Floristic Quality Assessment for Wyoming Flora: Developing Coefficients of Conservatism

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Executive Summary

The floristic quality assessment (FQA) method, based on plant species composition, provides a systematic way to describe baseline site conditions, make comparisons between different community types, set conservation priorities, and monitor changes in environmental quality over time. Central to FQA are coefficients of conservatism values (C-values), assigned to plant taxa that express the degree to which each taxon is restricted to ecosystems where the species composition, vegetation structure, and operation of ecological processes are within the ranges of variability that existed before Euro-American settlement. Several wetland studies in Wyoming have included FQAs that relied on surrogate C-values derived from C-values assigned in adjoining states, because Wyoming specific values had not been developed. To support future FQA in the state, we assembled a panel of botanical and ecological experts with field-based knowledge of Wyoming's flora to assign C-values to 1,296 wetland species. We also compared these final C-values to surrogate values, to see if these surrogate values might be acceptable for use in FQA when time or money are lacking for developing final C-values and found there was agreement between efforts.

1.0 Introduction

Land management agencies, conservation organizations, and researchers require tools to assess the quality of natural and created landscapes. Studies have shown that plant species can be used as measurable attributes to indicate the quality of a wetland plant community (Taft et al. 1997, USEPA 2002, DeKeyser et al. 2003). The Floristic Quality Assessment (FQA) is a standardized tool based on plant species composition that provides a systematic way to describe baseline site conditions, make comparisons between different community types, set conservation priorities, and monitor changes in environmental quality over time (Taft et al. 1997).

The FQA is based on the premise that the distribution of plant species across the landscape is a result of numerous abiotic and biotic factors, including natural and anthropogenic disturbances (Swink and Wilhelm 1979, 1994, Wilhelm and Masters 1995, Taft et al. 1997). The composition of vegetation growing at a particular site integrates spatial and temporal factors and thus can serve as an indicator of ecological integrity or condition (Taft et al. 1997, USEPA 2002). This report explains the process used by the Wyoming Natural Diversity Database (WYNDD) to develop the Coefficients of Conservatism values for Wyoming that are the building blocks of a Floristic Quality Assessment and outlines the practical uses of FQA.

1.1 Coefficients of Conservativism

Coefficient of Conservatism values (C-values) are assigned to individual plant species within specific geographic areas (Wilhelm and Masters 1995). A C-value is a rank ranging from 0 to 10 and represents the degree to which a plant taxon is restricted to ecosystems where the plant species composition, vegetation structure, and operation of ecological processes are within the ranges of variability that existed before Euro-American settlement (Swink and Wilhelm 1979, 1994, Wilhelm and Masters 1995). Conservative plant species with high C-values (9 or 10) are restricted to such ecosystems and are absent from ecosystems in which human activities or influences have shifted the composition, structure, or ecological processes outside of their pre-Euro-American ranges. In contrast, non-conservative plants with low C-values (0 to 3) often are found in human altered ecosystems; they may be present in unaltered ecosystems as well, but they are not restricted to them and so are poor indicators of them. The assigned C-value is not a reflection of the plant's wetland indicator status, density, dominance, rarity or frequency within the defined geographical area (Rocchio and Crawford 2013).

Traditionally, a panel of expert botanists is brought together to assign C-values to a flora by group consensus (Jones 2005, Rocchio et al. 2007, Zomlefer et al. 2013). This places the subjectivity of the FQA method upfront. Once the C-values have been assigned, applying FQA becomes an objective, repeatable method to investigate ecological condition and can be easily incorporated into other wetland assessment methodologies (Rocchio and Crawford 2013).

Studies have shown the proportion of conservative plants found in an area to be inversely correlated to the severity of human disturbances (Wilhelm and Masters 1995, Lopez and Fennessy 2002, Tibbets et al. 2015, 2016a, 2016b). Unaltered ecosystems have both conservative and non-conservative plants present. As disturbance increases, the relative proportion of conservative plant species decreases, as illustrated in Figure 1. Therefore the proportion of conservative plants present in an ecosystem can be used as an indicator of ecological integrity (Rocchio and Crawford 2013).

