U. S. LENTIC WETLAND ECOLOGICAL HEALTH ASSESSMENT
(Derived by the computer from the U. S. Lentic Wetland Inventory Form)
USER MANUAL
(Current as of 5/24/2017)

This document is intended to accompany the *U. S. Lentic Wetland Ecological Health Assessment Form* that uses data contained in the *U. S. Lentic Wetland Inventory Form.* Another form entitled the *U. S. Lotic Wetland Ecological Health Assessment* is available for lotic (flowing water) wetlands.

ACKNOWLEDGEMENTS

Development of these assessment tools has been a collaborative and reiterative process. Many people from many agencies and organizations have contributed greatly their time, effort, funding, and moral support for the creation of these documents, as well as to the general idea of devising a way for people to look critically at wetlands and riparian areas in a systematic and consistent way. Some individuals and the agencies/organizations they represent who have been instrumental in enabling this work are Dan Hinckley, Tim Bozorth, and Jim Roscoe of the USDI Bureau of Land Management in Montana; Karen Rice and Karl Gebhardt of the USDI Bureau of Land Management in Idaho; Bill Haglan of the USDI Fish and Wildlife Service in Montana; Barry Adams and Gerry Ehlert of Alberta Sustainable Resource Development; Lorne Fitch of Alberta Environmental Protection; and Greg Hale and Norine Ambrose of the Alberta Cows and Fish Program.

BACKGROUND INFORMATION

Introduction

Public and private land managers are being asked to improve or maintain wetland (lentic) habitat and water quality on lands throughout the West. Three questions that are generally asked about a wetland site are: 1) What is the potential of the site (e.g., climax or potential natural community)? 2) What plant communities currently occupy the site? and 3) What is the overall health (condition) of the site? For a lentic site (wetlands adjacent to non-flowing water bodies), the first two questions can be answered by using the U. S. Lentic Wetland Inventory Form along with a document such as *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen and others 1995), *Classification and Management of USDI Bureau of Land Management's Riparian and Wetland Sites in Eastern and Southern Idaho* (Hansen and Hall 2002), *Classification and management of upland, riparian, and wetland sites of USDI Bureau of Land Management's Miles City Field Office, eastern Montana USA* (Hansen and others 2008), or a similar publication written for the region in which you are working. The health question can be answered by using this *U. S. Lentic Wetland Ecological Health Assessment,* which summarizes data collected in the *U. S. Lentic Wetland Inventory Form.*

This lentic ecological health assessment provides a site rating useful for setting management priorities and stratifying wetland sites for remedial action or more rigorous analytical attention. We use the term lentic [still water wetland] health to mean the ability of a lentic wetland to perform certain functions. These functions include sediment trapping, shoreline maintenance, water storage, aquifer recharge, wave energy dissipation, maintenance of biotic diversity, primary production, and wildlife habitat. More detailed discussions of wetland terminology, including lotic and lentic wetlands as well as jurisdictional and functional wetlands, can be found in the *Lentic Wetland Inventory Form User Guide.*

Lentic Wetland Ecological Health

The health of a lentic site (a wetland located adjacent to a still water body) may be defined as the ability of that system (including the saturated and inundated near-shore emergent wetland and all the shoreline area that is influenced by the lentic waters) to perform certain wetland functions. These functions include sediment trapping, shoreline maintenance, water storage, aquifer recharge, wave energy dissipation, primary biotic production, and wildlife habitat. A site's health rating may also reflect management considerations. For example, although *Centaurea maculosa* (spotted knapweed) or *Euphorbia esula* (leafy spurge) may help to trap sediment and provide soil-binding properties, other functions (i.e., productivity and wildlife habitat) will be impaired; and their presence should be a management concern. Excellent sources of practical ideas and tips on good management of these wetland sites in Alberta are found in *Caring for Shoreline Properties* (Valastin and others 1999) and *Caring for the Green Zone* (Adams and Fitch 1995), and *Riparian Areas: A User's Guide to Health* (Fitch and Ambrose 2003). In Saskatchewan some excellent resources are *Streambank Stewardship, Your Guide to Caring For Riparian Areas in Saskatchewan* (Huel 1998) and *Managing Saskatchewan Wetlands—A Landowner's Guide* (Huel 2000).

No single factor or characteristic of a wetland site can provide a complete picture of either site health or the direction of trend. The lentic wetland ecological health assessment is based on consideration of physical, hydrologic and vegetation factors. It relies heavily on vegetative characteristics as integrators of factors operating on the landscape. Because they are more visible than soil or hydrological characteristics, plants may provide early indications of riparian health as well as successional trend. These are reflected not only in the types of plants present, but also by the effectiveness with which the vegetation carries out its wetland functions of stabilizing the soil, trapping sediments, and providing wildlife habitat. Furthermore, the utilization of certain types of vegetation by animals may indicate the current condition of the wetland and may indicate trend toward or away from potential natural community (PNC).

In addition to vegetation factors, an analysis of site health and its susceptibility to degradation must also consider physical factors (soils and hydrology) for both ecologic and management reasons. Changes in soil or hydrologic conditions obviously affect the function of a wetland ecosystem. Moreover, degradation in physical characteristics are often (but not always) more difficult to remedy than vegetative degradation. For example, downcutting of an unstable overflow point may lower the water table and thus change site potential from a *Typha latifolia* (common cattail) habitat type to an *Agropyron smithii* (western wheatgrass) habitat type or even to an upland type. Sites experiencing significant hydrologic, edaphic (soil), or climatic changes will likely also have new plant community potential.

This ecological health assessment is not designed to serve as an in-depth and comprehensive analysis of ecologic processes. Such analysis may be warranted on a site and can be done after this evaluation has identified particular areas of concern. Nor does this approach yield an absolute rating to be used in comparison with wetlands in other areas or of other types. Appropriate comparisons using this rating can be made between neighboring wetlands of similar size and type and between subsequent assessments of the same site.

The assessment procedure has been tested in Montana, Idaho, North Dakota, South Dakota, and other surrounding states and western Canada since 1992. Some potential uses for this rating are: 1) for stratifying wetlands by degree of ecologic dysfunction, 2) for identifying ecologic problems, and 3) when repeated over time, for monitoring to detect functional change. A less direct, but also important, value of an environmental assessment of this kind is its educational potential. By getting land managers to focus on individual riparian functions and ecologic processes, they may come to better understand how the parts work together and are affected by human activities.

A single evaluation provides a rating at only one point in time. Due to the range of variation possible on a wetland site, a single evaluation cannot reliably indicate trend (whether the site is improving, degrading, or stable). To monitor trend, ecological health assessments should be repeated in subsequent years during the same time of year. Evaluation should be conducted when most plants can be identified in the field and when hydrologic conditions are most nearly normal (e.g., not during peak spring runoff or immediately after a major storm). Management regime should influence assessment timing. For example, in assessing trend on rotational grazing systems, one should avoid comparing a rating after a season of use one year to a rating another year after a season of rest.

There are some visible changes to riparian area health which we have no simple way to measure. An obvious and commonly encountered example is excess entrained sediment. This may indicate serious degradation, but we leave it out of the assessment due to difficulty in knowing how much is normal. Instead, we address on-site causes of sediment production: bare ground, shoreline with poor root mass protection, and human-caused structural damage to the shoreline.

DATA FORM ITEMS

Record ID No. This is the unique identifier allocated to each polygon. This number will be assigned in the office when the form is entered into the database.

Administrative Data
A1. Agency or organization collecting the data.

