selecting a particular design and location for fences include climatic factors (e.g., deep snow, high water), big-game migrations, cattle, sheep, vehicles, people, public access, falling trees, swampy ground, beaver activity, visual contrast, topography, and soil type. A thorough evaluation of these factors, with an eye toward avoiding management and maintenance problems in the future, will enhance the prospects for management success. As a general rule, fences have the least amount of problems when kept out of the riparian zone or floodplain. Crossing public access routes and providing for passage (e.g., cattle guard or stile) is often much simpler and less prone to conflict than adjoining or paralleling a road or trail and crossings with gates. Typically, the larger the size of the area fenced, the greater its cost-effectiveness and utility.

All of the above, combined with *proper construction*, affect the future fence maintenance requirements. The best fence design, in the best location, for the best reason, will still become a maintenance and management problem if it is not built correctly. Inspection and maintenance should be performed regularly and in a timely manner. Design problems should be identified early and modified as soon as possible to prevent a small problem from becoming a major one.

Ease of Application: The terrain, climate, type of riparian system, and type of fence, as well as the type of livestock, will determine the ease of application. Fencing projects will vary from being easy to extremely difficult.

Expected Responses: Fencing of riparian areas to exclude livestock and establish riparian pastures has been very effective. Most systems respond in the first few years and begin functioning properly. However, some systems (e.g., horizontally unstable systems) may take years to heal.

Limitations: Fences constructed improperly across drainages are going to require extensive maintenance as a result of climatic events. There are a number of designs of swing panels, breakaways, etc., but all seem to require maintenance from time to time.

Fences are going to interfere or disrupt movements of wildlife and access of humans. Proper design and location can lessen most of these impacts (e.g., fishermen ladders, smooth wire, wire spacing, etc.).

2. Name: Prescribed Burns

References:

Britton, C.M., J.E. Cornely, and F.A. Sneva. 1980. Burning, haying, grazing and non-use of flood meadow vegetation. Research in Rangeland Management, 1980 Prog. Rept., Spec. Rept. 586, Agr. Exp. Sta., Oregon State Univ., Corvallis, OR.

Fischer, W.C. 1978. Planning and evaluating prescribed fires. A standard procedure. USDA, FS Gen. Tech. Rep. INT-43.

Gruell, G.E. 1983. Fire and vegetative trends in the northern Rockies: Interpreted from 1871-1982 photographs. Forest Service Gen. Tech. Rep. INT-158.

Lawrence, W.H. 1954. Michigan beaver populations as influenced by fire and logging. Ph.D. dissertation. Univ. of Michigan, Ann Arbor, MI.

Mueggler, W.F. 1976. Ecological role of fire in western woodland and range ecosystems.

Shier, G.A. and R.B. Campbell. 1978. Aspen sucker regeneration following burning and clearcutting on two sites in the Rocky Mountains. Forest Science 24(2):303-308.

White, R.S. and P.O. Currie. 1983. The effects of prescribed burning on silver sagebrush. J. Range Mgt. 36(5):611-613.

Objectives: Prescribed burns offer opportunities for modifying vegetation communities or vertical structure. Burns accelerate nutrient cycling, spring greenup, sprouting, forage availability, and soil movement; modify soil surface temperatures and moisture conditions; and provide vegetative treatments in lieu of herbicides.

Areas of Applicability: There is universal application to riparian systems.

Techniques: The techniques to burn riparian areas are basically the same as they are for upland areas and include defining the goal and objectives of the burn, selecting the treatment area, determining the size, and assembling a fire prescription.

Various techniques are available to help achieve burn objectives under different conditions of weather, topography, and fuel characteristics. These different firing techniques can be correlated closely with burning objectives, fuels, and weather factors to prevent harmful effects to vegetation, wildlife, air quality, and human health.

Basically, all fires can be categorized on the basis of behavior and spread. Fires move either in the same direction as the wind (head fire), in the opposite direction of the wind (back fire), or at a right angle to the wind (flank fire).

Head fires are the most intense because of faster spread rates, wider burning zones, and greater flame lengths. Back fires are the least intense and have the slowest spread rates, narrow burning zones, and short flame lengths. Intensities of flank fires are intermediate.

The following discussion represents those firing techniques most commonly used in prescribed burning programs; other methods exist and combinations of two or more firing techniques can be used on individual projects:

A. Head firing consists of allowing the fire to burn with the wind or upslope. Such a fire can be started along prepared control lines on the upwind or downslope portion of the burn unit. Since these fires move with the wind, their intensity and spread rate are directly influenced by wind speeds.

   Head fires are one of the most difficult kinds of fires to control and use effectively because they closely imitate wildfire behavior. The fire moves in the direction of maximum spread and attains maximum intensity unless barriers or fuel breaks are encountered. Though head fires have the highest rates of spread and flame lengths, they also provide the largest burned areas per unit of time with a minimum of ignition.

   Advantages of this method include lower costs due to rapid burnout of smaller size class fuels, and greater convective lift associated with higher intensities and wind speeds

B. Back firing consists of lighting the fire so that it backs into the wind or moves downslope. Fires are started from prepared control lines on the upslope or downwind side of the burning unit. Variations in wind speeds have very little effect on the rate of spread of backfires burning into the wind.

