8 CLOSURE AND DECOMMISSIONING

A. INTRODUCTION TO ROAD CLOSURE AND DECOMMISSIONING

There are many reasons for closing or proactively "abandoning" a forest or ranch road,[1] most of which involve excessive maintenance costs, lack of continued need or continuing water quality problems (Table 36). Not all roads need to be part of the permanent or seasonal road system. For example, temporary roads are used once, and then "put-to-bed" until they are needed again. In addition to newly built temporary roads, there are many miles of existing roads that may no longer be needed, and older abandoned roads that are now overgrown and are not planned for reuse. The same techniques can be used to stabilize these older roads, to prevent future erosion and sediment delivery to streams and other waters, and, as an added benefit or incentive, save the work and expense of continued maintenance.

1 California Forest Practice Rules (Appendix C) officially refers to "road abandonment" as the method of proactive road closure and stabilization for private forest lands in California. The treatments are more commonly known as road closure or road decommissioning. There are a number of different terms used to describe the process of permanently or temporarily closing roads so as to minimize their erosion potential and threat to the watershed and its streams. Regardless of the name that is used, the treatments that are applied to prevent and control future erosion and sediment delivery from these "closed" routes are largely the same and are described in this chapter.

Roads can be classified in a number of useful ways. In Chapter 2 (Planning), active roads were classified as permanent, seasonal or temporary. This denotes road standard and size, as well as the likely period of use. Roads can also be classified into four activity classes: active, inactive, closed (decommissioned) and abandoned (legacy).

Active roads (permanent, seasonal and temporary) are part of the overall road network that must be actively inspected and maintained. These inspection and maintenance methods have already been described in Chapter 7.

Inactive roads (including **"stored roads"**) are those roads needed only infrequently, for fire control, tree thinning, recreation or other

TABLE 36. Conditions commonly leading to road closure

1. Roads constructed for temporary access (designated temporary roads).
2. Spur roads which are no longer needed for management for the next few years or for many years (e.g., all timber has been cut).
3. Roads with excessively high maintenance costs.
4. Roads which have persistent erosion and water quality problems, often located in areas of extremely erodible soils.
5. Roads crossing extremely steep slopes or inner gorge locations where landsliding risk is high and sediment could enter the stream channels.
6. Roads crossing slopes with high or extreme landslide risk or on-going landslide activity caused by incompetent bedrock or unstable soils.
7. Roads exhibiting potential for large fill slope or cutbank failures, often showing tension cracks and scarps in the roadbed.
8. Roads built with excessive sidecast of fill in unstable locations or perched above stream channels.
9. Old roads built in, along, or immediately adjacent stream channels or up narrow stream channel valleys.
10. Old, abandoned roads which have overgrown with vegetation and now have washed-out stream crossings and/or fill failures.

forest or ranch management activities. These roads remain largely unused for most of the year, or for a number of years in succession. There is a tendency to not maintain these routes because they are not often used, have low traffic volumes, and may only be used intermittently for administrative purposes. **However**, **all drainage structures on inactive roads *must* still be inspected and maintained because they are just as likely (or more likely) to plug and fail as those on more actively traveled routes.**

Closed or decommissioned roads were originally constructed as active roads, but have since been proactively closed to traffic and treated to reduce their potential environmental impact. These roads were "put-to-bed" or "vacated" with stream crossing drainage structures and fills being excavated and removed, road and landing surfaces permanently drained, and unstable fill slopes stabilized or removed (excavated).

Abandoned roads (sometimes called legacy, ghost or orphan roads) were at one time a part of the active road network, but are no longer used. They are found most commonly on forest and ranch lands and may constitute 15% to 25% of the overall road network that was historically constructed in a managed watershed. They may have been abandoned for a few years or for decades. Instead of being decommissioned or proactively closed, they were left to naturally "stabilize" and revegetate. Many are now overgrown and may show past, ongoing or future erosional problems or threats.

Because of their age and low standard of construction, and where they may have been built, old abandoned roads can still pose a significant environment threat to a watershed and it streams. **Just because a road has been abandoned and may be overgrown does not mean it is no longer a threat to the watershed** (Figures 254a and 254b). **Some failures may have already occurred along an abandoned or legacy road, but others are often still waiting to happen years or decades later when culverts finally plug or unstable fill slopes fail** (Figure 255).

There are thousands of miles of these abandoned or orphan roads both on private forest

and ranch lands and on public forest and range lands. They have received increased attention in recent years because of the threat they often represent to water quality and downstream aquatic habitat. These unused orphan or legacy roads may have been abandoned because they were no longer needed, or because they cross unstable areas, required excessive maintenance or caused persistent environmental damage. **Only a sound, detailed field assessment can differentiate between those legacy roads that pose little or no threat to a watershed, from those that could severely impact downstream water quality and aquatic habitat when they fail.**

FIGURE 254A-B. *Abandoned, unmaintained roads, whether in forested watersheds (254a) or in rural and ranchland areas (254b), represent a potential threat to streams and water quality.*

FIGURE 255. *Gully formed by culvert plugging and stream diversion on an old, unmaintained forest road. The degree of threat posed by old roads depends on the terrain the road crosses. Typically, the most serious threats occur where roads cross stream channels and steep, wet and/or unstable hillslopes.*

Many orphan roads have drainage structures, including stream crossings, which are in disrepair and are no longer being inspected or maintained. Some of the most vulnerable sites may have already failed, but others are likely to fail in the future (Figure 256). **These abandoned, legacy roads often represent a significant threat of non-point source pollution from roaded, managed wildland watersheds, especially when they occur in steep mountainous areas with heavy rainfall and unstable terrain. Landowners and resource managers should continue to work aggressively to inventory and**

FIGURE 256. *Unmaintained, culverted stream crossings, like this one, will eventually plug and either wash out or divert streamflow down the road. Most abandoned roads have drainage structures that are very undersized and often rusted through. Damage from the diversion of even small streams can cause large gullies or debris slides when released on steep, erodible slopes.*

proactively treat these potential sources of erosion and sedimentation. Good progress has been made over the last 20 years to identify legacy roads in the field, to prioritize them for permanent closure and to begin their treatment.

Good land stewardship requires that all roads, regardless of how frequently they are used and whether or not they are officially designated or recognized as part of the drivable road network, be regularly inspected and treated to protect water quality. Inactive and temporary roads that contain culverted stream crossings or other drainage structures *require* inspection and maintenance, and they should not be abandoned without first employing proper road closure techniques (Figure 257).

Any road that is not regularly inspected and maintained should be formally closed (decommissioned) and proactively treated so they will not have the potential to significantly impact streams, water quality or downstream aquatic ecology. Roads should never be abandoned by simply blocking them off or letting vegetation take over without first decommissioning stream crossings and performing proactive erosion control and erosion prevention work along the road alignment (Figure 258).

FIGURE 257. *Former log stringer bridge across a large fish bearing stream has been removed, with only a single log for left foot traffic. The bridge provided the only access to over two miles of forest road containing numerous culverted stream crossings that can no longer be maintained. Roads that have not been properly decommissioned require inspection and maintenance. The roads on the other side of this bridge have recently been scheduled for decommissioning.*

FIGURE 258. *Recently constructed barrier blocks access to an unmaintained road, but undrained surface runoff has already gullied the road behind the barrier and now delivers eroded sediment to a stream. Road and storm maintenance cannot be performed when large barriers are constructed. Immovable road barriers should only be installed on roads that have been properly decommissioned.*

B. TECHNIQUES FOR ROAD CLOSURE AND DECOMMISSIONING

It is no longer sufficient to close roads by simply installing or locking a gate or blocking the road with an impassable barrier, because those actions will not prevent future road failures, erosion, sediment delivery, or water quality problems from occurring (Figure 259).

Specific techniques, described below, are available to successfully prevent road-related debris flows, to prevent or correct stream diversions (the leading cause of serious gullying in many areas), to prevent stream crossing washouts and fill failures, to dewater gullies and landslides fed by road runoff, to disconnect road surface runoff from streams, and to control surface erosion (rilling and raveling) from abandoned road surfaces and fill slopes.

FIGURE 259. *Gating a road closes it to unauthorized traffic and may reduce surface erosion, but does nothing to protect the road from major failures. Scarps in the road fill behind this gate signal a slope failure that threatens to deliver sediment to an adjacent fish-bearing stream if it is not treated.*

FIGURE 260. *Untreated, abandoned section of forest road does not threaten water quality and needs little or no treatment for decommissioning. Roads to be decommissioned typically require minimal treatment for most of their lengths, and then concentrated erosion prevention work at a relatively few locations (e.g., stream crossings).*

Closing a road does not imply that every foot of the road needs intensive treatment to prevent future erosion (Figure 260). **Rather, the goal of proactive road closure is to aggressively treat only those sites and road segments which have a potential to generate erosion and to deliver sediment to stream channels.** Segments of road which pose no risk of sediment delivery can be left intact and receive only minimal road drainage improvements (Figure 261). When and if the road is again needed to provide access to the area, it can be reconstructed with minimal effort.