A2. Funding Agency/Organization.

A3a. BLM (Bureau of Land Management) State Office.

A3b. BLM Field Office/Field Station.

A3c. BLM Office Code (recorded in the office).

A3d. Is the polygon in an active BLM grazing allotment (recorded in the office)?

A3e, f. For BLM polygons, the BLM Office Code, whether the polygon is in an active BLM grazing allotment, and the Allotment Number is supplied by the BLM. These items are entered into the computer in the office; the computer then references a master list of Allotment ID's to complete the remaining Allotment information. Because some polygons incorporate more than one Allotment, space is provided to enter two sets of Allotment information. The master Allotment list is periodically updated by the BLM National Applied Resource Sciences Center to make needed corrections.

A4. USDI Fish and Wildlife Service Refuge name.

A5. Indian Reservation name.

A6. USDI National Park Service Park/National Historical Site name.

A7. USFS (Forest Service) National Forest name.

A8. Other location.

A9. Year the field work was done.

A10. Date of field work by day, month, and year.

A11. Names of all field data observers.

NOTE: Information for items **A12a-h** is found in the office; field evaluators need not complete these items.

A12. The several parts of these items identify various ways in which a data record may represent a resampling of a polygon that may have been inventoried again at some other time. The data in this record may have been collected on an area that coincides precisely with an area inventoried at another time and recorded as another record in the database. It may also represent the resampling of only a part of an area previously sampled. This would include the case where this polygon overlaps, but does not precisely and entirely coincide with one inventoried at another time. One other case is where more than one polygon inventoried one year coincides with a single polygon inventoried another year. All of these cases are represented in the database, and all have some value for monitoring purposes, in that they give some information on how the status on a site changes over time. ***This is done in the office with access to the database; field evaluators need not complete these items.***

A12a. Has any part of the area within this polygon been inventoried previously, or subsequently, as represented by any other data record in the database? Such other records would logically carry different dates.

A12b. Does the areal extent of this polygon exactly coincide with that of any other inventory represented in the database? In many cases, subsequent inventories only partially overlap spatially. The purpose of this question is to identify those records that can be compared as representing exactly the same ground area.

A12c. Does this record represent the latest data recorded for this site (polygon)?

A12d. If A12b is answered Yes, then enter the record ID number(s) of any other previous or subsequent re-inventories (re-samplings) of this exact polygon for purposes of cross-reference.

A12e. Enter the years of any records recorded in item A12d as representing other inventories of this exact polygon.

A12f. Even though this polygon is not a re-inventory of the exact same area as any other polygon, does it share at least some common area with one or more polygons inventoried at another time?

A12g. Enter the years of any other inventories of polygons sharing common ground area with this one.

A12h. If A12f is answered Yes, then enter the record ID number(s) of any other polygon(s) sharing common ground area with this one.

A13a. Has a management change been implemented on this polygon?

A13b. If A13a is answered Yes, in what year was the management change implemented?

A13c. If A13a is answered Yes, describe the management change implemented.

Location Data
B1. State in which the field work was done (recorded in the office).

B2. County or municipal district in which the field work was done (recorded in the office).

B3. This field for allotment, range, or management unit is intended for entities other than the BLM to use for grouping polygons by management unit. The BLM management units are grouped using the grazing allotment information in A3 above.

B4a. For lentic polygons the area is usually listed as a lake name, or other local designation that identifies the area where the inventory is conducted. If possible, use a name that is shown on the 7.5 minute topographic map.

B4b. Record the stream (if there is one) with which the inventoried lentic wetland is associated. Such association may be by inlet or outlet surface flow, or by general ground water (sub surface) connection.

B4c, d. Polygons are grouped together for management purposes. For example, all polygons around Henry's Lake in the Idaho Falls Field Office could be identified as Group Name: Idaho Falls Field Office; Group Number: 1 (recorded in the office).

B5. Polygon number is a sequential identifier of the portion of the area assessed. This is referenced to the map delineations. Sequences normally progress clockwise.

B6. Elevation (feet or meters) of the polygon midpoint. Elevation is interpolated from the topographic map(s).

B7a. Record the latitude and longitude of the polygon, along with the GPS projection and accuracy. Record the degrees, minutes, and seconds, along with decimal degrees. ***NOTE: All of North America is latitude = North, and longitude = West.***

B7b. Record any comments pertaining to the "other" location.

B8. Identity the hydrologic unit code(s) (HUC) associated with the reach of stream contained in the polygon are recorded. The HUC data is obtained from the US Geological Survey (USGS) National Hydrography Dataset (NHD) (USGS 2012). Based on the finest level of resolution available from the USGS for the stream reach, the levels of HUC information are entered by the computer onto the form. The USGS has divided the nation into successively smaller hydrologic units, based on drainage basins and watersheds. These units fit into hierarchical levels, uniquely identified by a pair of digits for each successive level (i.e., an eight-digit number identifies a drainage at the fourth (subbasin) level; and a twelve digit HUC identifies one at the sixth (subwatershed) level (Figure 1).

As defined by the USGS (2012), a ***hydrologic unit*** is "a drainage area delineated to nest in a multi-level, hierarchical drainage system. Its boundaries are defined by hydrographic and topographic criteria that delineate an area of land upstream from a specific point on a river, stream or similar surface waters. A hydrologic unit can accept surface water directly from upstream drainage areas, and indirectly from associated surface areas such as remnant, non-contributing, and diversions to form a drainage area with single or multiple outlet points. Hydrologic units are only synonymous with classic watersheds when their boundaries include all the source area contributing surface water to a single defined outlet point."

Provision is made on the data form for multiple HUC units, because a polygon may include all, or part, of more than one HUC unit (especially when finer levels, such as the subwatershed [sixth] level, are identified).

The HUC data provided includes these items:

- HUC identification number to as many digits as have been delineated by USGS, down to the sixth level (12 digits);
- River miles of the stream from this HUC unit that fall within this polygon;
- Percent of the polygon stream reach that is located in this HUC unit (e.g., 100 percent if the entire polygon is all in one HUC unit;
- Name of the region (first level of the HUC) (and its size in square miles);
- Name of the subregion (second level of the HUC) (and its size in square miles);
- Name of the basin (third level of the HUC) (and its size in square miles);
- Name of the subbasin (fourth level of the HUC) (and its size in square miles);
- Name of the watershed (fifth level of the HUC) (and its size in square miles); and
- Name of the subwatershed (sixth level of the HUC) (and its size in acres).

