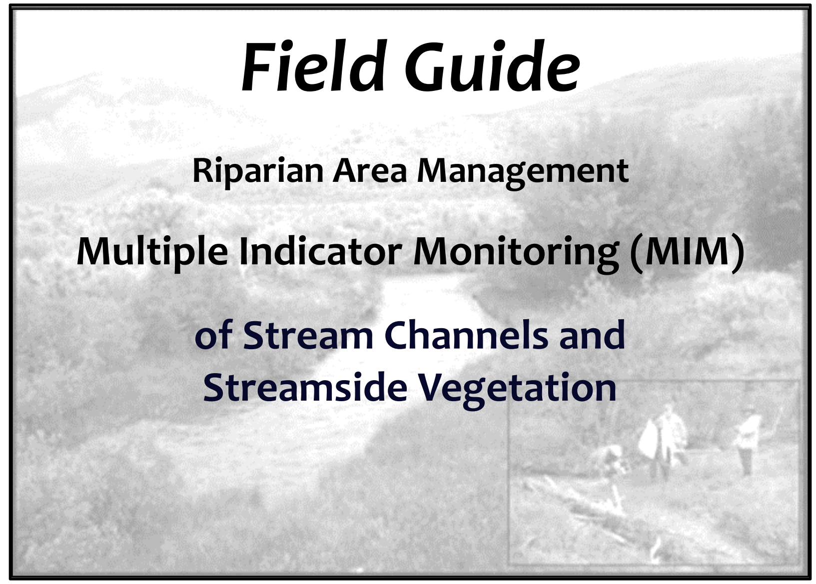


Field Guide

Riparian Area Management

Multiple Indicator Monitoring (MIM)

of Stream Channels and Streamside Vegetation

Summary of Field Procedures in:

TECHNICAL REFERENCE 1737-23, Version 2

January 2025

Timothy A. Burton, Fisheries Biologist/Hydrologist
Retired USDI Bureau of Land Management/USDA Forest Service, Boise, Idaho

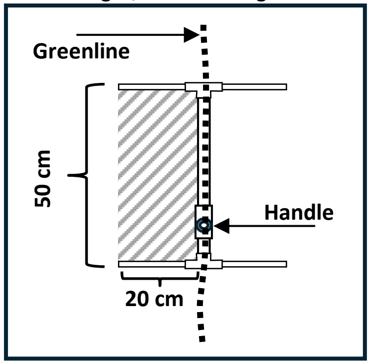
Steven J. Smith, Riparian Ecologist/Rangeland Management Specialist
Retired USDI Bureau of Land Management, Prineville, Oregon

Mark A. Gonzalez, Riparian/Wetland Ecologist (Soils)
USDI Bureau of Land Management, Prineville, Oregon

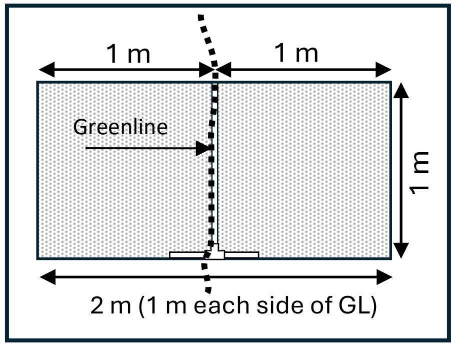
This field guide summarizes the MIM protocol and includes instructions for setting up DMAs, systematic procedures, the rules used to locate the greenline, and the specific procedures for each indicator. It is intended to be carried in the field to maintain consistent application of the rules. **The field guide should only be used after gaining a working knowledge of the Technical Reference and appropriate training**. The Technical Reference provides detailed information about the monitoring protocols and examples of various conditions that may be encountered. The field guide is written in the order data is collected.

Quadrat Configurations for the MIM Procedures
(using the 42 cm x 50 cm frame)

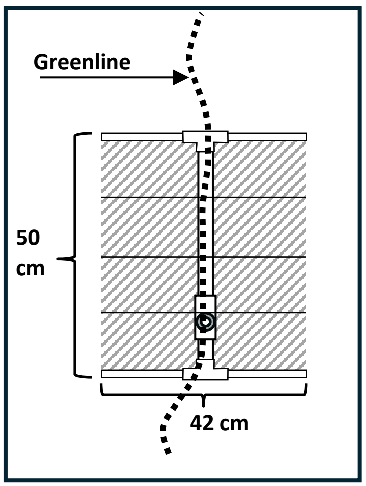
Greenline Composition, Woody Species Height, Stubble Height



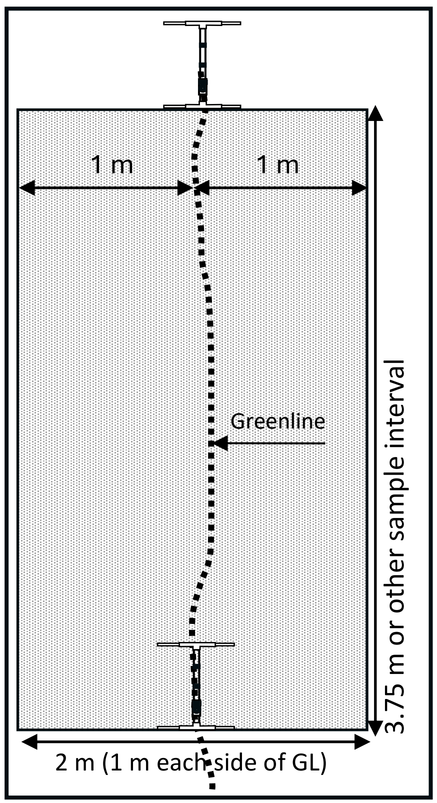
Woody Riparian Species Age Class



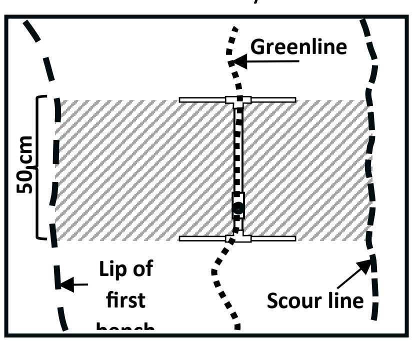
Streambank Alteration



Woody Riparian Species Use



Streambank Stability and Cover



bends. Carefully measure the length of the thalweg into, through, and out of meanders.

- When a channel bifurcates around a bar or island, **follow the main channel,** which will visually contain most streamflow. If in doubt, walk both sides of an island to determine which channel contains the thalweg (i.e., the deepest trace of the channel). Note which channel was measured; draw a sketch so subsequent monitoring can account for changes in channel conditions.

Step 5. Continue measuring horizontal distance and water depths to the top of the DMA. Continue measuring and recording water depths at each riffle crest and each pool bottom. Continue measuring and recording the horizontal distances from the riffle crests to the maximum pool depth and conversely from the maximum pool depth to the next riffle crest in an upstream direction to the top of the DMA. As you near the upstream end of the DMA, pay attention to the location of the riffle crests.

If a riffle crest is within the DMA, proceed to the next pool bottom (even if it is beyond the upstream DMA marker). If the riffle crest is upstream of the top DMA marker, then stop and do not make any additional measurements.

Step 6. Measuring residual pool depth and pool frequency in dry or non-flowing channels (optional method).

- Residual pool depth is conventionally measured in perennial streams during baseflow conditions when water is exiting pools through riffle crests. There are some important fisheries in intermittent streams (e.g., streams with winter-spawning steelhead that dry up during summers), where information on residual pools may be desired. If water is no longer flowing over riffle crests, a "no-flow" alternative method can be used to measure residual pool depth.

To use this method, extend a level line (mason line, measuring tape, or 2-m measuring rod) from the lowest point in the riffle crest to the maximum pool depth and measure the vertical drop from this horizontal reference. A level placed on a taut mason line, tape, or measuring rod will ensure the line (or rod) is horizontal. Record "0" for the depth at the riffle crest, and record the depth of the pool bottom and the distances between pool features.

Table of Contents

NOTE: Some references to figures, tables, and appendices in this field guide refer to content in the MIM technical reference (TR 1737-23, version 2, 2024). Refer to the MIM technical reference for additional information.

Designated Monitoring Areas (DMAs)

Locating DMAs

Stratify the Stream Reaches: Stratification is the first step in the process of categorizing riparian complexes or stream reaches into subgroups that share similar qualities. These subgroups are referred as strata.

Determine the Type of DMA:

- Representative DMA. A Representative DMA is a monitoring site in a riparian complex that is representative of a larger area. It is generally representative of the stratum it is located in.
- Reference DMA. Reference DMAs are chosen to represent the potential or desired conditions within an area or strata. Reference DMAs provide an important benchmark with which to compare Representative DMA data. It is important to collect reference data within the same stratum as the representative data.
- Critical DMA. Critical DMAs are used to monitor localized conditions that address site specific issues such as fish spawning. Data from a critical DMA is not representative and cannot be extrapolated to a larger area.

Randomly locate the DMA: Measure the total length of the stream in the selected complex, complex sub reach, or reach. Subtract 150 m from the total length. Then randomly select a number between 1 and the difference. Locate the DMA.

Set-Up and Monument the DMAs

Once the location of a DMA has been determined, a permanent reach is established. The following procedure is recommended when establishing a new DMA:

1. Define the Reach. The default length of the reach to be monitored extends 150 m along the stream. Longer reaches may be needed on larger streams (greenline to greenline width > 7.5 m or 25 feet).

2. Install Reach Markers. Permanently mark the lower and upper ends of the reach with reach markers. Place the lower marker on the left side (looking upstream) and the upper marker 150 m upstream at least 2 m away from the top of the bank on the right side (looking upstream).

3. Install Reference Marker. A permanent reference marker should be used to help relocate the DMA. A post placed in the proximity of the reach will help crews relocate the downstream permanent marker. A site sketch, notes, and pictures also help ensure that the site will be accurately relocated in the future.