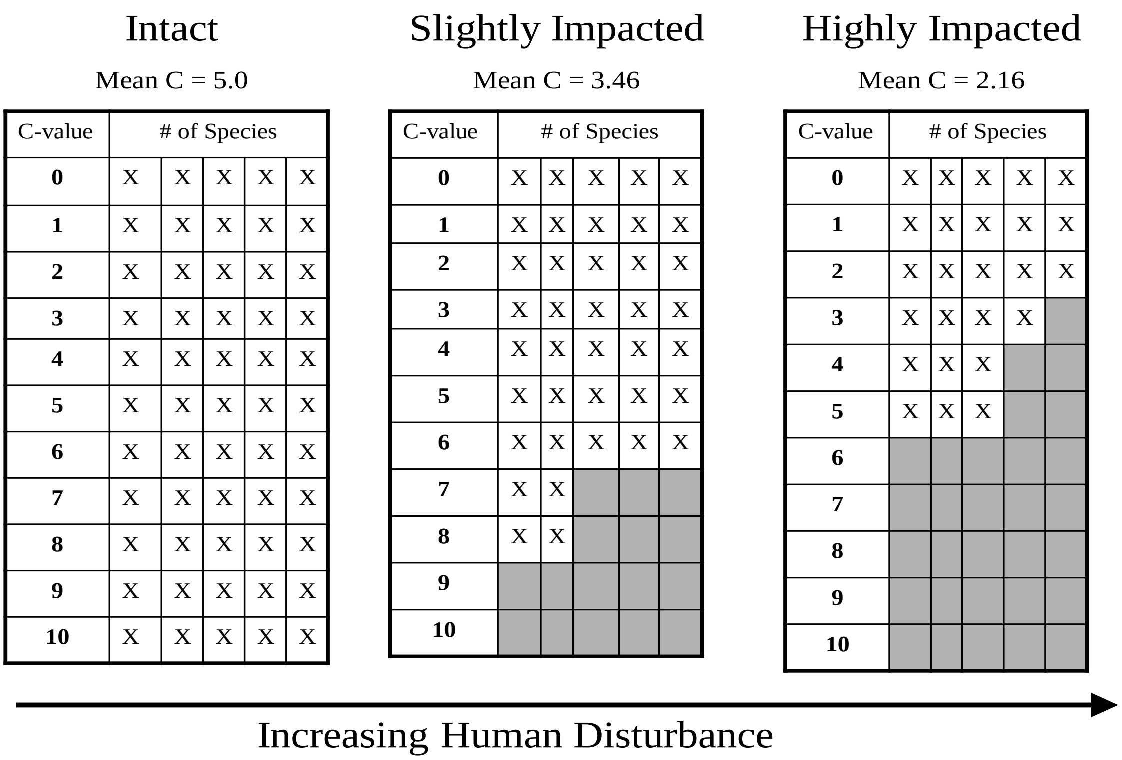

Figure 1. A Hypothetical Example of the Relationship between Mean C and Human Disturbance (from Rocchio and Crawford 2013*).*

1.2 Floristic Quality Assessment Metrics

C-values are used to calculate a number of metrics for the FQA, such as the average C-value of a site (Mean C) and the Floristic Quality Assessment Index (FQI), which weights Mean C with species richness to describe site quality (Swink and Wilhelm 1979, 1994). FQA metrics are useful for monitoring and assessment, evaluating the performance of mitigation and restoration sites, targeting protection and conservation priorities, establishing baseline condition, and informing regulatory decisions (Medley and Scozzafava 2009).

The most straightforward FQA metric is Mean C. Mean C is an average of the C-values for species present at a site and is calculated as follows:

$$\bar{C} = \sum(C1+C2+C3+...Cn)/N$$

C = the coefficient of conservatism for each species identified in the assessment area
N = the total number of species counted in the assessment area.

Mean C has been found to decline with increasing human disturbance and has been used as an indicator of ecological integrity (Figure 1) (Wilhelm and Masters 1995, Lopez and Fennessy 2002, Rocchio and Crawford 2013, Tibbets et al. 2015, 2016a, 2016b).

The Floristic Quality Assessment Index (FQI) metric, is calculated by multiplying the Mean C by the square root of the total number of species in an assessment area (Swink and Wilhelm 1979, 1994, Taft et al. 1997).

$$\text{FQI} = \bar{C} * \sqrt{N}$$

$\bar{C}$ = Mean C
N = Species Richness.

FQI accounts for the potential bias of assessment area size by weighting Mean C by species richness (Wilhelm and Masters 1995). Mean C and FQI can both be calculated for all species at a site or for only native species.

Miller and Wardrop (2006) developed a third metric, the Adjusted FQI, to eliminate the sensitivity of FQI to species richness and to incorporate non-native species. The Adjusted FQI is calculated as a percentage of the maximum attainable FQI score for a site, assuming that the maximum attainable Mean C is 10 and that all species are native:

$$\text{Adjusted FQI} = \left(\frac{\bar{C}}{10} * \frac{\sqrt{N}}{\sqrt{S}}\right) * 100$$

$\bar{C}$ = Mean C
N = native species richness
S = native + nonnative species richness

The selection of which FQA metric to use depends on the objectives of the project. All FQA metrics recognize that each plant species present at a site has adapted to a unique set of biotic and abiotic conditions, and therefore can contribute useful information about a site's quality (Rocchio and Crawford 2013). C-values can act as weights that represent the tolerance of the species to disturbance, and thus can enhance standard measurements of species richness and diversity (which often treat all plant species equally) (Andreas et al. 2004). The C-values can also be considered categorical variables and can be used to investigate the relative abundance of plants with high or low sensitivity to disturbance (Andreas et al. 2004).

1.3 Using FQA

The FQA metrics can be used as a standalone method to evaluate ecological integrity, or can be integrated into other monitoring and assessment protocols. To use any of the FQA metrics, the plant community is inventoried or sampled to compile a complete list of vascular plant taxa on a site. The observer can collect presence/absence data by walking the site and identifying all vascular species present, or by recording the abundance of each species in plots or transects

(Rocchio and Crawford 2013). C-values can also be applied to historic vegetation data and FQA metrics can be calculated to evaluate temporal changes to sites or to understand historic site conditions. All FQA metric scores are sensitive to sampling method and effort, thus it is important to only compare data from survey methods that use equivalent levels of floristic survey effort (Mueller-Dombois and Ellenburg 1974, Andreas et al. 2004).

Careful consideration of wetland type and natural variability in plant species composition must be taken into account when comparing FQA metric scores. Plant communities and baseline FQA metric scores can vary greatly between wetland types, affecting the ability to compare FQA metric scores across types. For example, in the absence of human alteration, plant communities in playa wetlands may have lower FQA scores than emergent marshes within the same study area. Emergent marshes may be relatively abundant where playa wetlands are rare. If your project objective was to protect rare ecosystems it would be inappropriate to decide which wetland to protect based on a comparison of the overall FQA scores.

Additional advantages and limitations of using FQA methods are discussed in Taft et al. (1997), Lopez and Fennessy (2002), Andreas et al. (2004), and Rocchio and Crawford (2013).