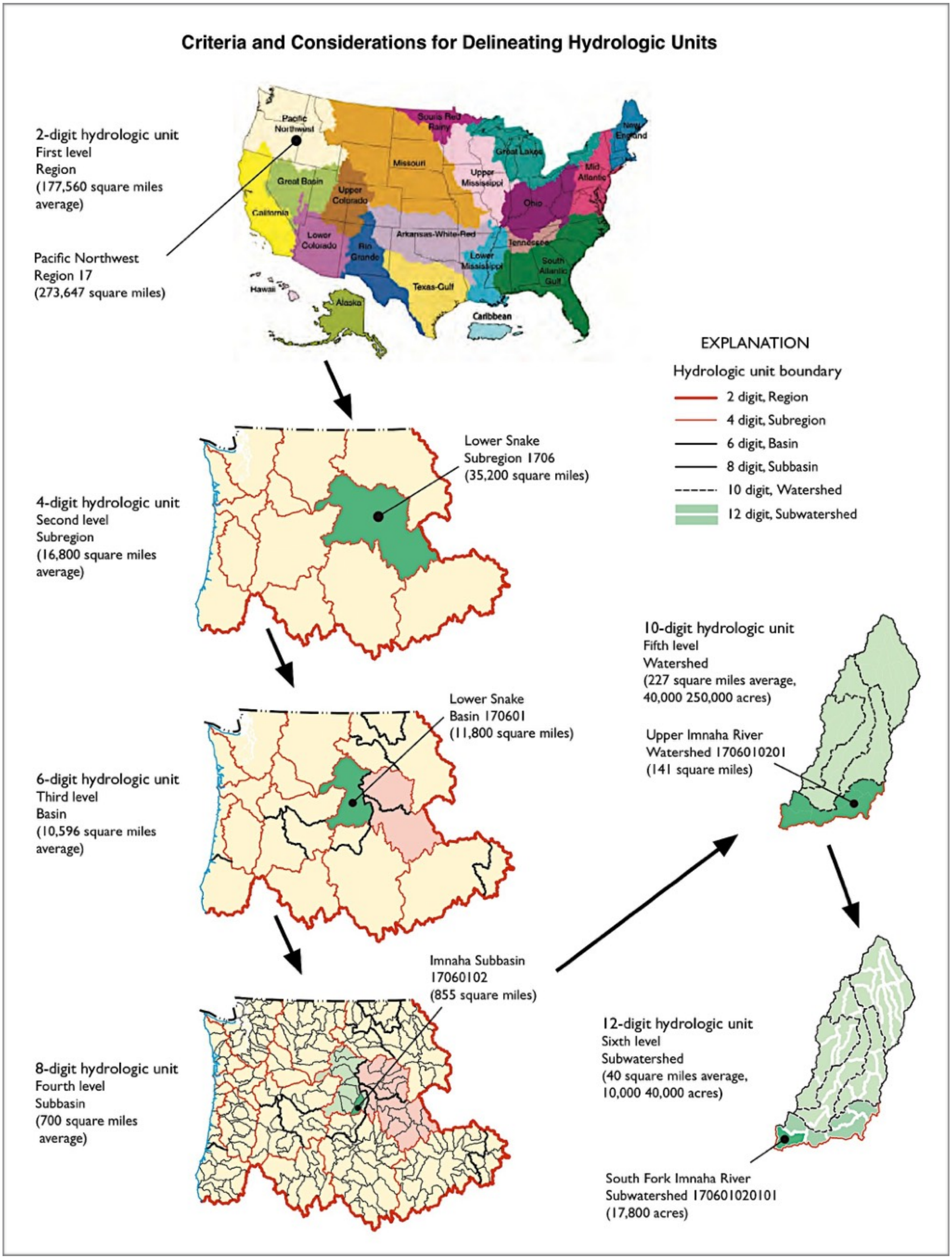

Figure 1. Hierarchy for the six nested levels of hydrologic units, as they are successively subdivided, and the numbering scheme increases by two digits for each level of greater resolution (adapted from the USGS 2012)

Selected Summary Data

C1. Wetland type is a categorical description of predominant polygon character. Select from the following list of categories that may occur within a lentic system the one that best characterizes the majority of the polygon. Observers will ***select only one category*** as representative of the entire polygon. If a significant amount of other categories are present, indicate this in Vegetation Comments (item D17) or consider dividing the original polygon into two or more polygons.

Category Description

Wet Meadow. A grassland with waterlogged soil near the surface, but without standing water for most of the year. This type of wetland may occur in either riparian (lotic) or in still water (lentic) systems. A lotic wet meadow has a defined channel or flowing surface water nearby, but is typically much wider than the riparian zone associated with the classes described above. This is often the result of the influence of lateral groundwater not associated with the stream flow. Lotic and lentic wet meadows may occur in proximity (e.g., when enough groundwater emerges to begin to flow from a mountain meadow, the system goes from lentic to lotic). Such communities are typically dominated by herbaceous hydrophytic vegetation that requires saturated soils near the surface, but tolerates no standing water for most of the year. This type of wetland typically occurs as the filled-in basin of old beaver ponds, lakes, and potholes.

Marsh. A frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions. A marsh generally has a mineral soil substrate does not accumulate peat.

Fen. A peat-accumulating wetland that receives some drainage from surrounding mineral soil and usually supports marsh-like vegetation.

Bog. A peat-accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly sphagnum.

Spring/Seep. Groundwater discharge areas. In general, springs have more flow than seeps. This wetland type may occur in a riparian (lotic) or still water (lentic) system.

Reservoir. An artificial (dammed) water body with at least 8 ha (20 ac) covered by surface water.

Stock pond. An artificial (dammed) body of water of less than 8 ha (20 ac) covered by surface water.

Lake. A natural topographic depression collecting a body of water covering at least 8 ha (20 ac) with surface water.

Pothole, Slough, or Small Mountain Lake. A natural topographic depression collecting a body of water covering less than 8 ha (20 ac) with surface water.

Other. Describe any other wetland type encountered, which is not associated with a surface water channel.

Upland. This designation is for those areas which are included in the inventoried polygon, but which do not support functional wetland vegetation communities. Such areas may be undisturbed inclusions of naturally occurring high ground or such disturbed high ground as roadways and other elevated sites of human activity.

C2. The size (acres/hectares) of polygons large enough to be drawn as enclosed units on topographic maps is determined in the office using a planimeter, dot grid, or GIS. For polygons too small to be accurately drawn as enclosed units on the maps, polygon size is calculated using polygon length (item C7) and average polygon width (item C7a).

C3a-d. Evaluators may be asked to survey some areas that have not been determined to be wetlands for the purpose of making such a determination. Other polygons include areas supporting non-wetland vegetation types. A "Yes" answer indicates that no part of the polygon keys to a riparian habitat type or community type (HT/CT). Areas classified in item C8 as any vegetation type described in a riparian and/or wetland classification document for the region in which you are working are counted as functional wetlands. Areas listed as UNCLASSIFIED WETLAND TYPE are also counted as functional wetlands. Other areas are counted as non-wetlands, or uplands. The functional wetland fraction of the polygon area is listed in item C3c in acres and as a percentage of the entire polygon area in item C3d.

C4. Lentic wetlands associated with open water, like lakes and ponds, typically have a shore. The ***shore*** is defined as a variable width area that contains all points reached over time by the water's edge along the water body between its high stage and current water level—i.e., the area that is visibly affected by periods of inundation and drying between seasonal and longer cyclic high and low water levels. (The time frame is generally taken to mean the recent period of hydrologic record, or the extent indicated by physical evidence present.) The ***shoreline*** is defined much more narrowly as a 1-2 m (3.3-6.6 ft) band stretching along the landward side of the water's edge TODAY. A defined shoreline means there is narrow band or line that is distinctive and distinguishable. Therefore, the actual position of the shoreline shifts over time with water level.

C5. Polygon length is measured in the field or by scaling from the map. This data is considered accurate to the nearest 0.16 km (0.1 mi). Polygon length may be the same as shoreline length, but may not be in cases of much curved shoreline, or for polygons that have no shoreline (i.e., wet meadows or marshes). The shoreline is defined as a linear feature extending at the time of observation along the water's edge 1 m (3 ft) wide back from the water onto the land.

C6. In some cases, the polygon data is used to characterize, or represent, a much larger, or longer, area. The length represented by the polygon is given. For example, a 0.8 km (0.5 mi) polygon may be used to represent 3.2 km (2 mi) of total shoreline length. In this case, 0.8 km (0.5 mi) is the shoreline length in the polygon (item C5), and 3.2 km (2 mi) is the overall shoreline length entered in item C6.