4. Record the GPS Coordinates of the DMA: Accurate GPS readings should be collected at the lower and upper reach markers.

5. Populate the Header Form in the MIM Data Module.

6. Take Photos. Photos should be taken before the site is impacted by monitoring activities. The markers should be visible in the photos.

or riffle (R) for any comparatively fast-moving water. For the purposes of the MIM protocol, it is not necessary to further divide stream habitat features into more discreet units, such as glide or run. The pool category is intended to include both pool and glide, and the riffle category is meant to include both riffle and run.

10. Residual Pool

Step 1. Identify the riffle crest. Beginning at the downstream marker of the DMA, proceed upstream and identify the first riffle crest (pool tail). The riffle crest is best identified when looking upstream. It is the top of the riffle or upstream end of shallow, rippling water. It coincides with the point where water exits or spills from a pool. To qualify as a pool, it must be at least one-half the width of the active channel. Small “pocket” pools are not counted. The distance from the lower marker in the DMA to the first riffle crest is not measured.

An effective technique is to have one individual wade in advance to measure the maximum or thalweg depths of the channel at both the riffle crests and in pools. The second observer follows and measures the distances between riffle crests and pool bottoms.

Note: Pools are separated by riffle crests. Do not subdivide large pools into two or more pools because of a channel bedform that is not a true riffle crest or “spill” point out of a pool.

Step 2. Determine the thalweg depth of the riffle crest. Measure and record the thalweg depth of the riffle crest to the nearest hundredth of a meter (0.01 m) with the measuring rod. The depth measurement is made in the thalweg or deepest part of the channel in the stream cross section.

Note: Orient the measuring rod vertically when making depth measurements. In fast-moving water, the water surface will form a high-pressure ridge on the upstream side of the measuring rod and a low-pressure depression on the downstream side of the measuring rod. For consistency, measure the water depth on the side of the rod to average the hydraulic ridge and depressions.

Step 3. Locate the pool upstream from the riffle crest and find the deepest point. This is best accomplished by wading up through the pool to feel depth changes and by probing with the 2-m measuring rod.

Step 4. Measure the horizontal distance from the riffle crest to deepest point in pool and the maximum pool depth. Follow the thalweg and proceed upstream to find the maximum pool depth. Record the horizontal distance from the riffle crest to the maximum pool depth to the nearest decimeter (0.1 m). Measure and record the maximum depth of the pool to the nearest hundredth of a meter (0.01 m). Horizontal distance along the thalweg is measured with a 2-m measuring rod, metric tape, or laser rangefinder. Depths are measured with a 2-m measuring rod or other survey instrument with resolution of 0.01 m (1 cm).

- When tracing the thalweg, make sure to carefully measure distances around meander bends. Do not truncate thalweg length by measuring across meander

- Return all particles back to the channel. Many macroinvertebrates rely on coarse particles for part of their life cycle. Throwing these particles with macroinvertebrates on a dry streambank needlessly harms an important component of the aquatic environment.

- If the water is too deep to practically acquire substrate particles, use visual clues, sound, and the 2-m measuring rod to probe the channel bed at the calculated intervals across the channel to estimate particle sizes**.** Flag estimated particle sizes in the data sheet. It may be possible to differentiate sand, fine gravel, coarse gravel, fine cobble, coarse cobble, boulder, and bedrock by a combination of visual clues, sound, and feel. For example, silt and clay may appear as plumes of turbid water generated from walking or probing the channel bed. Sounds might also distinguish particle classes. Silt and clay should generate almost no sound, sand and fine gravel a scratchy sound on a depth rod, and coarser material might generate a ringing sound and the measuring rod might bounce off the coarser particles when the channel bed is probed. Finally, walking on the channel bed might provide a feel of the dominant particle sizes, but finer material trapped in the interstices of larger particles might be difficult to assess by this method.

For estimated particle sizes in deep water, **flag the sample as an estimate** and use the sample-class sizes in Table 7.

Table 7. Particle size classes for use when estimating particle size.

Particle-size class	Representative size (mm)
Clay and silt	2
Sand	2
Very fine - Fine gravel	4
Medium – Very coarse gravel	32
Small Cobble	90.5
Large Cobble	181
Small – Medium Boulder	512
Large – Very Large Boulder	2048
Bedrock	4097

Step 4. Make sure 10 samples are collected per transect. If a transect produces fewer than 10 samples, then move upstream 0.5 m and collect the remaining samples evenly across the active channel. For example, if large particles (large cobbles or boulders) are encountered in the transect, ensure that they are not sampled more than once. If the chosen interval results in hitting a particle a second time in the transect, do not record that particle size, and continue with the original sample interval to the other side of the channel. When the first transect yields fewer than 10 samples, move upstream 0.5 m (or more if necessary to avoid the same large particles in the original transect) and space the remaining samples evenly across the active channel at the new location. Two or more passes may be required for some small streams.

Step 5. Indicate the stream habitat feature (pool or riffle). Note whether the substrate transect traversed a pool or riffle. Select pool (P) for any comparatively deep, flat water,

Systematic Monitoring Procedures

After the DMA has been established and monumented, and the header form has been populated, proceed with the following steps:

__Step 1.__ **Develop a list of plant species using standard NRCS naming conventions**. A list of plants found within the DMA will aid field crews and dramatically reduce the amount of time required to complete a DMA. The list should include the common name, scientific name, and the NRCS species code to by used in the MIM Data Module. Determine key species for stubble height and woody species use (if used) and create species lists for both. Use the tables in the electronic modules, the back of this field guide, or a sheet of paper to record plants.

__Step 2.__ **Determine the appropriate sampling interval.** The interval between plots may be paced or measured. **The default sample interval is 3.75 m.** For DMAs > 150 m long, the sampling interval is 1/40 of length of the DMA.

__Step 3.__ **Establish the location of the first sample.** Use a random number generator to select a number from 1 to 5 (the first sample point is randomly selected every time the DMA is monitored). From the bottom of the DMA take the random number of steps to locate the first sample.

__Step 4.__ **Measure the Sampling Interval.** After data have been collected at the randomly located first point, the next sample point is located using a fixed sampling interval.

__Step 5.__ **Sample the Entire DMA.** Monitor along the greenline at the appropriate sampling interval up the left bank to the upstream end of the DMA and down the right bank to the downstream end of the DMA.

__Step 6__**. Evaluate the precision level based on the sample size**. After sampling the entire DMA, check the sample-size estimator, which is programmed into the data entry module, to determine the precision of the data for several indicators (i.e., for those that produce a mean or proportion).

Rules to Establish the Greenline Location

The greenline is generally defined as a linear grouping of live perennial vascular plants, embedded rock, or anchored wood on or near the water's edge (adapted from Winward 2000). It often forms a relatively continuous line of perennial vegetation adjacent to the stream. Individual linear groupings are considered part of the greenline when they meet the rules described in this section. The greenline can also be composed of partially or entirely embedded rock and/or anchored wood. For incised streams, the greenline may be located above the floodplain on a ***terrace*** (Winward 2000). In these cases, the greenline may include, or be limited to, non-hydrophytic species (i.e., upland species).

The greenline may occur on either a flat or sloped surface. In addition, there are a list of other specific conditions or features that will further define the greenline (e.g., roots, bases of overstory woody plants, presence of ***slump blocks***).

Greenline Rules: There are two greenline rules; either rule **a.** or rule **b.** (below) must be met.

a. Live, perennial, vascular herbaceous vegetation; live woody understory; embedded rock; anchored wood: When viewed at 90 degrees from the ground surface, the greenline must have at least 25% absolute cover of <u>any combination</u> of: (1) live, perennial ***foliar cover*** of vascular herbaceous vegetation or live woody understory, (2) embedded rock, or (3) anchored wood (not live) <u>AND</u> no bare patches > 10 cm x 10 cm within the Daubenmire quadrat. Bare patches are defined as any combination of rocks smaller than 15 cm (intermediate axis), litter, annual plants, dead plants that do not qualify as anchored wood (see below), or nonvascular plants. ***Absolute cover*** is defined as the area of the ground surface covered by vegetation or other qualifying coverages (i.e., embedded rock or anchored wood). It is expressed as a percent of area.

(1) <u>Live perennial foliar cover of vascular herbaceous vegetation and/or live woody understory</u>: Foliar cover, in general, includes all live plant parts and is the shadow cast if the sun was directly overhead. Before concluding a plant is dead and moving the frame, ensure that it is not just senesced. Live shrubs or trees < 0.5 m tall are considered woody understory. *All vegetation must be rooted within the quadrat*; foliar cover rooted outside the quadrat is not considered (i.e. foliar cover hanging over the quadrat but not rooted in the quadrat is not considered).

(2) <u>Embedded Rock</u>: The greenline may include rock that is at least 15 cm in diameter (intermediate axis) and at least partially embedded in the streambank with no evidence of erosion behind it; this includes all talus slopes (with at least 15 cm diameter rock) and bedrock. Embedded rock must be above the scour line (i.e., not in the active channel).

(3) <u>Anchored Wood</u>: The greenline may include logs or root wads that are at least 10 cm in diameter and are anchored into the streambank such that high flows are not likely to move them. Standing dead shrubs and trees (including their root systems) are considered anchored wood if they are not likely to move during high flows. There should be no evidence of erosion behind them. Anchored wood at the location of the greenline must be above the scour line and not in the active channel, although the log or root wad may extend below the scour line.

b. Woody overstory: Live woody plants are considered woody overstory if they are ≥ 0.5 m tall (these are considered young and mature plants for this protocol). If the base(s) of woody overstory plants are located closer to the water line or scour line than qualifying perennial herbaceous vegetation, woody understory, rock, or wood (as described in Section 5.2.3.a), the greenline is located at the base of the overstory plant(s). The woody overstory plant(s) must be rooted above the scour line. *Foliar cover of woody overstory vegetation <u>is not</u> considered for identifying the greenline; as a result, the woody base(s) do not need to comprise 25% of the quadrat a*nd the bare patch rule does not apply.

