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ABSTRACT
A system is presented for the classification and management of uplands, riparian, and wetland sites within the USDI Bureau of Land Management's Miles City Field Office in eastern Montana. The Miles City Field of the USDI Bureau of Land Management lies within the northern Great Plains and occupies approximately the eastern 1/3 of Montana. The concepts and terminology used in this document are consistent with usage proposed by Daubenmire (1952, 1968, 1978), and are used in numerous other vegetation-based ecological site classifications for North America. A dichotomous key utilizing indicator plant species is provided for field identification of the habitat types and major seral plant communities (for example community types) that are stable for time frames relevant to land management decisions. The habitat types (for example ecological site types) are identified first in the key. If this is not possible, the key then identifies the major seral community types. Within the description of each community type is a discussion of possible habitat types for the site. Each "type" includes detailed information for managing a particular site. The work utilized 1,126 sample plots resulting in a total of 96 different plant communities identified to either the habitat type (and phase) or community type level. There were 62 identified riparian/wetland types and 28 upland types. In addition, six types are types that can occur in both riparian/wetland and upland situations. There were a total of 663 unique species recorded for the 1,126 sampled stands. Of the 663 species, 551 (83 percent) were native, and 112 (17 percent) were introduced or contain an introduced element. The document can be downloaded from www.ecologicalsolutionsgroup.com.

INTRODUCTION

The vegetation of eastern Montana occupies an area of complex physiographic features, and diverse plant communities including upland, riparian, and wetland types. Land managers and scientists alike have long recognized the need to classify plant communities and landscapes, and have developed numerous forest and range (in other words, upland), riparian, and wetland classifications over the years. A number of vegetation-based ecological site classification and management documents have been developed for the region, including Cooper and Pfister (1985), Girard and others (1989), Hansen and Hoffman (1988), Hansen and others (1984), Hansen and others (1995), Hoffman and Alexander (1987), Mueggler and Stewart (1980), Pfister and others (1977), Thompson and Hansen (2001), and Thompson and Hansen (2002).

Other, more limited works, included Mackie (1970) for a limited number of drainages in the Missouri River Breaks of north central Montana, Jorgensen (1979) for the Yellow Water Triangle of north central Montana, and Roberts (1980) of the Bear's Paw and Little Rocky Mountains of north central Montana.

This resulted in a number of documents covering different portions of the landscape in eastern Montana. The only document covering the entire study area was by Hansen and others (1995). However, this work only dealt with the riparian and wetland areas, and not the uplands. Large areas of the uplands were either not covered or incompletely covered by the numerous upland works. Therefore, the work by Hansen and others (2008) represents one of the first taxonomic (in other words, not just a list of types) vegetation-based ecological site classifications to cover an ***entire*** landscape of a large region, including the upland, riparian, and wetland sites.

The present study was started in the early fall of 2007 with the following objectives:

1. Develop one single vegetation-based ecological site classification and management document for all lands (in other words, uplands, riparian sites, and wetlands) within the administrative boundary of the USDI Bureau of Land Management's Miles City Field Office. The work would build from the earlier regional works of Cooper and Pfister (1985), Hansen and Hoffman (1988), Hansen and others (1984), Hansen and others (1995), Hoffman and Alexander (1987), Pfister and others (1977), Thompson and Hansen (2001), and Thompson and Hansen (2002), in addition to collecting new data to supplement these earlier works.
2. Relate the various types to the soils and climate of the area.
3. Present management information (where applicable) for the various habitat types and community types, including forage productivity, timber productivity, wildlife information, response to fire, rehabilitation

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/restoration considerations, and recreational uses and considerations.

4. Determine successional relationships for the habitat types and major seral community types.
5. Relate the work to similar studies in this and adjacent regions.

PHYSIOGRAPHY AND GEOLOGY OF STUDY AREA

The study area is located in the eastern portion of Montana within the western part of the Great Plains Province. The Great Plains Province extends from the Dakotas into the eastern portions of Montana, Wyoming, and Colorado. The study area covers over 110,075 km^2 (42,500 mi^2), including all or part of 17 of Montana's 56 counties. The USDI Bureau of Land Management's Miles City Field Office manages more than 1.1 million surface ha (2.7 million ac) of public land and over 5.0 million ha (12.4 million ac) of subsurface mineral estate in eastern Montana.