C7a. Record average width of the polygon, which in smaller wetlands corresponds to the width of the entire wetland area. The width (average, minimum and maximum) will be determined in the field as the distance perpendicular to the longest axis.

C7b. Record the range of width (ft/m), narrowest to widest, of the wetland area in the polygon.

C8. List the riparian habitat type(s) and/or community type(s) found in the polygon using a manual for identifying types in the region in which you are working, such as *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen and others 1995), *Classification and Management of USDI Bureau of Land Management's Riparian and Wetland Sites in Eastern and Southern Idaho* (Hansen and Hall 2002), *Classification and management of upland, riparian, and wetland sites of USDI Bureau of Land Management's Miles City Field Office, eastern Montana USA* (Hansen and others 2008), or a similar publication written for the region in which you are working. If the habitat type cannot be determined for a portion of the polygon, then list the appropriate community type(s) of that portion. If neither the habitat type nor community type can be determined for any portion of the polygon (or in areas where the habitat and community types have not been named and described), list the area in question as unclassified wetland type and give the dominant species present. Indicate with the appropriate abbreviation if these are habitat types (HT), community types (CT), or dominance types (DT), for example, PSEMEN/CORSTO HT. For each type listed, estimate the percent of the polygon represented. If known, record the successional stage (i.e., early seral, mid-seral, late seral, and climax), or give other comments about the type. As a minimum, list all types which cover 5% or more of the polygon. The total must approximate 100%. Slight deviations due to use of class codes or to omission of types covering less than 5% of the polygon are allowed. ***NOTE:*** For any area classified as an unclassified wetland type, it is important to list any species present which can indicate the wetness or dryness of the site.

NOTE: Open water in the polygon that does not have emergent vegetation, but that is less than 2 m (6.6 ft) deep is counted as a type called Open Water.

FACTORS FOR ASSESSING LENTIC WETLAND HEALTH
(Derived by the computer from the U. S. Lentic Wetland Inventory Form)

NOTE: In the following instructions the corresponding *Lentic Wetland Inventory Form* item numbers (from which the health is derived) are shown in parentheses. Details of how these source data items are collected are located in the *Lentic Wetland Inventory Form User Guide.* For polygons contained in the Lentic Wetland database, all calculations are done by the computer. Some factors on the evaluation may not apply on all sites. For example, sites without potential for woody species are not rated for tree and shrub regeneration or utilization.

1. Vegetative Cover of the Polygon (D12). Around lentic water bodies vegetation cover helps to stabilize shorelines, control nutrient cycling, reduce water velocity, provide fish cover and food, trap sediments, reduce erosion, reduce the rate of evaporation (Platts and others 1987), and contributes primary production to the ecosystem. This question focuses on how much of the entire polygon area is covered by standing plant growth. Item 8 below assesses the amount of human-caused bare ground. Although there is some overlap between these two items, the bare ground to be counted in item 8 is strictly limited in definition, whereas all unvegetated area not inundated by water is counted in this item. The only area within the polygon exempt from consideration is area covered by water, including water between emergent plants such as cattails and bulrushes. Areas such as boat docks, hardened pathways, and artificial structures are counted as unvegetated along with any bare ground, downed wood, and other plant litter. The rationale is that all such unvegetated areas contribute nothing to several of the important lentic wetland functions.

The evaluator is to estimate the fraction of the polygon covered by plant growth. Vegetation cover is ocularly estimated using the canopy cover method (Daubenmire 1959). ***NOTE:*** For field determination of vegetative cover include ***all rooted plant material*** (live or dead). Do not include fallen wood or other plant litter. Do not consider the polygon area covered by water (such as between emergent plants).

Scoring:
6 = More than 95% of the polygon area is covered by rooted plant material (live or dead).
4 = 85% to 95% of the polygon area is covered by rooted plant material (live or dead).
2 = 75% to 85% of the polygon area is covered by rooted plant material (live or dead).
0 = Less than 75% of the polygon area is covered by rooted plant material (live or dead).

2. Invasive Plant Species (Weeds) (D13c). Invasive plants are alien species whose introduction does or is likely to cause economic or environmental harm. Without regard to whether the disturbance that allowed their establishment is natural or human-caused, weed presence indicates a degrading ecosystem. While some of these species may contribute to some riparian functions, their negative impacts reduce overall site health. This item assesses the degree and extent to which the site is impacted by the presence of invasive plants. The severity of the weed problem on a site is a function of density/distribution (pattern of occurrence), as well as abundance of the weeds. A weed list should be used that is standard for the region.

The site's health rating on this item combines two factors: weed density/distribution class and total canopy cover. A perfect score of 6 out of 6 points can only be achieved if the site is weed free. A score of 4 out of the 6 points means the weed problem is just beginning (i.e., very few weeds and small total canopy cover [less than 1%]). A moderate weed problem gets 2 out of 6 points. It has a moderately dense weed plant distribution (a class between 4 and 7) and moderate total weed canopy cover (between 1% and 15%). A site scores 0 points if the density/distribution is in class 8 or higher, or if the total weed canopy cover is 15% or more.

2a. Total Canopy Cover of Invasive Plant Species (Weeds). From the total percentage of polygon area occupied by the combined canopy cover of all species of invasive plants. ***NOTE:*** For field determination of vegetative cover related questions included is ***all rooted plant material*** (live or dead). Not included is fallen wood or other plant litter. Polygon area covered by water (such as between emergent plants) is not included.

Scoring:
3 = No invasive plant species (noxious weeds) on the site.
2 = Invasive plants present with total canopy cover less than 1% of the polygon area.
1 = Invasive plants present with total canopy cover between 1 and 15% of the polygon area.
0 = Invasive plants present with total canopy cover more than 15% of the polygon area.

2b. Density/Distribution of Invasive Plant Species (Weeds). This item rates the polygon for weed plant density/ distribution based on categories illustrated in Item D13 of the Lentic Wetland Inventory.

Scoring:

3 = No invasive plant species (noxious weeds) on the site.
2 = Invasive plants present with density/distribution in categories 1, 2, or 3.
1 = Invasive plants present with density/distribution in categories 4, 5, 6, or 7.
0 = Invasive plants present with density/distribution in categories 8, or higher.

NOTE: Prior to the 2001 season, the health score for weed infestation was assessed from a single numerical value that does not represent weed canopy cover, but instead represents the fraction of the polygon area on which weeds had a well established population of individuals (i.e., the area infested).

3. Disturbance-Increaser Undesirable Herbaceous Species (D14b). Areas with historically intense grazing often have large canopy cover of undesirable herbaceous species, which tend to be less productive and which contribute less to ecological functions. A large cover of disturbance-increaser undesirable herbaceous species, native or exotic, indicates displacement from the potential natural community (PNC) and a reduction in upland health. These species generally are less productive, have shallow roots, and poorly perform most upland functions. They usually result from some disturbance, which removes more desirable species. Invasive plant species considered in the previous item are not reconsidered.

A list of disturbance-increaser undesirable species that are counted is presented below. Other disturbance-increaser undesirable species may also be present on a site, but consistency and comparability will be maintained by always counting the same set of species.