Planned, systematic road closure can be an inexpensive and effective technique for minimizing long-term resource damage caused by roads built in steep areas and can prevent large scale damage to road alignments that require costly repairs if the road is to be reopened

FIGURE 261. *Decommissioned forest road in an area of gentle slopes and no stream crossings. Road decommissioning in "easy" terrain can be an inexpensive process that returns the former, compacted roadbed to productive forest or grasslands. Road decommissioning can be either permanent (never to be reopened) or temporary. The two treatments are generally similar and provide protection to the watershed for as long as the road is closed.*

FIGURE 262. *The most important types of heavy equipment used for road decommissioning include hydraulic excavators, bulldozers (with hydraulic rippers), and dump trucks (for endhauling). Usually, the largest equipment that can easily work in the particular setting is selected to maximize productivity. Other support equipment, including water pumps and straw blowers, provide key functions for special decommissioning tasks.*

for future use. It also provides land managers with an opportunity to permanently prevent or control the majority of post-construction road-related erosion and its associated on-site and downstream impacts. In addition, implementing technically sound road closure practices also minimizes structural damage to widespread, expensive forest and ranch land road networks that cannot be economically maintained for the long time period between harvest rotations or other land uses.

There is little difference between treatments that are meant to permanently close a road and those designed for temporary closure. **When a temporary road is built, or when a permanent or seasonal road is to be closed and removed from the active road network, erosion prevention work should be performed so that continued maintenance is not necessary. All closed roads should be storm-proofed by excavating stream crossings and removing culverts, excavating unstable or potentially unstable road and landing fills, treating the ditch and road surface to disperse runoff and reduce surface erosion, and planting bare soil areas.**

The goal of road closure is to leave the road so that little or no maintenance is required for stability while the road is unused. Heavy equipment used for road closure typically includes a hydraulic excavator (a standard backhoe is too small and generally not versatile enough to effectively perform road closure tasks), a bulldozer (D5 to D7 size, with hydraulic rippers for decompacting rocked roads) and dump trucks (when needed for endhauling spoil and debris to stable disposal sites) (Figure 262).

Road decommissioning consists of three basic tasks.

1. Complete excavation of stream crossing fills, including 100 year flood channel bottom widths and stable side slopes (e.g., ~2:1).

2. Excavation of unstable or potential unstable sidecast and fill slope materials that could otherwise fail and deliver sediment to a stream.

3. Road surface drainage treatments (ripping, outsloping and/or cross draining) to disperse and reduce surface runoff.

1. STREAM CROSSING EXCAVATIONS

All stream crossings on temporary or abandoned seasonal and permanent roads scheduled for decommissioning need to be completely removed before the first winter period following their installation or closure (if not, they should be capable of passing the 100-year flood flow for that channel).

Removing (decommissioning) a stream crossing involves excavating and removing all fill materials placed in the stream channel when the crossing was built. Fill material should be excavated to recreate the original channel grade (slope) and orientation, with a channel bed that is as wide, or slightly wider, than the original watercourse (Figure 263). If the channel sideslopes were disturbed, they should be graded (excavated) back to a stable angle (generally less than 50% (2:1)) to prevent slumping and soil movement. The bare soils should then be mulched, seeded and planted to minimize erosion until vegetation can protect the surface, and the approaching road segments should be cross-road drained

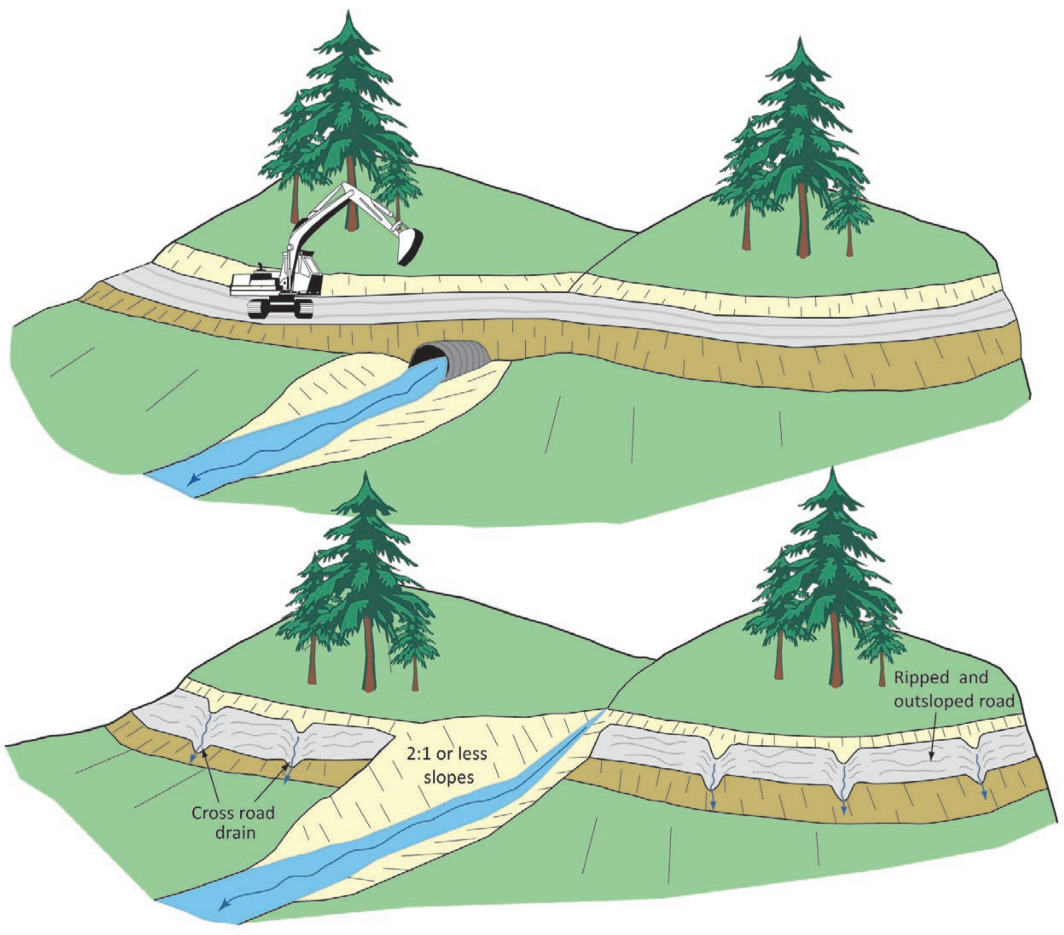

FIGURE 263. *On roads that are to be closed (decommissioned), all stream crossing culverts and fills should be removed. Stream crossing excavations are best performed using an excavator. The original channel should be excavated and exhumed down to the former streambed, with a channel width equal or greater than the natural channel above and below the crossing. Sideslopes should be laid back to a stable angle, typically a 2:1 (50%) gradient, or less. Spoil can be endhauled off-site or stored on the road bench adjacent the crossing, provided it is placed and stabilized where it will not erode or fail and enter the stream.*

to prevent road runoff from discharging across the freshly excavated channel sideslopes.

Procedures for removing stream crossings on abandoned, permanent or seasonal roads are similar to those used on temporary roads. Both culverted and unculverted stream crossings (e.g., culverts, plate arch crossings or log crossings) should be completely excavated or removed so that no soil materials are left in or next to the channel following road closure. It is not enough to simply excavate and remove the culvert; the entire fill must also be excavated (Figure 264). As with temporary stream crossings, the excavation should extend down to the level of the original channel bed, with a channel as wide, or wider, than the original channel.[2] Channel sideslopes should be sloped back to a stable angle and spoil material removed to a stable storage site (Figure 265). Erosion control measures, such as seeding, planting and mulching, should be applied to prevent subsequent surface erosion (Figures 266a–266e; Figures 267a and 267b; Figures 268a and 268b).