1.4 Need for Wyoming C-values

Floristic quality assessment methods could not be used in Wyoming prior to this effort because C-values had never been assigned to the state's wetland flora. However, Tibbets et al. (2015, 2016a, 2016b) developed surrogate C-values using data from surrounding states to calculate FQA metrics to understand wetland condition. For this project, we compared these surrogate C-values to the C-values developed using an expert panel in order to determine if the two methods were consistent with one another. This comparison of methods is especially relevant for states or regions that do not currently have C-values assigned for their wetland flora.

2.0 Methods

2.1 Developing a Wyoming Wetland Plant List

Target wetland plants of Wyoming were identified from the U.S. Army Corp of Engineers (USACE) National Wetland Plant List (USACE 2016). This list was further refined by WYNDD Botanist, Bonnie Heidel and Wetland Ecologist, Lindsey Washkoviak by referencing Dorn (2001), the Rocky Mountain Herbarium checklist (using a 2015 version of unpublished data), and recent technical literature, as reflected in an existing database of Wyoming flora maintained by WYNDD. Taxonomy in the WYNDD database, as well as the wetland plant list, corresponds to the treatment of Dorn (2001). Future efforts will reference Wyoming wetland flora with taxonomic updates reflected in the Rocky Mountain Herbarium database and with the U.S. Department of Agriculture (USDA) PLANTS names (USDA 2016), but that is currently beyond the scope of this project.

2.2 Assigning Wyoming's C-values

2.2.1 Wyoming Floristic Quality Assessment Expert Panel

A panel of botanical and ecological experts with field-based knowledge of Wyoming's wetland flora was assembled to make C-value assignments during the fall of 2016 (Table 1). Panel members participated in a video conference hosted by WYNDD's Wetland Ecologist to review the process for assigning C-values adapted from Rocchio and Crawford (2013). Panel members then worked individually to assign C-values to all native wetland species they were familiar with. Each panel member was provided with a table of the target wetland plant list and guidelines to assist with C-value assignments. C-value definitions and assignment guidance used by panel members are found in Appendix A.

Table 1. Floristic Quality Assessment Panel Members

Name	**Organization/Affiliation**	**Name**	**Organization/Affiliation**
Kurt Flaig	WEST Inc.	Paige Wolken	Army Corps of Engineers
Kent Werlin*	Biota Research & Consulting, Inc.	Katharine Haynes	USDA Forest Service
Heidi Anderson*	National Park Service	Kate Dwire	USDA Forest Service
Emma Freeland	Bureau of Land Management	Karen Clause	Natural Resource Conservation Service
Lindsey Washkoviak*	Wyoming Natural Diversity Database	Joy Handley	Wyoming Natural Diversity Database
George Jones*	Wyoming Natural Diversity Database	Bonnie Heidel*	Wyoming Natural Diversity Database

*Participated on the review panel

WYNDD's Wetland Ecologist compiled all panel member assignments and calculated the median, mode, and range of C-values assigned to each species to be used in deriving final C-values based on rules adapted from Rocchio and Crawford (2013):

1. All non-native species were assigned a final C-value of 0
2. For each native species, if the range in values assigned by the panel members was ≤ 3 values
    a. the final C-value was the mode, if present
    b. in cases where two modes were present, the final C-value was the median value
    c. if no mode could be calculated, then the final C-value was the median value
3. If the range in values assigned by the panel members was > 3 values, the species was flagged for review by a second, smaller review panel
4. Decimal values were rounded up to the nearest integer.

2.2.2 Re-evaluating Surrogate C-values

Tibbets et al. (2015) compiled data from Colorado (Rocchio et al. 2007), Montana (Pipp 2015), Nebraska (Rolfsmeier and Steinauer 2003), and the Dakotas (The Northern Great Plains Floristic Quality Assessment Panel 2001) into a database to assign surrogate C-values to a portion of Wyoming's wetland flora. For this project, we compared surrogate and panel-derived C-values for all of Wyoming's wetland flora to investigate if the relative effort and final results were similar and to test the validity of using surrogate data when formal C-values are not available.

C-values for Wyoming wetland species found in neighboring states were evaluated. The surrounding states used a diversity of taxonomic nomenclatures. To reconcile nomenclatural differences, the WYNDD Database Manager linked accepted Wyoming nomenclature to all possible synonyms recognized by the USDA PLANTS database (USDA 2016) and NatureServe. The WYNDD Botanist and Wetland Ecologist completed a thorough quality assurance and validation review to ensure C-values were accurately assigned to the correct taxa in the Wyoming database. A surrogate C-value was calculated for all wetland species based on the same set of rules used to evaluate C-values assigned by Wyoming's expert panel (Section 2.2.1). For species in relative agreement (range ≤ 3) final surrogate C-values were assigned. Species with wide disagreement (range > 3) were flagged for review, however this review was not part of the scope of this project.

All states used methods derived from Swink and Wilhelm (1979, 1994) and Taft et al. (1997), however the inclusion of non-native species differed among states. For example, Colorado assigned a value of 0 to non-native species and native species that are almost always found in non-natural or highly disturbed areas. Montana assigned a value of 0 to highly invasive, non-native species and a value of 1 to less-invasive, non-native species. Native species assignments for Montana began at a C-value of 2. The Dakotas and Nebraska did not include non-native species in their C-value assignments. Consequently, a native species with the same level of fidelity to disturbed habitats found in all states could have C-values ranging from 0 to 2. All states had general agreement with rules and definitions to assign values greater than 2.