   This is one of the easiest and safest techniques because it produces minimum scorch, directs more head down than upward, and can be used effectively in heavy fuels. The slow movement of back fires allows considerable preheating of unburned fuels to occur, improving fuel consumption during actual burning. Other advantages include low intensities, low spotting potential, and slow rate of spread, enabling greater control.

C. Strip head firing may be the most versatile method of prescribed burning. Strip head firing involves lighting a line, or series of lines, progressively into the wind or downslope. Each strip creates a head fire and a back fire. The head fire moves upslope, or with the wind, until it burns into an area already burned out by a previous strip, or until it meets a back fire moving downslope from a previous strip. The back fire moves downslope or into the wind at relatively slow rates of spread until it meets a fuel break or control line, or the head fire created by the next strip.

   Strips vary in width depending upon the fuel type, weather conditions, topography, and desired levels of intensity. The maximum intensity of strip head fires occurs when the head fire from one strip burns together with the back fire from another strip. This maximum intensity can be controlled by varying the width between each strip; the wider the strips, the greater the intensity attained by the head fire before it reaches the previous strip’s back fire.

   Advantages of strip head fires include quick firing, rapid smoke dispersal, lower costs, greater control of fire intensity, and ability to burn large blocks and be used at the upper ends of prescriptions (higher fuel moisture contents).

D. Flank firing consists of lighting lines of fire into the wind and parallel to the wind direction. The strips or lines of fire then burn fires that are intermediate in intensity between head fires and back fires. This technique is not able to withstand variation in wind direction and requires good coordination. Advantages include fairly rapid burnout; intermediate fire intensities; fast area ignition; need for fewer control lines; and usefulness on flat ground, in securing flanks, and in combination with other firing techniques.

E. Spot (spot head) firing is an exact procedure that requires considerable experience by the practitioner. This method is similar to strip head firing except that a series of small spot fires are started rather than a line fire. The spots burn in all directions until they come together, minimizing the possibility of any spot gaining sufficient momentum to start a hot run. Timing and spacing of the individual fire spots are keys to successful application of this method.

   Spot head fires may give a wide range of results as each spot will burn with varying intensity, ranging from low-intensity back fires, to intermediate flank fires, to high-intensity head fires. As two spots begin to burn together, interaction between the two can occur, yielding the highest intensity.

   Spot head fires are advantageous because they can be used with light and variable winds and for open burning, ignite the area quickly, allow for intensity to be adjusted by spot distance, have a moderate cost, and need no interior firelines.

Ease of Application: A great deal of planning is required to have any success with prescribed fires. Information from fire control centers can be of great assistance.

Expected Responses: Prescribed burning, if done properly, is a very effective tool in changing or altering plant succession (seral stage). Good response is usually seen after one complete growing season. However, this will vary in relationship to weather conditions.

Limitations: Realize that in riparian habitats, fuel moisture conditions are likely to be higher within the burn block than the surrounding uplands. Control conditions may be considerably different than usually anticipated in prescribed fires. As a result, more physical barriers or larger suppression crews may be required to ensure adequate control.

Extensive planning is necessary and large crews may be required to ensure that the burn is properly carried out and that things remain under control. Sometimes the window (time slot) that allows for a proper burn is small. Weather conditions can delay a project from year to year.

Areas of special concern (sensitive species) may not be good candidates for prescribed burns.

Specific limitations for the various techniques listed above are as follows:

A. Head firing disadvantages include greater difficulty in control from higher intensities, greater spotting potential, greater residual burning after passage of flaming front, and lower rates of fuel consumption due to relatively high spread rates.

B. Back firing drawbacks include slow rate of burning, need for presence of strong wind velocities to assist in smoke dissipation, and increased cost.

C. Limitations to strip head fires are that they require more personnel during ignition, require personal access for igniters to move through the unit, need more fuel for ignition, and take more time than head fires.

D. Flank firing is disadvantageous because it requires close coordination prior to ignition, steady wind direction, and good knowledge of fire behavior. It also does not work well in heavy fuels.

E. There are constraints to using spot head fires because of the importance of timing and spacing of fire spots, necessary for physical access if firing is not done aerially, possibility of zones of increased fire intensity if spots are too close, and creation of higher intensity head fires if spots are too far apart.

3. Name: Forestry Practices

References:

Anonymous. 1981. Factors affecting the development of woody vegetation on riparian lands. In: The Platte River Ecology Study, An Unpublished Summary Report, USDI, FWS. Northern Prairie Wildlife Research Center, Jamestown, ND.

Brunsfeld, S.J. and F.D. Johnson. 1985. Field guide to the willows of east central Idaho. Forest Wildlife and Range Experiment Station, Univ. of Idaho, Moscow, ID. Bull. 39.

Crawford, H.S., R.G. Hooper, and R.F. Harlow. 1976. Woody plants selected by beavers in the Appalachian Ridge and Valley Province: USDA, FS Research Paper NE-346.