Achillea millefolium (common yarrow)	*Agropyron repens* (quackgrass)	*Antennaria* species (everlasting; pussytoes)
Artemisia ludoviciana (cudweed sagewort)	*Descurainia sophia* (fixweed)	*Fragaria virginiana* (wild strawberry)
Juncus balticus (Baltic rush)	*Lepidium perfoliatum* (clasping pepperweed)	*Medicago lupulina* (black medick)
Mentha arvense (field mint)	*Plantago major* (common plantain)	*Poa pratensis* (Kentucky bluegrass)
Potentilla anserina (silverweed)	*Sisymbrium* species (tumblemustard)	*Taraxacum officinale* (common dandelion)
Thlaspi arvense (field pennycress)	*Trifolium* species (clover)	*Verbascum thapsus* (common mullein)

NOTE: For field determination of vegetative cover related questions included is ***all rooted plant material*** (live or dead). Not included is fallen wood or other plant litter. Polygon area covered by water (such as between emergent plants) is not included.

Scoring:

3 = Less than 5% of the site covered by disturbance-increaser undesirable herbaceous species.
2 = 5% to 25% of the site covered by disturbance-increaser undesirable herbaceous species.
1 = 25% to 50% of the site covered by disturbance-increaser undesirable herbaceous species.
0 = More than 50% of the site covered by disturbance-increaser undesirable herbaceous species.

4. Preferred Tree and Shrub Establishment and/or Regeneration (D3 and D6c). (*This item is skipped if the site lacks potential for trees or shrubs.*) Not all wetland areas can support trees and/or shrubs. However, on those sites where such species do belong, they play important roles. The root systems of woody species are excellent shoreline stabilizers, while their spreading canopies provide protection to soil, water, wildlife, and livestock. Young age classes of woody species are important for the continued presence of woody communities not only at a given point in time but into the future. Woody species potential can be determined by using a key to site type (Thompson and Hansen 2001, 2002, 2003). (***NOTE:*** Vegetation potential is commonly underestimated on sites with a long history of disturbance.)

The following species are excluded from the evaluation:

- *Artemisia cana* (silver sagebrush), including subsp. *cana* and *viscidula*;
- *Artemisia frigida* (fringed sagewort);
- *Crataegus* species (hawthorn);
- *Gutierrezia sarothrae* (broom snakeweed);
- *Opuntia* species (prickly pear);
- *Rosa* species (rose);

- *Sarcobatus vermiculatus* (greasewood);
- *Symphoricarpos* species (snowberry);
- *Tamarix* species (saltcedar; tamarisk);
- *Yucca glauca* (soapweed); and
- all non-native species (e.g., *Elaeagnus angustifolia* [Russian olive], *Tamarix* species [saltcedar; tamarisk], etc.).

These are species that may reflect long-term disturbance on a site, that are generally less palatable to browsers, and that tend to increase under long-term moderate-to-intense grazing pressure; ***AND*** for which there is rarely any problem in maintaining presence on site. Examples of the latter include *Artemisia cana* (silver sagebrush) and *Sarcobatus vermiculatus* (greasewood). Both are considered climax species in many riparian situations and rarely have any problem maintaining a presence on a site. Only under extreme long-term grazing pressures will these species be eliminated from a site. On the other hand, *Elaeagnus angustifolia* (Russian olive) and *Tamarix* species (saltcedar; tamarisk) are especially aggressive, undesirable exotic plants.

As discussed above, the main reason for excluding these plants is they are far more abundant on many sites than are species of greater concern (i.e., *Salix* species [willows], *Cornus sericea* [red-osier dogwood], *Amelanchier alnifolia* [Saskatoon serviceberry], and many other taller native riparian species), and they may mask the ecological significance of a small amount of a species of greater concern. ***FOR EXAMPLE:*** A polygon may have *Symphoricarpos occidentalis* (western snowberry) with 30% canopy cover showing young plants for replacement of older ones, while also having a trace of *Salix exigua* (sandbar willow) present, but represented only by older mature individuals. We feel that the failure of the willow to regenerate (even though there is only a small amount) is very important in the health evaluation, but by including the snowberry and willow together on this polygon, the condition of the willow would be hidden (overwhelmed by the larger amount of snowberry).

Consider as available all tree and shrub plants to which animals may gain access and that they can reach. For tree species, this means mostly just seedling and sapling age classes. When estimating degree of utilization, count browsed second year and older leaders on representative plants of woody species normally browsed by ungulates. Do not count current year's use, because this would not accurately reflect actual use when more browsing can occur later in the season. Browsing of second year or older material affects the overall health of the plant and continual high use will affect the ability of the plant to maintain itself on the site. Determine percentage by comparing the number of leaders browsed or utilized with the total number of leaders available (those within animal reach) on a representative sample (at least three plants) of each tree and shrub species present. Do not count utilization on dead plants, unless it is clear that death resulted from over-grazing. ***NOTE:*** If a shrub is entirely mushroom/umbrella shaped by long term intense browse or rubbing, count browse utilization of it as heavy.

> **Scoring:** (*Consider all shrubs within animal reach and seedlings and saplings of tree species. If the site has no potential for trees or shrubs [except for the species listed above to be excluded], the computer automatically replaces both the Actual Score and Possible Score with zero.*)
> **6 =** More than 15% of the total canopy cover of preferred trees/shrubs are seedlings and saplings.
> **4** = 5% to 15% of the total canopy cover of preferred trees/shrubs are seedlings and saplings.
> **2** = Less than 5% of the total canopy cover of preferred tree/shrubs are seedlings and saplings.
> **0** = Preferred tree/shrub seedlings or saplings absent.

5a. Browse Utilization of Available Preferred Trees and Shrubs (D5a and D6c). (*This item is skipped if the site lacks trees or shrubs; for example, the site is a herbaceous wet meadow or cattail marsh, or all woody plants have already been removed.*) Livestock and/or wildlife browse many riparian woody species. Excessive browsing can eliminate these important plants from the community and result in their replacement by undesirable invaders. With excessive browsing, the plant loses vigor, is prevented from flowering, or is killed. Utilization in small amounts is normal and not a health concern, but concern increases with greater browse intensity.

The following species are excluded from the evaluation:
- *Artemisia cana* (silver sagebrush), including subsp. *cana* and *viscidula*;
- *Artemisia frigida* (fringed sagewort);
- *Crataegus* species (hawthorn);
- *Gutierrezia sarothrae* (broom snakeweed);
- *Opuntia* species (prickly pear);
- *Rosa* species (rose);

- *Sarcobatus vermiculatus* (greasewood);
- *Symphoricarpos* species (snowberry);
- *Tamarix* species (saltcedar; tamarisk);
- *Yucca glauca* (soapweed); and
- all non-native species (e.g., *Elaeagnus angustifolia* [Russian olive], *Tamarix* species [saltcedar; tamarisk], etc.).

These are species that may reflect long-term disturbance on a site, that are generally less palatable to browsers, and that tend to increase under long-term moderate-to-intense grazing pressure; ***AND*** for which there is rarely any problem in maintaining presence on site. Examples of the latter include *Artemisia cana* (silver sagebrush) and *Sarcobatus vermiculatus* (greasewood). Both are considered climax species in many riparian situations and rarely have any problem maintaining a presence on a site. Only under extreme long-term grazing pressures will these species be eliminated from a site. On the other hand, *Elaeagnus angustifolia* (Russian olive) and *Tamarix* species (saltcedar; tamarisk) are especially aggressive, undesirable exotic plants.