In the Miles City Field Office, the Great Plains Province is represented at the surface by broad basinal features. The basins within the Great Plains Province have accumulated sediments, such as sands, shales, and limestone, several miles in thickness. These basins form the source and reservoirs of Montana's fossil energy reserves of coal, crude oil, and natural gas. Large parts of two of these basins (the Williston Basin and the Powder River Basin) lying within this study area hold vast reserves of these fossil energy reserves, and continue to be the focus of energy development activities.

Two major river systems also dissect the eastern Montana landscape, the Missouri River and the Yellowstone River. The Missouri River roughly divides the northern third of the study area, flowing west to east from the Fort Peck Dam to Fort Union near the Montana-North Dakota border and the confluence of the Missouri and Yellowstone Rivers. The Missouri River receives significant additions to its flow from the Milk River, the Poplar River, and Big Muddy Creek, all of which flow from north to south into the parent stream. Average flows of the Missouri River equal approximately 312 m^3/s (11,000 ft^3/s) at Culbertson, Montana, approximately 32.2 km (20 mi) upstream of the Montana-North Dakota border.

The Yellowstone River flows northeast through the study area from Bighorn, Montana, past Sidney, Montana, near the Montana, South Dakota border. Major tributaries include the Tongue River and Powder River, both of which flow south to north into the parent stream. The average annual flow of the Yellowstone River, as gauged at Sidney, Montana, is approximately 368 m^3/s (13,000 ft^3/s).

The geology, soils, and climate of the region have produced a diverse mosaic of vegetation types on the landscape. The following photos attempt to show some of the vast diversity associated with this region (Figures 1 to 2).

Figure 1—Terry Badlands north of Terry, Montana.

Figure 2—Big Sheep Mountains in the fall north of Terry, Montana.

CLIMATE

The climate of eastern Montana is characterized as continental, having a long, cold winter and short, warm summers. For example, the highest temperature ever recorded in Montana was 47° C (117° F) at Medicine Lake on July 5, 1937, and at Glendive on July 20, 1893, both of which are in the study area. The coldest temperature ever recorded in Montana occurred in the Rocky Mountains (-57° C [-70° F]) at Rogers Pass. Miles City, which lies in the center of the study area, has seen temperatures as low as -39° C (-38° F) and as high as 45° C (113° F). The average temperature at Miles City is 9° C (49° F), with average highs in July of 31° C (88° F) and average lows in January of -8° C (17° F) (The Weather Channel 2008).

Average day of last frost in Miles City is May 14 and average day of first freeze is September 20, yielding a growing season of approximately 128 days. Average wind speed at Miles City is 15.6 km/h (9.7 mi/h), typically from the northwest. Miles City has an average precipitation of 34 cm (13.5 inch), with the most average precipitation occurring in June (6.2 cm [2.4 inch]) and the least in December (11.4 cm [0.5 inch]) (The Weather Channel 2008).

METHODS

Development of the Ecological Site Classification

We use the ***habitat type*** approach as outlined by Daubenmire (1952, 1968, 1970, 1978) in classifying riparian and wetland sites. We have adopted the ***habitat type*** approach for three main reasons:

1. While the habitat type is based on a climax plant association said to represent long-term biotic potential on the site, it also includes a series of seral stage communities, any one of which may occupy the site at some time in its history—even repeatedly following disturbance. Therefore, a site can be quite thoroughly described by naming its climax vegetation, as well as its current vegetation community. For example, a site may be described as being a *Fraxinus pennsylvanica/Prunus virginiana* (green ash/chokecherry) habitat type presently occupied by the *Populus deltoides/Symphoricarpos occidentalis* (Great Plains cottonwood/western snowberry) community type consisting of a mixed stand of old growth *Populus deltoides* (Great Plains cottonwood) with young *Fraxinus pennsylvanica* (green ash) saplings establishing in the shrub-dominated understory. The reader then is given a clear idea of the kind of site it is, the potential vegetation and the current vegetation.

2. The habitat type approach is primarily a vegetation-based, ecological site classification. A given habitat type may include a variety of soils types. A description of soils is included in a description of the habitat type, and soils information may be used to help characterize lower levels in the classification such as phases. Therefore, the habitat type approach uses vegetation is as an integrator of the landscape and climatic conditions. This is especially appropriate in riparian zones where soils are commonly young and the pedogenic process is susceptible to frequent disruption by fluvial processes. Daubenmire noted that soil is a critical important ecological factor. However, he felt that vegetation responds to differences in moisture, fertility, temperature, and aeration rather than to parameters such as color, texture, structure, depth, sequence of horizons, and other soil features that are easily observed by the human eye.