Crouch, G.L. 1978. Effects of protection from livestock grazing on a bottomland wildlife habitat in northeastern Colorado. Proc. of the Lowland River and Stream Habitat in Colorado Symposium, Greeley, CO.

_________. 1979. Long term changes in cottonwoods on a grazed and an ungrazed plains bottomland in northeastern Colorado. Res. Note RM-370, USDA, FS Rocky Mt. For. and Range Exp. Sta., Ft. Collins, CO.

_________. 1985. Effects of clearcutting a subalpine forest in central Colorado on wildlife habitat. USDA, FS Res. Paper RM-258.

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Densmore, R. and J. Zasada. 1983. Seed dispersal and dormancy patterns in northern willows: Ecological and evolutionary significance. Canadian J. of Botany, 61pp.

Everest, F.H. and R.D. Harr. 1982. Silvicultural treatments - influence of forest and rangeland management on anadromous fish habitat in western North America. USDA, FS. Tech. Rep. PNW-134.

Fenner, P., W.S. Brady and D.R. Patton. 1985. Effects of regulated water flows on regeneration of Fremont cottonwood. J. Range Mgt. Vol. 38(2):135-138.

Hall, J.G. 1960. Willow and aspen in the ecology of beaver on Sagehen Creek, California. Ecology, Vol. 41(1):484-494.

Kindschy, R.R. 1985. Response of red willow to beaver use in southeastern Oregon. J. Wildl. Mgt. Vol. 49(1):26-28.

McCashion, J.D. and R.M. Rice. 1983. Erosion on logging roads in northwestern California: How much is avoidable? J. of Forestry, Vol. 81(1):

McKnight, S.S. 1970. Planting cottonwood cuttings for timber production in the south. USDA/SFES, FSRP-SO-60.

Peterson, D.L. and G.L. Rolfe. 1982. Nutrient dynamics and decomposition of litterfall in floodplain and upland forests of central Illinois. Forest Science, Vol. 28(4):667-681.

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Sedell, S.R. and S.L. Froggatt. 1984. Importance of streamside forests to large rivers: The isolation of the Willamette River, Oregon, USA, from its floodplain by snagging and streamside forest removal. Verh. Internat. Verein. Limnol. 22-Stuttgart.

Triska, F.S. 1984. Role of wood debris in modifying channel geomorphology and riparian areas of a large lowland river under pristine conditions: A historical case study. Verh. Internat. Verein. Limnol. 22-Stuttgart.

U.S. Department of the Interior. 1983. Willow planting for riparian habitat improvement. BLM Tech. Note 363, Denver, CO.

Objectives: Woody vegetation plays a significant role in the external energy dynamics and internal biological continuum of riparian ecosystems throughout a watershed. Forestry practices can often include riparian management objectives. Forestry treatment opportunities can include silvicultural manipulations of *all* woody species to improve riparian vegetation age class, physical structure, distribution, diversity, canopy, succession, understory composition, edge, and the ultimate creation of additional niches.

Areas of Applicability: These techniques are applicable wherever forestry resources are managed.

Techniques: The type of forestry manipulation (e.g., patch cutting, buffer zones, thinning, girdling, burning, and tree or slash pile barriers), season of application, and type of harvest operation should all be evaluated and planned, relative to both their positive and negative impacts to riparian systems. Mitigating stipulations or Best Management Practices (buffer zones, low impact road design, runoff manipulation, and winter cutting) can be effective in managing physical and biological forest management impacts to riparian areas.

Ease of Application: The ease of application depends on the type of treatment or mitigating measures required. For example, mitigating measures, such as road design in the contract specifications and contract administration for a timber sale, are more critical than for stand improvement work, such as a thinning.

Expected Responses: Periodic manipulation of conifers, aspen, and willows can provide a greater diversity of vegetative community strata. It can also affect long-term availability of browse, nutrient or material cycling, and community succession. Cover or canopy manipulations in riparian coniferous stands can stimulate the growth or regeneration of aspen or shrubs, open parks, and increase light penetration, benefitting terrestrial and aquatic food chains. Woody debris and slash management benefit terrestrial species by increasing nutrient recycling, nesting, perching, and feeding, and benefit aquatic systems in terms of instream cover, streamflow, bank storage, energy dissipation, and geomorphological floodplain stability.

Limitations: The timing of forest management needs with riparian management needs may limit opportunities to accomplish both objectives with one treatment.

4. Name: Vegetation Plantings

References:

Allen, H.H. 1978. Role of wetland plants in erosion control of riparian shorelines. In: Wetland Functions and Values: The State of Our Understanding. American Water Resources Assoc.

Anderson, B.W. and R.D. Ohmart. 1981. Final report: Revegetation for wildlife enhancement on the Cibola National Wildlife Refuge. Center for Environmental Studies, Arizona State Univ., Tempe, AZ. Contract No. 7-07-30-V0009.

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Objective: The purpose of these techniques is to reestablish native plant communities and physical conditions that will stabilize and allow the system to function properly.

Areas of Applicability: There is universal application to riparian ecosystems.