The main reason for excluding these plants is they are far more abundant on many sites than are species of greater concern (i.e., *Salix* species [willows], *Cornus sericea* [red-osier dogwood], *Amelanchier alnifolia* [Saskatoon serviceberry], and many other taller native riparian species), and they may mask the ecological significance of a small amount of a heavily utilized species of greater concern. ***FOR EXAMPLE:*** A polygon may have *Symphoricarpos occidentalis* (western snowberry) with 30% canopy cover showing only light utilization, while also having a trace of *Salix exigua* (sandbar willow) present showing intense utilization. We feel that, although there is only a small amount of willow present, the fact that it is being heavily utilized is very important to the health evaluation. By including the snowberry and willow together on this polygon, the condition of the willow would be hidden (overwhelmed by the larger amount of snowberry).

When estimating degree of utilization, count browsed second year and older leaders on representative plants of woody species normally browsed by ungulates. Do not count current year's use, because this would not accurately reflect actual use when more browsing can occur later in the season. Browsing of second year or older material affects the overall health of the plant and continual high use will affect the ability of the plant to maintain itself on the site. Determine percentage by comparing the number of leaders browsed or utilized with the total number of leaders available (those within animal reach) on a representative sample (at least three plants) of each tree and shrub species present. Do not count utilization on dead plants, unless it is clear that death resulted from over-grazing. ***NOTE:*** If a shrub is entirely mushroom/umbrella shaped by long term intense browse or rubbing, count browse utilization of it as heavy.

> **Scoring:** (*If the site has no woody vegetation [except for the species listed above to be excluded], replace both Actual Score and Possible Score with NA.*)
> **3** = None (0% to 5% of available second year and older leaders of preferred species are browsed).
> **2** = Light (5% to 25% of available second year and older leaders of preferred species are browsed).
> **1** = Moderate (25% to 50% of available second year and older leaders of preferred species are browsed).
> **0** = Heavy (More than 50% of available second year and older leaders of preferred species are browsed).

5b. Live Woody Vegetation Removal by Other Than Browsing (D6g). Excessive cutting or removing parts of plants or whole plants by agents other than browsing animals (e.g., human clearing, cutting, beaver activity, etc.) can result in many of the same negative effects to the community that are caused by excessive browsing. However, other effects from this kind of removal are direct and immediate, including reduction of physical community structure and wildlife habitat values. ***Do not include natural phenomena such as natural fire, insect infestation, etc. in this evaluation.***

Removal of woody vegetation may occur at once (timber harvest), or it may be cumulative over time (annual firewood cutting or beaver activity). This question is not so much to assess long term incremental harvest, as it is to assess the extent that the stand is lacking vegetation that would otherwise be there today. Give credit for re-growth. Consider how much the removal of a tree many years ago may have now been mitigated with young replacements.

Four non-native species or genera are excluded from consideration because these are aggressive, invasive exotic plants that should be removed. They are *Elaeagnus angustifolia* (Russian olive), *Rhamnus cathartica* (common buckthorn), *Caragana arborescens* (common caragana), and *Tamarix* species (saltcedar; tamarisk).

Determine the extent to which woody vegetation (trees and shrubs) is lacking due to being physically removed (i.e., cut, mowed, trimmed, logged, cut by beaver, or otherwise cut from their growing position). The actual timeframe is not as important as the actual ecological effect. Time to recover from this kind of damage can vary widely with site characteristics.

What we really need to measure is the extent ***today*** of any damage remaining to the vegetation structure as a result of the woody removal. We expect that the woody community will recover over time (re-grow), just as an eroding bank will heal with re-growing root mass. This question simply asks how much woody material is still missing from what should be there? --as judged by indications, such as stumps and other clues to what was removed. The amount of time since removal doesn't really matter, if re-growth has been allowed to progress. If 20 years after logging, the site has a stand of sapling spruce trees, then it should get partial re-growth credit, but not full credit, because the trees still lack most of their potential habitat and ecological value. (***NOTE:*** In general, the more recent the removal, the more entirely it should be fully counted; and conversely, the older the removal, the more likely it is to have been mitigated by re-growth.)

This question is really looking at volume (three dimensions) and not canopy cover (two dimensions). For example, if an old growth spruce tree is removed, a number of new seedlings/saplings may become established and could soon achieve the same canopy cover as the old tree had. However, the value of the old tree to wildlife and overall habitat values is far greater than that of the seedling/saplings. It will take a very long time before the seedlings/saplings can grow to replace all the lost habitat values that were provided by the tall old tree. On the other hand, shrubs, such as willows, grow faster and may replace the volume of removed plants in a much shorter time. Answer this question by estimating the percent of woody material that is missing from the site due to having been removed by human action. Select a range category from the choices given that best represents the percent of missing woody material.

> **Scoring:** (*If the site has no trees or shrubs* ***AND*** *no cut plants or stumps of any trees or shrubs [except for the species listed above to be excluded], replace both Actual Score and Possible Score with NA.*)
> **3** = None (0% to 5% of live woody vegetation expected on the site is lacking due to cutting).
> **2** = Light (5% to 25% of live woody vegetation expected on the site is lacking due to cutting).
> **1** = Moderate (25% to 50% of live woody vegetation expected on the site is lacking due to cutting).
> **0** = Heavy (More than 50% of live woody vegetation expected on the site is lacking due to cutting).

6. Human Alteration of Polygon Vegetation Community Composition (F9a). Human alteration of the vegetation is meant to include all changes to the plant community composition or structure on the polygon from human causes (e.g., logging, mining, roads, construction, or development) or by agents of human management (e.g., livestock). ***It is not meant to include transitory or short-term removal of plant material that does not alter long term plant community composition*** (i.e., grazing at carefully managed levels or wood cutting that does not change long term species composition of the community). Also include impacts caused by extreme concentrations of managed wildlife, rationale being that wildlife concentrations great enough to cause significant site damage are usually the result of human management choices. Beaver activities that alter vegetative communities will not be included in this question, but are included in the utilization question.

Of concern are the kinds of change that diminish or disrupt the natural wetland function of the vegetation. These include, but are not limited to, conversion of natural communities to lawns or hayfields (but not the actual mowing), changing plant community composition (e.g., causing replacement of willows with rose and snowberry, woody species with herbaceous species, etc.), replacing native plants with tame plants, replacing deep rooted plants with shallow rooted plants, and/or replacing tall species with short species. In a case where the vegetation community is altered, due to removal of woody cover that allows conversion to a long term cover of a different kind of vegetation (i.e., cottonwoods/poplars are cut, and the site changes to a *Poa pratensis* [Kentucky bluegrass] cover), then the polygon gets a low score for both woody vegetation removal and for alteration of the vegetation community.

On polygons adjacent to water, remember that the polygon extends out to where the water is two meters deep. (***NOTE:*** Do not count the same area twice by including it as both a vegetative and a physical alteration, unless there clearly are both kinds of alteration. Decide into which category a particular effect should go. For example: A timber harvest may clear vegetation, but not necessarily cause physical damage on one area; while on another area it may cause both clearing of vegetation and disruption of the soil by heavy equipment.)

> **Scoring:**
> **6** = Less than 5% of polygon vegetation community composition is altered by human activity.
> **4** = 5% to 15% of polygon vegetation community composition is altered by human activity.
> **2** = 15% to 35% of polygon vegetation community composition is altered by human activity.
> **0** = 35% or more of polygon vegetation community composition is altered by human activity.