When there is woody overstory and little or no understory (i.e., if the understory is < 25% absolute cover), and if the shrub or tree canopy is directly overhead, the frame is placed on a simulated line connecting the rooted base of the shrubs or trees roughly parallel to the streamflow (≤ 75 degrees) on the stream side of the rooted base of shrubs or trees. When there is no canopy cover directly above the line joining the bases of woody species, the frame is moved away from the stream until the greenline is encountered or the distance from the scour line (or water's edge if the scour line is under water) is 6 m slope

Finally, as long as the sampling process minimizes bias and strives to collect samples equally distributed across the channel, another approach is to step or pace sampling points across the channel. For example, an individual with a 30-cm-long wading boot (Figure 69) could pace heel to toe and collect samples every 0.3 m across a 3-m-wide channel. For a 4.5-m-wide channel, the samples would be collected 0.45 m apart, alternating between the toe and the instep of the boot. As always, look away from the channel bed and minimize bias by pointing the index finger straight down to collect each sample at the designated point.

Step 3. Measure the diameter of samples collected. Align the longest axis (a-axis; Figure 64) of the particle perpendicular to the gravelometer (Figure 70.A). Pass the particle through the smallest slot in the gravelometer or template possible (Figure 70.B). If a template is not used, measure the middle width (intermediate or b-axis) of the particle in millimeters.

- A gravelometer is highly recommended to reduce observer subjectivity. They are shown to increase precision and accuracy over rulers because of reduced bias and observer error, and elimination of parallax error (Bunte and Abt 2001). Gravelometers are designed to measure the intermediate or b-axis of particles. They are inexpensive and greatly increase speed and accuracy of measurements. Openings in the gravelometer match the Wentworth scale (Wentworth 1922) and can be used to estimate the particle-size class or phi scale based on Krumbein and Sloss (1963).
- If a small particle falls into the fines category, is touched in between larger particles, and the observer is unable to collect it, the particle size can be estimated (e.g., < 2 mm or < 6 mm). Substrate sampling inherently under samples fine sediments given the nature of particle interstices and the ability of a finger to isolate and pick up individual particles < 10 mm in diameter. Make a concerted effort to point finger vertically toward substrate and pick up the first particle touched; be especially sensitive to the general difficulty of picking up small particles that might be located between larger particles.
- Do not measure the same particle twice. If the particle is so large that the sample interval falls on it more than once, measure only the first time encountered and follow the instructions in step 4 to obtain a replacement sample.
- When a particle is too large to pick up or embedded or cemented into the channel, measure the smallest visible length, which is likely the b-axis. Most particles will rest like a shingle on a channel bed with the smallest axis (the c-axis) oriented vertically. Assume the c-axis is not accessible or visible and that smallest axis visible is the b-axis. Flag the as an estimate in the data sheet.
- For particles that exceed the largest opening in the gravelometer (the 180 mm opening), measure the intermediate axis using the millimeter scale along the edge of the gravelometer. If the particle exceeds 300 mm, the gravelometer will have to be flipped to determine the cumulative length of the intermediate axis (or b-axis).
- When algae are present on the substrate sediment, be especially mindful to distinguish and differentiate algae from fine organic sediment; do not sample algae. Sample the inorganic or mineral substrate below the organic growth.

known issue with this indicator. If the side of the finger touches a larger particle and the center of the finger can extend further down to the bed, select the lower particle touched by the center of the finger. With the finger on the bed, use the thumb in combination with the index finger to capture the fine particle and bring it out of the stream for measurement.

- Collect samples at equal spacing across the channel. Because water depth and water velocity affect particle size, and because depth and velocity change across the channel, the entire width of the active channel must be sampled at each transect. If pacing, measure to the starting point (i.e., 0.25 m as above) with the rod, collect the first sample there, and then pace at approximately 0.5-m intervals from that location to the other sample points across the channel.
- Make sure the samples are all collected from the active channel (i.e., from scour line to scour line). Do not collect samples above the scour line; this area technically represents streambanks or islands, not the streambed. Do collect from parts of the channel beneath undercut banks. If the channel bed is partly or completely dry, continue to collect samples uniformly across the channel from scour line to scour line.
- Do not sample large particles if any part of the particle extends above the scour line elevation (Figure 68).
- Depositional features (e.g., ***point bars***) that are not covered by vegetation and located below the scour line are considered streambed material and should be included in the sample.
- When collecting other greenline-based data prior to establishing the substrate transect, avoid trampling the streambed at the location where the substrate samples will be collected. However, in reaches where trampling the channel bed cannot be avoided due to the presence of a soft substrate dominated by silt and clay, collect substrate data before trampling the streambed and before collecting the greenline-based indicators. Repeated trampling of a soft channel bed can result in changes to particle sizes and depth of pools. In very small streams with soft, unconsolidated substrate, it is also possible to modify pool depths with trampling. In such cases, complete the entire thalweg survey first, and while proceeding upstream in that survey, locate and measure substrate at cross sections before sampling the other indicators.

There are several practical ways to measure the active channel width and to determine the sample interval for substrate measurements, including use of the 2-m measuring rod and pacing using boot length or step length. Generally, for narrow channels (defined here as channel widths ≤ 4 m from scour line to scour line), the 2-m measuring rod can be placed along the scour line and the intervals measured directly from the rod.

For channels wider than 4 m, it can be cumbersome to simultaneously hold a measuring rod in place while measuring sample intervals and collecting substrate particles, especially if the current is strong. A tape stretched tautly across the channel from scour line to scour line can be more practical.

distance. Exposed live shrub or tree roots of woody overstory plants rooted above the scour line are part of the greenline.

Additional Rules for Identifying the Greenline

Flooded greenline: Do not sample vegetation indicators or GGW when the greenline is flooded during high streamflow. The greenline is never located in the water.

Perennial vegetation growing in water: During low-flow periods, some plants will be observed growing in slow-moving water at the stream margin. Some sedges, spikerushes, rushes, and bulrushes are adapted to grow in the water for most or all the growing season. The greenline is never located in the water.

Perennial plants occupying the entire channel or drainageway: For dewatered channels on intermittent streams, dry channels, or vegetated drainageways (those with no distinct channel), if vegetation occupies the entire width of the channel or drainageway, the greenline is at the deepest part of the channel (thalweg) or the lowest point in the vegetated drainageway.

Slump blocks and bank fractures: Slump blocks are relatively discreet blocks of soil/sod that have obviously broken from the bank or terrace and slipped towards or into the streambed. If a slump block is present, the greenline is located on the bank or terrace behind the block at the location nearest the channel where the greenline rules are met. If the fracture is at least one-fourth of the MIM frame length, the greenline is up the bank behind the fracture as described above for slump blocks.

False banks: ***False banks*** are sections of bank that have broken off (i.e. a slump block) from a high bank, terrace, or streambank and have become reattached to the streambank. False banks are stable features and do not have fractures, stream scour, or streambed between the former block (now a section of the bank) and the bank or terrace.

Islands: Islands are defined as areas within the channel at an elevation at or above the scour line and are surrounded by water at summer low flow, or bounded by a channel that is scoured frequently enough to keep perennial vegetation from growing. The greenline follows the outside channel on each side of the island and does not cross onto an island.

No greenline present: When the greenline is not present within 6 m (slope distance) from the scour line (or from the water's edge if the scour line is under water), **the greenline is considered absent at that sample point** (NG is recorded for vegetation composition and 100% is recorded for the percent cover). Note that this rule is infrequently used but must be included to limit observers from "chasing" a greenline too far from the stream to be relevant.

- If there is no greenline present, the monitoring frame is placed on the edge of the first ***bench*** within 6 m of the scour line (or water's edge if the scour line is under water) and only streambank alteration and streambank stability and cover are recorded.
- If there is no bench present within 6 m, the frame is placed at 6 m slope distance from the scour line (or from the water's edge if the scour line is under water) and only streambank alteration and streambank stability and cover are recorded.

Note: If the 6 m mark falls on a vertical or near vertical face, or on an otherwise inaccessible location, only streambank stability and cover would be recorded (and may have to be visually estimated if it is beyond the reach of observers).

1. *Greenline Composition*

Step 1. Conduct a reconnaissance and develop a plant species list. Prior to collecting greenline composition data, it is critical that observers identify the plant species located on the site.

- Complete a reconnaissance of the DMA and make a list of the most abundant and common vascular plant species along the greenline. When moving from one end of the DMA to the other, it is important to avoid trampling vegetation on the greenline. Where possible, greenline plants should be observed from the stream channel, which allows a good observation position and avoids trampling the greenline.
- If recording stubble height and woody species use, identify key species for those methods at the same time.
- For identification of unknown plants, collect plants or photograph diagnostic features. Record unknown plants as UNK1, UNK2, etc. and collect specimens for later identification. After identification, replace the UNK codes with the appropriate plant code.

Step 2. Locate the greenline composition quadrat. Greenline composition is recorded at the sample interval at the location where the greenline rules have been met. There are two sides to the MIM frame that are divided by a 50-cm-long center bar. The composition quadrat (20 cm x 50 cm) uses only the vegetated side of the MIM frame, upslope from the greenline.

Step 3. Record herbaceous understory. This is the relative foliar cover of all live, perennial herbaceous vascular plant species. Viewing above the quadrat frame at 90 degrees to the ground surface, record by species the *relative amount* of live foliar cover of herbaceous plants rooted in the quadrat having 10% or more foliar cover by composition. The monitoring frame is marked to provide references for 12.5%, 25%, and 50 % areal extent. Although relative cover is recorded, these markings just help to provide a visual estimate of the proportions of the quadrat. The markings help calculate proportions whether absolute or relative. When cover is 100%, the proportions work for either relative or absolute cover. The proportional markings are also helpful when plants are distributed uniformly throughout frame with small gaps.