3. The dynamics of edaphic and hydrologic conditions on the landscape typically cause the formation of complex mosaics of vegetation communities as intermixes of all stages of stand maturity and seral stage. We believe that the habitat type system of classifying sites offers the best presently available means for developing a working terminology for these natural places.

USE OF THE CLASSIFICATION

Overview

No two vegetation communities are exactly alike due to differences in climate, parent material, topography, elevation, disturbance regimes and a host of other variables. The ecological site classification concept used in this study is based on the premise that vegetation on a site reflects the culmination of all the elements at work there. Those species present on site best reflect the principal forces acting there.

This approach results in a classification that establishes baseline information for upland, riparian, and wetland sites within the USDI Bureau of Land Management Miles City Field Office administrative boundary. It provides land managers with information enabling them to develop appropriate management strategies and policies. Two features of this classification that increase its utility for land managers are the dichotomous key and the successional hierarchy established in the habitat type framework. The dichotomous key offers a simple approach to identifying vegetation types. Users, with some knowledge of the local flora, need only to identify the dominant overstory and understory species, and some indicator species, to use the classification. Type descriptions provide species lists, summarize physical parameters, outline successional trends, and present viable management strategies.

Another useful feature of the classification is the successional framework inherent within the habitat type concept. A habitat type represents the land area that supports, or has the potential to support, the same climax vegetation wherever it occurs (Daubenmire 1968). The climax vegetation, or plant association, represents the endpoint of succession on a site. Community types (intermediate, seral plant communities with similar floristic components in all structural layers) represent intermediate stages of succession. They can be organized within the framework of a habitat type system to form successional paths useful in predicting the pattern of community replacement from the pioneer to climax stages. Projection of potential, future vegetation communities in an area provides land managers with a tool for developing strategies and realistic goals.

Management Interpretations
Habitat type classifications provide a relatively permanent and ecologically-based system of land stratification in terms of vegetational potential (Daubenmire 1976). The habitat type is the basic unit in classifying land units or sites based on biotic potential, it emphasizes similarities in ecosystems which carry implications for a variety of land management objectives. Some of the practical implications of habitat type classification are in predicting livestock and wildlife forage production and wildlife habitat values, inventory, land type mapping, timber production, species selection for regeneration and/or rehabilitation, development of best management practices, growth rates of trees and shrubs, susceptibility of trees and shrubs to insects and disease, depth of soil moisture penetration, potential for producing browse after fire, soil management criteria, impacts of recreational uses, natural areas for preservation, downed woody fuels on the forest floor, and successional trends following disturbance. In addition, habitat types offer a basis of comparison and evaluation useful in designing and carrying out field experiments in ecology or applied natural resource disciplines.

There are typically three misconceptions about the use of habitat type classification: 1) the expectation of an abundance of climax vegetation to be present on the current landscape, 2) that natural resource managers need to manage solely for climax vegetation, and 3) that use of a habitat type classification requires climax or near-climax vegetation. For the first two misconceptions, the opposite is true. A very high percentage of our landscape has experienced disturbance resulting in domination by various seral stages. In the second case, preferred management strategies quite often favor seral, instead of climax potential species, regardless of habitat type. In the third misconception, comparing the relative reproductive success of certain plant species present, having known successional process, generally permits identification of the habitat type. In general, succession is more rapid for undergrowth species, providing insight into the habitat type for the site. Where stands have been severely disturbed, are in an early seral stage, or have a closed canopy resulting in a depauperate understory, comparison of the stand with nearby stands on physically similar sites can assist in habitat type identification.

Habitat type classification and management systems provide a critical part of the information needed to: describe the variety of vegetation communities potentially occupying an area; characterize the effect of disturbances or management on plant community distributions, threatened and endangered species, and other entities of conservation concern; identify realistic objectives and related management opportunities; provide a framework to document successional relationships and seral communities; streamline monitoring design and facilitate extrapolation of monitoring interpretations; assess multi-resource potentials, capability, and suitability of management alternatives; provide a framework to help evaluate upland (in other words, forests and rangelands), riparian sites, and wetland health; assess risks for invasive species, fire, insects, disease, and flooding; conduct project planning and watershed analysis, and predict activity outcomes for a project or for land and resource management planning; allows planning of disturbed site vegetation rehabilitation/restoration to be based on site potential; and more effectively communicate with all stakeholders.