Techniques: Watershed vegetation treatments are most important in the recovery of degraded and lost riparian sites. Typically, these techniques have utilized the direct planting of shrubs, trees, poles, roots, tubers, and seedlings in an attempt to establish desired vegetation species or communities.

Basically there are three methods to establish (reestablish) native vegetation: using cuttings, transplanting dry root stock, and seeding. A brief description of each follows:

A. Using cuttings to establish vegetation works well for woody riparian vegetation like willows and cottonwoods. The first step is to collect native cuttings, prior to leafing out, from sites close to the site that will be planted. The cuttings are cut at a 45-degree angle and can be planted directly or stored in buckets of water for a few days. When storing them in water, survival will be augmented by adding rooting stimulants.

   The length of a cutting is determined by the depth of the water table where it will be planted. Eight to 15 inches are added to the cutting length to determine the length above ground. To establish larger cottonwoods, 4 to 6 feet must be left above ground. When planting the cutting, it is of *extreme importance* that the cut end of the plant is placed into the water table. The terminal end of the plant is sometimes pruned to prevent flowering and direct more activity towards root growth. If pruned, the top of the plant should be painted to prevent excessive loss of moisture and provide optimal survival.

   Successful plantings at higher elevations, usually take place after snowmelt and peak runoff. For lower elevations, the preferred time is before greenup. A tool, developed by the Coconino National Forest, is useful in planting riparian species. It is a modified forest tool, the “KBC Bar” for tree planting. The handle is shortened to accommodate welding a steel rod to the tip of the planting bar. For larger cottonwoods, a post hole digger or auger works well.

B. Dry root stock or transplants require digging a hole that is large enough to accommodate the existing root mass without scrunching it. A couple of inches are added to the depth of the hole to provide room for adding a soil mixture or enhancer. A mix of 1/3 soil, 1/3 sand, and 1/3 fertilizer is often used. Prepared soil enhancers or mulches can be used as well. Sometimes the existing soils are adequate at the site and do not require any form of enhancers. This can be determined by a soil scientist.

The bottom couple of inches are filled with the soil, soil mixture and/or enhancer, and the plant is place in the hole. The hole is then filled around the root mass or ball, stopping every so often and adding water to remove air pockets around the roots. Depending on the size of the tree/shrub, it may need to be staked to provide stability until the root system has had time to establish itself, usually 1 year.

C. Successful broadcast seeding is done in the fall before snow flies and/or early spring before moisture and greenup. Broadcasting seeds during the winter, on top of the snow, has been fairly successful. If the seeds are being applied to a small area, a hand spreader works fine. After application, the area should be raked or scuffed to cover the seeds to some degree. If the seeds are being applied to a large area, a drill is more appropriate. The drill should be set to the appropriate depth to allow for good germination.

   Seeding may not be necessary if a natural seed source is close at hand. Roughing an area with the teeth on a front-end loader provides texture that supplies microclimates sufficient for seeds to collect, be covered, and germinate.

There are other opportunities for reestablishing vegetation, like planting sod plugs, that are not covered in this document.

Ease of Application: Some of these methods are labor intensive and can be expensive. However, most of the labor can be supplied by volunteers and the actual techniques are quite easy to apply.

Expected Responses: Only limited success may be experienced if site conditions are unfavorable. Special considerations are therefore necessary to design treatments that optimize microsite factors, such as soil and organic (carbon) accumulations, cool temperature pockets, and season-long moisture availability. Consideration of these factors should facilitate the establishment and vigorous recovery of (native) vegetation most suited for the ecological site conditions.

If conditions are favorable and techniques are properly applied, most cutting efforts will result in a 60 to 80 percent survival rate going into the second growing season. The survival rates for dry root plantings vary greatly, with some results as low as 5 percent and some as high as 60 percent after the first growing season. Success of seeding projects relates directly to climatic events.

Limitations: Dry root stock plantings will usually require special care (watering) for survival. Dry root stock from nurseries often is not acclimated to the new site, thus limiting survival.

In some instances, the causes for the change to the undesired plant community have not been addressed. *Without a change in other management activities (e.g., grazing) to go along with attempts to change vegetative communities, many planting operations will fail.*

5. Name: Opportunities from Mineral Activities

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Objective: The objective of these techniques is to rehabilitate the impacts (mitigation) of mineral exploration and development.

Areas of Applicability: This technique has universal application with modification to particular sites based on climatic factors.

Techniques: Minerals activities offer extensive opportunities for development of new riparian vegetation and areas through the application of innovative or off-site mitigation for surface disturbances, multiple-use runoff design considerations in surface reclamation plans, and capitalization of incidentally developed resources, such as new artesian flows or surface reservoirs. In addition, extensive surface disturbances such as roads or mine spoils, when viewed as water collection and yield surfaces, often can provide opportunities for water yield management to enhance the development of wet meadow or marsh sites, improving onsite sediment retention and rangeland productivity. Examples of such practices could include the following:

A. Development of “dry hole” flowing wells into riparian areas (e.g., Red Desert Wetlands - Green River Resource Area).

B. Reclamation design to utilize mine spoil runoff or mine drainage for creating reservoirs, marshes, and wet meadow basins (e.g., Skull Point Reservoir - Kemmerer Resource Area).