- For example, if a quadrat contains 25% absolute foliar cover of Nebraska sedge and 25% absolute foliar cover of Kentucky bluegrass with 50% other (bare ground, litter, moss, etc.) for the purposes of relative cover, the observer will record compositions of 50% Nebraska sedge and 50% Kentucky bluegrass.
- Senesced leaves from the current year are considered live.
- Do not record herbaceous plants or plant parts that are clearly dead. Do not count dead leaves of previous season as cover; they should be moved if they obscure live vegetation.

Table 6. Woody species browse height by animal class (BLM 1992).

Class of Animal	Height Browsed	
	Meters	Feet
Sheep, antelope, or bighorn sheep	1.1	3.5
Deer	1.4	4.5
Cattle	1.5	5.0
Horse, elk, or moose	2.1	7.0

9. Substrate

Step 1. Determine the interval length to obtain 10 evenly spaced particles in the cross section. Use a measuring rod or laser rangefinder to determine the width of the ***active channel*** (the active channel is located between the ***scour lines*** of the stream). Where scour lines are indistinct, measure the channel bed, which is bounded by the points where the channel bed (relatively flat) meets the streambank (the sloped surface above channel bed). Divide this width by 10. Alternatively, count the number of heel-to-toe steps across the active channel width, divide by 10 to determine the interval length. Collect the first sample at one-half this interval length, and all subsequent samples at the interval length, so that the last particle selected is not directly on the scour line.

For very small and narrow streams, collect 5 samples on each of 2 crossings (i.e., cross once, move upstream 0.5 m, then cross again). If after 2 passes, the sample is still short of 10 particles, follow the instructions in step 4 below to obtain additional samples.

- When the transect crosses a multiple-thread channel or flows around islands, total the active channel width of all active channels (including bifurcated flow around islands) and divide by 10 to determine the interval length. Distribute sample collection proportionately across the width of all active channels. Baseflow channels convey water at and below the scour line; they do not include overflow channels that can form on the floodplain or above the scour line as a consequence of high-magnitude flood events.

Do not sample particles on the streambanks or islands that are above the scour line.

Step 2. Determine the first sample location and begin sampling particles. Start the cross-channel transect at one-half the interval length, and then collect all subsequent particles at the full interval length. For example, if the width of the active channel at the sample location is 5 m, the sampling interval is 0.5 m, and the first sample is collected at 0.25 m (½ x 0.5 m) from the scour line. All subsequent samples are collected at 0.5-m intervals, and the last sample, or particle number 10, should be approximately 0.25 m from the scour line on the opposite side of the channel.

- Stand downstream of the transect to avoid disturbing the streambed (if possible). To locate the sampling point, place the index finger at that point, and **without looking at the streambed**, reach into the stream and obtain the first particle in the substrate that touches the index finger. It is especially important to collect a fine particle if it is the first particle encountered. Under-sampling fine particles is a

Table 5. Woody species use class and descriptions.

Use Class	Mid-point	Description
Unavailable	**Blan k**	Shrubs and trees that have most (> 50%) of their actively growing stems > 1.5 m (5 ft) tall for cattle browsing. This should be adjusted if the questions to be answered involves other herbivores.
None	**0**	No browse of key woody plants.
Slight (1%–20%)	**10**	Browse plants appear to have little or no use. Available leaders may show some use, but 20% or less of the available current year's leaders have use.
Light (21%–40%)	**30**	There is obvious evidence of use of the current year's leaders. The available leaders appear cropped or browsed in patches and 60%–79% of the available current year's leaders of browse plants remain intact.
Moderate (41%–60%)	**50**	Browse plants appear rather uniformly used and 40%–59% of the available current year's leaders remain intact.
Heavy (61%–80%)	**70**	The use of the browse gives the general appearance of complete search by browsing animals. Most available leaders are used, and some terminal buds remain on browse plants. Between 20%–39% of the available current year's leaders remain intact.
Severe (81%–100%)	**90**	The use of the browse gives the appearance of complete search by browsing animals. There is browsing use on second- and third-years' leader growth. Plants show a clublike appearance, indicating that most active leaders have been removed. Only 0%–19% of the available current year's leaders remain intact.

- Annual and non-vascular plants, bryophytes, litter, dead plants, and bare ground are not recorded.
- When recording data, use the USDA-NRCS PLANTS Database species codes (http://plants.usda.gov/).
- The total for all understory composition (herbaceous plants, woody plant understory, rock, and/or wood), must be 100%.

Step 4. Record woody species understory. Woody species understory includes all live woody plants < 0.5 m tall that are rooted in the quadrat and have 10% or more foliar cover by composition. Woody species understory plants are recorded as a percent relative foliar cover by composition along with the herbaceous vegetation. Record by species the *relative amount* of live foliar cover for woody understory plants rooted in the quadrat having 10% or more foliar cover by composition.

- Exposed live roots of woody understory plants rooted in the quadrat are recorded in the same manner as understory woody stems—note the species code and percent foliar cover of the total understory. If it is not possible to determine the species of the observed roots, assume the roots are part of the most dominant woody plant that is closest to the quadrat and record that species. Roots of overstory woody plants are considered differently (see step 7).
- Do not record dead woody understory plants or plant parts that are clearly dead (dead woody plants are usually dry and brittle). Caution should be used to ensure plants are not simply dormant.
- When recording data, use the USDA-NRCS PLANTS Database species codes (http://plants.usda.gov/).

Step 5. Record understory of embedded rock and anchored wood.

- Embedded rock (the code is RK) is defined as rock that is at least 15 cm in diameter (intermediate axis), at least partially embedded in the streambank, has no evidence of erosion behind it, is above the scour line, and is not likely to move during high flows.
- Anchored wood (the code is WD) is defined as dead woody plants or dead woody plant parts (including dead roots) that are at least 10 cm in diameter, are anchored into the streambank, have no evidence of erosion behind them, are above the scour line, and not likely to move during high flows. This includes standing overstory dead shrubs or trees. If the quadrat contains a standing dead shrub or tree, it must be entirely dead. If any part of the woody plant is alive, it is not anchored wood but is considered woody understory (if < 0.5 m tall) or woody overstory (if $\geq$ 0.5 m tall; see step 6.)
- Embedded rock and anchored wood must also have 10% or more relative cover in the quadrat.
- Record rock and wood as a relative percentage of the total understory cover (vegetation, rock, and/or wood), totaling 100%.

Step 6. Record important plants with < 10% cover and grouped understory plants.

- **Important Plants with < 10% Foliar Cover**: Generally, understory plants with < 10% relative foliar cover are not recorded; however, if desired, plants that have < 10% relative foliar cover can be recorded. This is usually done if there is a need to more closely monitor minor or rare species for management purposes. If there is no need to record the amount of these minor species, but their occurrence is of interest (e.g., presence of noxious weeds), the observer records the plant(s) species name on the comments sheet by quadrat number.
- **Grouped Plants**: To the extent possible, all plants with 10% or more foliar cover should be identified by species. When individual plant species are < 10%, but together comprise at least 10% of the relative foliar cover, they may be recorded as a group. Examples would be mesic forbs (MFE for early seral and MFL for late seral) or mesic graminoids (MG), upland grass (UG), sedge (CAREXRH for rhizomatous and CAREXTF for tufted), and rush (JUNCUS). If known, include a list of the individual plant species that comprise the groups for a particular DMA in the DMA narrative.

Step 7. Record woody species overstory. Woody species overstory includes all live woody plant species at least 0.5 m tall that are either rooted in or overhanging the quadrat. Woody plants overhanging the composition quadrat must be rooted on the side of the stream being sampled. Do not record plants that are rooted on the opposite bank or those that are on islands that overhang the quadrat.

- Foliar cover is not used for woody species overstory composition. If any live part of the woody overstory (at least 0.5 m tall) is either rooted in or directly above the quadrat, it is counted as part of the composition. The observer does not attempt to estimate the relative cover of woody overstory by species, but records 100% if there is one species in the overstory, 50% for each if there are two species in the overstory, 33% for each if there are three species in the overstory (arbitrarily designating one as 34% to total 100%, most commonly the plant with the highest cover), and so forth. The total overstory percentage must add up to 100%. If there are many large shrubs or trees on the site, a hand-held densitometer (sighting periscope) is helpful to determine if the woody plant parts are directly above the quadrat.
- Live woody roots, ground-level stems, or bases of woody overstory plants: If woody overstory plants have exposed live roots or one or more woody stems/shrub or a tree bole(s) rooted in the quadrat at the ground/understory level, they are recorded as overstory (not anchored wood or understory).
- Multiple sizes of the same species in a quadrat: It is possible to have multiple sizes of the same woody species in both the understory and the overstory. They are distinguished in the data form by their composition percentages and height class designations (see woody height class method). For example, a quadrat may have yellow willow (*Salix lutea,* code SALU2) in the understory (i.e., < 0.5 m tall and rooted in the quadrat) and one or more overstory SALU2 plants 0.5 m or taller rooted in or overhanging the quadrat. The plant code SALU2 would be recorded along with its percentage of the total understory for the short plant. SALU2 would be recorded again on another row and given the appropriate percentage of the

- Distinguishing individual plants may be difficult in some situations. - Clonal, root sprouting, or rhizomatous plants can have multiple stems that comprise a single plant (e.g., coyote/sandbar willow [*Salix exigua*], wild rose [*Rosa* spp.], snowberry [*Symphoricarpos* spp.], root-sprouting cottonwood [*Populus* spp.], golden currant [*Ribes aureum*], and aspen [*Populus tremuloides*]). Although generally not as pronounced, clumped willows can also have multiple stems that are part of the same plant. In both cases, consider all stems growing in a relatively defined cluster to be part of the same plant. To help distinguish a defined cluster, consider all stems within 30 cm (12 inches) of each other at ground level as the same plant. Often, several shoots or stems may be outside the quadrat. As indicated above, if any live part of the woody plant is **rooted in or overhanging the quadrat** and it is the closest plant of that key species to the start of the quadrat, estimate its use class. See Appendix F for a list of common rhizomatous woody plants.