Developing Reasonable and Attainable Management Goals and Objectives
After upland, riparian, and wetland habitat types and community types have been identified on a site, there are several uses for the information. Understanding of the information available in this document will increase over time with use. Some examples of the uses of the information are discussed below.

Land management plans sometimes call for attaining certain vegetation communities. Using this document, an understanding of what vegetation is feasible for a site can be gained. For example, on a degraded site with only a scattering of *Artemisia tridentata* subsp. *wyomingensis* (Wyoming big sagebrush), the potential canopy cover can be learned from the canopy cover tables in the text. Specific objectives can then be written to increase the canopy cover on the site of *Artemisia tridentata* subsp. *wyomingensis* (Wyoming big sagebrush) from 3 percent to 20 percent. The canopy cover tables can be used to write species lists for site rehabilitation or restoration projects. For example, on oil or gas pad, there may be limited vegetation remaining. The canopy cover tables provide a list of species that could be on the site. The species that are most desirable, available for planting, and easiest to obtain or establish can be selected.

If the goal is to provide shading of a stream for fish habitat, the tables will provide a list of species that will grow on a type, so that informed decisions can be made to avoid planting species unsuited for the purpose. Long-term planning, land use decisions, threatened and endangered species consultations, and environmental documents can be guided by successional information present in each habitat type or community type described.

Therefore, habitat type classification systems are useful to land and resource managers by providing: a permanent and ecologically based system of site classification that is referenced to vegetation potential (Daubenmire 1976); a vegetational classification for near-climax to climax communities; a way in which successional stages can be identified and described, thereby increasing our knowledge and ability to predict change on the landscape; and a basis for predicting results of management decisions or expected trends resulting from natural disturbances.

OVERALL RESULTS

The work resulted in a total of 96 different plant communities identified to either the habitat type (and phase) or community type level. A taxonomic key is included to key to the various types, along with an appendix showing photos/illustrations of the 86 indicator species used in the key (trees = 14; shrubs = 24; graminoids = 41; and forbs = 7). Each indicator species is discussed in terms of its family, origin status (native vs. introduced), habit, habitat/distribution, inflorescence, stems, leaves, and similar species.

In the text, each habitat type or community type contains a detailed discussion on the ecology and management of the type including: number of stands sampled; distribution within the study area; the status of the type (in other words, riparian/wetland type or upland type); location on the landscape; vegetation of late seral to climax stands, and disturbed and/or early to mid seral stands (including canopy cover, range of canopy cover, constancy, prominence index, and origin status (native vs. introduced); successional information; soils; livestock management information (forage production, species palatability, etc.); timber management information (if appropriate) (for coniferous and some deciduous types—tree population analysis of stand data, timber productivity [basal area, site index, cumulative mean annual increment, etc.]); wildlife management information; fisheries management information (if appropriate); fire management information; rehabilitation/restoration considerations; recreational uses and other considerations; and other studies.

Table 1 shows the break down by type (in other words, coniferous forest, deciduous forest, shrub, graminoid, and forb types) of the 1,126 stands sampled.

Table 2 shows the break down of the 96 different plant communities by riparian/wetland (62) or upland types (28). Six types are types that can occur in both riparian/wetland and upland situations.

Table 3 gives the overall break down by lifeform (tree, shrub, graminoid, forb, and ferns and allies) of species recorded throughout the entire study. There were a total of 663 unique species (in other words, species richness) recorded for the 1,126 sampled stands. Of the 663 species, 551 (83 percent) are native, and 112 (17 percent) were introduced or contain an introduced element.

Table 1—Number of stands and number of habitat types (h.t.)/community types (c.t.) by lifeform.

Type	Number of Stands	Number of h.t.s/phases	Number of c.t.'s
Coniferous Forest Types (h.t./c.t.)	108	13	0
Deciduous Forest Types (h.t./c.t.)	265	5	15
Shrub Types (h.t./c.t.)	337	13	14
Graminoid Types (h.t./c.t.)	347	24	8
Forb Types (h.t./c.t.)	69	1	3
Totals	**1,126**	**56**	**40**

Table 2—Number of stands, number of riparian/wetland types, and number of upland types by lifeform.