C. Development of low-profile diked or rock-armored water spreaders, to collect and infiltrate increased runoff resulting from road construction (e.g., Riley Ridge Oil and Gas Field - Pinedale Resource Area).

D. Riparian habitat development in association with surge or evaporation ponds (e.g., 10-Mile Marsh and Bridger Power Plant - Green River Resource Area).

Ease of Application: Most of these efforts are expensive and labor intensive. They usually require the use of heavy equipment. The equipment and labor at the mine site often can be used to rehabilitate the site or to create mitigation sites.

Expected Responses: Success will vary greatly (0 to 100 percent) and is related to the soils, type of tailings, and water quality of the site. For places like Alaska, aufeis and permafrost must be considered. For the most part, success will increase if native vegetation is used on the site. However, on some sites, because of the type of spoils, nonnative vegetation is the only vegetation that can establish itself.

Limitations: *Caution must be taken in using mine wastes or spoils in reclamation projects. Mine spoils are often materials with high concentration of salts, heavy metals, or acidic residues*. In most cases heavy equipment with experienced and/or willing operators is necessary to achieve success. It can sometimes take years to achieve the desired plant community.

6. Name: Structures

References:

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Objectives: Physical structures are placed in watersheds to control erosion and/or degradation of a site. They are also placed to dissipate energy, spread water, and stabilize banks, etc. *Before application to any site, determine whether the same objectives can be accomplished through vegetation management or impact reduction management.* These management techniques are preferred over the use of structures.

Areas of Applicability: Structures have universal application to perennial, intermittent, and ephemeral drainages of like sites.

Techniques: The construction of physical structures for riparian (erosion control) treatments, while widely applied, is expensive and labor intensive, requires ongoing maintenance, and often ends up treating the symptoms of riparian problems rather than their causes. *For these reasons, an interdisciplinary team effort should be applied on a watershed scale, to ensure the causes of riparian problems are corrected while their impacts are being treated*. Physical treatments designed with the following points in mind have high success:

A. Use of natural materials and transfer systems available at the site or easily obtainable (e.g., rock, vegetation, deadfall logs, transported sediment, etc.)

B. Expenditure of one-time treatment costs versus numerous followup or periodic treatments (e.g., riprap of a cutting bank to increase erosion resistance versus ongoing road maintenance, reconstruction, and continued erosion)

C. High amortization rates of capital expenditures for achieved effect. For example, if a gully trash-catcher costs $100 for materials and labor, and it takes 5 years for it to fill in and form an operational pocket meadow, the annual cost for the meadow is $20 for net effect; or, if annual sediment removal in an irrigation system costs $100,000, a $500,000 (silt trap) marsh development would be amortized out in only 5 years or less, if resulting recreational uses were also developed.

In many areas throughout the West, human developments, and changes in watershed equilibrium associated with them, may require the construction of major physical treatments to maintain or restore the entire drainage system's integrity.

For example, construction of major on-stream reservoirs can initiate repeated waves or runs of headcuts up tributary drainages, due to repeated changes in pool levels of the reservoir. These headcuts can lead to a continued undermining and accelerated erosion of former riparian depositional sites throughout entire watersheds. These situations may require major gradient restoration and energy-transfer structures at the mouth of such tributaries, to correct or mitigate this type of a compounding impact and prevent a breakdown of the entire system.

The following physical treatments have been utilized to solve a variety of riparian problems or initiate the reformation of stable conditions:

1. Gully plugs
2. Gabions
3. Drop structures
4. Check dams
5. Water spreaders
6. Spring developments
7. Reservoirs
8. Trash catchers (in perennial and ephemeral drainages)
9. Reinforcement structures for energy dissipation (riprap, channel armoring, trees, fence posts, wire, tires)
10. Drainage reconstruction
11. Grassed waterways
12. Low water crossings (concrete, gravel, gabions)

No one structure or treatment can typically be prescribed for all situations. By identifying key factors, forces, and conditions affecting each site, the most likely structural solution will often evolve through the factor-analysis process. Key factors for consideration include the following:

1. The full annual range of streamflow volume and its timing.
2. Gradient above and below the site, relative to flow velocities at all stages.
3. Soil type and resistance to erosion at all flow stages and velocities to be encountered throughout the year.
4. Dynamics of sediment transport, volume, and storage throughout the year or over the expected life of the structure.
5. Expected performance life of the treatment structure and its net effect, considering potential channel or riparian changes after installation.
6. Effects on the biota.

Accelerated erosion is often the basic problem to be solved in most riparian structural treatments. In this regard, basic strategies can be used to:

1. Intercept the accelerated erosion at its source, through stabilization, to preserve a riparian site and correct the source of the problem.
2. Intercept and store the sediment en route to develop new riparian areas.
3. Increase channel erosion resistance factors and flow velocities, to pass the accelerated amount of sediment through the system to someone else downstream.

Ease of Application: Application and labor varies from very easy to extremely difficult. Some of the techniques can be done by hand, while others will require all types of equipment. Planning for structures should include engineering and hydrologic input.

Expected Responses: Response is directly related to properly classifying the site (ecological site) and determining its potential. Understanding the site results in most projects having a high success rate. Most failures result from trying to apply a technique that worked well for one site without realizing that the new site is different.

Success of a project often depends on whether the management situation that allowed the problem to occur has been corrected. *Structural treatments will not replace or overcome poor management. Management must be appropriate before any treatments are initiated. The cause, not the symptoms, must be identified and addressed.*

Limitations: Application of a particular treatment to the wrong site can be disastrous. A good understanding (classification) of the site and how it functions (aggradation, degradation, hydrology, etc.) is necessary. For example, if Rosgens' (1985) stream classification system is used, B2 channel types are areas where cross channel structures will be successful while on C2 channel types, cross channel structures would be disastrous.

Many forms of physical treatments will require some level of maintenance. This can be costly and time consuming, and needs to be incorporated into a cost/benefit analysis.

7. Name: Beaver

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Objectives: Historically, beaver have been key agents of riparian succession and ecology throughout North America. Beaver can be used to naturally transform pioneer woody vegetation into physical features that result in the expansion of floodplains, riparian community structure, diversity, and productivity.

Areas of Applicability: There is universal application for habitat where beaver occur either historically or presently.

Techniques: Basic considerations in managing beaver include watershed erosion rates and volumes, dam and pond cycling frequencies, construction material demand rates, availability (or potential) of suitable adjacent woody vegetation, types of adjacent woody vegetation (e.g., willow-based beaver complexes cycle faster than aspen, which are faster than cottonwood, etc.). Other factors include carrying capacity, population dynamics and their management, and site-specific factors, such as bank stability, vegetative cover, soil type, stream slope, order, and size.

Ecosystem management, capitalizing on the beneficial effects of beaver activity, can be used to achieve riparian maintenance or improvement objectives through adjustments in land-use activities. For example, accelerated erosion could be mitigated by accelerating cycling rates of beaver complexes and meadow formation in order to collect and stabilize the increased runoff and sediment in the drainage. Special management may be required to maximize woody and herbaceous vegetation regrowth rates in order to supply abundant building material and provide the basis for accelerated dam-building activity and cycling frequency.

Other examples could include treatments such as maximizing beaver populations (and possibly supplemental dam reinforcements) through an initial construction phase, followed by population reductions and management for maintenance levels or desired effect.

In other cases, beaver could be used to initiate or accelerate the natural restoration of degraded or lost riparian systems. Identifying limiting factors and providing supplemental management techniques to compensate for these factors are important. With physical site conditions improved for initiation of natural riparian establishment, the system could develop to a self-sustaining level within as little as 3 to 4 years. By planting beaver in degraded sites, providing supplemental dam reinforcing material during initial construction (to reduce dam washout prospects), and maximizing vegetative regrowth and establishment, the physical laws and processes of nature can be used to accelerate riparian recovery and succession.

By starting lower in first-, second-, and sometimes third-order drainages, or below areas of erosion, beaver activity and stream sediment transport can be capitalized upon to reelevate the bed level of incised channels; reactivate floodplains; increase streambank water storage and aquifer recharge; and increase sediment deposition and storage, creating favorable microsite conditions for maximizing natural vegetative stabilization of the drainage.

Once viable beaver complexes become established and are self-sustaining (3 to 4 years), the complexes themselves will begin to form natural gully plugs of a quarter- to half-mile in length, accelerating sediment deposition and riparian recovery further upstream. By facilitating the establishment of beaver dam complexes at intervals along a drainage or throughout a watershed, this process can create a leap frog effect, helping to accumulate or stabilize sediment in place throughout the system.

Ease of Application: The most difficult and frustrating aspect of this technique is live trapping of beaver. This process can be time consuming and requires dedication. However, once they are captured, they are easy to handle and receptive to being moved to a new site.

Expected Responses: If the techniques are followed as expressed above, the success rate is usually high, but this also depends on the site they are moved to and the time of year they are moved. For best results, beavers should be moved in the fall, allowing for time to gather a food cache, but limiting their time to explore before having to set up shop for the coming of winter. Providing a food cache at a particular site may be helpful. *Beavers should not be expected to set up shop at a particular site; a general area should be planned and the beavers will choose the site.*

Limitations: Moving beavers at the wrong time of year can result in them leaving the area and becoming a nuisance downstream. They can be destructive to habitat as well as beneficial. If homeowners are nearby, over time the beavers may be liked or disliked based on what they are doing to the private lands. In these areas, it is important to work in cooperation with adjacent landowners.

Beavers can be disruptive to the habitat of other wildlife species. Caution should be used in introducing beavers into areas where they were not endemic. For example, they may alter the migration patterns of fish.

Special consideration needs to be applied to areas where livestock use occurs.

8. Name: Bank Stabilization

References:

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Objective: The objective of bank stabilization is usually to accelerate soil and water conservation efforts. For the most part these practices are considered *temporary*, and are being used to *speed* up natural processes. Therefore, it is *important* that adjustments be made in management of the area that created the problem before placement of such treatments. In some cases, this erosion is natural and should be allowed to continue for the system to function properly, thus establishing new point bars for vegetation establishment.

Areas of Applicability: There is universal application to perennial and intermittent streams.

Techniques: Bank treatments usually fall into one of three basic categories — juniper, log, and rock riprap or gabion treatment:

A. Juniper treatment consists of cutting green trees or gathering discarded Christmas tress and anchoring them into banks in areas with high erosion and sloughing. They provide an advantage over the other methods by being more cost effective, as well as acting as sediment traps that provide sites for vegetation to establish itself.

   Tree size depends upon the size of the system and the availability of equipment. Trees with bushy or heavy crowns are preferred. Trees are angled downstream and attached by wire to an anchor point. Fence posts and deadmans are used to secure the anchor points. Trees are placed generally at one tree per yard of bank.

B. Log structures are usually used where vegetation is not successfully holding the bank together. Logs are placed at the base of the bank (streambed level), end to end. Preferred tree size is 10 to 12 inches in diameter and 10 foot lengths. The type can be varied (aspen, lodgepole pine, etc.). A source should be selected that is close by and readily available.

   The logs are anchored to the bank by driving 7 foot pieces of 1/2- or 5/8-inch rebar through them and into the banks at a 45 degree angle. The rebar is driven into the bank by using post pounders until only 12 inches are remaining. The remaining rebar is bent over and angled downstream towards the bank. A backhoe is then used to fill behind the structures. Larger materials (fist size rocks) are placed first to prevent undercutting of the structures, and fines are placed last to provide sites for vegetation establishment.

C. The use of gabions or placement of riprap is usually reserved for sites that have extreme erosion. Normally, when placing riprap, rock pieces of an average size of 24 inches are ideal for this type of work, but this will vary with the size of stream. When using gabions, the size of rock only needs to exceed the size of the wire mesh.

   Hand labor can be used to accomplish these tasks, if small in nature, but heavy equipment, like a backhoe, will be required to complete large projects.

   There are a variety of materials that can be substituted in this technique, but the technique remains the same for the most part.

Ease of Application: Juniper trees, 8 to 10 feet in height, can be easily handled by two people and hauled in a pickup truck. Once at the site, they can be easily dragged by hand. This is an excellent treatment that can be carried out by volunteers like boy scouts, YCC, etc.

Larger projects will require the use of heavy equipment and skilled operators.

Expected Responses: Placement of juniper trees will markedly reduced water velocities (73 percent reductions have been recorded) and promote the collection of sediment. The collection of fines provides a site below the vertical bank that native plant succession usually occupies during the first growing season. Vegetation capturing sediment results in the deepening and narrowing of the channel, increased bank (water) storage capability, and improved water quality.

The expected results from using logs, riprap, or gabions are much the same as for junipers. The cost to implement, though, is much higher.

Limitations: Juniper treatment works well on straight and slightly curved banks. Stabilization of outside curves will require structures such as riprap. Log treatments are better suited for second- and some third-order streams. Gabions are rather unsightly until revegetation takes place.

All of these techniques are temporary and efforts will be negated if management actions are not implemented to correct the original problems.

9. Name: Recreation Planning

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Objectives: The objectives of these techniques are to protect, manage, and improve riparian habitats at existing recreation sites and during the development of future recreation sites.

Areas Of Applicability: There is universal application with modification to particular sites based on flood potential, climate, and soil/vegetation factors.

Techniques: Concentration of recreation use within a riparian habitat can be devastating, to the point that the very values that made the area attractive are eliminated or greatly reduced. As leisure time increases, the recreational use of riparian areas will increase. Without proper management of the important areas, onsite and off-site impacts can be significant. Potential management actions for recreational activities within riparian zones include:

A. Conduct detailed soil, water quality, vegetation, threatened-endangered species inventory and analysis prior to recreation site development or riparian site disturbances.

B. Evaluate adjacent uplands for potential hazards to human concentration (slides, flash flood runoff, insect/animal concentrations,etc.).

C. Analyze flood potential for human safety and structural needs for all potential and existing sites.

D. Retain enough vegetation in recreation development sites to maintain stable banks and fish cover. Retain enough woody vegetation of sufficient width and height along perennial streams to ensure favorable water/terrestrial temperatures and supplies of large organic debris for aquatic life.

E. Manage recreation use of riparian areas to prevent erosion or compaction that impairs soil productivity, and prohibit sediment loads or damage to bank vegetation that impairs channel stability, aquatic habitat, or other riparian values. Where such damage cannot be prevented, relocate recreation sites outside riparian zones.

F. If at all possible, locate new recreation sites outside of riparian areas, except day use only activities.

G. Design sites to prohibit land vehicles from getting into streams and damaging streambanks.

H. Eliminate livestock grazing in developed recreation sites to reduce cumulative impact on riparian ecosystems.

I. Design or redesign recreation sanitary facilities to prevent waste from affecting riparian soils, vegetation, water, or human safety.

J. Develop recreation sites that utilize riparian habitats for quality experiences not for quantity of human use. Disturbances to soils and vegetation should be kept to less than 15 percent of the developed site.

K. Design use areas to provide maximum noise filtering to increase human enjoyment and reduce stress on wildlife in riparian areas.

L. Plant dense native vegetation in locations to screen and reduce human use of vulnerable wildlife habitats and fragile soils, etc. Also use boulders and other natural looking devices to control unwanted human activity.

M. Develop a signing program to interpret, reduce vandalism, and direct human use to and away from given areas.

N. Keep road construction to a minimum. Develop trails to direct people to and away from given areas.

O. Where feasible, locate new facilities outside 100-year floodplain. Sign 100-year floodplain in all recreation use areas.

P. Shrubs and saplings should be maintained and encouraged within the developed areas for the benefit of wildlife and humans (screening, noise reduction, cover, and movement corridors for birds).

Q. Concentrate camping activities in small areas of the developed recreation site to maximize low use areas.

R. Control pets, such as dogs and cats, to reduce predation on wildlife, wildlife harassment, and disturbance of other recreationists.

S. Most importantly, maintain a presence at the recreation developments. If a presence cannot be maintained at these sites, don’t develop them, or if already developed, close them down until they can be managed properly.

Ease Of Application: Physical limitations to the development of recreation sites within riparian zones are normally limited to the width of the floodplain. However, other considerations must also be evaluated before the decision to develop is made, such as benefits versus impacts to humans as well as the environment, human safety, aesthetics, long-term site productivity, etc.

Expected Responses: Long-term productivity and aesthetic values of riparian habitats are expected to be maintained at a high level common for riparian areas. Human enjoyment of these areas will also be maintained at a high level.

Limitations: Intensive planning and design will be necessary to properly prepare recreation developments within riparian habitats. To adequately manage these recreation sites will require a significant level of manpower to maintain, clean, and police them. Some limitations will be required related to flood potential and human safety.

10. Name: Road Construction and Maintenance

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Objectives: The objectives of these techniques are to protect, manage, and improve riparian habitats by improving road design, location, and maintenance.

Areas of Applicability: There is universal application with modification to particular sites based on soils, flood potential, and vegetation factors.

Techniques: Road construction in and adjacent to riparian areas has a high potential of altering stream channels, impacting water runoff and soil erosion, causing disturbance of vegetation and wildlife habitats, and reducing the human enjoyment of these unique environments. Roads and road construction impacts on riparian zones can be avoided or significantly reduced through careful planning, mitigating practices, and commitment to long-term maintenance. Potential management actions pertaining to road construction and maintenance include:

A. Conduct detailed soil, vegetation, and threatened-endangered species inventory and analysis prior to any surface disturbance.

B. Analyze flood potential for human safety and structural stability.

C. If at all possible, locate all new roads outside of riparian areas. Locate roads on natural/stable benches, ridges, and flat slopes near ridges or valley bottoms.

D. Design roads and stream crossings to minimize impacts to streambanks, riparian vegetation, water quality, and downstream environments.

E. Design roads with adequate structures/devices to prohibit vehicles from leaving the roads and off-roading in riparian zones or adjacent uplands that may adversely impact the riparian habitats.

F. Install signs that inform the public where use is encouraged, accepted, discouraged, or prohibited.

G. Revegetate all disturbed areas with native vegetation. This should stabilize the site, prevent erosion, and catch sediment. It should also reduce silt entering the water system, prevent the establishment of undesirable plants, add aesthetic viewing, and provide cover and food for wildlife. Special thought should be given to avoid drawing animals to heavily traveled roads.

H. Develop a road management plan for the entire watershed to minimize miles of roads needed.

I. Roads should be located on well-drained soils.

J. Any culverts or other stream-altering developments should allow for fish passage and free flow of instream debris.

K. Avoid large road cuts and fills and reduce road surface area to the minimum required for the purpose of the road and expected vehicle traffic.

L. Roads should be outsloped and designed with rolling grades or water bars to reduce surface water velocities and culvert requirements.

M. Road construction waste material should be hauled to a predesignated site and not sidecasted.

N. Exposed soils that cannot be revegetated might need riprapping.

O. Road construction material should not be taken from riparian or aquatic habitats.

P. Road design should consider future potential accidental spills of harmful chemicals, etc.

Q. Schedule timely and appropriate road maintenance.

R. Keep road gradients as low as possible and keep soil disturbance to a minimum.

S. Close all roads that are no longer needed and rehabilitate.

Ease of Application: Building and maintaining roads within riparian areas may or may not be easier than on the upland slopes adjacent to the riparian zone depending on a variety of factors, including soils, parent material, slope, vegetation, and political/environmental constraints.

Expected Responses: Onsite and downstream riparian values, as well as aesthetics, human enjoyment, water quality, and wildlife/livestock habitats, will improve and be maintained.

Limitations: Slopes, soils, construction and maintenance cost, threatened-endangered species, and other design considerations may limit road location options.

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