– **Note:** Seedlings commonly germinate and initiate growth very close together and are clearly individual plants and they should be recorded as such. Often this results in stems being closer than 30 cm from each other.

– If it is still difficult to distinguish individual plants using the 30 cm rule (commonly because they are dense, contiguous patches of clonal/root sprouting/rhizomatous woody plants), assess the use classes on all the stems together within the 2 m x 3.75 m (or other length) quadrat.

Step 4. Determine the available current year's growth. Current year's leaders are the current year's growth represented by long, thin, twig-like extensions growing from terminal buds that have not yet hardened into fibrous woody material. As leaders mature, cell walls thicken and harden into coarse, woody material in the second year. Browse on second-year and older leaders is not considered.

Step 5. Determine the woody species use class for selected plants. Plants are classified into a "use class" (Table 5). Table 5 use class descriptions are the standards by which use is judged.

- This process is repeated for the **first available individual** of each key woody species encountered within the quadrat as described in step 3.
- Review descriptions of use classes periodically while reading the quadrats to maintain precision and accuracy.

Step 6. Record the species code and use class. Record the USDA-NRCS PLANTS Database species code.

- Record the value that represents the midpoint for the appropriate use class for each key woody species evaluated. The midpoint is the numerical value in the middle of the range of each use class. For example, the slight use class has a range of 1–20%. The midpoint is 10%. The ONLY midpoint choices are 0, 10, 30, 50, 70, and 90 (see Table 5).
- If there are no available key woody species within the quadrat, leave blank in the data form. If woody plants are commonly unavailable, note this as a comment. This is a common occurrence when mature large woody plants dominate a site.

- Make a list of key species using the USDANRCS PLANTS Database species codes.
- When moving from one end of the DMA to the other and observing plants, it is important to avoid trampling vegetation on the greenlines. Where possible, greenline plants should be observed from the stream channel, which allows for a good observation position at right angles to the streambank and avoids trampling the greenline.

Step 2. Locate the woody riparian species use quadrat. The woody riparian species use quadrat is 2 m wide (1 m on each side of the greenline) and the length of the sample interval (3.75 m is a common default for small streams; larger streams will have a longer sample interval and a longer quadrat).

- Use a 2-m rod or the handle of the MIM frame (1 m long) to define the 2 m width of the quadrat.
- Because the woody riparian species use quadrat is larger than the greenline composition quadrat, sometimes the top of the DMA interrupts the 2 m x 3.75 m quadrat. If this occurs, record the appropriate woody plants from the sample point to the top marker of the DMA, cross to the other bank, measure the remaining distance and record the woody plants as instructed. If the bottom marker interrupts the woody riparian species use quadrat (i.e., shortens the quadrat), record only those woody plants from the sample point to the bottom marker.
- For very narrow streams with woody plants in the channel, the width of the woody riparian species use quadrat does not extend beyond the middle of the channel (this will also avoid sampling plants rooted on the opposite bank).

Step 3. Locate the available key woody riparian species within the quadrat. The default procedure is to use the individual of each key woody species rooted in or overhanging the quadrat that is closest to the start of the quadrat (i.e., only consider the first plant of each key species encountered when proceeding up or down the greenline transect from one sample point to the next).

- ***Available woody species*** are plants having > 50% of the current year's leaders within reach of the browsing animal (Table 6). If the plant being evaluated has > 50% of the current year's leaders above the reach of the browsing animal, the shrub is considered unavailable for browsing and the plant is not assessed for woody species use. For example, for assessing cattle use, observers would only consider key woody plants having > 50% of their current year's leaders below 1.5 m (5 ft), which is considered browsable; if woody plants have > 50% of the current year's leaders above 1.5 m (5 ft), they are considered unavailable.
- If a key woody plant straddles the boundary of the quadrat (i.e., some parts are rooted both inside and outside the quadrat), evaluate the entire plant, even if part of the plant is outside the quadrat.
- If any part of a key woody plant is hanging over the quadrat, evaluate the entire plant.
- If a key woody plant straddles the sample interval (is rooted in or overhanging two adjoining quadrats), estimate its browse in only one quadrat.

overstory as described above. Both entries would then be given a separate height class as described in the woody species height class method.

- Same overstory plant in multiple quadrats: If a single overstory shrub or tree has branches or leaves hanging over more than one quadrat (i.e., spans the sampling interval), it is included in each quadrat because cover, for the purpose of calculating species composition, is the metric of interest. In addition, the occurrence and height of large overstory plants are used to calculate a shade index, which requires large plants to be recorded in every quadrat they occupy.
- Dead woody overstory plants/plant parts: Do not record woody overstory plants that are clearly dead. Caution should be used to ensure plants are not simply dormant. Plant parts either rooted in or hanging over the quadrat must be alive to be considered overstory (e.g., completely dead stems or branches rooted in or over the quadrat, even if connected to what appears to be a live plant, are not overstory).
- When recording data, use the USDA-NRCS PLANTS Database species codes (http://plants.usda.gov/).
- Total woody overstory cover, when present, will be 100%. If a quadrat has vegetation, rock, or wood in the understory and a woody overstory, the quadrat total will be 200%.

Step 8. **Record no greenline cover.** When no greenline cover exists (i.e., vegetation, embedded rock, or anchored wood) within 6 m (slope distance) of the scour line or water's edge (if the scour line is under water), record "NG" in the Species column and record "100" in the % Cover column.

2. Woody Species Height Class

Step 1. Locate the woody height quadrat. The woody height quadrat is identical to the greenline composition quadrat.

Step 2. Locate and record the height of all woody plants recorded in the greenline composition quadrat.

- Locate the tallest live part of the woody plant(s) species recorded in the composition quadrat. For example, if a yellow willow (*Salix lutea*) has one live branch hanging over the quadrat at 1 m above the ground, but it has connected live plant parts that extend to 3 m in height (tallest live part), record height class 4 (2–4 m). *The tallest part does not need to be in or over the quadrat*). Exclude the tallest plant part of the shrub or tree if it is a dead branch. Find and record the tallest live plant part. Note that this method records all woody plants, not just woody riparian plants.
- Record the height class according to Table 1, based on an estimate of the height of the plant from its rooted base to the tallest live part of the plant. This can be done by one of several methods: estimate the height class visually comparing it to the height of a known object, such as a person or a measuring rod; estimate the height class by extending the measuring rod vertically from the ground up to the top of

the plant; or estimate height using the vertical distance or height measurement with a laser range finder.

- Record the height of clonal, root sprouting/rhizomatous species. It may be difficult to determine which plant is attached to the qualifying plant part when encountering clonal, root sprouting, or rhizomatous species that have multiple stems that comprise a single individual plant. Examples include coyote/sandbar willow (*Salix exigua*), wild rose (*Rosa* spp.), snowberry (*Symphoricarpos* spp.), root-sprouting cottonwood (*Populus* spp.), golden currant (*Ribes aureum*), and aspen (*Populus tremuloides*); consider all stems of the same species growing in a relatively defined cluster to be part of the same plant. To help distinguish a defined cluster, consider all stems of the same species growing within 0.3 m (12 in) of each other at ground level as the same plant. If it is still difficult to distinguish individuals of these kind of species, record the tallest part of the clonal/rhizomatous plant that occurs from the existing sample point to the next sample point.

Note: Seedlings of non-rhizomatous woody plants commonly germinate and initiate growth very close together and are clearly individual plants. They should be recorded as such. Often this results in stems being closer than 0.3 m from each other.

- Be aware that woody seedlings with < 10% foliar cover will not be recorded in the composition method and therefore will not receive a woody species height class (these plants will be recorded in the woody riparian species age class method).
- The handle of the frame (which by design is 1 meter in length) and/or a survey rod can be used to help estimate the height of woody plants that are >1 m.
- A densitometer can be used to assist in determining if a woody plant is overhanging the quadrat.
- If there are no woody species in the composition quadrat, leave blank.

Table 1. Woody Species Height Class.

Height Class	***Height Range***	***Composition Category***
1	**<0.5 m**	**Understory**
2	**0.5–1.0 m**	**Overstory**
3	**1.0–2.0 m**	
4	**2.0–4.0 m**	
5	**4.0–8.0 m**	
6	**8.0 m**	

Table 2. Woody riparian species age classes for single-stemmed species (e.g., cottonwood, aspen, maple).

Age Class	***Stem Height and Diameter***
Seedling	Stem is < 1 m tall OR < 2.5 cm in diameter at 50% of height from ground level
Young	Stem is ≥ 1 m tall OR 2.5–7.6 cm in diameter at 50% of height from ground leve
Mature	Stem is ≥ 1 m tall and > 7.6 cm in diameter at 50% of height from ground level

Table 3. Woody riparian species age classes for multi-stemmed (clumpy) species (most willows, alder, birch).

Age Class	***Stem Height and Diameter***
Seedling	1 stem < 0.5 cm in diameter at the base and < 0.5 m tall
Young	2-10 stems < 1 m tall, OR 1 stem 0.5–1 cm in diameter at the base
Mature*	≥ 2 stems over 1 m tall OR > 10 stems that are ≥ 1 cm in diameter at the base

* Mature plants can be height suppressed due to repeated, heavy browsing. Thus, the mature class includes larger diameter stems that are shorter than 1 m tall (Singer et al. 1994, Chadde and Kay 1991).

Table 4. Woody riparian species age classes for low growing or dwarf shrubs that are generally mature at approximately 30–50 cm tall (e.g., short-fruit willow, wolf willow, hoary willow, and undergreen willow).