Type	Number of Stands	Number of Riparian / Wetland Types	Number of Upland Types	Both[a]
Coniferous Forest Types (h.t./c.t.)	108	2	9	2
Deciduous Forest Types (h.t./c.t.)	265	18	1	1
Shrub Types (h.t./c.t.)	337	15	10	2
Graminoid Types (h.t./c.t.)	347	23	8	1
Forb Types (h.t./c.t.)	69	4	0	0
Totals	**1,126**	**62**	**28**	**6**

[a]Both—Refers to habitat types or community types that can occur in both riparian/wetland and upland situations. The probability of occurrence in either a riparian/wetland site or an upland site is discussed in the write-up on each habitat type or community type.

Table 3—Total number of unique species by lifeform and by native, introduced, or both for the 1,126 sampled stands.

Lifeform	Number	Native[a]	Introduced[b]	Both[c]
Trees	14	13	1	0
Shrubs	77	72	2	3
Graminoids	140	116	17	7
Forbs	422	342	60	20
Ferns and Allies	10	8	0	2
Totals	**663**	**551**	**80**	**32**

[a]Native = native to pre-Columbian North America.
[b]Introduced = introduced by post-Columbian human immigrants.
[c]Both = species contains native and introduced elements (***NOTE:*** Those plant specimens only identified to genus and the genus includes both native and introduced species, were identified as "Both.")

Hansen and others (2008) presents a table (table 6; pages 35 to 41) showing ***species richness (in other words, the total number of plant species recorded in stands sampled)*** for each habitat type and community type. The table also shows additional information on total number of species per lifeform. The table includes only those types (h.t./c.t.) that had a large enough sample size to include a summary table in the description of the type. Some general trends are as follows:

- Disturbance generally causes an increase in species richness.
- The smaller the sample size, the lower the species richness. Therefore, caution should be exercised when making comparison to stands with a limited sample size.
- Woody-dominated types tend to have a greater overall species richness than herbaceous-dominated types. There are exceptions to this trend, such as the *Andropogon scoparius/Carex filifolia* (little bluestem/threadleaf sedge) habitat type with a species richness of 126 and a total sample size of 29 stands.
- Types found on mesic sites tend to have the greatest species richness, with those found on either dry sites or the wet sites having lower species richness. Many of the wetland herbaceous types are monospecific in undisturbed sites, and upon disturbance, the species richness increases, generally due to invasion by weedy species. An example is the *Scirpus pungens* (three-square bulrush) habitat type that has a species richness of 5 in relatively undisturbed stands (N = 6), and a species richness of 44 in disturbed stands (N = 5).

Some specific results are as follows:

Coniferous Forest Types

Highest species richness = 106 species (*Pinus ponderosa/Prunus virginiana* [ponderosa pine / chokecherry] habitat type, the *Berberis repens* [Oregon grape] phase; riparian/wetland type; number of stands sampled = 14).

Lowest species richness = 22 species (*Pseudotsuga menziesii/Juniperus scopulorum* [Douglas fir/Rocky Mountain juniper] habitat type; upland type; number of stands sampled = 2).

Deciduous Forest Types

Highest species richness = 197 species (disturbed and/or early to mid-seral stands of the *Fraxinus pennsylvanica/Prunus virginiana* [green ash/chokecherry] habitat type; riparian/wetland type; number of stands sampled = 90).

Lowest species richness = 27 species (*Elaeagnus angustifolia* [Russian olive] community type; riparian/wetland type; number of stands sampled = 3).

Shrub Types

Highest species richness = 116 species (disturbed and/or early to mid-seral stands of the *Artemisia cana* subsp. *cana/Agropyron smithii* [plains silver sagebrush/western wheatgrass] habitat type; riparian/wetland type; number of stands sampled = 31).

Lowest species richness = 18 species (*Tamarix chinensis* [salt cedar] community type; riparian/wetland type; number of stands sampled = 3).

Graminoid Types

Highest species richness = 126 species (*Andropogon scoparius/Carex filifolia* [little bluestem/threadleaf sedge] habitat type; upland type; number of stands sampled = 29).

Lowest species richness = 5 species (late seral to climax stands of the *Scirpus pungens* [three-square bulrush] habitat type; riparian/wetland type; number of stands sampled = 6).

Forb Types

Highest species richness = 26 species (*Glycyrrhiza lepidota* [American licorice] community type; riparian/wetland type; number of stands sampled = 4).

Lowest species richness = 8 species (*Polygonum amphibium* [water smartweed] community type; riparian/wetland type; number of stands sampled = 7).