7. Human Alteration of Polygon Physical Site (F10). The purpose of this question is to assess physical change to the soil, bank/shore integrity, hydrology, etc. as it affects the ability of the natural system to function normally. Changes in shore and bank contour and any change in soil structure will alter infiltration of water, increase soil compaction, and cause increased sediment contribution to the water body. Every human activity in or around a natural site can alter that site. This question seeks to assess both the areal extent and degree of severity of the accumulated effects of all human-caused physical change.

Include all changes to the physical attributes of the site caused by human actions (e.g., logging, mining, housing development) or by agents of human management (e.g., livestock) and also any effects from concentrated wildlife use (rationale being that wildlife concentrations great enough to cause significant site damage are usually the result of human management activities.) The kinds of physical change that diminish or disrupt the natural wetland functions on the site include, but are not limited to, hummocking, pugging, animal trails (livestock or wildlife), human roads, trails, buildings, landscaping, boat launches/docks, beach clearing and building, or rip-rapping of shores and banks. (***NOTE:*** *Do not count the same area twice by including it as both a vegetative and a physical alteration, unless there clearly are both kinds of alteration. Decide into which category a particular effect should go.* For example: A cottage owner may clear vegetation to gain a view of the lake without causing physical damage to one area; whereas, if he/she hauls in sand to enhance the beach, there may also be physical alteration of the same site.) This item is scored in two parts:

7a. The percentage of the whole polygon area that is altered by human activities (**F10a**).

Scoring:
12 = Less than 5% of the polygon is physically altered by human activity.
8 = 5% to 15% of the polygon is physically altered by human activity.
4 = 15% to 35% of the polygon is physically altered by human activity.
0 = More than 35% of the polygon is physically altered by human activity.

7b. Severity of the human-caused alteration (**F10d**).

Scoring:
3 = ***No physical alterations*** to the site by human activity.
2 = Human alterations to the physical site are ***slight*** in effect.
1 = Human alterations to the physical site are ***moderate*** in effect.
0 = Human alterations to the physical site are ***severe*** in effect.

8. Human-Caused Bare Ground (F11c). Bare ground is soil not covered by plants, litter or duff, down wood, or rocks larger than 6 cm (2.5 in). Bare ground is not productive, provides no habitat for wildlife, is exposed to erosion, and is at risk of weed invasion. Although natural processes often do temporarily expose the soil surface, caused by human activity indicates a deterioration of riparian health. Land exposed by naturally lowering lake and slough water levels and other natural bare ground are excluded as normal and beyond management control. Human land uses causing bare ground include, but are not limited to, livestock grazing, recreation, roads, and industrial activities.

Scoring:
6 = Less than 1% of the polygon is human-caused bare ground.
4 = 1% to 5% of the polygon is human-caused bare ground.
2 = 5% to 15% of the polygon is human-caused bare ground.
0 = 15% or more of the polygon is human-caused bare ground.

9. Degree of Artificial Withdrawal or Raising of Water Level (F5). Although water levels naturally fluctuate on a seasonal basis in most systems, many wetland systems are affected by human-caused (artificial) additions or withdrawals. This artificial changes of water level rarely follow a temporal regime that maintains healthy native wetland plant communities. The result is often a barren band of shore exposed or inundated for much of each growing season. This causes shore material to destabilize, and often provides sites for weeds to invade. Such conditions are extremely detrimental to healthy riparian function.

Not all lentic wetlands evaluated with this form will have surface water potential, but any wetland may have its water table degraded by draining, pumping, or diverting its surface or subsurface supply. On such lentic wetlands as marshes and wet meadows, look for evidence of drainage ditching, pumping, and the interruption of normal surface drainage inputs by livestock watering dugouts, cross slope ditches, or dams upslope.

In this item the evaluator is asked to categorize the degree to which the system is subjected to artificially rapid or unnaturally timed fluctuations in water level. Reservoirs intended for storage of water for power generation, irrigation, and/or livestock watering typically exhibit the most severe effects, but water may be diverted or pumped from natural systems for many other reasons (domestic use, industrial use, livestock watering, etc.). This item requires the evaluator to make a subjective call by choosing as a best fit one of the categories of drawdown severity described below. (***NOTE:*** Be careful to consider the scale of the water body as it relates to the scale of change. Pumping a small dugout full of water for livestock might severely impact a 0.8 ha (2 ac) slough, but be negligible to a lake covering a section of land.)

Be sure to document the grounds for your estimate. If there is no way to know with any reasonable degree of certainty how much water is being removed, it may be better to document the situation and to zero out this item (not answer it). During periods of drought lakebeds become exposed and often exhibit wide zones of almost barren shore. ***The evaluator must be careful not to attribute this natural phenomenon unfairly to a human activity.***

Severity Categories of Lentic Water Level Manipulation

Not Subjected	The water body, or wetland, is not subjected to artificial water level change (e.g., drawdown, addition, stabilization, etc.). This category may include very small amounts of change that cause no detectible fluctuation in water level.
Minor	The water body or wetland is subject to no more than minor artificial water level change. The shore area remains vegetated, and withdrawal of water is limited or slow enough that vegetation is able to maintain growth and prevent soil exposure. A relatively narrow band affected by the water level fluctuation may support only annual plants.
Moderate	The water body or wetland is subject to moderate quantities, speed and/or frequency of artificial water level change. Where water is removed, it is done in a way that allows pioneer plants to vegetate at least half of the exposed area resulting from drawdown. Where water is added, some flooding may occur at levels or times not typical to the area/ season.
Extreme	The water body or wetland is subjected to extreme changes in water level due to volume (extent), speed and/or frequency of artificial water addition or removal. Frequent or unnatural levels of flooding occur where water is added, including extensive flooding into riparian and/or upland areas; or no natural annual drawdown is allowed to occur. In extreme artificial drawdown situations, a wide band of exposed bottom remains unvegetated.

Scoring:
9 = The water body, or wetland, is ***not subjected*** to artificial water level change.
6 = The degree of artificial water level change is ***minor.***
3 = The degree of artificial water level change is ***moderate.***
0 = The degree of artificial water level change is ***extreme.***

Calculating the Lentic Health Score
To arrive at the overall site health rating, the scores are totaled for all the factors, and that total is divided by the possible perfect score total. An example score sheet is shown below.

Vegetation Factors	**Actual Pts**	**Possible Pts**
1. Vegetative Cover of Polygon	6	6
2a. Total Canopy Cover of Invasive Plant Species (Weeds)	1	3
2b. Density/Distribution Pattern of Invasive Plant Species (Weeds)	1	3
3. Disturbance-Increaser Undesirable Herbaceous Species	2	3
4. Preferred Tree and Shrub Establishment and/or Regeneration	2	6
5a. Browse Utilization of Available Preferred Trees and Shrubs	2	3
5b. Live Woody Vegetation Removal by Other Than Browsing	3	3
6. Human Alteration of Polygon Vegetation Community Composition	4	6
Vegetative Score:	**21**	**33**
Soil/Hydrology Factors		
7a. Percent of Polygon Physical Site Altered by Human Activities	8	12
7b. Severity of Human-Caused Alteration of Polygon Physical Site	2	3
8. Human-Caused Bare Ground	2	6
9. Degree of Artificial Withdrawal or Raising of Water Level	9	9
Soil/Hydrology Score:	**21**	**30**
TOTAL SCORE:	**42**	**63**

Health Rating Formula: Health Rating = (Total Actual Score) / (Total Possible Score) x 100%

Health Rating = (42) / (63) x 100% = 67%

Health Category: 80 to 100% = Proper Functioning Condition (Healthy)
60 to less than 80% = Functional At Risk (Healthy, but with Problems)
Less than 60% = Nonfunctional (Unhealthy)

A manager should realize that a less than perfect score is not necessarily cause for concern. An area rated at 80% is still considered to be functioning properly. At the same time, ratings of individual factors can be useful in detecting strengths or weaknesses of a site. A low score on any factor warrants management focus. For example, the sample score sheet shown above has low scores for invasive plant species, tree and shrub regeneration, and bare ground (items 2, 4, and 8). These are factors in which a management change might result in improvement on a subsequent assessment.