Age Class	***Stem Height and Diameter***
Seedlin g	1 stem < 0.5 cm in diameter at the base and < 30 cm tall
Young	2-10 stems < 30 cm tall OR 1 stem ≥ 0.5 cm in diameter at the base
Mature	≥ 2 stems over 30 cm tall

8. Woody Riparian Species Use

Step 1. Conduct a reconnaissance to determine key woody riparian species. Key woody riparian species are relatively palatable to grazing animals, relatively abundant, important for stream/riparian function and habitat, and serve as indicators of environmental and management changes. Record all species that meet the key woody species criteria. Common key woody species in riparian areas include most species of willow (*Salix* spp.), alder (*alnus* spp.), birch (*Betula* spp.), dogwood (*Cornus* spp.), cottonwood (*Populus* spp.), and aspen (*Populus tremuloides*). There are many woody species common in riparian areas that do not experience significant browsing because they are not palatable to ungulates; therefore, they are not key woody species. Examples include boxelder (*Acer negundo*), hawthorn (*Crataegus* spp.), ash (*Sorbus* spp.), spruce (*Picea* spp.), and chokecherry (*Prunus virginiana*).

- even if part of the shrub is outside the quadrat. The presence of even one stem within the quadrat requires the observer to determine if that stem is connected to others outside of the quadrat.

Note: Seedlings commonly germinate and initiate growth very close together and are clearly individual plants. They should be recorded as such. Often this results in stems being closer than 30 cm from each other.

- Only evaluate woody riparian species rooted in the quadrat. Do not consider plants that are not rooted in the quadrat (i.e., woody overstory hanging over the quadrat are not considered).
- For each species identified, record the USDA-NRCS PLANTS Database species code in the species column. If multiple species are rooted in the quadrat, record each one in a separate row on the data sheet.
- If an individual woody plant spans more than one quadrat, it is only recorded in the first quadrat in which it occurs.

Step 3. Count and record each woody riparian plant by age class. For each woody riparian species recorded, count and record the number of individual plants within each age class.

Record the number of plants by species for each age class, not the number of stems. For single-stemmed species, use the classes in Table 2. For multi-stemmed species, use the classes in Table 3.

- **Low-growing shrubs.** Some low-growing riparian shrubs are considered mature when they are a minimum of approximately 30 cm tall, such as Wolf's willow (*Salix wolfii*), undergreen willow (*Salix commutata*), mountain willow (*Salix eastwoodiae*), shortfruit willow (*Salix brachycarpa*), and diamondleaf willow (*Salix planifolia* spp. *monica*). Table 4 should be used for most low-growing willows. It should not be used for matted willows like arctic willow (*Salix arctica*) and snow willow (*Salix nivalis*), which are even shorter statured. If a question arises, use plant growth form descriptions in the literature to determine the appropriate age class. See Appendix F for a list of common dwarf riparian shrubs.

Clonal, Root Sprouting/Rhizomatous Species. It is difficult to age class rhizomatous/root sprouting species such as coyote/sandbar willow (*Salix exigua*), wild rose (*Rosa* spp.), snowberry (*Symphoricarpos* spp.), root-sprouting cottonwood (*Populus* spp.), golden currant (*Ribes aureum*), and aspen (*Populus tremuloides*); therefore, if root sprouting/ rhizomatous species occur in the quadrat, record a "1" in the rhizomatous column of the DMA form. See Appendix F for a list of common rhizomatous riparian shrubs.

Note: Aspen and cottonwood that are not root sprouting should be considered single-stemmed species.

• If there are no riparian woody species rooted within the quadrat, leave blank.

3. Streambank Alteration

Step 1. Locate the streambank alteration quadrat and observation lines: The frame is placed with the center bar on the greenline. This is the same position used to locate some other indicators, including greenline cover and composition and stubble height.

Step 2. Count the lines that intercept an alteration: Look down at the entire frame and determine the number of lines within the quadrat that intersect an alteration. The streambank is considered altered when there is obvious evidence of trampling, shearing, trailing, or pugging:

- Trampling is the result of hoof prints, footprints, or wheel or tread-tracked depressions in the soil at least 0.5 in (13 mm) deep and exposure of bare soil. The depression is measured from the top of the soil surface to the bottom of the impression. Alternatively, displaced soil is moved into a pile or ridge that is at least 0.5 in (13 mm) high.

Shearing results in the removal of a portion of the streambank by ungulate hooves, leaving a smooth vertical surface and an indentation of a hoofprint at the bottom or along the sides. Shearing may also result in the formation of a slump block that is roughly the area of a single hoof print.

- Trailing occurs when hooves, feet, or wheels/treads have repeatedly moved over the same area to create a compacted or devegetated path, even though the soil may be depressed < 0.5 in (13 mm).
- Streambank alterations may also produce a rut, depression, or pug that has formed from hoof prints, footprints, or wheels/treads and has held or is able to hold water or alter surface hydrology.

Step 3. Record the number of lines (0–5) that intersect one or more alterations*.* Record only one occurrence of alteration, trampling, shearing, trailing/compaction, or pugging per line.

Note: There may be multiple alterations along a single observation line, but only the number of lines with alterations are counted, not the number of alterations that intersect a single line. **It is important to record only the current year's streambank alterations, i.e., features that are obvious.** Disturbance features that are old, such as relict disturbances from a previous year, tend to be nondistinctive. Current year's alterations commonly include bits of live vegetation pushed into the soil. Follow these guidelines when determining the number of alterations:

- Do not record hoof prints or trampling on streambanks with fully developed, deep-rooted hydrophytic vegetation (e.g., *Carex* spp., *Juncus* spp., and *Salix* spp.), unless plant roots or bare soil is exposed, and the minimum 0.5 in (13 mm) displacement or impression has been created.
- Record an alteration when an observation line crosses a vertical face that has formed from ***hoof shear.***

- Record alterations from compacted or devegetated livestock game or foot trails (or vehicle paths) on or crossing the greenline that are the obvious result of the current season's use. Preexisting trails that have revegetated are not considered current season's alterations and are not counted.
- When there is no greenline identified within 6 m from scour line (or the toe of the streambank) streambank alteration is recorded at the edge of the first bench (or 6 m from the scour line). If the scour line is under water, the 6 m limit is measured from the water's edge.
- Do not omit a measurement if there are no alterations. Record "0" if none of the lines in the quadrat intersects an alteration.
- If the sampling plot falls underneath a shrub and the surface is inaccessible to view, it is improbable that a large ungulate could have or would have stepped on the quadrat; record "0" alterations.
- While collecting monitoring data, avoid walking or stepping on the greenline so that the act of monitoring does not generate streambank alterations.
- A ruler can be used to trace the path of an observation line when there is question whether the line intersects or misses an alteration.
- A hoofprint that is in or under water is not considered an alteration and is not counted. In contrast, a deep hoof print, also referred to as a pug and that holds water below the ground surface is an alteration.

Step 4. Evaluate streambank alteration along the entire DMA. Evaluate streambank alteration at each sampling quadrat at the predetermined sampling interval along the entire DMA.

4. *Streambank Stability and Cover*

Step 1. Identify the streambank. Streambank stability is assessed on that part of the streambank between the scour line and the lip or edge of the first relatively flat bench above the scour line (for erosional banks, and the top of the bar for depositional banks). The top of the bar is commonly about the same elevation as the bankfull stage, which is associated with the floodplain elevation.

- Locate the scour line. The scour line is generally identified by (1) the lower limit of sod-forming or perennial vegetation on depositional banks, or (2) the ceiling of undercut banks at or slightly above the base-flow elevation, or (3) the elevation of the trim line or erosional line that forms on erosional banks and which corresponds to the elevation of undercut banks elsewhere in the DMA. The scour line is best observed on a straight, well-vegetated section of a reach. Look upstream, downstream, and across the channel for a consistent elevation that matches the description of the scour line. The scour lines are not always continuous; however, by noting the approximate elevation or height above the water surface where scour lines are well defined, one can extrapolate or project them to streambanks where scour lines are not evident due to a lack of

greenlines on the opposite streambanks. In addition, there shouldn't be any bare spots larger than a 10 cm x 10 cm patch.

- Establish a single cross-valley transect to maintain maximum separation of adjacent transects across the island and two (or more) channels. At each unvegetated/uncovered segment, create a vector that originates on the cross-valley transect and is oriented perpendicular to streamflow. Measure the uncovered length of each vector and add the cumulative lengths to determine the GGW for each cross-valley transects.

Note: The inclusion of embedded rock and anchored wood as qualifying cover is a change from the 2011 version of MIM (Burton et al. 2011). Users should make note of this change if the DMA has a significant trend in GGW that is the result of this rule change and not from a change in channel shape or streambank conditions.

Note*:* Emergent or floating aquatic vegetation that are in water are not qualifying cover, mainly because these plants would be below the scour line and part of the active channel. Qualifying cover (vegetation, embedded rock, and/or anchored wood) must be above the scour line.

7. Woody Riparian Species Age Class

Step 1. Locate the woody riparian species age class quadrat. The woody riparian species quadrat is 1 m x 2 m wide, centered on the greenline (1 m on each side of the greenline.

- For very narrow streams with woody plants in the channel, the width of the woody riparian species age class quadrat does not extend beyond the middle of the channel (this will also avoid sampling plants rooted on the opposite bank).
- **Bottom of the DMA:** If the bottom marker interrupts the woody riparian species age-class quadrat (i.e., shortens the quadrat), record only those woody plants from the sample point to the bottom marker (see Section 4).

Step 2. Identify all woody riparian plants rooted within the 1 m x 2 m quadrat. Woody riparian plants are those with a ***wetland indicator status*** rating of facultative, facultative wetland, or obligate. Record all woody riparian plants in the quadrat.

- An effective way to layout the quadrat is to lay the frame down along the greenline with the handle on the ground. Place the rod across the greenline with the 1 m mark centered on the greenline. To determine if a plant is in the quadrat, move the 2 m rod to the end of the handle and identify all woody riparian plants in the quadrat. There are other ways to layout the quadrat with the frame and rod; however, the most important aspect is to ensure that the 1 m x 2 m quadrat is centered on the greenline.
- Look carefully and closely at the ground surface to locate any woody riparian plants in the quadrat. Seedlings can be very small and are often hidden in herbaceous vegetation.
- Distinguish individual plants can sometimes be difficult. To distinguish individual plants from one another when shrubs have multiple stems growing close together, consider all stems within 30 cm (12 in) of each other at ground level as the same plant. Record the age class of the entire shrub to which that stem is connected,

- Pay special attention to the vector that is perpendicular to streamflow around meander bends. Being off by a few degrees on a meander can generate high observer errors in calculating GGW.