2 See Appendix C for California Forest Practice Rule language specifying this requirement.

FIGURE 264. *Poorly "decommissioned" stream crossing where the culvert was removed by trenching and the excavated spoil was piled next to the trench (see arrow) where it could easily erode into the stream. The entire stream crossing fill will be rapidly eroded and delivered to the stream if correct excavation and decommissioning treatments are not implemented before the next runoff event.*

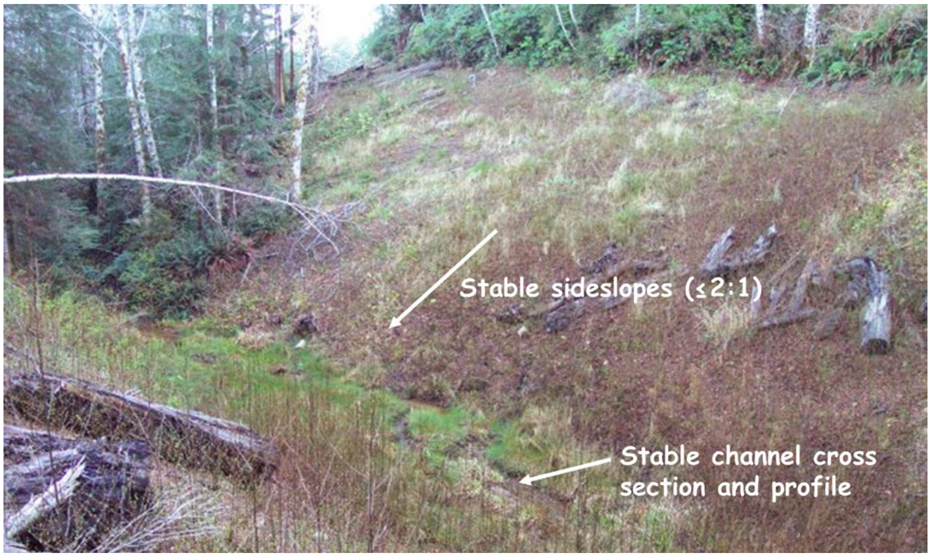

FIGURE 265. *Properly decommissioned stream crossing, with 2:1 (stable) sideslopes, adequate channel width for flood flows, and a uniform channel grade (no humps of unexcavated fill) extending between the natural channel above and below the crossing. Because the slopes were dry, excavated spoil material was used to outslope the adjacent road approaches. The sideslopes were seeded with grass and straw mulched to minimize erosion following decommissioning.*

FIGURES 266A–E. *This five-photo sequence shows the permanent decommissioning of a stream crossing on a former logging road. The road was no longer needed and has been permanently closed. The first step (266a) was to clear vegetation from the fill and from upstream of the crossing, where the channel had been filled with logging debris several decades earlier.*

FIGURE 266B. *Once cleared, an excavator excavated the fill material and several dump trucks were used to end-haul spoil material to a nearby, stable disposal site.*

FIGURE 266C. *The channel was excavated (exhumed), and the side-slopes were sloped back to stable angles, exposing several buried stumps that signaled the level of the original ground surface. The bare slopes were then seeded, mulched with straw, and planted with trees. All the logs visible on the right bank had been buried in the crossing fill. They were removed and placed on the final ground surface.*

FIGURE 266D. *Four years later, the site showed significant revegetation, and minimal channel adjustment (scour) or surface erosion.*

FIGURE 266E. *Finally, 2 years later (and 6 years after decommissioning) the site showed heavy alder growth that had naturally seeded in from adjacent areas. The conifers beneath the alder canopy will eventually overtake the alder trees.*

FIGURE 267A. *Dual, undersized, elevated culverts at this small stream crossing have been a barrier to fish passage since the road was built decades ago. The outlet of the culvert on the right has been crushed closed, probably by heavy equipment performing maintenance work. Road and stream crossing decommissioning was used to permanently reopen the channel to fish passage.*

FIGURE 267B. *The stream crossing fill was excavated and pushed down the alignment, away from the crossing. The gentle, excavated sideslopes were seeded, mulched with straw and covered with locally derived tree limbs and brush. The channel was excavated to the original streambed elevation, where rounded cobbles were exhumed, and constructed with the same width as the upstream and downstream channel reaches.*

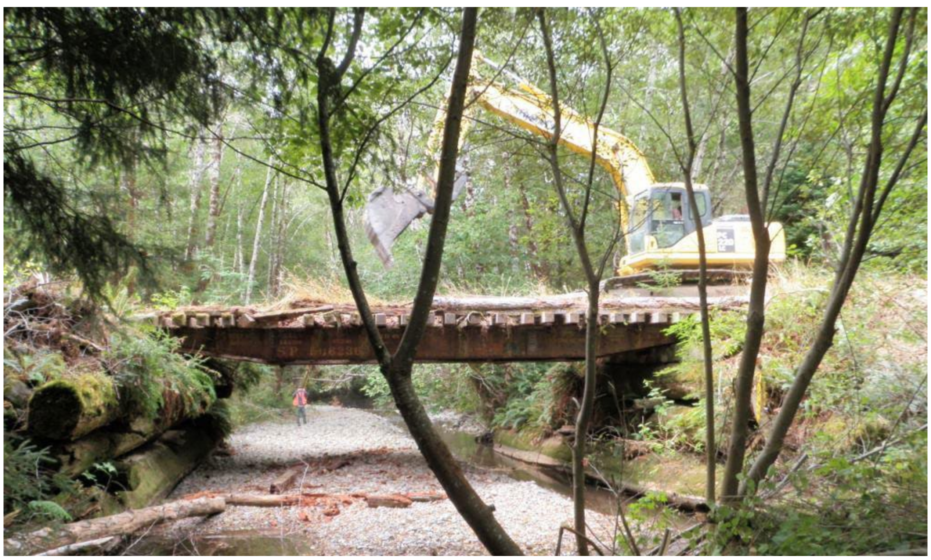

FIGURE 268A. *Abandoned road and flatcar bridge over a large fish bearing stream. Unlike log stringer bridges, which are often covered with a thick layer of soil, flatcar bridges do not have a cap of soil that could enter the stream when they eventually fail. However, the log abutments were beginning to collapse and the collapsed logs and bridge would likely cause future flow deflections and channel erosion.*

FIGURE 268B. *Because the road was to be permanently closed, the bridge was removed as a part of road decommissioning. The lower, partially embedded abutment log on each side of the crossing was left in place to protect the newly excavated streambanks. The sideslopes were excavated and sloped back at a gentle angle, and then mulched with woody debris. Natural channel width was retained through the crossing.*

2. TREATMENT OF UNSTABLE AND POTENTIALLY UNSTABLE FILLS

i. Road and landing fill slope excavation

Any unstable or potentially unstable road or landing fills (or sidecast) should be excavated and stabilized so material does not fail and enter a watercourse, impact off-site fish habitat, threaten bridges or homes that may be located downstream, or destroy downslope vegetation. Such areas include sidecast and fill materials which show recently developed scarps or cracks (e.g., Figures 269a—269c; Figures 270a and 270b), or perched fill and debris immediately adjacent stream channels (Figures 271a and 271b). These potential failure sites occur most often 1) around the perimeter of landings, 2) on sidecast constructed roads built across steep slopes, especially those near stream channels, 3) where roads have been built on steep slopes over springs or seeps, or 4) where roads have been cut into steep headwater swales or "dips" in the hillside (Figures 272a and 272b; Figures 273a – 273c). Cribbed fills which were installed at unstable areas during initial road construction or reconstruction should

FIGURE 269A. *Hydraulic excavator loading a 10-yd³ dump truck with fill material removed from an unstable road fill slope. The road decommissioning process whereby excavated spoil is endhauled off site, rather than placed against the cutbank, is call "Export Outslope" (EOS). EOS is used where unstable fill material must be excavated, but the cutbank is unstable or wet and cannot be buried. Spoil is endhauled to the nearest stable disposal site.*

FIGURE 269B. *This low standard forest road was scheduled for decommissioning because of slope stability and erosion problems along its alignment. Prior to road grading, inventory crews had identified cracks and small scarps along 50 feet of the road bench and outer fill. If it failed, the debris slide would deliver sediment to a stream just downslope.*

FIGURE 269C. *The fill slope has been excavated and the spoil endhauled to a nearby spoil disposal site (exported outslope: EOS). Note the buried stumps that were exhumed and the basal flair that told the excavator operator where the original ground surface was located and how deep to dig. The cutbank has not been buried so the resulting outslope of the former road bench is strictly a result of roadbed and fill slope excavation.*

FIGURE 270A. *Tall, dry cutbank where the road cut across the nose of a ridge. Just down the road an unstable fill was excavated to prevent a potential fill slope failure and this favorable site was used for spoil disposal.*

FIGURE 270B. *Spoil excavated from the nearby unstable fill slope was hauled to this section of road and placed (and compacted) against the cutbank. This type of treatment is called an "Import Outslope" (IOS), where most of the fill used to outslope the former roadbed was imported from another, nearby excavation site. Using local spoil disposal sites, provided they are suitable, can save significantly on endhauling costs.*