3.0 Results

3.1 Wyoming C-values

The panel reviewed 1,429 Wyoming target wetland vascular plant species. Of those, 1,192 species (83%) are native to the state according to Dorn (2001) and accounts from the Rocky Mountain Herbarium. One-hundred ninety-four species (13%) are exotic, and 43 species (3%) have unknown or undetermined nativity status in Wyoming. All 194 exotic wetland species (Table 2) and an additional 306 exotic upland species were given final C-values of 0. The panel members assigned C-values to 1,102 native species or species of unknown nativity collectively referred to as native species hereafter. C-values assigned to target wetland plants apply to all species level or subordinate taxa in the WYDD database except for cases where there is evidence that subordinate taxa respond differently to disturbance.

Table 2. C-value Assignments to Wyoming Wetland Plant Species

1. Target wetland plant species	1,429
2. Species to which final C-values were assigned	1,296
2a. Exotic	194
2b. Natives Species	1,102
3. Species to which no C-values were assigned	133

Panel members were instructed to only assign C-values to species they were familiar with. As a result, 133 species were not assigned a C-value by any panel member. Approximately 34% (417 species) were assigned a C-value by only one panel member (Figure 3). The remaining 683 species had more than one C-value assigned, and 156 of these were assigned values by 5 or more panel members (Figure 2). The panel members were in complete agreement for 84 species (i.e., the range in assigned C-values was 0) and were in relative agreement (range of 1 to 3) for 44% (n = 486) of native species (Figure 4). Panel members were in wide disagreement (range >3) for 10% (n = 113) of native species. The second review panel assigned final values by consensus for these 113 species. Final taxonomic review identified 6 taxonomic errors that were removed from the final wetland species list found in Appendix B.

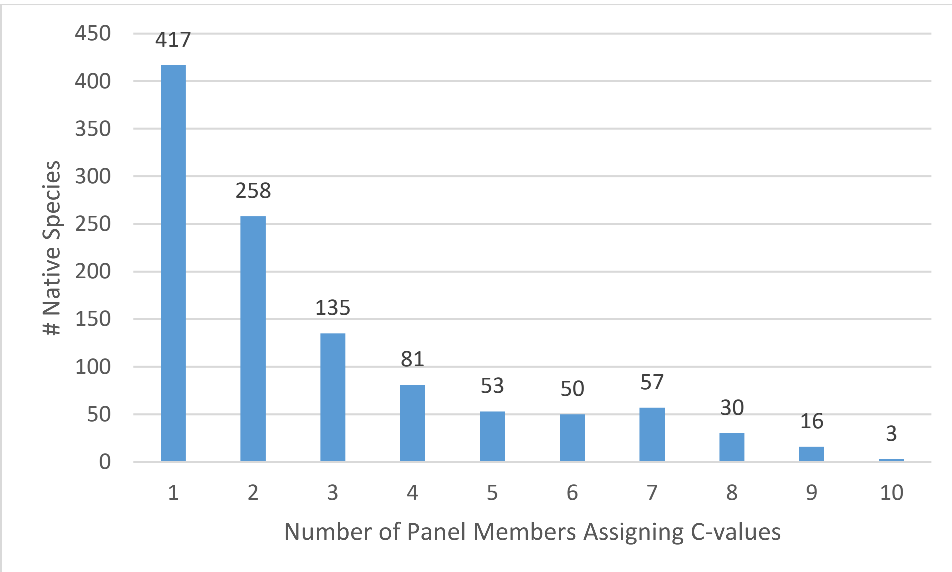

Figure 2. The Number of Native Wetland Species That Were Assigned C-values by Different Numbers of Panel Members

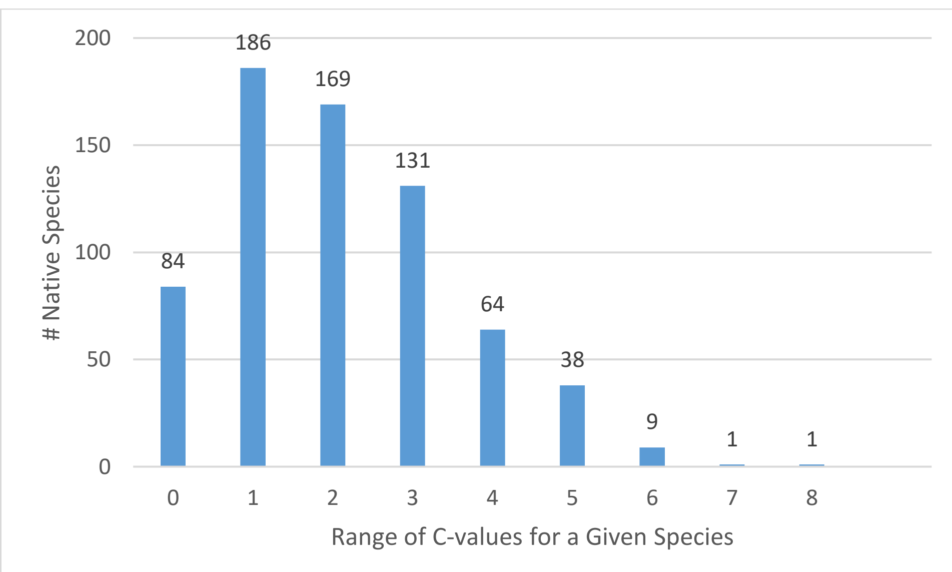

Figure 3. Range in C-values for each Native Wetland Species that Received an Assignment by Two or More Panel Members.

The final C-values calculated from the values assigned by panel members ranged from 0 to 10 (Figure 4). Most (87%) ranged from 4 to 8. C-values ≤ 3 or ≥ 9 were assigned to less than 1% of the native wetland plants.