- Do not measure GGW when there is no greenline. If the greenline composition is marked "NG" leave the GGW measurement blank for the same quadrat. Similarly, if there is no greenline within 6 m of the channel on the opposite bank, leave the GGW measurement blank.

- When vegetation occupies the entire channel (i.e., the vegetated drainageway), do not record the GGW.

- If using a laser rangefinder, make sure to align the objective of the rangefinder directly above the greenline. Standing on or next to the greenline but holding the rangefinder 1 dm or more off the greenline introduces unnecessary error to a simple and repeatable measurement. The measuring rod can be positioned vertically on the greenline to help align the rangefinder and minimize errors.

- It can be difficult to acquire a laser target in woody vegetation. If one bank is covered in dense woody vegetation, use the 2-m measuring rod to obtain a measured increment from the vegetated bank and then add the laser rangefinder distance from the end of the rod to the opposite greenline.

- When calculating GGW around islands or braided channels, the idea of main streamflow can become confusing as each sub-channel might have a different orientation. In fact, if lines are projected perpendicular to flow across islands, it is possible that the trajectory of one GGW path crosses the trajectory of another GGW path. Therefore, **in multiple channel situations, establish one cross-valley transect** and measure the cumulative unvegetated or uncovered width (illustrated in black line segments) of each unvegetated vector that originates from the cross-valley transect. This cross-valley transect should be oriented to maximize separation with adjacent GGW transects to avoid introducing spatial autocorrelation to adjacent GGW measurements.

- Where 2 or more channels exist in a cross section and there is no vegetated island, the GGW is measured on lines perpendicular to streamflow in each channel to a point where the lines from adjacent channels intersection.

- Keep in mind, multi-channel situations are the exception, not the norm, and GGW is likely not a major indicator of trend in these situations, especially in braided systems that are inherently unstable and have high rates of sediment movement.

Step 2. Exclude qualifying cover measurements on islands. When an island has qualifying cover (i.e., at least 25% foliar cover of perennial vegetation, embedded rock (≥ 15 cm in the intermediate axis or b-axis), and/or anchored wood) along the greenline-to-greenline transect, exclude the length of qualifying cover to obtain the GGW. Qualifying cover must be above the scour line.

- The GGW transect should be thought of as a 50-cm band from the greenline on one bank to the greenline on the other bank. However, any part of this band that contains at least 25% qualifying cover is excluded from the distance between

vegetation, bank trampling, or collapsed of undercut banks. For example, if the ceiling of undercut banks and the lower limit of sod-forming vegetation are located 5 cm (2 in) above the water-surface elevation, then that height above water surface is used consistently at all quadrat locations to define the location of the scour line, even where evidence of a scour line is locally absent.

- Locate the first bench above the scour line. The lip or edge of the first bench is the point on the streambank where the slope changes from the relatively flat top to the slope toward the stream. The first relatively flat bench may coincide with an in-channel depositional bar below the floodplain, with the top of the bank at the floodplain elevation, or with the lip of a terrace above the bankfull stage. On depositional banks, the bench is commonly associated with a gentler slope break and may not be distinct. And on erosional banks, such as cutbanks located on the outside bank of a meander bend, the evaluated streambank and cover quadrat may extend to the edge of a terrace. In stable systems, the edge of the first bench and the top of the bar commonly coincides with the floodplain or bankfull elevation.

Step 2. Locate the streambank stability and cover quadrat. The streambank stability and cover quadrat is 50 cm long (i.e., the length of the MIM frame), extends from the scour line to the lip of the first bench, and runs straight up the streambank. This means that the width of the stability and cover quadrat will vary depending on the distance between the scour line and the first bench. The lip of the first bench is the point where the slope changes from a relatively flat surface to the slope inclined toward the stream channel.

- Always assess streambank stability and cover when streamflow is at or below the scour line.

- Small intermittent channels with relatively dense perennial vegetation growing in the streambed (with no observable scour line, i.e., no undercut banks and the lower limit of sod is into the channel bottom) are sometimes encountered. In those cases, the streambank stability and cover quadrat is from the edge of the active channel (which typically coincides with where the channel bed meets the upward inclined streambank) and extends up the streambank to the lip of the first bench. Note that the active channel is defined in the MIM protocol as the channel bed up to the scour line.

- The greenline might coincide with or be above the scour line. The lower end of the stability and cover quadrat is not determined by the greenline, it is established by the scour line (although many times the greenline and the scour line are the same).

- Do not include any part of the channel below the scour line or within the active channel when determining streambank stability and cover. The streambed is not part of the streambank.

- The streambank stability and cover quadrat is always oriented perpendicular (straight up the streambank) and is not oriented to the greenline. Because the MIM frame can be rotated up to 75 degrees to follow the greenline, it is important to orient the stability and cover plot straight up the streambank and to avoid offsetting it whenever the direction of the greenline deviates from the horizontal contour of the streambank.

Step 3. Determine the kind of streambank in the quadrat. Address each of three questions to determine streambank stability and cover.

Question 1: What kind of streambank is it?

The choices are depositional (D) or erosional (E), which are defined as:

- **Depositional (D)** – This applies to all streambanks associated with sand, silt, clay, or gravel deposited by the stream. These are recognizable as "bars" along the channel margins adjacent to the greenline and at or above the scour line. Bars are typically lenticular-shaped mounds of deposition adjacent to the streambank. Depositional streambanks are usually at a low angle from the water surface (generally, but not always < 30°) and are not associated with a distinct bench. Depositional banks are common on the inside bank of a meander bend and may also occur along straight reaches. They are uncommon on outside banks of meander bends.

  Note: Small deposits of fine sediment or micro-features in the streambank or channel bed at or near the water's edge do NOT denote depositional banks. Depositional banks are a macro-feature of the stream channel and usually extend to approximately the bankfull elevation of the stream channel. It is important to ignore small patches of ***fines*** when designating the kind of bank.

- **Erosional (E)** – This applies to all remaining banks that are not identified as depositional. Erosional streambanks are normally at a steeper angle to the water surface (generally, but not always, more than 30°) than are depositional banks and are usually associated with an apparent bench, floodplain, or terrace. Such banks typically occur on the outside of meander bends and on both sides of the stream in straight reaches. When there is sufficient stream energy, erosional banks may also occur on the inside bank of a meander bend. For deep, narrow stream channels, erosional banks are dominant on both sides of the stream.

Question 2: Is the streambank covered?

View the quadrat perpendicular to the ground surface. Record covered (C) or uncovered (U) bank, which are defined as:

- **Covered (C)** – The applies to banks within the streambank stability and cover quadrat that have 50% or more absolute cover of one or a combination of the qualifying cover categories described below:

  - The cover quadrat has at least 50% absolute foliar cover of perennial vegetation within 50 cm from the soil surface (i.e., no more than 50 cm above the ground surface of the quadrat). Absolute foliar cover is the percent of the ground surface that is covered by the aerial portions (leaves and stems) of plants when viewed from above.

Note: Vegetation does not need to be rooted in the quadrat. Tall graminoids or shrub branches draped over the streambank stability and cover quadrat are considered cover provided they are within 50 cm (20 in) of the soil surface,

6. Greenline-to-Greenline Width

Step 1. Measure the horizontal distance between the greenlines on each side of the stream and perpendicular to the streamflow. The GGW can be measured with the 2-m measuring rod, a measuring tape, or a laser rangefinder. Each measuring device has advantages and disadvantages depending on the channel characteristics and types of vegetation communities on the streambanks. For example, a laser rangefinder may be the most expedient way to measure GGW but may be difficult where streambanks are covered in woody vegetation, and it is hard to obtain a reliable laser target. A rangefinder can take two-thirds less time to make measurements in an herbaceous-dominated community than the 2-m measuring rod. The measuring rod and tape are less expensive options. The measuring rod can be efficient where the channel is ≤ 4 m wide or where the banks are physically inaccessible because of dense woody vegetation. A measuring tape, while precise, can be quite tedious and slow. If the tape is being used to also locate sampling locations for substrate, it makes sense to also use it for GGW, though GGW is not always equal to the active channel width (scour line to scour line width) used to determine substrate sampling locations.

Measure from the greenline associated with the center bar on the monitoring frame. When the frame is rotated because the greenline is not parallel to the streamflow, measure GGW on the downstream end of the frame. Measuring consistently from the same end of the frame will improve observer agreement. Measure GGW to the nearest decimeter (0.1 m). The orientation of the GGW measurement must be a single straight line perpendicular to the average direction of streamflow. The measurement line does not bend for minor changes in streamflow direction within the channel.

- Measure the horizontal distance between the greenlines perpendicular to the streamflow and record this distance to the nearest decimeter (0.1 meter). GGW is a straight line and does not bend.
- For consistency, measure the distance from the downstream end of the frame, which coincides with the "start" of the sample point.
- GGW is a measure of horizontal distance, not slope distance; therefore, it is important to hold the tape or rod as close to level as possible when making this measurement. If using a laser rangefinder, ensure that it has a specific horizontal distance mode and ensure that the device is set on that mode.
- **GGW is measured at each sample point in the upstream direction only**. Measurements are not made when collecting data in the downstream direction to avoid a potential issue related to spatial autocorrelation.
- Stand in the channel and downstream of the GGW transect to best judge the predominant streamflow path. Sometimes an individual standing on the streambank has a better vantage point to determine flow paths and can help orient the measuring rod, tape, or viewing direction of laser rangefinder so that GGW is measured perpendicular to streamflow.