Hansen and others (2008) also presents a table (table 7; pages 42 to 48) showing the average number of species of trees, shrubs, graminoids, forbs, ferns/allies, and ***average number of individual species per stand sampled*** by habitat type (h.t.) and community type (c.t.). The table includes only those types (h.t./c.t.) that had a large enough sample size to include a summary table in the description of the type. Once again, some general trends are as follows:

- Disturbance generally causes an increase in the average number of species per stand.
- The smaller the sample size, the lower the average number of species per stand. Therefore, caution should be exercised when making comparison to stands with a limited sample size.
- Woody-dominated types tend to have a greater overall average number of species per stand than herbaceous-dominated types. Once again, there are exceptions to this trend, such as the *Agropyron spicatum/Bouteloua curtipendula* (bluebunch wheatgrass/sideoats grama) habitat type with an average number of species per stand of 32.1 and a total sample size of 4 stands.
- Types found on mesic sites tend to have the largest average number of species per stand, with those found on either dry sites or the wet sites having lower diversity. Many of the wetland herbaceous types are monospecific in undisturbed sites, and upon disturbance, the average number of species per stand increases, generally due to invasion by weedy species. An example is the *Scirpus pungens* (three-square bulrush) habitat type that has an average number of species per stand of 1.6 in relatively undisturbed stands ($N = 6$), and a species richness of 7.4 in disturbed stands ($N = 5$).

Some specific results are as follows:

<u>Coniferous Forest Types</u>

Highest average number of species per stand = 29.0 species (*Juniperus scopulorum/Agropyron spicatum* [Rocky Mountain juniper/bluebunch wheatgrass] habitat type; upland type; number of stands sampled = 5).

Lowest average number of species per stand = 14.0 species (*Juniperus scopulorum/Cornus stolonifera* [Rocky Mountain juniper/red-osier dogwood] habitat type and the *Pseudotsuga menziesii/Juniperus scopulorum* [Douglas fir/Rocky Mountain juniper] habitat type; riparian/wetland type and upland type respectively; number of stands sampled = 6 and 2 respectively).

<u>Deciduous Forest Types</u>

Highest average number of species per stand = 34.2 species (*Populus tremuloides/Berberis repens* [quaking aspen/Oregon grape] habitat type; riparian/wetland type; number of stands sampled = 4).

Lowest average number of species per stand = 7.2 species (*Populus deltoides*/Recent Alluvial Bar [Great Plains cottonwood/Recent Alluvial Bar] community type; riparian/wetland type; number of stands sampled = 13).

<u>Shrub Types</u>

Highest average number of species per stand = 34.2 species (*Juniperus horizontalis/Carex heliophila* [creeping juniper/sun sedge] habitat type; upland type; number of stands sampled = 6).

Lowest average number of species per stand = 6.1 species (undisturbed stands of the *Salix exigua* [sandbar willow] community type; riparian/wetland type; number of stands sampled = 17).

<u>Graminoid Types</u>

Highest average number of species per stand = 32.1 species (*Agropyron spicatum/Bouteloua curtipendula* [bluebunch wheatgrass/sideoats grama] habitat type; upland type; number of stands sampled = 4).

Lowest average number of species per stand = 1.5 species (late seral to climax stands of the *Scirpus acutus* [hardstem bulrush] habitat type; riparian/wetland type; number of stands sampled = 16).

<u>Forb Types</u>

Highest average number of species per stand = 8.3 species (*Glycyrrhiza lepidota* [American licorice] community type; riparian/wetland type; number of stands sampled = 4).

Lowest average number of species per stand = 1.4 species (late seral to climax stands of the *Typha latifolia* [common cattail] habitat type; riparian/wetland type; number of stands sampled = 36).

Additional information on average number of species per lifeform is also presented in the table.

Finally, Hansen and others (2008) presents a table (table 8; pages 49 to 55) showing the average number of species of trees, shrubs, graminoids, forbs, ferns/allies, and ***average canopy cover of each lifeform group per stand sampled*** by habitat type (h.t.) and community type (c.t.). The table includes only those types (h.t./c.t.) that had a large enough sample size to include a summary table in the description of the type. This enables a quick comparison of structural complexity among the types described in the study area.