FIGURE 271A. *This abandoned, inner gorge road was targeted for permanent closure (decommissioning) because of the steep slopes, unstable road fill and the proximity of a fish bearing stream. Vegetation has been cut from the fill slope and straw bales have already been staged along the road for mulching after the heavy equipment work is complete. Most of the decommissioning involved endhauling spoil about 1000 feet down the road to a broad, low gradient area located far from the stream.*

FIGURE 271B. *After decommissioning, all the potentially unstable fill material has been excavated and endhauled offsite. Some excavated material has been placed along dry portions of the cutbank, but seeps and springs have been left uncovered to freely drain down the slope. The excavated fill slope and road bench has been covered with alder trees that were growing on the slope, and the remaining bare soil areas were seeded and mulched with straw. The threat to the stream at the base of the slope has been eliminated.*

FIGURE 272A. *Log landing on a forest spur road had developed large cracks and scarps around its outside perimeter where soil and wood waste had been sidecast onto steep slopes above a fish bearing stream. The fresh scarps had developed over several years and were identified by an inventory crew surveying for erosion problems in the watershed. An excavator is beginning the fill slope excavation and spoil material was pushed against the inside of the landing by a bulldozer (not visible).*

FIGURE 272B. *The excavation required a temporary road be built across the middle of the long fill slope to reach all the unstable material. The concave excavation surface mimics the shape of a potential slide plane and thereby assures that most of the unstable fill material has been removed. Spoil materials were pushed up against the inside of the large landing, entirely on a stable, excavated bench. As in Figure 271B this type of outsloping is called an "Inplace Outslope" (IPOS), where all the excavated materials were stored locally (note person for scale).*

FIGURE 273A. *Log landing with spoil and woody debris pushed over the edge and onto steep streamside slopes. This road and landing was previously managed for timber harvesting and had been recently added to Redwood National Park (RNP). As a part of watershed restoration, the road and landing were to be permanently decommissioned (RNP).*

FIGURE 273B. *Using Inplace Outsloping (IPOS) techniques, the rocky sidecast soils were excavated and placed against the tall cutbank of this dry ridge. Woody debris was separated from the dirt and chipped for mulch. Three years later, alder trees have invaded the bare soil surface and were rapidly growing. Minor surface erosion and rilling had occurred while the surface was sparsely vegetated, but there was no sediment delivery to a stream (note person for scale) (RNP).*

FIGURE 273C. *By the following year, rapidly growing alder trees had completely covered the decommissioned, outsloped landing surface and surface erosion rates were near zero. The threat posed by the unstable fill was completely eliminated by the decommissioning treatment (note person for scale) (RNP).*

also be removed and outsloped if they potentially could fail into a downslope stream channel.

Potentially unstable road material that is likely to enter any watercourse, threaten life or property, or damage other sensitive resources should be excavated and treated during road closure and decommissioning operations. All spoil material should be placed in a stable location and revegetated. Spoil disposal sites often include the cut portion of closed roads, stable topographic benches, rock pits and the inside portion of landings and turnouts. Consult a qualified geologist about suitable areas for spoil disposal.

Cutbank failure materials are often completely caught and stored on the road prism. For this reason, cutbank instabilities often do not need the same amount of treatment and stabilizing as is needed on fill slopes and at stream crossings. Some buttressing, revegetation and upslope drainage control may be required to prevent larger failures and erosion that could affect water quality. No active ditches or diversions should be left at the base of an unstable or raveling cutbank on a closed road. **In fact, ditches should not be left open and functioning when a road is closed because all ditches are likely to eventually become plugged with sediment or vegetation and cause water to be diverted onto the road surface and adjacent hillslopes.**

ii. Road recontouring or obliteration

Sometimes roads are completely recontoured and the landscape topographically restored to what it looked like prior to road construction. This may happen unintentionally, over short road lengths, when stream crossings are decommissioned (e.g., Figures 265 and 266d) or roads are outsloped with spoil generated from fillslope or stream crossing excavations elsewhere (e.g., Figure 270b). It may also occur or where roads must be fully recontoured to address concerns about slope stability (e.g., Figure 269c). Where scenic or resource values are high, and visitor use is expected, the goal in some parks, natural areas, biological preserves, and recreation sites might be to "obliterate" or fully recontour the former road prism so that there is little or no physical indication a road was ever constructed (Figures 173a and 173b; Figures 274a and 274b; Figures 275a and 275b).

iii. Road to trail conversions

Occasionally, in high visitor use wildland recreation areas, former roads are turned into public trail systems for hikers, bicyclists and equestrian users. A special category of road decommissioning called road-to-trail conversion, or trail outsloping,

is performed to convert from vehicle use to narrower, non-motorized visitor use trails (Figure 276). Many of these former roads are converted directly to narrow pedestrian trails along the original alignment, with detours around hazards or excessively steep pitches, or to provide access to open vistas or points of interest (Figures 277a and 277b). Other trails are kept comparatively wide and low gradient to allow for emergency vehicle access or to provide for access and use by disabled persons (Figure 278; Figures 279a and 279b). Road to trail conversions are still designed to provide for an access route that removes most of the original and most serious threats to water quality, while requiring comparatively low levels of trail maintenance (Figure 280).

3. ROAD SURFACE RUNOFF AND OTHER DRAINAGE STRUCTURES

Roads that are to be decommissioned and no longer maintained should have adequate, self-maintaining surface drainage so that the road surface is stable and will not erode and deliver sediment to streams.

Most temporary roads should have been built as outsloped roads, and any ditched

FIGURE 274A. *Abandoned forest road that was reopened for decommissioning and erosion prevention treatments. The proposed treatment was to completely restore and recontour the hillslope in this biological reserve and conservation area.*

FIGURE 274B. *After treatment, remnant stumps that had been buried by road construction and sidecasting were exhumed and gave the excavator operator a good idea where the original ground surface had been located. The outsloping was performed with little or no endhauling, as fill materials from the outside of the road prism were excavated, placed and compacted against the dry cutbank. Most of the cutbank has been buried and the slopes recontoured to their original form. The exposed soil was not seeded with grass, and rice straw was used as a mulch to prevent the introduction of non-native weeds. Litter from the adjacent forest quickly covered the surface.*

FIGURE 275A. *Switchback logging roads were constructed down a scenic grassland prairie to access redwood forests lower on the hillslopes. Shortly before this photo was taken, these roads and the forests in the distance were acquired by the National Park Service and added to Redwood National Park (NPS, RNP).*

FIGURE 275B. *Because of the wide and scenic vistas, and the expected use of the grasslands by future park visitors, these roads were decommissioned by full recontouring (road obliteration). Within two years, the recontoured roads and slopes had been invaded by native grasses and their presence was barely noticeable (NPS, RNP).*

FIGURE 276. *This road-to-trail conversion (decommissioning) was undertaken when the forested area, once commercial timberlands, was acquired and converted to a biological preserve. Part of the ecological mandate was to decommission former logging roads to reduce erosion rates to protect streams and fish habitat, while still preserving hiking access to many of the biologically unique areas. Here an excavator is recontouring a former logging road while constructing a new trail near the top of the old cut slope. The surface of the recontoured slope has been mulched with limbs and woody debris. All stream crossings and unstable road fills have been excavated along the old road alignment.*

FIGURE 277A. *Former private forest road, now in a U.S. BLM Biological Reserve, has been scheduled for out-sloping and conversion to a trail. The purpose of the decommissioning project was to recontour the old logging road and convert the route to hiking access for visitors and researchers. Note the stump in the right foreground.*

FIGURE 277B. *The former road was decommissioned by excavating the sidecast fillslopes and placing the excavated fill against the dry cut banks. The excavated fillslopes were covered with rice straw and woody debris to control erosion while preventing the introduction of exotic grass and weed species. The once-straight road has been converted into a winding trail that follows the original landscape contours. Topographic swales and stream channels have all be excavated and recontoured*

FIGURE 278. *An illegally constructed road had been built across this steep hillside to access a new home site. Because of high erosion rates and slope instability, and because it was not permitted, regulatory agencies required the road to be fully decommissioned and recontoured. After excavation and recontouring, the bare slopes were seeded and watered to achieve a rapid and complete groundcover of grass. The decommissioning was approved to include a narrow trail for use as an emergency fire escape route, using small quads (off-road vehicles). A new and better alignment to reach the home site was subsequently found and constructed through proper permitting processes.*

FIGURE 279A. *This former (abandoned) forest road crossed relatively gentle topography that had been recently converted to a public use area. The road was to be decommissioned to remove the potential erosion threats, while at the same time opening trail access to the public. Note the conifer tree partially visible in the center background, behind the deciduous alder trees.*