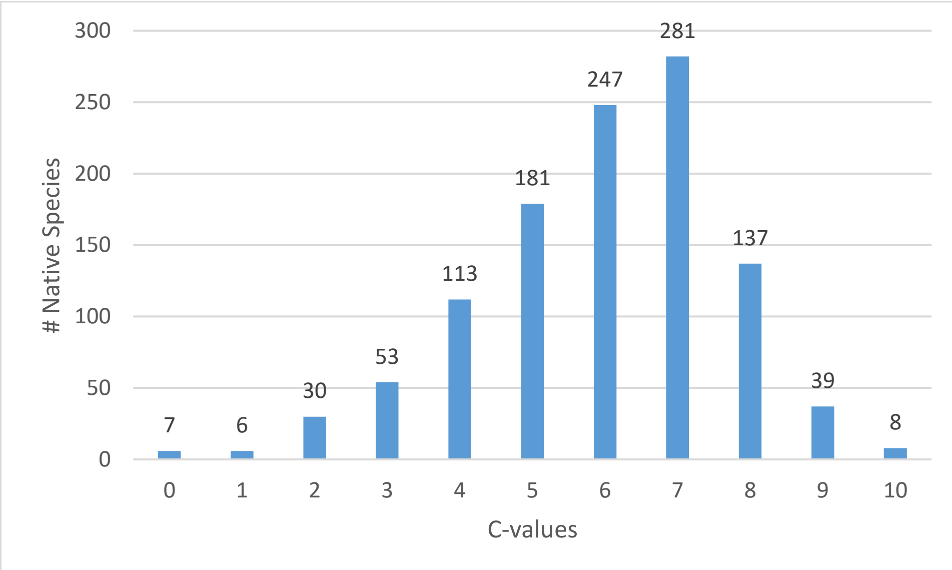

Figure 4. Number of Native Wetland Species Assigned Each Final C-value

3.2 Surrogate C-values

Surrogate C-values could be calculated for 924 native target wetland species using rules in section 2.2.1. The number of species assigned to each surrogate C-value can be seen in Figure 7. One hundred thirty-six species were assigned no C-values by any state and 371 species received a C-value assignment from only one state. States were in complete agreement (range = 0) for 82 native species and in relative agreement (range in C-values of 1 to 3) for 471 species (Figure 5). One hundred seventy-four species would require additional review because they were not in relative agreement (range > 3). Many of these species were not in relative agreement because one state considered a species to be non-native (C-value = 0) and other states considered that same species to be native and relatively conservative (C-value ≥ 4) (Figure 6).

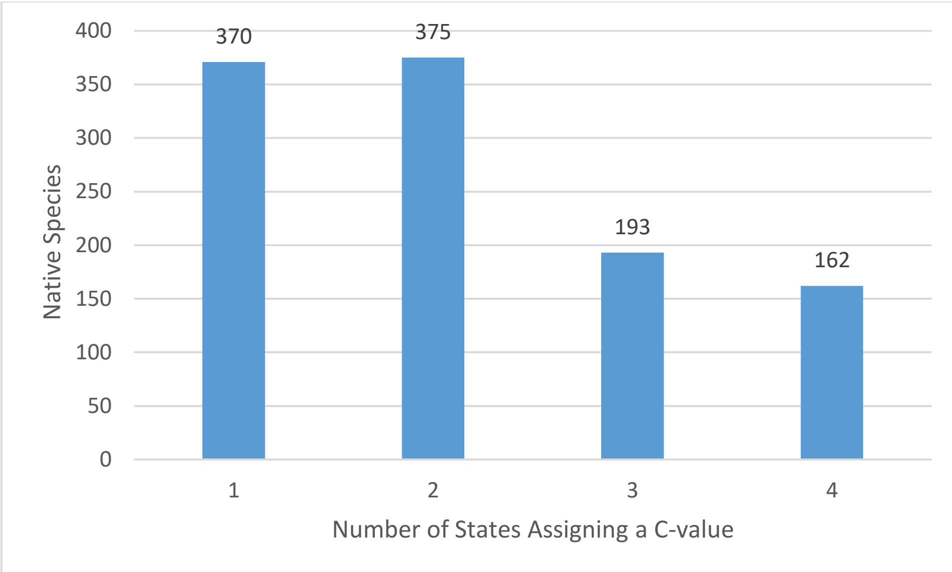

Figure 5. The Number of Native Wetland Species That Were Assigned C-values by Different States

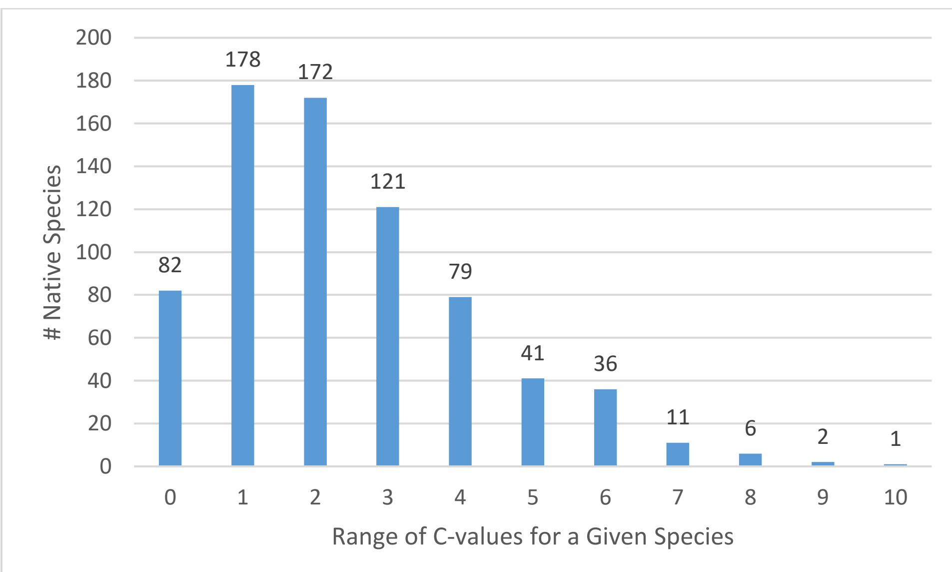

Figure 6. Range in C-values for each Native Wetland Species that Received an Assignment by Two or More States.