OTHER POTENTIAL MANAGEMENT CONCERNS

10. Overflow Structure Stability (F6c). Often the most dynamically unstable point in a lentic system is at the overflow, or outlet. Natural systems usually evolve behind a relatively stable outlet structure, but the overflow structures, or spillways, of man-made water bodies often become unstable and erode, wash out, or downcut causing severe disruption to the lentic system dependent on that body of water.

Scoring:
6 = The overflow structure is made of concrete, pipe, or armored rock and appears stable.
4 = The overflow structure is unprotected or is made of other material, but still appears stable.
2 = The overflow structure is made of concrete, pipe, or armored rock, but appears unstable.
0 = The overflow structure is unprotected or is made of other material and appears unstable.

11. Trend (D16). Trend refers, in the sense used, not specifically to successional pathway change, but in a more general sense of apparent community health. By definition, trend implies change over time. Accordingly, a precise trend analysis would require comparison of repeated observations over time. However, some insights into trend can be observed in a single visit. For example, the observer may notice healing (re-vegetating) of a degraded streambank and recent establishment of woody seedlings and saplings. This would indicate changing conditions that suggest an improving trend. If such indicators are not apparent, the observer would select the category status unknown.

LITERATURE CITED

Adams, Barry and Lorne Fitch. 1995. Caring for the green zone, riparian areas and grazing management. Alberta Riparian Habitat Management Project. Lethbridge, Alberta, Canada. 37 p.

Alberta Natural Heritage Information Centre. 1999. Natural regions and subregions of Alberta. Internet website: http://www.gov.ab.ca/env/parks/anhic/abnatreg.html. Edmonton, Alberta, Canada. T5K 2J6.

Cooperrider, Allen Y., Raymond J. Boyd, and Hanson R. Stuart. 1986. Inventory and monitoring of wildlife habitat. USDI Bureau of Land Management, Denver Service Center, Denver, Colorado, USA. 858 p.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deep water habitats of the United States. USDI Fish and Wildlife Service, Office of Biological Services, Washington, DC, USA. Publication Number FWS/OBS-79/31. 107 p.

Cows and Fish. 2001. Invasive Weed and Disturbance-caused Herbaceous Species List For Use in Riparian Health Assessment and Inventory in Alberta--draft. Alberta Riparian Habitat Management Program. Lethbridge, Alberta, Canada.

Daubenmire, R. D. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33:43-66.

Federal Interagency Committee for Wetland Delineation. 1989. Federal manual for identifying and delineating jurisdictional wetlands. US Army Corps of Engineers, US Environmental Protection Agency, USDI Fish and Wildlife Service, and USDA Soil Conservation Service Cooperative Technical Publication, Washington, DC, USA. 76 p.

Fitch, L., B.W. Adams and G. Hale, Eds. 2001. Riparian Health Assessment for Streams and Small Rivers - Field Workbook. Lethbridge, Alberta: Cows and Fish Program. (adapted from Riparian and Wetland Research Program, School of Forestry. 2001. Lotic health assessments: Riparian Health Assessment for Streams and Small Rivers [Survey] User Guide. University of Montana, Missoula, Montana, USA. January 2001.) 75 p.

Fitch, L. and N. Ambrose. 2003. Riparian areas: A user's guide to health. Lethbridge, Alberta: Cows and Fish Program. ISBN No. 0-7785-2305-5. 46 p.

Hansen, Paul L. and James B. Hall. 2002. Classification and management of USDI Bureau of Land Management's riparian and wetland sites in eastern and southern Idaho. Bitterroot Restoration, Inc., Corvallis, Montana, USA. 304 p.

Hansen, Paul L., Robert D. Pfister, Keith Boggs, Bradley J. Cook, John Joy, and Dan K., Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Miscellaneous Publication No 54. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula, Montana, USA. 646 p.

Hansen, Paul L., William H. Thompson, J. Gant Massey, and Max Thompson. 2008. Classification and management of upland, riparian, and wetland sites of USDI Bureau of Land Management's Miles City Field Office, eastern Montana USA. Prepared for the USDI Bureau of Land Management Miles City Field Office, Miles City, Montana, USA. 640 p. plus 91 p. of Appendix B (Indicator Species).

Huel, Denis. 1998. Streambank stewardship, your guide to caring for riparian areas in Saskatchewan. ISBN No. 1-896793-20-7. Saskatchewan Wetland Conservation Corporation. Regina, Saskatchewan, Canada. 43p.

Huel, Denis. 2000. Managing Saskatchewan Wetlands—a landowner's guide. ISBN No. 1-896793-26-6. Saskatchewan Wetland Conservation Corporation. Regina, Saskatchewan, Canada. 68 p.

Lichvar, Robert W. 2012. The National Wetland Plant List. ERDC/CRREL TR-12-11. Cold Regions Research and Engineering Laboratory, U.S. Army Engineer Research and Development Center. Hanover, New Hampshire, USA. 224 p. Available online at http://rsgisias.crrel.usace.army.mil/NWPL/#.

Mitsch, William J., and James G. Gosselink. 1993. Wetlands. Second Edition. Van Nostrand Reinhold, Publishers, New York, New York, USA. 722 p.

Shaw, S. P., and C. G. Fredine. 1956. Wetlands of the United States: Their extent and their value for waterfowl and other wildlife. USDI Fish and Wildlife Service, Circular 39. Washington, DC, USA. 67 p.

Stewart, R. E., and H. A. Kantrud. 1972. Classification of natural ponds and lakes in the glaciated prairie region. USDI Fish and Wildlife Service, Research Publication 92. 57 p.

Thompson, William H. and Paul L. Hansen. 2001. Classification and management of riparian and wetland sites of the Saskatchewan prairie ecozone and parts of adjacent subregions. Saskatchewan Wetland Conservation Corporation. Regina, Saskatchewan, Canada. 298 p.

Thompson, William H. and Paul L. Hansen. 2002. Classification and management of riparian and wetland sites of the Alberta Grassland Natural Region and adjacent subregions. Bitterroot Restoration, Inc. Prepared for the Alberta Riparian Habitat Management Program-Cows and Fish, Lethbridge, Alberta, Canada. 416 p.

Thompson, William H. and Paul L. Hansen. 2003. Classification and management of riparian and wetland sites of Alberta's Parkland Natural Region and Dry Mixedwood Natural Subregion. Bitterroot Restoration, Inc. Prepared for the Alberta Riparian Habitat Management Program-Cows and Fish, Lethbridge, Alberta, Canada. 340 p.

United States Geological Survey (USGS).2012. Coordinated effort between the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), the United States Geological Survey (USGS), and the Environmental Protection Agency (EPA). The Watershed Boundary Dataset (WBD) was created from a variety of sources from each state and aggregated into a standard national layer for use in strategic planning and accountability. Available URL: <http://datagateway.nrcs.usda.gov>.

Valastin, Pat and others. 1999. Caring for Shoreline Properties. Alberta Conservation Association. Edmonton, Alberta, Canada. T5L2W4. 29 p.