FIGURE 279B. *In the same view as Figure 279a (note the conifer tree now clearly visible), the unstable road fillslopes next to the fish-bearing stream (left, off photo) were excavated and the fill used to recontour the old road cuts and restore the site's original topography. Because it was in a new U.S. BLM conservation area, bare soil areas created during decommissioning were mulched with wood chips generated on-site. A compacted gravel surface was then installed to make the trail accessible to all visitors.*

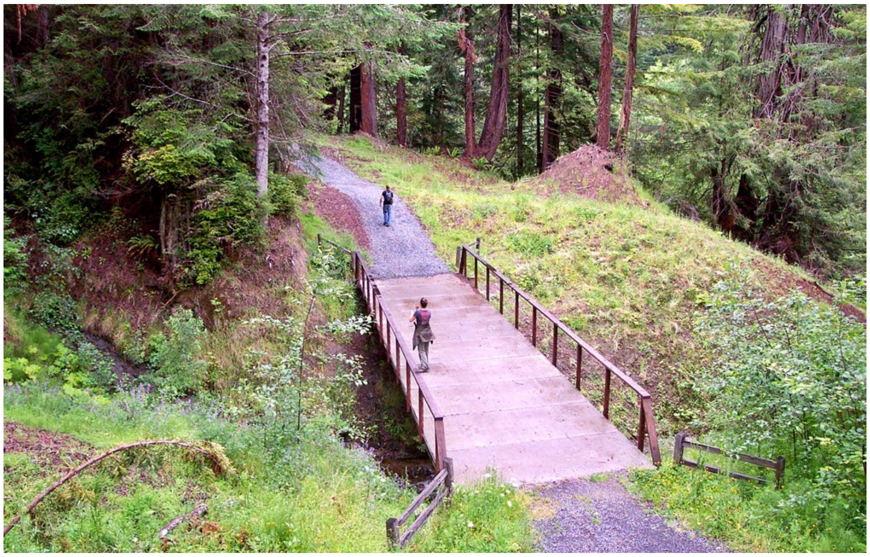

FIGURE 280. *An old, abandoned logging road was converted to a trail system through the use of trail-outsloping. Here, a formerly culverted stream crossing was converted to a "reduced size" I-beam bridge (see also Figure 150) that was primarily intended for hiking access, but which was also designed for use by small vehicles in emergency situations and for occasional maintenance needs. The erosional threat has been largely eliminated along the trail by various road-to-trail decommissioning treatments.*

segments of roads to be closed should be outsloped or drained with cross road ditches during closure operations. Outside road berms should be removed to encourage continuous drainage off the road surface.

Inside road ditches should be eliminated when decommissioning temporary and abandoned roads so that water is not diverted and gullies do not form. Cross-road drains placed at regular intervals along the former road should be made deeper than standard waterbars and extend all the way from the cutbank to the outside edge of the road in order to intercept all ditch flow. On steep sections of road (>10%) cross drains should be skewed at 45° to the road alignment (instead of the usual 30°) to reduce the threat of erosion at the inlet (Figure 281).

Springs and seeps should be drained straight across the former road bench, provided the slope below is stable (Figure 282). Since inside ditches will be breached and no longer carry runoff, ditch relief culverts are no longer needed on closed roads and can be removed and salvaged (recycled), or left in place if the road is to be reopened at some time in the future.

FIGURE 281. *Between treated stream crossings and fill slope excavations, decommissioned roads should have permanent road drainage treatments, including road decompaction (ripping or subsoiling) and constructed cross road drains. Cross road drains are permanent road drainage features, like waterbars but much more substantial so they will function indefinitely and will not be broken down by rainfall, runoff or any kind of unwanted recreational traffic (usually bicycles or motorcycles). Like waterbars, they are usually excavated into the firm roadbed, mounded on the downhill side and spaced closely enough to prevent significant erosion on the roadbed or below the point of discharge.*

FIGURE 282. *Deep cross road drains are constructed everywhere there is a spring or seep on the former road cutbank. This helps drain the road and the hillslope as uniformly and frequently as possible. Except for very short sections next to a cross road drain, inside ditches should not be retained.*

Cross-road drains should be placed frequently enough such that flow through individual drains will not require the use of rock armor energy dissipaters to prevent erosion at the outlet. However, cross drains that carry spring flow or flow from small upslope gullies may require a deeper excavation or armoring at their outlet and should be discharged into vegetation to filter water and sediment before runoff reaches a stream (Figure 282).

Ripping and planting abandoned roads can reduce runoff and erosion, and greatly increase the amount of forest and ranch land in production (Figure 283; Figures 284a and 284b). Ideally, the abandoned road surface should be scarified (ripped or plowed to a depth of 18–24 inches), outsloped at least 4% more than the road grade, waterbarred, seeded and planted to control surface runoff and erosion (Figure 285). Wet, spring-fed cutbanks along outsloped roads should not be covered with spoil, and roads that are not outsloped should have frequent cross-road drains installed.

Tree growth on compacted or rocked road surfaces is generally much slower than on adjacent, uncompacted sites unless the roadbed is mechanically ripped. Ripping is most effective in breaking compaction and promoting tree growth when it is conducted with a winged subsoiler that lifts and shatters the soil. Ripping can also be performed using hydraulically operated chisel teeth mounted on the back of a bulldozer, although several passes may be required to disaggregate the entire roadbed (Figure 286).

4. EROSION CONTROL

Most erosion control work along closed roads is accomplished by 1) the physical excavation of stream crossings, unstable fills and landing sidecast, 2) installation of cross-road drains, 3) road ripping, and 4) local road outsloping. These techniques are usually performed by heavy equipment. Other hand-labor erosion control and revegetation practices that may be of use include mulching, installation of energy dissipation (e.g., rock armoring and woody debris), seeding and planting.

The banks of all excavated stream crossings, as well as all bare soil areas immediately adjacent or near a watercourse, should be seeded and mulched with straw (3,000 to 5,000 lbs/acre—or complete ground coverage to a depth of about 3 inches) or another mulching product. Straw can be hand spread or blown onto the soil surface using trailer-mounted straw blowers. On slopes over about 45%, or where high winds

FIGURE 283. *Small bulldozer with hydraulically operated rippers (three 30 inch long steel chisels) is decompacting a seasonal road as a part of road decommissioning. Road ripping should be a standard decommissioning practice. All decommissioned roads should be ripped to decompact the road bench, improve and speed revegetation and reduce surface runoff. If the road is to be outsloped, and spoil is placed on the former roadbed, the compacted road bench should first be ripped to a depth of 18 to 24 inches, or greater. If it isn't ripped, infiltrating water will pond on the compacted surface and may cause soil saturation or contribute to slope failure.*

FIGURE 284A. *On forest roads which are to be formally closed, rather than just "abandoned," the roadbed can be returned to forest or grassland production by ripping and disaggregating the surface and then planting with trees. Figures 278a and 278b show a road before and after ripping and decompaction. This simple, inexpensive treatment also helps reduce runoff from compacted areas. It is recommended that enough passes be made with the tractor so the surface is completely disaggregated.*

FIGURE 284B. *A road after ripping and decompaction.*

FIGURE 285. *Former forest road that has been ripped, slightly outsloped and converted to a hiking trail. The decommissioning treatment needed in this upper hillslope setting was minor and yet largely eliminated surface runoff from the alignment.*

FIGURE 286. *On gentle terrain, ripping (soil decompaction) maybe the only treatment that is needed to decommission a road, eliminate unwanted traffic, reduce runoff and return it to native vegetation.*

are common, mulches will need to be tacked, punched or secured to the ground surface to hold them in-place and in full contact with the ground surface. Straw can be punched into loose soil using shovels, crimpers or a spiked roller, or held onto the surface using jute netting, or a "tacking" spray (Figure 287). Mulches can also be purchased in rolls, in which the mulch is bound between fine biodegradable, plastic netting, which can then be rolled out and secured or "stapled" to the ground.

If rock armor materials are plentiful, the channel-bottom of excavated stream crossings can be armored with well graded, appropriately sized rock to minimize subsequent channel downcutting or widening. However, rock armor should not be necessary for erosion control if all fill material is removed from the crossing and the original channel profile, streambed and sideslope configuration are reconstructed by excavation. If the natural channel armor was not removed during initial culvert installation, it should be sufficient to protect the channel from downcutting.

Rock and/or woody debris can be placed at the outlets to cross-road drains that are expected to carry substantial spring-flow. Rock armor is generally preferable because it is more permanent and adjusts its position when there is minor channel downcutting. But none of the cross drains should carry sufficient runoff to cause serious erosion. If they do, or you think they might, then the site and all the fill material should be completely excavated as though it was a small stream crossing.