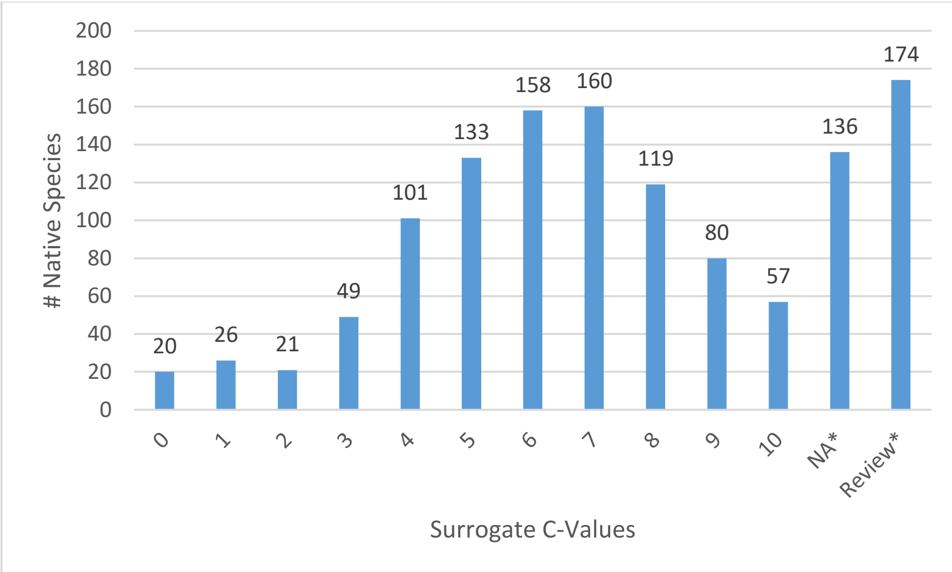

Figure 7. Number of Native Wetland Species Assigned Surrogate C-values.

** 136 species which received no C-value assignments from a state (NA) and 174 species that would require review because their values differed by > 3 values between states*

3.3 Comparing Surrogate C-values To Wyoming's Panel-Derived Values

Eight-hundred forty species had C- value assignments from both the panel and surrogate efforts (Figure 8). For a given species, an assigned panel and surrogate C-value that differed by more than three values was considered significantly different (Rocchio et al. 2007). Seven-hundred ninety-two (94%) of these species' C-value assignments were in relative agreement (range ≤ 3) between efforts and 561 (67%) of those species were within 1 C-value of each other. Less than 5% of species (n = 48) were in wide disagreement between efforts (range > 3). These results suggest that both methods are consistent in placing the species in the same spectrum of the 0 – 10 C-value scale.

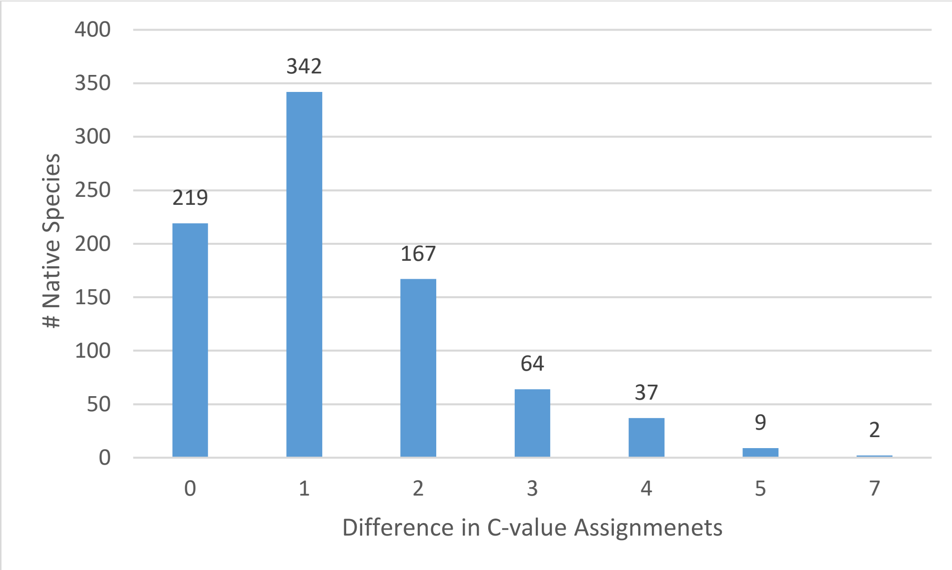

Figure 8. Difference between Panel Assigned and Surrogate C-values for Native Target Wetland Species of Wyoming

Table 3 summarizes the comparison of surrogate and panel-derived C-values. Each method produced a similar number of rule derived C-value assignments and number of species in need of review. Our effort illustrates that using data from surrounding states with similar ecological conditions is a valid, straightforward, and cost effective way to assign surrogate values if time and funding constraints prevent a state from developing formal, panel derived C-values. States should be cautious using surrogate C-values since it is not a peer- reviewed method, and it can skew results when developing regional or eco-regional C-values.