- If the selected key species(s) do not comprise a 7.5-cm diameter tuft anywhere in the quadrat but occurs as an individual plant or several individual plants < 7.5 cm in diameter, select the key plant species(s) nearest the inside corner of the quadrat by the handle.
- If the selected key species do not occur anywhere in the quadrat, do not record a key species for that quadrat.

Step 4. Measure the stubble height. Use a ruler with 1-inch increments to determine median stubble height. Measure the median leaf length of all the leaves of the key species plant(s) within the 7.5 cm circle and round it to the nearest inch. Alternatively, use a metric ruler with 1-cm increments, note the units, and round it to the nearest 2-centimeter increment.

Note: Make sure the zero mark on the ruler begins at the edge of the ruler. Some rulers include a blank margin before the zero mark. Do not use rulers with these margins.

- Determining the median residual vegetation height will take some practice. Be sure to include all of the key species' leaves within the sample. The easiest method of doing this is to grasp the sample near the base of the leaves, stand the leaves upright, move the hand up the leaves until about half of them fall away, and then measure the height at that location.
- If part of the plant or the 7.5-cm circle occurs outside the quadrat, measure the median leaf length of the entire plant or 7.5-cm circle, even though part of the plant is outside the quadrat.
- Measure and record the stubble height for each key species found within each quadrat.
- Do not measure seed stalks (culms) on grass and sedge species. Grasses in particular have tall and relatively unpalatable culms and relatively short basal leaves.

Note: Some species of spikerushes (*Eleocharis* spp.), rushes (*Juncus* spp.), and bulrushes (*Schoenoplectus* spp., *Scirpus* spp.) have relatively palatable, leaflike culms that are commonly grazed. For these species, include culms in the measurement of stubble height.

Step 5. Record the plant species, stubble height, and presence of grazing. Record the USDA-NRCS PLANTS Database species code and the stubble height to the nearest 1 inch (or alternatively, to the nearest 2-cm increment).

- Mark a Y (Yes) in the 'grazed' column if it appears that the plant you are measuring has been grazed. Mark an N (No) in the 'grazed' column if it appears that the plant being measured has not been grazed. This estimate allows practitioners to distinguish samples that are clearly grazed from those that are not. Stubble height data will be summarized for all key species, all grazed key species, and all ungrazed key species. This is useful for developing utilization estimates based on height-weight relationships. If there are no key herbaceous species within the quadrat, leave blank.

within the vertical projections of the quadrat, and are attached to the soil either inside or outside the quadrat.

Note: Senesced, dormant, and dead plants are counted as cover if they are rooted/attached in the soil. (Also note, this description of cover, used to determine streambank cover, is not the same as the cover criteria used to identify the greenline). Detached plant matter is regarded as litter or debris and is not cover unless it is anchored wood.

- The cover quadrat has at least 50% absolute cover of live exposed roots of perennial vegetation.
- The cover quadrat has at least 50% absolute cover of rocks with a diameter (as measured by the intermediate axis or b-axis) of 15 cm (6 in) or greater (refer to Substrate Section 6.2.6 for a description of the intermediate axis (or b-axis). The rock does no need to be embedded. Include bedrock as rock cover.
- The cover quadrat has at least 50% absolute cover of anchored large woody debris with a diameter of 10 cm (4 in) or greater (standing dead trees/roots and root wads are considered large woody debris).
- The cover quadrat has at least 50% absolute cover in a combination of perennial vegetation, roots, qualifying rock (≥ 15 cm intermediate axis) and/or LWD.

- **Uncovered (U)** – This applies to all banks that are not covered, meaning the streambank cover quadrat has < 50% cover of perennial vegetation, rock, and anchored wood. Uncovered banks are commonly represented by inorganic material (i.e., soil and small rocks ≤ 15 cm in intermediate or b-axis diameter) as well as organic material such as litter, fine debris, moss, etc. that are susceptible to displacement by streamflow.

After reviewing the criteria above, determine the absolute cover for each of the cover constituents: (1) perennial foliar vegetation cover, (2) rock, and (3) large wood. Record each cover constituent to the nearest 10%. If two or more cover types overlap, do not add the overlap amounts; only record the portion of overlapping cover closest to or directly on the ground surface (e.g., record rock on the ground and not the overlapping vegetation cover immediately above the rock). Do NOT include annual plants, moss, bare ground, and/or litter in these estimates.

Question 3: Is the streambank stable? This question applies to erosional banks only. No response is recorded for depositional banks, as covered depositional banks are considered stable and uncovered depositional banks are unstable. For erosional banks, determine if one of the instability features (***fracture***, ***slump***, ***slough***, or ***eroding***) is present, or if instability features are ***absent***. If more than one instability feature is present, select the single most-prominent feature. Each feature class is illustrated in Appendix H and described below.

- **Fracture (F)** – A fracture is a visible crack at the top of streambank where the fracture-bounded area has not detached entirely from the streambank (i.e., it is not yet a discrete slump block as defined below). Fractures indicate a high risk of breakdown or streambank failure. To qualify, the fracture must be at least one-fourth of a frame length (12.5 cm).

Note: The fracture feature might express itself on the surface at the top of the bank or first bench but recognize that the fracture plane extends underneath the slump to an elevation below the top of the first bench, and thus it counts as a feature of stability within the bank stability plot.

- **Slump (SP)** – This applies to a portion of streambank that has obviously slipped, resulting in a block of soil and/or sod separated from the streambank. Some slump blocks are the result of hoof shear, causing displacement of a small portion of streambank downward. Other slump blocks represent collapses of large sections of the streambank considerably wider than the monitoring frame. The slump feature must be obvious and at least one fourth of the frame length (12.5 cm).
- **Slough, or sluff (SF)** – This applies to streambanks where loose, disaggregated soil or sod material has been shed or cast off and has accumulated either on an inclined slope or at the base of a vertical or nearly vertical streambank. The slough must be obvious and at least one-fourth of the frame length (12.5 cm). Slough commonly forms from ungulate trampling on a streambank, as well as by the freeze-thaw cycles, wetting and drying, and other processes that form dry ravel. Dry ravel is defined as loose, unconsolidated, disaggregated particles moved by gravity down a slope (Gabet 2003).
- **Eroding (E)** – Eroding features are bare and usually steep (within 10 degrees of vertical), and usually located on the outside bank of meander bends. Sometimes erosional features are encountered that are not steep (i.e., not within 10 degrees of vertical), do not have fractures, slumps, or slough, but they are bare and eroding. Such banks are not stable and are therefore designated as eroding. The erosion feature must be obvious and at least one-fourth of a frame length (12.5 cm).

  Note: Undercut streambanks are scoured or eroded below the elevation of the base of sod or the roots of vegetation, and because such erosion occurs mostly below the scour line, it is not considered an eroding bank. Such undercut streambanks are stable if there is no slough, slump, fracture, and/or erosion above the scour line or ceiling of the undercut bank.
- **Absent (A)** – This applies when none of the above-listed characteristics are present. Absent implies a stable streambank**.**

5. Stubble Height

Step 1. Conduct a reconnaissance to determine key graminoid species. ***Key graminoid species*** are grass and grass-like plants that are relatively palatable to grazing animals, relatively abundant, important for stream/riparian function and habitat, and serve as indicators of environmental and management changes. Stabilizing ***hydrophytic*** species make effective key species due to their contributions to soil stability and wetland function.

- If stabilizing hydrophytic graminoids are severely lacking or absent, choose palatable and relatively abundant non-stabilizing mesic (or hydrophytic)

graminoids, even if they are not part of the desired plant community. Examples of common palatable mesic graminoids that are not generally considered to be desirable in the plant community include Kentucky bluegrass (*Poa pratensis*), creeping bentgrass (*Agrostis stolonifera*), meadow foxtail (*Alopecurus pratensis*), etc. Observers should make every effort to identify the plants used for key species, however, it is acceptable to use graminoid groups if necessary (e.g., mesic graminoid – MG, or Carex Rhizomatous - CAREXRH).

Note: Avoid using prostrate (i.e., ground-hugging) graminoids for key species, for example, brookgrass (*Catabrosa aquatica*), or prostrate forms of creeping bentgrass (*Agrostis stolonifera*).

- More than one key species may be used; collectively, the combination of all key species should be abundant enough for an adequate sample to be obtained (preferably at least 50 samples per DMA). Generally, no more than four key species are used at a DMA.
- Make a list of key species using the USDA-NRCS PLANTS Database species codes. Indicate whether the measurements are made in inches or centimeters (default is inches as most grazing-use criteria are defined in inches).
- If it is not possible to sample at least 50 plants due to a lack of key species, stubble height data is still informative; however, the smaller sample size will decrease data precision.
- When moving from one end of the DMA to the other while observing plants, it is important to avoid trampling vegetation on the greenline. Where possible, greenline plants should be observed from the stream channel, which allows a good observation position at right angles to the streambank and avoids trampling the greenline.

Step 2. Locate the stubble height quadrat. This is the same 20 cm x 50 cm quadrat used for the greenline composition and woody species height class methods.

Step 3. Locate the available key species within the stubble height quadrat. Locate each available key species that occurs nearest to the inside corner of the quadrat near the handle of the frame. When the key species is not located within the inside corner of the quadrat, search the entire quadrat and locate the key species closest to the inside corner.

- ***Available key graminoids*** are plants that are accessible to grazing animals. ***Unavailable key graminoids*** are those that are completely inaccessible to grazing animals (e.g., located beneath dense woody overstories, rock outcrops, or on steep slopes).
- Most riparian graminoid species grow tightly together, forming dense mats with little distinct separation of individual plants. As a result, the sampling method uses a 7.5-cm (3-in) diameter circle of the vegetation (tuft) for a single species. Even if part of the 7.5-cm diameter patch is outside the quadrat, measure the entire 7.5-cm patch.
- If multiple individuals of the same key species occur within the quadrat, only the individual plant located nearest to the inside corner is measured.