5. REVEGETATION

Vegetation is the ultimate, long-term erosion control agent. However, because it takes time to grow a thick, effective cover, some physical erosion control measures (such as straw mulch, netted blankets or biotechnical methods) are often needed for the first year or two following road decommissioning or closure. Seeding with grass and legumes reduces surface erosion and can improve soil physical condition. Planting trees and shrubs adds longer lasting vegetative cover and provides stronger root systems which enhance slope stability. Within

FIGURE 287. *Most often, a uniform cover of straw mulch is all that is needed to temporarily control surface erosion on the excavated sideslopes of decommissioned stream crossings until they can naturally revegetate. Wood chips, or native brush and slash, also work well to control surface erosion in some environments. Here, jute netting has been used instead of straw, as a trial treatment. Rolled and tacked erosion control blankets, or jute netting tacked over a layer of straw mulch, can be used on sideslopes that are steeper than about 2:1 (50%). To avoid spreading non-native weed species, many areas can employ rice straw whose seed and weed species are not adapted to growing in most upland environments. Rice straw mulch also has a roughness or "stickiness" that allows it to hold in place on slopes steeper than wheat or grass straw.*

their appropriate range, conifers, hardwoods and other tree species provide for long term land stability and erosion control. Planting woody vegetation, including trees, is best conducted during the wet season or immediately after the first few wet season rain events, when there is sufficient soil moisture to aid in plant survival.

a. Seeding methods

Seeding with grass and other fast growing species can be used to protect slopes from raindrop and rill erosion, if it is planted and grows to provide a thick cover before the first wet season rains. Seeding is best performed immediately after the surface is restored, with mulch then applied to cover the seed and the bare soil. The rough surface provides miniature traps for seeds, fertilizer (if used) and rain water, creating a favorable environment for seed germination and growth. **Mulches increase seedling establishment by improving germinating conditions and controlling erosion until the plants become established.**

The two basic methods for spreading seed are dry seeding and hydraulic seeding. Each method is suited for specific ground conditions (Table 37). Dry seeding and fertilizing along small roads is often done with cyclone-type rotary seeders. This method is usually done by hand for road-related applications, but may also be performed by truck and aerial application for larger jobs. Hand seeders, called belly grinders, are typically restricted to moderate or gentle slopes and can

TABLE 37. Guidelines for seeding method selection[1]

Site conditions	Sample situations	Seeding method
Steep (>50%) or windy slopes, high to extreme erosion hazard	Steep cutbanks and fill slopes	Hydraulic seeding with a sprayed or tacked mulch
Moderate (30-50%) and steep slopes, medium to high erosion hazard	Moderate and steep cutbanks and fill slopes; stream crossing fills and bridge sites	Hydraulic seeding or dry seeding with a mulch
Gentle and moderate slopes, medium to high erosion hazard	Cutbanks, fill slopes, and spoil disposal sites not near a watercourse	Hydraulic seeding or dry seeding; mulch where needed
Gentle and moderate slopes, low to moderate erosion hazard	Cutbanks, fill slopes, and spoil disposal sites not near a watercourse	Dry seeding; mulch if needed to improve revegetation

[1]Modified from: BCMF (1991)

shoot seed and fertilizer from 15 to 20 feet. Seed can also be spread by hand, throwing the seed across the surface, but its distribution will not be even. Drilling seed into the planting bed ensures an even distribution, but may not be possible due to the steepness of many road cuts and fills. In hydraulic seeding (hydro-seeding), seed, mulch (or binder) and fertilizer is applied in a water-based slurry from a pump truck or portable trailer (Figure 288). Hydroseeding

FIGURE 288. *Hydroseeding (spraying a slurry of water, mulch, seed and fertilizer) on bare soil areas can be an effective erosion control and revegetation treatment for large disturbed areas, or for bare soil areas along open roads. It is most useful for treating spoil disposal sites, after they have been graded and smoothed, and for treatments along newly upgraded roads where the truck or trailer can have easy access. Hydroseeding decommissioned roads is more difficult because access is cut off as the treatments progress. Rather, hand seeding and mulching is usually the preferred treatment.*

may be necessary for planting 1:1 or steeper slopes, where the seed must be "tacked" to the slope because of high ravel or erosion rates.

Regardless of the method selected, seed must be evenly distributed to result in a continuous plant cover. Seeding onto a roughened soil surface or thinly covering the seed with soil and mulch ensures good germination. In dry climates or in soils with poor water holding capacities, broadcast seeding may yield poor results unless the seeds are covered with mulch that helps retain near-surface soil moisture, or the site is watered during the first year. For best success, seeding should be completed just prior to the first wet season rains.

b. Seed types and fertilization

Severely disturbed sub-soils and cutbank exposures are usually infertile, and fertilizer applications containing nitrogen (N), phosphorous (P), potassium (K), and occasionally sulphur (S) may be needed for successful grass-legume establishment and growth. Fertilization rates vary according to the level of nutrients needed for establishment. Soils can be tested for nutrient content before fertilizer mixes are prepared. More often, commercial mixes are used which provide all the necessary nutrients for plant growth. When hydroseeding is performed, fertilizer is usually one component of the slurry application.

Parent materials and subsoils are always deficient in nitrogen. A common recommendation for deficient soils is to broadcast ammonium phosphate sulfate fertilizer (16-20-0) at the rate of 500 lbs/acre at planting time. This provides sufficient nutrients for the first growing season. However, **care needs to be taken that fertilizers or nutrient rich runoff from fertilized slopes are not transported to, and pollute, nearby streams and waterbodies.** Critical sites (e.g., stream crossings) that may need to be fertilized probably should not be broadcast fertilized simply to maintain plant vigor and an adequate ground cover. Planting legumes and nitrogen fixing species in infertile soils is often suggested because they are able to grow without nitrogen fertilizer. Before seeding, legume seeds require inoculation with a nitrogen fixing bacteria which then grows on its roots and fixes nitrogen the plants can then use.

Utilizing a mix of seeds, or focusing on native species, increases the likelihood that one of the plant species will find local conditions favorable and produce a good plant cover. If a commercial seed mix is used, it is important that plants known to be effective in erosion control be found in the mix, that the species are adapted to grow in the local environment, and that the species are compatible in mixtures (i.e., that one doesn't out-compete the other). **In general, seed mixes should be kept simple.** The grass-legume ratio, by live pure seed, should be about 70:30 in humid regions and 80:20 in dry regions. It is a good idea to consult your local Natural Resources Conservation Service or other comparable resource agency for seeding recommendations for your specific area and need. Non-native, invasive plants and grasses should not be used.

Typically, a combination of 2 to 5 species, including sod forming grasses, bunch grasses and legumes, is used for erosion control. Legumes are included for their deeper roots and nitrogen fixing capability. Seed mixes suitable for an area depend on the soil and climatic conditions of the site. Native seed is often preferred because of its tolerance to local soil and climate conditions. Seeding rate depends on the desired species mix, seed weight and viability of the seed stock.

In California, the California Interagency Seeding Guide for erosion control plantings (1986) is a short publication which describes general seed mixes which have been found to be useful for erosion control within the Mediterranean climate of California (Table 38). It describes

TABLE 38. Species, growth characteristics and minimum seeding rates of plants known to be effective in controlling erosion on California forest and ranch lands[1]

Species	Characteristics	Planting	Pounds per acre pure live seed[2] (lb/acre)		Minimum annual rainfall (in)	Growth rate/ longevity
			Good seedbed[3]	Poor seedbed[4]		
Annual Grasses (Usually fast growing, adaptable, and competitive.)						
Annual or Wimmera-62 ryegrass	Fast, winter growing, short-lived grass, requires fertilization to persist, very competitive (to the detriment of other seeded plants)	Never plant with perennial grasses, legumes, or flowers; should be less than 50% of any annual grass mix.	22	50	12	Fast, short-lived
Barley	Winter grain, grows fast and tall	May be seeded at 100 lb/ acre without being overly competitive.	150	200	12	Fast, temporary
Blando brome	Winter growing, self-seeding grass, very adaptable to various climates	Use in any proportion with annual grasses, keep to less than 70% when planted with legumes; should not be planted with flowers or perennial grasses.	15	50	12	Fast, re-seeds
Panoche red brome	Winter active, self-seeding grass, common in low rainfall areas; very drought tolerant	Best if planted alone in droughty areas; in wetter areas may be used as 25% mix with legumes, flowers, or shrubs.	10	20	7	Fast, re-seeds
Zorro annual fescue	Winter growing, early maturing, self- seeding grass; very drought tolerant; good in low-fertility, acid soils	Is compatible with perennial native grasses and shrubs; can comprise 70% of mix with annual legumes and 25% of mix with flowers, legumes, and shrubs.	10	20	10	Fast, re-seeds
Perennial Grasses (Usually restricted to sites requiring deep rooting and/or minimum maintenance; are slow growing in the first year and do not compete well with most annual grasses; flowers or annual grasses may constitute up to 50% of a mix with perennial grasses.)						
Berber orchardgrass	Long lived, drought tolerant bunch grass; good for dryland areas	Palestine orchardgrass may be substituted as second choice, but no others will survive without irrigation.	10	20	16	Medium
Luna pubescent wheatgrass	Long lived, fast maturing, sod farming, winter active grass	Often used on deeper soils, such as fill slopes; including serpentine soils.	20	40	16	Slow
Mission veldtgrass	Long lived, densely tufted bunchgrass	Outstanding in coastal sandy soils	30	40	14	Slow
Smilo	Long lived, drought tolerant bunchgrass	Best on well drained soils that once grew chamise in brushlands; best stands obtained after fire.	10	20	16	Slow