Table 3. Comparison of Panel Assigned and Surrogate C-values

	Panel C's	Surrogate C's
# assignments in relative agreement (Range ≤ 3)	553	555
# assignments by 1 panel member or state	417	370
# of species in need of review (Range > 3)	113	174
# of species with no C-values assigned	133	136

4.0 Summary

WYNDD assigned C-values to 1296 species based on expert consensus using methods adapted from Rocchio and Crawford (2013) that can now be used to calculate FQA metrics to assess Wyoming's wetlands. Surrogate C-values were found to be a valid option to use if formal C-values have not been developed for a state or region, however they should not replace the need to develop these formal C-values. WYNDD will continue to house and maintain the C-value data sets. Data and documentation can be found on the WYNDD website (www.uwyo.edu/wyndd). Surrogate data is available upon request.

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Appendix A: Guidance for Assigning Coefficients of Conservatism adapted from Rocchio and Crawford (2013)

Assigning Coefficients of Conservatism

Coefficient of Conservatism (C-value): a rank expressing the degree to which a plant taxon is restricted to ecosystems in which the species composition, vegetation structure, and operation of ecological processes are within the ranges of variability that existed before Euro-American settlement.

Plants with high C-values (9 or 10) are restricted to such ecosystems and are absent from ecosystems in which human activities or influences have shifted the composition, structure, or ecological processes outside of their pre-Euro-American ranges. These taxa are good indicators of unaltered ecosystems.

In contrast, plants with low C-values (0 to 3) often are found in altered ecosystems; they may be present in unaltered ecosystems as well, but they are not restricted to them and so are poor indicators.

C-values can be used to calculate multiple Floristic Quality Assessment (FQA) metrics which index the degree to which the site has been altered from pre-Euro-American conditions (Mean C, FQI, and FQAI). In unaltered ecosystems, the vegetation often contains plants with C-values across the range from high to low, but a relatively large proportion of the plants have high C-values. Consequently, the FQAs of such ecosystems are relatively high. But in heavily altered ecosystems, plants with high C-values are absent; the vegetation is composed of plants with lower C-values, and the FQAs also are low.

An ecosystem may be altered by the influence of novel ecological features or human disturbances, such as aggressively spreading exotic plants, pollution by agricultural chemicals, draining, or diversion of water into/out of a site. Or the alteration may come from substantial changes to the timing or intensity of ecological processes that operated before Euro-American settlement. Examples are change in the timing of annual flooding, reduction in the frequency of fire, or increase in the amount of grazing.

The C value is independent of rarity, fidelity to plant communities, dominance, wetland indicator status, or fidelity to climax ecosystems. When assigning, C-values only consider the niche of the species within habitats in which it has established on its own (e.g., not gardens or restoration plantings).

For each species that you have strong familiarity with, please assign a C-value ranging between 0 and 10, using the guidelines in Table 1 below. Please don't try to guess at a C-value for species you have only observed once or twice. You need to feel confident that you have a grasp on the full range of that species' ecological niche. Although the guidelines use ranges of C-values, please assign a **single** value to each species. The guidelines are intended to ensure that you are in the correct part of the continuum but ultimately you have to decide on a single value.

Definitions
Unaltered ecosystems: Ecosystems in which the composition, structure, function, and ecological processes are within their historic range of variability (i.e. historic = pre-Euro-American settlement). Unaltered ecosystems contain species spanning the range of C-values. With increasing alteration of the ecosystem, species more sensitive to human disturbance (with high C-values) are replaced by species more tolerant to disturbance (with lower C-values). See diagram below.

Human disturbances: Effects induced by post-Euro-American settlement human activity that modify the composition, structure, function, and/or ecological processes of ecosystems. Examples include hydroperiod alteration, nutrient enrichment, invasive/non-native species encroachment, sedimentation, removal of vegetation (ranging from mowing to logging), soil compaction, habitat conversion, increase in toxins/pollutants/heavy metals, changes in fire/flooding regime, introduced pests/pathogens, etc.

Table 1. Guidelines for assigning coefficients.

C-value Range	Description
0 to 3	Species that readily occur and persist in areas where human disturbances have converted ecosystems into human-created habitats such as old fields, tilled or plowed areas, ditches, managed roadsides and utility rights-of-way. These are areas where the soil has been severely disturbed. These species can also be found in a wide range of ecosystem conditions where ecological processes, functions, composition, and structure range from being unaltered to severely modified by human disturbances. Given that they are very tolerant of a wide range of frequency, severity, and duration of human disturbance, they are not useful indicators of unaltered ecosystems.
4 to 6	Species that readily occur and persist in ecosystems where ecological processes, functions, composition, and/or structure have been moderately altered by human disturbances. These species are often matrix-forming or dominant species
7 to 10	Species that are restricted or mostly restricted to unaltered ecosystems where ecological processes, functions, composition, and structure have not been (or minimally) modified by human disturbances. These species are excellent indicators of unaltered ecosystems functioning within their natural range of variability.