Some general trends are as follows:

- Disturbance generally causes an increase in the average canopy cover of a stand.
- Woody-dominated types tend to have a greater overall average canopy cover per stand than herbaceous-dominated types. Once again, there are exceptions to this trend, such as the stands of the late seral to climax *Stipa comata/Carex heliophila* (needle-and-thread/sun sedge) habitat type with an average canopy cover per stand of 200.0 percent and a total sample size of 4 stands.
- Types found on mesic sites tend to have the largest average canopy cover per stand, with those found on either dry sites or the wet sites having lower amounts. Many of the wetland herbaceous types are monospecific in undisturbed sites, and upon disturbance, the average number of species per stand increases resulting in an increase in average canopy cover, generally due to invasion by weedy species. An example is the *Carex rostrata* (beaked sedge) habitat type, *Carex rostrata* (beaked sedge) phase that has an average canopy cover per stand of 97.1 percent in relatively undisturbed stands ($N = 12$), and an average canopy cover per stand of 126.9 percent in disturbed stands ($N = 4$).

Some specific results are as follows:

Coniferous Forest Types

Highest average canopy cover per stand = 325.4 percent (*Pinus ponderosa/Cornus stolonifera* [ponderosa pine/red-osier dogwood] habitat type; riparian/wetland type; number of stands sampled = 4).

Lowest average canopy cover per stand = 93.2 percent (*Pinus flexilis/Agropyron spicatum* [limber pine/bluebunch wheatgrass] habitat type; upland type; number of stands sampled = 8).

Deciduous Forest Types

Highest average canopy cover per stand = 356.5 percent (*Elaeagnus angustifolia* [Russian olive] community type; riparian/wetland type; number of stands sampled = 3).

Lowest average canopy cover per stand = 68.7 percent [*Populus deltoides*/Recent Alluvial Bar [Great Plains cottonwood/Recent Alluvial Bar] community type; riparian/wetland type; number of stands sampled = 13).

Shrub Types

Highest average canopy cover per stand = 227.8 percent (*Shepherdia argentea* [silver buffaloberry] community type; riparian/wetland type; number of stands sampled = 27).

Lowest average canopy cover per stand = 39.3 percent (*Sarcobatus vermiculatus/Agropyron spicatum* [greasewood/bluebunch wheatgrass] habitat type; upland type; number of stands sampled = 3).

Graminoid Types

Highest average canopy cover per stand = 200.0 percent (*Stipa comata/Carex heliophila* [needle-and-thread/sun sedge] habitat type; upland type; number of stands sampled = 4).

Lowest average canopy cover per stand = 84.0 percent (late seral to climax stands of the *Spartina pectinata* [prairie cordgrass] habitat type; riparian/wetland type; number of stands sampled = 6).

Forb Types

Highest average canopy cover per stand = 134.1 percent (*Glycyrrhiza lepidota* [American licorice] community type; riparian/wetland type; number of stands sampled = 4).

Lowest average canopy cover per stand = 73.9 percent (*Salicornia rubra* [red glasswort] community type; riparian/wetland type; number of stands sampled = 9).

Additional information on average number of species and average canopy cover per lifeform is also presented in the table.

We also have a section on coniferous timber productivity, which includes distribution of the conifer types along a moisture gradient, tree population analysis, and timber productivity (site index, basal area, culmination of mean annual increment [a measure of tree growth]).

In addition, we have included discussions on number of plant species commonly found in the study area. These species typically present challenges to land managers. Some are native species, while others are invasive, weedy species. We have attempted to explain the ecology of these species to better interpret and understand their role on the landscape. Our hope is that this information will assist land managers in making informed decisions. The plant species are: *Juniperus scopulorum* (Rocky Mountain juniper)—ecological considerations, water use, habitat values; *Artemisia tridentata* subsp. *wyomingensis* (Wyoming big sagebrush)—ecological considerations, fire effects, palatability, wildlife uses, rehabilitation/restoration considerations; *Artemisia cana* subsp. *cana* (plains silver sagebrush)—ecological considerations, fire effects, palatability, wildlife uses, rehabilitation/restoration considerations; *Sarcobatus vermiculatus* (greasewood)—ecological considerations, fire effects, palatability, wildlife uses, rehabilitation/restoration considerations; annual

Bromus (brome) species such as *Bromus japonicus* (Japanese brome) and *Bromus tectorum* (cheatgrass)—species descriptions, physical site requirements, ecological considerations, forage values, fire adaptations; and *Elaeagnus angustifolia* (Russian olive), *Tamarix chinensis* (salt cedar), and *Agropyron cristatum* (crested wheatgrass).

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