Annual clovers and vetch (Annual clovers are used because of their ability to provide their own nitrogen. This makes them suitable for low fertility areas that would otherwise need fertilizer, The seed should be inoculated with nitrogen fixing bacteria prior to planting. May be seeded alone or in mixes.)						
Rose clover	Self-seeding legume	Used on slightly acid soils.	20	30	10	Medium, re-seeds
Lana wollypod vetch	Widely adapted, self-seeding legume	Useful for providing wildlife food and habitat, alternates should be used in fire hazard areas.	45	60	14	Medium, re-seeds
Shrubs (Most shrubs must be transplanted from cans or liners; these may be directly seeded.)						
Australian saltbush	Low growing, semi-prostrate perennial; plant is drought and alkali tolerant	–	5	20	10	Slow
Duro California buckwheat	Widely adapted and drought tolerant	Used extensively in road side seeding; is adapted to much of the state of California.	10	20	10	Slow
Flowers (Flowers are useful for short duration cover on sites with low erosion potential; seldom persist for more than 1-2 years; do not plant with annual grasses and do not fertilize with nitrogen. Poppies and lupine have the record for persisting the longest of most flowers.)						
California poppies	Can be planted on most weed-free soils; will not compete with grasses or weeds	–	5	20	10	Slow
Lupine	Adapted to a variety of soils; lupine should be inoculated with bacteria before seeding	Several varieties of Lupinus may be planted	5	20	10	Slow

[1]Kay and Slayback (1986). Plants are known to control erosion in the Mediterranean climate of California. Specific soils and rainfall may limit the use of each species. Suggested seeding rates are a minimum; consider increasing rates as difficulty of site and climate increase.
[2]"Pure-live seed" = % germination x % purity divided by 100.
[3]"Good seedbed" = seed covered with soil, slopes 3:1 or flatter, straw secured to slope at 1.5 to 2 tons/acre.
[4]"Poor seedbed" = poor soil, steep slopes, no seed coverage (no mulch). May be hydroseeded.

seeding rates and environmental requirements for a number of proven perennial and annual grasses, annual clovers and vetch and several shrub and flower species, and outlines the steps to successful plantings. Similar guides should be available for most other areas, and public road and land management agencies are often able to provide assistance and guidance on local seed selections for erosion control purposes.

c. Timing of seeding

The most important considerations in seeding are timing of application, even distribution of seed and covering the seed with soil. Planting at the wrong time is the most common reason for seeding failure. Seeding must be done early enough in the growing season so that an adequate ground cover can become established before the critical wet weather period. Seed application should begin immediately following heavy equipment operations and soil disturbance, and a minimum of 6 weeks before periods of drought or damaging frost. Fall seeding is best in areas with summer drought.

Planting and seeding for erosion control requires the development of a rapid, persistent and continuous plant cover. Annual grasses often produce the quickest protection, but are only a temporary solution and can sometimes actually impede the growth of other plants. Perennial grasses are slower to establish but provide better root systems than annuals. Perennials may also have difficulty competing and surviving when seeded with annual grasses in the same mix. Annual legumes provide nitrogen to the soil as they grow, but they too are relatively slow to grow and may not compete well with heavily seeded annual grasses. Shrubs and trees are slow to provide a ground cover, and may not compete well when seeded with other species, but they often provide the best long term stability to a disturbed road site. Fortunately, native shrubs and trees will seed naturally on many disturbed sites in forested and grassland areas. Planting or transplanting can be used to speed their return.

Following seeding, all bare soils on newly constructed, reconstructed, upgraded and closed roads should be planted with trees and/or other woody vegetation (Figure 289). In addition, the slopes and channel banks adjacent to excavated (decommissioned) stream crossings can be planted with willow, alder or other riparian tree species (Table 39) and shrub species (Table 40) compatible with the local site conditions. These woody species take longer to become established, but they provide the long-term ground cover and soil binding needed for effective erosion prevention, soil development and slope stability on these heavily disturbed sites.

C. DECOMMISSIONING EFFECTIVENESS

Road decommissioning is performed to reduce or eliminate the threat of future human-caused sediment delivery from the former road, and its impact on downstream areas, while returning the disturbed lands to their natural watershed function. The effectiveness of road decommissioning tasks, in relation to sediment prevention and watershed protection, is usually expressed as sediment "savings" over two time periods: 1) the volume of sediment that has been prevented from being delivered to stream channels (long term effectiveness) and 2) the volume of sediment that is eroded from the decommissioned sites and delivered to local stream channels in the first several years after decommissioning activities (short term effectiveness). **The goal of a decommissioning project is to maximize long-term effectiveness (sediment savings) and to minimize short-term sediment release from the treated sites.**

FIGURE 289. *Tree planting (or planting woody species suitable for the specific environment of the road) is the final long term treatment for the decommissioned roadbed and for the riparian sideslopes where stream crossings have been excavated and restored for the long term. This planted redwood tree, and those conifers and hardwoods that naturally seed themselves onto the former roadbed, will eventually cover the alignment and provide for long term site stability.*

TABLE 39. Recommended tree species for revegetating California riparian zones[1]

Riparian species (common name)	Coastal	Interior valley	Interior foothill
California buckeye		✓	✓
Bigleaf maple	✓	✓	
California box elder		✓	
White alder	✓		✓
Red alder	✓		
California black walnut		✓	✓
Western sycamore	✓	✓	✓
Fremont cottonwood	✓	✓	✓
Coastal live oak	✓	✓	
California black oak			✓
Valley oak		✓	
Interior live oak		✓	✓
Red willow	✓	✓	✓
Black willow	✓	✓	✓
Sandbar willow	✓	✓	✓
Oregon ash	✓	✓	✓
California bay	✓		
Dogwood	✓	✓	✓
Wax myrtle	✓		
Elderberry	✓	✓	✓
Brewers saltbrush	✓	✓	
Coyote brush	✓	✓	✓
Mule fat	✓	✓	
Ceanothus spp.	✓	✓	✓
Western redbud	✓		✓
Mountain mahogany			✓
Button bush	✓	✓	
California buckwheat	✓	✓	✓
Toyon		✓	✓
California coffeeberry		✓	✓
Red flowering current			✓
California wild rose		✓	✓
California blackberry		✓	✓
Black sage			✓
Skunkbush sumac		✓	✓
Prunus spp.	✓	✓	✓
Rhus spp.	✓	✓	✓

[1]California Department of Fish and Wildlife (1992). When selecting species for a revegetation project, those species found in similar environmental conditions near to the project site should be preferred.

TABLE 40. Recommended shrub species revegetation for California riparian zones[1]

Riparian species (common name)	Coastal	Interior Valley	Interior Foothill
Elderberry	X	X	X
Brewers saltbush	X	X	
Coyote brush	X	X	X
Mule fat	X	X	
Ceanothus spp.	X	X	X
Western redbud	X		X
Mountain mahogany			X
Button bush	X	X	
California buckwheat	X	X	X
Toyon		X	X
California coffeeberry		X	X
Red flowering currant			X
California wild rose		X	X
California blackberry		X	X
Black sage			X
Squaw bush		X	X
Prunus spp.	X	X	X
Rhus spp.	X	X	X

[1]California Department of Fish and Wildlife (1992). When selecting species for a revegetation project, those species found in similar environmental conditions near to the project site should be preferred.