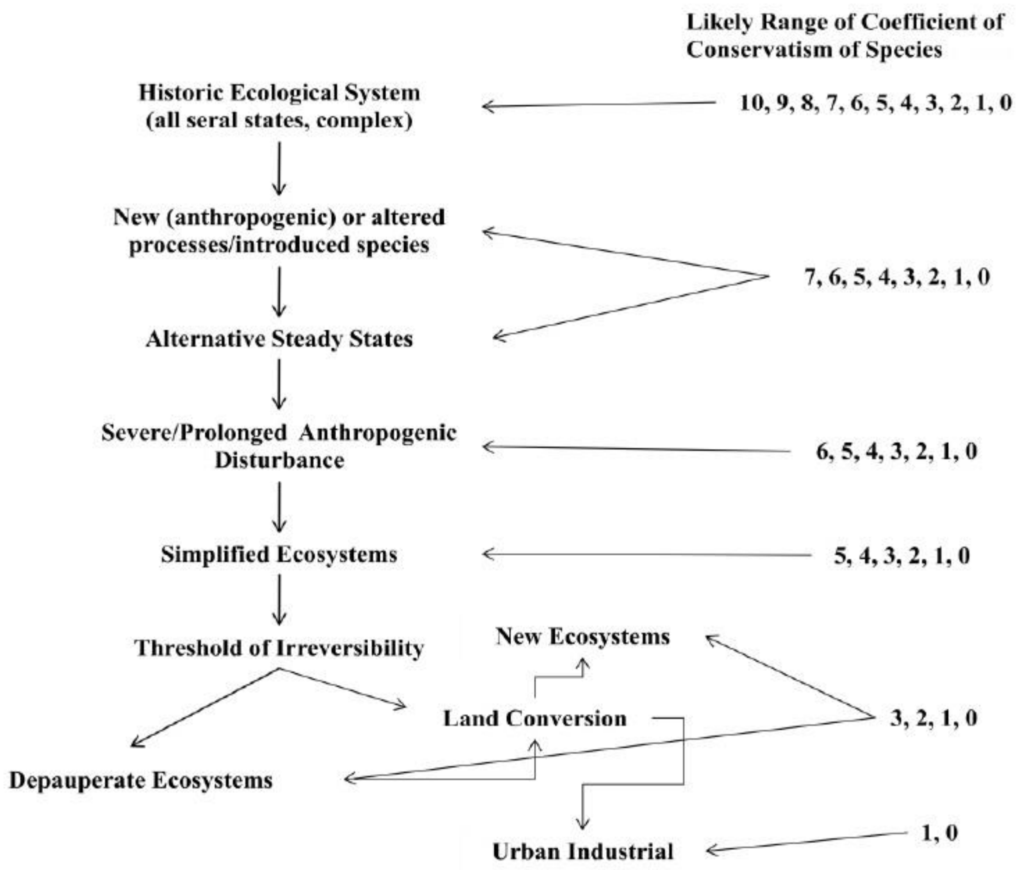
Database Notes: We have decided to use species names used by WYNDD at present. They conform to the treatment of Dorn (2001). Future efforts will cross-reference this list with taxonomic updates reflected in the Rocky Mountain Herbarium database and with the USDA PLANTS names, but that is currently beyond the scope of this project.

Please assign values to all species you are familiar with listed in the "Native Wetland Targets" tab. If your knowledge extends to the subspecies you may also assign C-values to the subspecific entry found under the Varieties_Subspecies_Nontarget tab, but this is not required.

Confidence Rating: Next to the C-value column is one for indicating your confidence in each C-value assignment. Please indicate **High, Moderate,** or **Low**. This field will be helpful when it comes time to compile individual results into an overall score.

If you find errors in the database or if the taxonomy is confusing, please notify Lindsey Washkoviak, WYNDD for clarification. lwashkov@uwyo.edu 307-438-0523

Ecosystem "States" and a Theoretical Distribution of C-Values



Intact

Mean C = 5.0

C-value	# of Species				
0	X	X	X	X	X
1	X	X	X	X	X
2	X	X	X	X	X
3	X	X	X	X	X
4	X	X	X	X	X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X	X	X	X
8	X	X	X	X	X
9	X	X	X	X	X
10	X	X	X	X	X

Slightly Impacted

Mean C = 3.46

C-value	# of Species				
0	X	X	X	X	X
1	X	X	X	X	X
2	X	X	X	X	X
3	X	X	X	X	X
4	X	X	X	X	X
5	X	X	X	X	X
6	X	X	X	X	X
7	X	X			
8	X	X			
9					
10					

Highly Impacted

Mean C = 2.16

C-value	# of Species				
0	X	X	X	X	X
1	X	X	X	X	X
2	X	X	X	X	X
3	X	X	X	X	
4	X	X	X		
5	X	X	X		
6					
7					
8					
9					
10					

Increasing Human Disturbance

<u>Someone hands you a specimen of Species X… what does it tell you about the integrity of the site it was growing in?</u>

- Nothing; species has such a wide amplitude that it provides no useful information about the site's integrity
  - <u>C values 0-3</u>
- Suggests the site is likely not a human-created habitat but can't tell how unaltered it is
  - <u>C values 4-6</u>
- Strongly suggests the site is of high integrity (unaltered)
  - <u>C values 7-10</u>

<u>Key to Coefficients of Conservatism (Fidelity Perspective):</u>

Is the species almost always restricted to unaltered ecosystems?

YES – Assign a coefficient of 7-10

NO – Go to next question

Does the species occur and persist in areas where human disturbances have converted ecosystems into human-created habitats?

YES– Assign a coefficient of 0-2

NO – Go to next question

Does the species mostly occur in native ecosystems but can persist where ecological processes, functions, composition, and/or structure are degraded/modified by human disturbances.

YES – Assign a coefficient of 5-6

Otherwise – Assign a coefficient of 3-4

<u>Key to Coefficients of Conservatism (Version 2: Colonization Perspective):</u>

Does the species colonize human-created sites? For example, sites with tilled soil, topsoil removed, new soil (i.e. fill), severe compaction (i.e., trails/dirt roads), permanent/semi-permanent change in vegetation structure (i.e. forest plantations).

YES - Routinely and often quickly colonizes human-created sites.

- Assign 0 - 2

Occasionally colonizes, or over the long-term will colonize, human-created sites but isn't one of the early pioneers of such sites.

- Assign 3 – 4

Rarely able to colonize human-created sites; and is very tolerant of human disturbance of its natural habitat.

- Assign 5 - 6

NO – Not able to colonize human-created sites; somewhat to not at all tolerant of human disturbance.

- Assign 7 - 10