Road decommissioning treatments have been shown to significantly reduce long-term sediment production from forest and ranch roads, including those that have been abandoned for years. **In general, the single most effective erosion prevention practice for all road decommissioning treatments, as measured by the reduction of post-decommissioning erosion and sediment delivery, is to correctly follow the generally accepted treatment prescriptions, standards and methodologies for road decommissioning, as outline above (see Weaver et al., 2006).** This is best done by utilizing skilled and experienced heavy equipment operators, and providing sufficient on-the-ground professional/technical oversight while decommissioning work is underway.

Decommissioning treatments for road surface runoff (hydrologic connectivity) and excavation of potentially unstable fill slopes have been shown to be highly effective sediment control measures. Hydrologic connectivity from the former road can be reduced to near zero by standard road surface ripping (decompaction), cross drain installation and road outsloping (Figure 290). Likewise, **unstable and potentially unstable road and landing fills that are identified and treated (excavated) during routine road decommissioning work has been a highly successful technique** for preventing road-related fill slope failures and sediment delivery. Since not all fill slopes are excavated and removed during decommissioning, there is always the chance that instabilities could develop in the future, but the most susceptible sites will have already been identified and treated.

Decommissioning (excavating) stream crossings using established protocols has also proven highly effective. Most short-term sediment loss from all road decommissioning sites originates at excavated stream crossings. The primary sources of this sediment delivery, accounting for about 90% of the soil loss from all road decommissioning work, include channel incision, surface erosion, and slumps on the sideslopes of excavated stream crossings. Studies show that operator error (mostly consisting of an equipment operator leaving unexcavated fill in the stream crossing) accounts for about 40% of the potential post-decommissioning erosion. The remaining 60% of sediment loss is judged to be unavoidable and a natural result of the channel developing a stable profile and plan form through the decommissioned stream crossing over the first few years after it was treated.

On most roads, stream crossing excavations will be the single greatest threat reduction treatment to implement, and also the largest short term source of sediment input to stream channels following road decommissioning work. Past monitoring of stream crossing removal has shown that 1) erosion at excavated stream crossings is the principal source of post decommissioning sediment delivery from treated roads (approximately 90%), and 2) a few crossings usually produce the majority of post-decommissioning sediment. The expected short term soil loss from these sites is greatly overshadowed by the long term sediment savings attributed to the decommissioning work.

Post-decommissioning erosion from excavated crossings is minimized by excavating stable, low gradient sideslopes and by completely excavating erodible fill that was placed in the channel when the crossing was constructed (Figure 265). **Typically, stream crossing decommissioning should be at least 95% effective;** that is, 95% of the expected or predicted erosion from a complete washout of the original stream crossing fill (if it was not treated) will have been prevented by decommissioning. The 5% that is eroded is the result of post-decommissioning channel adjustments that can be expected to occur over the first few wet seasons as the exhumed channel adjusts and newly excavated sideslopes stabilize.

It is critical to carefully inspect decommissioned crossings while equipment is performing the work, and while equipment remains onsite, to ensure that prescribed excavation depths and widths are reached and stream banks are sloped back to a stable angle. For larger crossings where some fill materials may remain after excavation, use rock armor or grade control structures where appropriate. However, **the most effective practice is to completely remove all fill materials**

FIGURE 290. *Deep, thorough ripping is a good treatment to largely eliminate surface runoff and "hydrologically disconnect" a former road from nearby stream channels.*

from the crossing so they are not left to erode and post-treatment adjustments can be minimized. Consider staging or sequencing sediment producing activities, such as stream crossing removal work, to avoid superimposing multiple sediment inputs throughout small watersheds that are sensitive to sediment pollution.

D. INSPECTIONS AND MAINTENANCE OF CLOSED ROADS

Closed roads are those temporary and "decommissioned" roads that are no longer open for vehicle traffic and have been proactively treated to remove environmental threats (Figures 291 and 292). Roads that are simply closed to traffic by barriers or gates but have not been treated for existing and potential erosion and sediment delivery problems are not truly considered closed. Gated and barricaded roads require regular seasonal and storm period inspections and maintenance, just like the open and maintained road network.

In theory, when a road is truly closed or decommissioned, all identifiable erosional threats and surface drainage problems have been treated. All stream crossings have been removed (excavated) to their pre-road condition and all permanent erosion control measures have been implemented. The fill slopes that could fail and deliver sediment to a stream channel have been inspected and those with the potential to fail have been excavated (removed) or otherwise stabilized. Road surface drainage has been treated so that surface runoff is mostly eliminated by deep tilling or decompacting. Any surface runoff from springs or seeps is directed across the former road alignment and drainage is not reliant on functioning ditches. Road drainage structures are constructed on the roadbed to prevent runoff from traveling down the road surface.

Newly closed or decommissioned roads are most vulnerable to erosion during the first several wet seasons after they are treated. Some post-closure erosion is to be expected within excavated stream crossings, some wet areas may show signs of rilling and slumping, and occasionally a fill slope that was not treated (excavated) may show signs of instability. Inspections can be performed several times during the first wet season, and perhaps for a few years thereafter following any significant storms or floods, to look for developing problems. Minor corrective treatments may be prescribed for one or more places along the alignment but most measures will be limited to

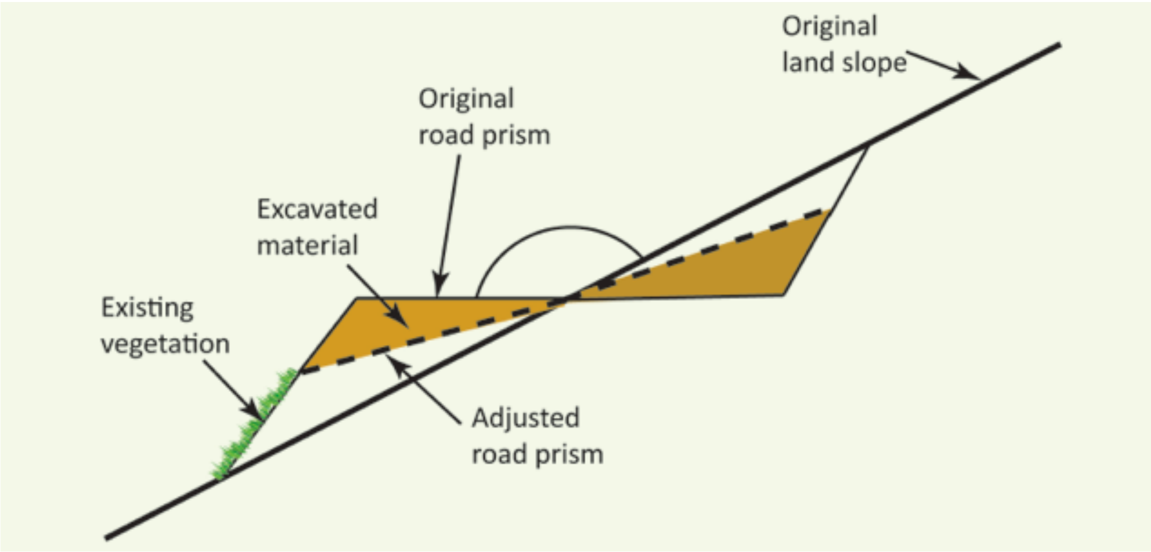

FIGURE 291. *Compared to gates or barriers, a more permanent closure method is to radically outslope the first 100 feet of the closed road so that the road is too steep to drive.*

FIGURE 292. *Severe outsloping, which prevents vehicle access, should only be used on temporary roads and decommissioned roads where all stream crossings have first been removed, unstable fill slopes have been excavated or stabilized, and road surface drainage is permanently dispersed. To help ensure vehicles do not use the closed road, logs, boulders and brush can be spread over the surface, especially near the beginning of the road, to discourage unwanted traffic. These roads should need no future maintenance, so vehicle access is no long needed.*

those that can be performed by hand labor. These might include planting, mulching, minor work to prevent bank erosion or gully stabilization.

Ideally, closed roads should not require significant maintenance. By definition, roads that have been formally closed (decommissioned) no longer have an open, available access route for heavy equipment to get to sites and perform emergency repairs or maintenance work. Only if there are serious, treatable problems along the alignment and the travel route is fairly easy to reconstruct is it usually worth reopening the road and applying corrective treatments. It does happen, but the problems are typically unforeseen as the road is being closed.

When wet season inspections identify significant problems, the proposed repairs typically must wait until the following dry season so damage is not done to the closed road and water quality is not impacted by heavy equipment operations. Once the repairs have been made, all sites that were disturbed or damaged by the road reopening will then have to be repaired and retreated as the heavy equipment works its way back out after performing the work. It is clearly to your advantage to do a thorough job identifying needed treatments along the road and then closing the road properly and completely the first time through. Regardless, sometimes reopening a closed road in order to treat one or more sites may still be warranted.

NOTES: