WASHINGTON NATURAL HERITAGE PROGRAM

Floristic Quality Assessment for Washington Vegetation

U.S. Environmental Protection Agency, Region 10
Seattle, Washiington

Prepared by
F. Joseph Rocchio and Rex. C. Crawford

January 18, 2013

Natural Heritage
Report 2013-03

Floristic Quality Assessment for Washington Vegetation

January 18, 2013

Prepared by:
F. Joseph Rocchio and Rex Crawford
Washington Natural Heritage Program
Washington Department of Natural Resources
Olympia, Washington 98504-7014

Acknowledgements

The expertise of individuals associated with Western and Eastern Washington Floristic Quality Assessment Panels made the assignment of coefficient of conservatism values possible. Without their involvement this project could not have been completed. Gratitude is also extended to the following regional botanical and ecological experts who participated in the initial FQA workshops and provided useful input toward the project: Linda Storm (U.S. Environmental Protection Agency, Region 10), Jon Bakker (University of Washington), Sarah Spear Cooke (Cooke Scientific), Scott Moore (Snohomish County), Wendy Gibble (University of Washington), Janelle Downs (Pacific Northwest National Laboratory), and Larry Loftis (U.S. Forest Service, Rod Clausnitzer (U.S. Forest Service).

Rex Crawford, John Gamon and Joe Arnett (Washington Department of Natural Resources, Natural Heritage Program) provided invaluable guidance on process and panel selection. Jack McMillen (Washington Department of Natural Resources, Natural Heritage Program) is primarily responsible for database development and his technological expertise is much appreciated.

Finally, the support of U.S. Environmental Protection Agency, Region 10 in providing funding for this work as part of the following Wetland Program Development Grant Assistance Agreements: (1) CD-00J26301 and CD-00J49101 to the Washington Department of Natural Resources Natural Heritage Program.

Cover photos: Background: *Subalpine-Montane Poor Sloping Fen*. Inset photos (clockwise from lower left): *Triantha glutinosa (C value = 6), Carex limosa (C value = 8); Scheuchzeria palustris ssp. americana (C value = 9), Castilleja miniata (C value = 6), and Drosera anglica (8).* Photographer: Joe Rocchio

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Ecological indicators have been widely promoted among a number of agencies, conservation organizations, and researchers as a means of guiding conservation and management decisions such as choosing sites for conservation, monitoring restoration progress, setting restoration performance goals, and tracking trends in ecological condition over time (Harwell et al. 1999, Andreasen et al. 2001, Young and Sanzone 2002, U.S. EPA 2002a, Parrish et al. 2003, Faber-Langendoen et al. 2008, Rocchio and Crawford 2009, Tierney et al. 2009). The selection and development of indicators to measure ecological integrity can be challenging, given the diversity of organisms and systems and the large number of ecological attributes that could be measured. Thus, indicators that are most sensitive to ecosystem changes and those which provide ecologically meaningful information are most promising for monitoring and assessment applications.

The distribution of vegetation across the landscape is a result of numerous abiotic and biotic processes and interactions including past and present climate, hydrology, soils, aspect, competition, and natural or anthropogenic disturbances. Spatial and temporal human disturbances have a strong role in determining which plant species are able to survive and/or compete in a particular site. As such, vegetation is known to be a sensitive measure of human impacts including hydrological alterations, sedimentation, vegetation removal, physical disturbance, watershed development, mining, presence of invasive plants, and nutrient enrichment (Elmore and Kauffman 1984; Kauffman and Krueger 1984; Fulton et al. 1986; Kantrud et al. 1989; Cooper 1990; Wilcox 1995; Johnson 1996; Weixelman et al. 1997; Bedford et al. 1999; Galatowitsch et al. 2000; Adamus et al. 2001; Azous and Horner 2001; Cronk and Fennessy 2001; Flenniken et al. 2001; DeKeyser et al. 2003; Jones 2004, 2005; Kauffman et al. 2004; Zedler and Kercher 2004; Cooper et al. 2005; Reiss 2006). Thus, the composition of vegetation growing at a particular site integrates spatial and temporal impacts and can serve as an indicator of ecological integrity or condition (Taft et al. 1997; U.S. EPA 2002b).

This report presents an approach, called the Floristic Quality Assessment (FQA), for using vegetation composition as a means of assessing ecological condition. FQA focuses particularly on the concept of plant ‘conservatism’ as an indicator of the ecological quality of a given site. FQA results provide numeric values which can be used to conduct ecological monitoring and assessment of Washington vegetation communities/ecosystems. Specifically, FQA can assist in prioritizing vegetation communities/ecosystems for protection, restoration, or management efforts, and to monitor the effectiveness of these actions.

FQA provides a unique approach to ecological monitoring and assessment which moves beyond traditional measures of species richness and abundance. The method has been developed and successfully tested throughout the United States including the Midwest, Eastern, Southeast, Great Plains, and portions of the interior Western states (Swink and Wilhelm 1979; Ladd 1993; Oldham et al. 1995; Herman et al. 1996; Northern Great Plains Floristic Quality Assessment Panel, 2001; Bernthal 2003; Andreas et al. 2004; Cohen et al. 2004; Rothrock 2004; Nichols et al. 2006; Jones 2005, and Rocchio 2007b).

The Washington Natural Heritage Program (WNHP) was recently awarded a series of wetland program development grants from U.S. Environmental Protection Agency, Region 10 to improve

WNHP data as it relates to the Washington Department of Ecology's Wetland Rating System (Hruby 2004). The Wetland Rating System provides a systematic process for categorizing wetlands and is intended to help develop criteria for managing and protecting wetland values. Category I wetlands are relatively undisturbed, rare or provide a high level of function, or unique functions. "Natural Heritage Wetlands" (i.e., rare/high quality wetlands as determined by WNHP) have been designated as Category I. Current information about Natural Heritage Wetlands is outdated (> 20 years old) and mostly limited to western Washington lowlands. WNHP is updating methods of assessing ecological condition, revisiting and updating information about known Natural Heritage Wetlands, identifying currently undocumented Natural Heritage wetlands, and preparing information for delivery to planners, consultants, land managers and the public. One of the ecological assessment tools useful for identifying potential Natural Heritage Wetlands is the Floristic Quality Assessment (FQA). In addition, although funding for this project is directed toward application in wetlands, the method developed here can be used in any ecological system, upland or wetland. The results provided here complete the first FQA for the West Coast and begin to fill a major data gap toward the development of a National Floristic Quality Assessment (Medley and Scozzafava 2009).

The objective of the Washington FQA project was to assign coefficients of conservatism for each vascular species in the Washington flora. To accomplish this, the following tasks were completed:

- A panel of botanical and ecological experts with field-based knowledge of western and eastern Washington was assembled (i.e. Western Washington Floristic Quality Assessment Panel and Eastern Washington Floristic Quality Assessment Panel);
- Both the Western and Eastern Washington Floristic Quality Assessment Panels (Panel) convened for a one day workshop to review the process of assigning coefficients of conservatism;
- Panel members subsequently assigned (individually) coefficients for those species which they were familiar;
- Panel coefficient assignments were synthesized by WNHP;
- A sub-panel (i.e. "Review Panel) of experts reconciled coefficient assignments for species which had wide disagreement across the Panel (only for western Washington assignments);
- A Microsoft Excel-based calculator was developed for calculating various index scores.

1.1 Plant Conservatism

1.1.1 Brief History

The concept of plant species conservatism has been around since at least the late 1930s when Frank Gould described the distribution of prairie plants in Dane County, Wisconsin according to how confined they were to undisturbed remnant prairies versus their ability to distribute to more disturbed habitats. For example, he referred to *Silphium laciniatum* and *Eryngium yuccifolium* as having "extreme conservativeness" due to the fact that both were essentially limited to undisturbed prairie remnants (e.g., not plowed) and had not migrated to more disturbed habitats such as roadsides, railroad right-of-ways, or even in "young prairies", which he described as old fields or cleared wooded areas that were revegetated by native prairie plants (Gould 1937). Conversely, he noted that *Tradescantia ohiensis* (=*T. reflexa*) was quite common on the "young prairies" and also commonly observed on railroad embankments and roadways but was not found on any of the relic, undisturbed prairies (Gould 1937). Curtis (1959), while summarizing Gould's research, as well as work by Anthoney (1937) and Thomson (1940), equated 'relative conservatism' to climax status of prairie plants (given Curtis' views on succession, the "climax" concept used here is assumed to be similar to the polyclimax theory of Tansley (1935)). Curtis noted that these researchers reported essentially three groups of native prairie species: (1) species confined to prairie remnants; (2) species that had spread to varying distances from the prairie border into disturbed habitats but were most abundant near the prairies; and (3) species whose distribution was not related to the original prairie area.

Swink and Wilhelm (1979, 1994) and Wilhelm and Ladd (1988) extended the conservatism concept to all ecosystem types, specifically "natural remnants." Wilhelm and Ladd (1988) defined species conservatism as "the degree of faithfulness a plant displays to a specific habitat or set of environmental conditions." They noted that:

> *conservative floristic elements are those species that, through millennia, have become supremely adapted to an environment determined by a specific set of biotic and abiotic factors. These factors include local edaphics and extremes of drought, humidity, inundation, fires, temperature, and faunal interactions, etc. Though these factors have changed over time, the changes have been gradual enough and buffered sufficiently by system complexity to allow gene pools to adapt. When changes occur rapidly, as they have in the post settlement period, these conservative species on a given tract are reduced in accordance with the severity of the changes.*

These researchers developed a rating scale to reflect a species relative conservatism for the purpose of identifying natural areas in the Chicago region. This scale was referred to as the coefficient of conservatism (C value) and initially ranged from 0-20 (Wilhelm and Ladd 1988). A coefficient of '0' was assigned to species which provided the observer with "absolutely no confidence that the land on which it is growing had ancestral ties to any presettlement order." Species that "suggest a pronounced affinity to some native community" were assigned a '5'. A coefficient of '10' was assigned to species that "not only typify stable or near-climax conditions, but also exhibit relatively high degrees of fidelity to a narrow range of synecological parameters." C values greater than 10 were reserved for rare (C value = 15) and endangered (C value = 20) species.

Wilhelm and Masters (1996) demonstrated the C value scale by describing a scenario in which someone brings you a specimen of a particular species and asks "how confident are you that the specimen was collected from a remnant natural plant community?" If one is absolutely confident that the species came from an intact natural plant community, a C value of '10' would be assigned to that species. A C value of '5' would reflect certainty that the species came from a natural community but little confidence that the community was not degraded. If one had no confidence that the species came from a natural community it would be assigned a ‘0’. Intermediate values along this continuum reflect for variation between these extreme values.

Taft et al. (1997) broadly defined the C value scale as: “native species most successful in badly damaged habitats were given C values of 0. At the other end of the spectrum, species virtually restricted to natural areas in Illinois received C values of 10.” They specifically noted that they were not “intending to estimate the degree to which a species is restricted to a certain habitat or to gauge its modality according to Curtis (1959).” According to Taft et al. (1997), species that corresponded with Grime’s ruderal species (Grime 2001) were assigned a C value of 0-1 while ruderal-competitive species corresponded to the 2-3 C value range. Thus, species adapted to frequent and severe disturbances including anthropogenic disturbances that often result in only brief opportunities for reproduction were assigned a C value between 0-3. The 4-6 C value range encompasses Grime’s competitive species (Grime 2001) and included many matrix or dominant species as well as species expected or with a high consistency in a given community type. The third group in Grimes CSR model of plant strategies (Grime 2001), stress-tolerators, does not clearly correspond to the 7-10 C value range. Species assigned a C value between 7-10 are those that do not tolerate much habitat degradation. This can include some annuals and biennials which are not typically associated with the stress-tolerator guild. Species that are mostly associated with natural areas but could be found persisting in habitats that were slightly degraded were assigned 7-8 while those restricted to relatively intact natural areas were assigned a 9-10.

Taft et al. (1997) summarized conservatism as relating to two ecological tenets: (1) plant differ in their tolerance to disturbance type, frequency, and amplitude; and (2) plants display varying to degrees of fidelity to habitat *integrity* (emphasis added). However, other themes such as fidelity to climax or ‘near-stable’ conditions (Curtis 1959; William and Ladd 1998; Bernthal 2003; Andreas et al. 2004; Jones 2005), fidelity to a narrow range of plant communities (Bernthal 2003; Oldham et al. 1995), or fidelity to remnant or high-quality natural communities (Herman et al. 1996; Rothrock 2004; Rocchio 2007b) have also been used to define the concept resulting in slightly different interpretations of conservatism over time. These variations may be driven by the characteristics of natural communities occurring in different landscapes or deliberate attempts to reconcile philosophical differences or attempts to clarify underlying value-laden concepts such as ‘climax’, ‘natural’, ‘intact’, ‘high-quality’, etc.).

The evolving definition of species conservatism can be quite confusing, often due to ill-defined terms. For example, many FQA efforts have used the term ‘disturbance’ without specifying if both natural and anthropogenic sources are being referred. Another example is the use of ‘climax or near-stable’ conditions which some may conflate with the term ‘integrity’. In other words, sites lacking any kind of disturbance may be construed as having the highest quality or integrity. However, if one equates integrity as ‘an ecosystem functioning within its natural or historic range of variation’, then early to mid-seral natural communities resulting from natural disturbance regimes can possess integrity in the same manner as a climax state. In this sense, conservative species are not simply restricted to relatively stable habitats such as fens, bogs, or old-growth forests but can also occur in periodically disturbed habitats such as riparian systems where a species might be closely tied to a historic flooding regime. If that flooding regime is altered by human disturbances the species may not be able to thrive. Thus, in this case, conservatism is not a measure of fidelity to climax or late-successional habitats rather fidelity to a set of narrow ecological conditions.

Conservatism is also not to be confused with rarity. There are many types of rarity which result from inherent life-history characteristics, ecological requirements, habitat distribution, scale of inference, and human-induced disturbances (Rabinowitz 1981). In some cases, conservatism and rarity may overlap, especially in scenarios where habitat specificity is a driver of rarity. However, in other cases rarity and conservatism are dissimilar. For example, conservative species can be quite common in their habitats (e.g. *Rhynchospora alba*) and even throughout their geographic range as long as high quality conditions suitable for their survival are common. On the other hand, some rare species (e.g., *Lupinus sulphureus* ssp. *kincaidii*) are able to persist in human-modified habitats. Thus, conservative species may or may not be rare.

In recent years, 'niche conservatism', which has been defined as "the degree to which plants and animals retain their ancestral ecological traits and environmental distributions", has become a hot topic in evolutionary biology research (e.g., Crisp et al. 2009; Wiens 2004). Niche conservatism is conceptually similar to species conservatism, however differs in that it is used in the context of evolutionary temporal scales and to explain speciation and ecological biogeography rather than site or ecological quality.

1.1.2 Project Definition

For this project, a conservative species is defined as:

> *"a species almost always restricted to intact ecosystems where ecological processes, functions, composition, and structure have not been (or minimally so) degraded/modified by human stressors."*

An intact ecosystem is defined as:

> *"an ecosystem in which the composition, structure, function, and ecological processes are within their historic range of variability (i.e. historic = pre-Euro-Asian settlement, around 1850 in the State of Washington)."*

Human stressors are defined as:

> *"effects induced by post-Euro-Asian settlement human activity that degrades the composition, structure, functions, and/or ecological processes of intact ecosystems to the extent that they no longer function within their historic range of variation. Examples include hydroperiod alteration, nutrient enrichment, invasive/non-native species, sedimentation, removal of vegetation (ranging from mowing to logging), soil compaction, habitat conversion, increases in toxins, pollutants, or heavy metals, changes in fire regime, introduced pests/pathogens, etc."*

The C values scale is defined as follows:

> **0 -3 –** Species that readily occur and persist in areas where human stressors have converted ecosystems into human-created habitats such as old fields, tilled or plowed

areas, ditches, managed roadsides and utility right-of-ways. These species can also be found in a wide range of ecosystems conditions where ecological processes, functions, composition, *and* structure range from being intact to severely degraded/modified by human stressors. Given that they are very tolerant of a wide-range of frequency, severity, and duration of human stressors, they are not useful indicators of intact ecosystems. These species tend to correspond to Grime's ruderal (0-1) and ruderal-competitive (2-3) species.

4-6 – Species that readily occur and persist in ecosystems where ecological processes, functions, composition, and/or structure have been moderately degraded/modified by human stressors. These species are often matrix-forming or dominant species and correspond to Grime's competitor species.

7-8 – Species that are mostly restricted to intact ecosystems but can persist where ecological processes, functions, composition, and/or structure are slightly degraded/modified by human stressors. Good indicators of intact ecosystems.

9-10 – Species that are almost always restricted to intact ecosystems where ecological processes, functions, composition, and structure have not been (or only minimally) degraded/modified by human stressors; excellent indicators of intact ecosystems.

1.2 Floristic Quality Assessment

The Floristic Quality Assessment (Swink and Wilhelm 1994), originally called the Natural Area Rating Index (Wilhelm 1977; Swink and Wilhelm 1979), was initially developed to assist in the identification of natural areas worthy of conservation actions (Swink and Wilhelm 1979, 1994; Taft et. al. 1997). In recent years, FQA has also been used extensively for monitoring and assessment of wetland condition for a variety of objectives (USACE 2003, 2005, 2006; Lopez and Fennessy 2002; Mack et al. 2004; Rocchio 2007b).

To determine overall floristic quality of a targeted area, an inventory of all plant species growing in the area is documented either using a qualitative approach such as thoroughly walking through the site and taking a census of all vascular plants observed or by employing a more quantitative and repeatable sampling procedure such as establishing vegetation plots or transects. From the compiled species list, 'coefficients of conservatism' or C values associated with each native species are averaged to provide a site-based indicator of ecological quality.

C values are assigned to all native species in a flora. Although the C values are subjectively assigned, they are *applied* consistently and objectively since value judgments have already been determined. The C values range from 0-10 and represent the collective opinion of local botanical and ecological experts regarding a species relative conservatism. Nonnative plants were not part of the pre-settlement flora, so no C values are assigned to them. However, if nonnative species are used in the calculation of FQA indices, they are given a default C value of 0. Because plants often exhibit varying degrees of conservatism due to physiological and ecological variations within the range of each species, C values are assigned on a regional basis.

The use of conservatism as an indicator of ecological quality is based on the premise that increasing disruption of natural ecological processes and functions results in a lower proportion of conservative species persisting in a particular natural community. Since European-Asian settlement began, human impacts have caused dramatic shifts in many ecological processes including natural disturbance regimes. Due to these impacts many ecological processes and disturbance regimes now function outside their natural range of intensity, frequency, or duration (Wilhelm and Masters 1996). Conservative plants are not able to adapt to human-induced alterations and thus are typically the first plants to disappear from a habitat impacted by human activities (Wilhelm and Masters 1996). The severity of human-induced impacts appears to be correlated to the proportion of conservative plants which are found within an area (Wilhelm and Masters 1996; Wilhelm and Ladd 1988; Lopez and Fennessy 2002; DeKeyser et al. 2003, Rocchio 2007b). Thus, non-conservative or generalist species tend to dominate habitats which have had been exposed to prolonged and/or severe human impacts, resulting in a loss of ecological complexity (Wilhelm and Masters 1996). These simplified, weedy habitats are not able to persist as self-sustaining ecological systems and can result in changes in nutrient, soil, and hydrological regimes (Wilhelm and Masters 1996; Lopez and Fennessy 2002). In summary, a high-quality natural ecological system is comprised of both conservative and non-conservative plants whereas highly disturbed, low-quality natural areas or sites of anthropogenic origin have few, if any, surviving conservative plants. Thus, the proportion of conservative plants in a plant community provides a powerful and relatively easy indirect assessment of the integrity of both biotic and abiotic processes and as such is indicative of the ecological integrity of a site (Figure 1; Wilhelm and Ladd 1988).

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 →

Figure 1. Theoretical Example of Relationship of Mean C to Human Disturbance

FQA refers to a method of assessing ecological condition that uses multiple indices, many of which share a common variable—the coefficient of conservatism value (C-value) of native species. Depending on the index, other variables such as species richness or the percentage of non-native species may also be used in the calculation. The indices commonly associated with FQA include Mean C and Floristic Quality Index (FQI). Mean C and FQI can be calculated using only native species as well as including non-native plants (the latter are assigned a default C value of 0). These metrics have also been calculated separately for each vegetation strata (Nichols et al. 2006).

The most straightforward conservatism-based metric is Mean C of native species which occur at a site or within a natural community (Rooney and Rodgers 2002; Taft et al. 1997). Mean C has been found to be correlated with increasing human disturbance (Figure 1) and thus has often been used as an indicator of ecological integrity (Andreas et al. 2004; Wilhelm and Masters 1996; Taft et al. 1997; Lopez and Fennessy 2002; Cohen et al. 2004; Bourdaghs et al. 2006; Miller and Wardrop 2006; Nichols et al. 2006). Mean C is calculated as:

$$\overline{C} = \sum C_i \div N$$

where C = C value, i = an individual native species, and N = native species richness

Another index is called the Floristic Quality Index (FQI) which is the arithmetic product of Mean C and the square root of species richness.

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

where $\overline{C}$ = average C values and N = native species richness

A metric developed by researchers in Pennsylvania, the Adjusted Floristic Quality Assessment Index (Adjusted FQI), attempts to eliminate the sensitivity of the FQI to species richness as well as incorporate the effect of non-native species by calculating an Adjusted FQI as a percentage of the maximum attainable FQI score for a site by assuming that maximum attainable Mean C is 10 and all species are native (Miller and Wardrop 2006). The following equation is used to calculate the Adjusted FQI:

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

where $\overline{C}$ = average C values; N = native species richness; and S = native + nonnative species richness

All of these conservatism-based indices recognize that each native plant species, not just the dominant, rare, or exotic species, contribute useful information about a site's quality due to each species' ability to adapt to a unique set of biotic and abiotic conditions (Herman et al. 1997). As such, the FQA provides a unique approach to ecological monitoring and assessment which moves beyond traditional measures of species richness and abundance and provides an estimate of the ecological quality of site based on the proportion of conservative plants present (Herman et al. 1997). However, the utility of using conventional indices or measures (e.g., species richness, % nonnative species, etc.) is not diminished and should also be used to provide a more comprehensive assessment of floristic quality.

2.0 METHODS

2.1 Western Washington FQA Database Development

An existing database, developed by the Washington Natural Heritage Program, was used for FQA database development. The database was developed in 2002 with the intention of creating county-level species lists for the entire state of Washington (the database was used to create the county level maps in USDA PLANTS). Taxonomy was based on USDA PLANTS (http://plants.usda.gov/). Scientific names from the *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973), the primary regional resource used to identify plants in the field, as well as names from the Washington Flora Checklist (http://biology.burke.washington.edu/herbarium/waflora/checklist.php) were included in the database. Specimens from the University of Washington and Washington State Herbaria were mined for additional species records. In 2011-2012, taxonomy was updated from PLANTS, life history information was added from PLANTS, wetland indicator status were added from the 2012 National Wetland Plant List (http://rsgisias.crrel.usace.army.mil/NWPL/), additional synonyms from the Washington Flora Checklist (WA Flora Checklist) were added, and native/introduced values were compared between the WA Flora Checklist and PLANTS.

Some additional information about the database:

- no new county records have been added since 2002;
- most information in the database was populated from data tables via relationships on scientific name or codes, with some manual cleanup;
- when no synonym appears in the Hitchcock column it is typically because the species was not documented in Hitchcock and Cronquist (1973);
- when infraspecific entities are recognized in PLANTS, they often list both the species and the subspecies/variety as a unique record. These records were kept in the database for the specific reason that some individuals may only know an entity at the species level. However, if only one infarspecific entity occurs the corresponding species level record was often purged from the database. When possible, C values were assigned to the subspecific entity, otherwise C values were assigned to the species level. See discussion below.

For this project, two separate databases were created. One for western Washington (all species occurring in counties west of the Cascade crest (all of Whatcom and Skamania counties were included) and another for eastern Washington (all species occurring in counties east of the Cascade Crest, excluding Skamania and Whatcom). Each database is in a Microsoft Excel format. Review of the FQA databases by WNHP and Panel members revealed that a few species were missing and thus added to the appropriate database.

Some species have multiple records in the database. This occurs for many different reasons. In some cases, there are records for the infraspecific taxa but not a record for the species level. This occurred when PLANTS and the WA Flora Checklist were in agreement about these taxa. When PLANTS only recognized one infraspecific taxa and the WA Flora Checklist recognizes more, then a species record was maintained to account for this. Conversely, if PLANTS recognized more than one infraspecific taxa but the WA Flora Checklist only recognized the species then a species record was maintained in the database. For example, PLANTS recognizes multiple varieties of *Achillea millefolium* while the WA Flora Checklist only recognizes the species. Thus, the database includes a record for *Achillea millefolium* and records for the six varieties recognized by PLANTS. Panel members were encouraged, when possible, to assign C values to the infraspecific taxa but to default to the species level if that is how the know the taxa.

Occasionally, the multiple entries represented duplication in the database. This often occurred when a species record and a single infraspecific taxa record were included in the database despite the fact that the WA Flora Checklist only recognizes one entity. To determine this, the single infraspecific taxa was cross-referenced to the corresponding WA Flora Checklist name. If the WA Flora Checklist recognized more than one infraspecific taxa (even if USDA PLANTS does not) then both records were kept as individual records (as described above). If the WA Flora Checklist only recognized one infraspecific taxa, then it was concluded that the species and infraspecific taxa records were the same entity and only one was kept in the database. For example, the database includes an entry for *Pseudotsuga menziesii* and *Pseudotsuga menziesii var. menziesii*. Since *P. menziesii var. menziesii* is the only variety of *P. menziesii* that occurs in western Washington (according to both PLANTS and the WA Flora Checklist), only *P. menziesii var. menziesii* record was kept in the Western WA FQA Database.. Conversely, PLANTS has a record for *Erythronium grandiflorum* and *E. grandiflorum ssp. grandiflorum* in western WA while the WA Flora Checklist recognized more than one subspecies (*E. grandiflorum* ssp. *grandiflorum* and ssp. *candidum*). In this case, both the PLANTS records were kept in the database to acknowledge the fact that WA Flora Checklist recognizes more than one infraspecific taxa.

2.2 General Approaches to Assigning Coefficients of Conservatism

The assignment of coefficients of conservatism has generally taken two approaches (although some FQA efforts have utilized a combination): (1) consensus format and (2) Delphi approach (*sensu* Brown 1968). Both approaches assemble a panel of botanical and ecological experts familiar with the geographic area of interest. The number of people on the panel varies depending on the format chosen for assigning C values as well as the individuals who agree to participate. In some regions, there are very few individuals who know the entire flora, thus it is important that the panel have a diversity of geographic and taxonomic expertise.

The consensus approach assembles the panel for a multi-day workshop during which the entire flora is collectively assigned a C value. The advantages of this approach are that it allows for group discussion and consensus decisions, the assignments are completed relatively quickly, and an appointed moderator ensures the panel’s interpretation of conservatism does not drift toward rarity, etc. The disadvantage is that strong personalities can dominate the decisions and scheduling can be very difficult, especially with a large panel.

The Delphi approach provides the panel with specific definitions of the various C values and then asks each Panel member to individually assign C values over a specific time frame. The individual C value assignments are then synthesized to provide a final C value for each species. The advantage of this approach is that scheduling is easier, the process allows for independent opinions (i.e. avoids the issue associated with strong personalities), and allows for quantification of the various opinions. The disadvantage is that little group discussion occurs, data management/analysis requirements are increased, and the process is open to the possibility that individual panel members misinterpret the definition of conservatism.

The process used for this project was a modified Delphi approach that also included elements of the consensus approach.

2.3 Assigning Coefficients of Conservatism to the Washington Flora

2.3.1 Assigning Western Washington Coefficients of Conservatism

Coefficients of conservatism for the western Washington flora were assigned using a modified Delphi approach. The Washington Natural Heritage Program (WNHP) invited 66 regional botanical and ecological experts to participate on the Western Washington Floristic Quality Assessment Panel (Panel). Of those, 34 participated either in a one-day workshop in Seattle (29 individuals) or a two hour webinar (five individuals), during which the FQA concept was introduced and Panel members were calibrated to assigning C values. WNHP coordinated and moderated the workshop and webinar.

Each of the 34 individuals was provided with the FQA database and guidelines to help them assign C values (Appendix A). They were allotted approximately two months to individually assign C values to species they were familiar with. C values definitions used are described in Section 1.1.2. Twenty five of those 34 individuals completed C value assignments and returned them to WNHP. Those 25 individuals comprise the Western Washington Floristic Quality Assessment Panel (Table 1).

Once Panel members completed their C value assignments the median, mode, and overall range of assigned C values for each species was calculated by WNHP. If the range of C values assigned was ≤ 3 then the mode was accepted as the final C value for that species. If no mode was calculated (i.e. each assignment was unique), then the median value was used. If the range was ≥ 4 then the species was considered to have wide disagreement among the Panel members and was flagged for review by a subset of the Panel called the “Review Panel”.

Seven members of the Panel were selected for participation on the Review Panel. These seven people were selected due to the fact that they either (1) had assigned C values to a large number of species and/or (2) some of their assignments were considered to be ‘outliers’ relative to what other Panel members assigned for a given species (Table 1). Based on the Review Panel’s collective experience and the descriptive statistics associated with each species, the Review Panel recommended a final C value for each species with an assigned C value range ≥ 4. This occurred during a one-day workshop held in Everett, WA in December, 2011.

Table 1. Western Washington Floristic Quality Assessment Panel Members

Name	Organization/Affiliation	Name	Organization/Affiliation
Clay Antieau*	Seattle Public Utilities, City of Seattle	Jan Henderson	U.S. Forest Service (retired)
Joe Arnett	Washington Department of Natural Resources, Natural Heritage Program	Vikki Jackson	Northwest Ecological Services, LLC
Elizabeth Binney*	Pacific Ecological Consultants, LLC	Linda Kunze	L.M. Kunze Consulting
Mignonne Bivin*	North Cascades National Park Complex	Cathy Maxwell	Consulting botanist
Chris Chappell	Consulting ecologist	Jenifer Parsons	Washington Department of Ecology
Marty Chaney	U.S. Department of Agriculture, Natural Resources Conservation Service	Laura Potash	U.S. Forest Service
Rex Crawford*	Washington Department of Natural Resources, Natural Heritage Program	Joe Rocchio**	Washington Department of Natural Resources, Natural Heritage Program
Peter Dunwiddie*	Consulting ecologist / University of Washington	Regina Rochefort	North Cascades National Park Complex
Steve Erickson*	Frosty Hollow Ecological Restoration	Debra Salstrom	SEE Botanical Consulting
Sarah Gage	Washington State Recreation and Conservation Office, Washington Biodiversity Council	Reid Schuller	Western Stewardship Science Institute
David Giblin	University of Washington Herbarium at the Burke Museum	Jeff Walker	URS Corporation, Seattle
Rod Gilbert*	U.S. Department of Defense, Joint Base Lewis-McChord	David Wilderman	Washington Department of Natural Resources, Natural Areas Program
Thor Hansen	Consulting ecologist		

*Review Panel member

** moderated the process of C value assignments

2.3.2 Assigning Eastern Washington Coefficients of Conservatism

Coefficients of conservatism for the eastern Washington flora were assigned using a modified Delphi approach. The Washington Natural Heritage Program (WNHP) invited 65 regional botanical and ecological experts to participate on the Western Washington Floristic Quality Assessment Panel (Panel). Of those, 39 agreed to participate on the panel. However, only 32 committed to receive training in assigning C values via either in-person workshops or a webinar. Eighteen people participated in a one-day workshop in Wenatchee (13 individuals) or Richland (five individuals), during which the FQA concept was introduced and Panel members were calibrated to assigning C values. A webinar training was also offered in lieu of the workshop for an additional seven people who could not make either workshop. In addition, seven individuals had previously received training due to their participation in the Western WA FQA. WNHP coordinated and moderated all workshops and webinar.

Each of the 32 individuals who received FQA training was provided with the FQA database and guidelines to help them assign C values (Appendix B; the eastern WA guidance slightly varied from what was used in western WA; based on the experience with the western WA guidance, slight changes were made with the intention of improving understanding and consistency in interpretation of the guidance). They were allotted approximately two months to individually assign C values to species they were familiar with. C values definitions used are described in Section 1.1.2. Twenty one of the 32 individuals completed C value assignments and returned them to WNHP. Those 21 individuals comprise the Eastern Washington Floristic Quality Assessment Panel (Table 2).

Table 2. Eastern Washington Floristic Quality Assessment Panel Members

Name	Organization/Affiliation	Name	Organization/Affiliation
Kathy Ahlenslager	Colville National Forest	Jennifer Miller	Idaho Department of Fish and Game
Joe Arnett	Washington Department of Natural Resources, Natural Heritage Program	Jenifer Parsons	Washington Department of Ecology
Katy Beck	Consulting botanist	Joe Rocchio*	Washington Department of Natural Resources, Natural Heritage Program
Edd Bracken	Washington Department of Fish and Wildlife	Debra Salstrom	SEE Botanical Consulting
Amy Cabral	Colville National Forest	Reid Schuller	Western Stewardship Science Institute
Pam Camp	U.S. Bureau of Land Management (retired)	Dana Visalli	Consulting botanist
Florence Caplow	Consulting botanist	David Wilderman	Washington Department of Natural Resources, Natural Areas Program
Rex Crawford*	Washington Department of Natural Resources, Natural Heritage Program	George Wooten	Botanist, Pacific Biodiversity Institute
Mark Darrach	Corydalis Consulting	Carolyn Wright	Consulting botanist
Peter Dunwiddie*	Consulting ecologist / University of Washington	Ben Zamora	Washington State University
Terry Lillybridge	Okanogan-Wenatchee National Forest (retired)		

*moderated the process of C value assignments

During the two training workshops, attendees assigned C values to a subset of species as a calibration process. Those assigned values (173 species at the Wenatchee workshop and 123 at the Richland workshop) were included in the final synthesis of C values assignment as separate "individual" assignments. Thus, in total, 23 unique assignments were considered in the analysis. Once Panel members completed their C value assignments the median, mode, and overall range of assigned C values for each species was calculated by WNHP. When it was calculated (if each C value was unique then no mode was calculated), the mode was used for the final C value for that species. If no mode was calculated (i.e. each assignment was unique), then the median value was used. No Review Panel was used for eastern WA C values assignments as subsequent analysis from the western Washington process suggested that 86% of the C values assigned by the Review Panel were in overwhelming agreement (+/- 1) with the calculated mode/median value. Thus, due to time and funding constraints WNHP opted to use the mode/median for all assigned species.

3.0 RESULTS

3.1 Western Washington Results

The total number of species occurring in western Washington, as recorded in the database, is 2,721 of which 74% are native species (Table 3). Of the 2,025 native species in the flora, 1,523 (75%) were assigned C values by the Panel (Table 3). The Panel was not able to assign C values to 502 native species (25% of native species). The 696 non-native species, which do not receive a C value assignment (they default to 0 in any conservatism-based index which includes nonnative species), comprise 26% of the flora. The C value assignments are stored in the Western Washington Floristic Quality Assessment Database and Calculator (http://www1.dnr.wa.gov/nhp/refdesk/communities/fqa/fqa_calculator.xls).

Table 3. Results of C value Assignments for Western Washington

Total Species in Database (native + nonnative)	**2,721**
Total native species	2,025 (74%)
Total non-native species	696 (26%)
Native Species Assigned C values	**1,523 (75%)**
Species with assigned C value range ≤ 3	1,008 (66%)
Species with assigned C value range ≥ 4	515 (34%)
Native Species Not Assigned C value	**502 (25%)**

A histogram of the assigned C values is shown in Figure 2. The distribution is normal but skewed toward higher values (Figure 2). Species assigned C value ≤3 constituted 18% (278) of the flora while 24% (366 species) was assigned a C value ≥ 7 species (Figure 2). Species assigned a C value of 4-6 comprised 58% (879 species) (Figure 2).

Each Panel member suggested C values for those species they were most familiar with. Consequently, some species had more input than others. The number of individual suggestions (sample size) for those 1,523 species which were assigned C values is shown in Figure 3. Approximately 24% (365 species) are based on one individual suggestion. Of the 1,158 species which had more than one suggested C value, the majority of the Panel was in agreement regarding the individual assignment of C values. For example, 52 species (5%) had a range of 0 indicating that the Panel was in complete agreement about those species' C value assignment (Figure 4). The Panel was in close agreement (range of assigned C values was 1 - 3) for 51% (591) of those species receiving more than one C value assignment (Figure 4). Thus, the panel was in relative agreement (i.e., range of assigned values was ≤ 3) for 56% of the total species assigned. The remaining 44% (515) were reconciled by the Review Panel.

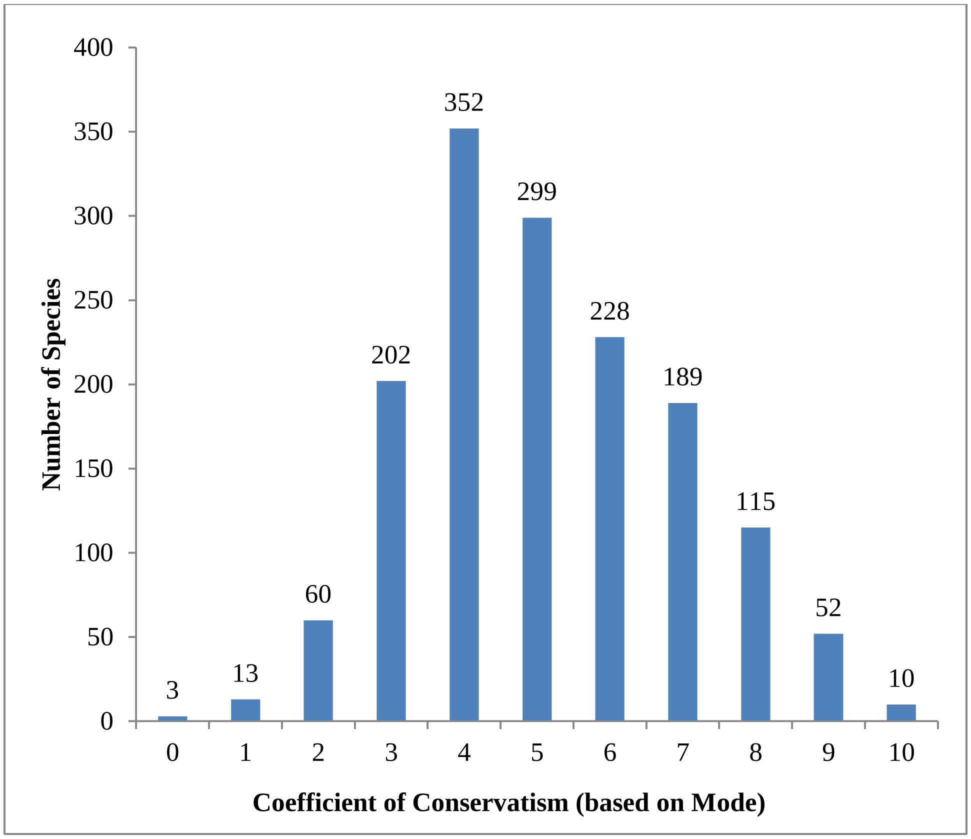


Figure 2. Distribution of Coefficients of Conservatism for Native Species for Western Washington

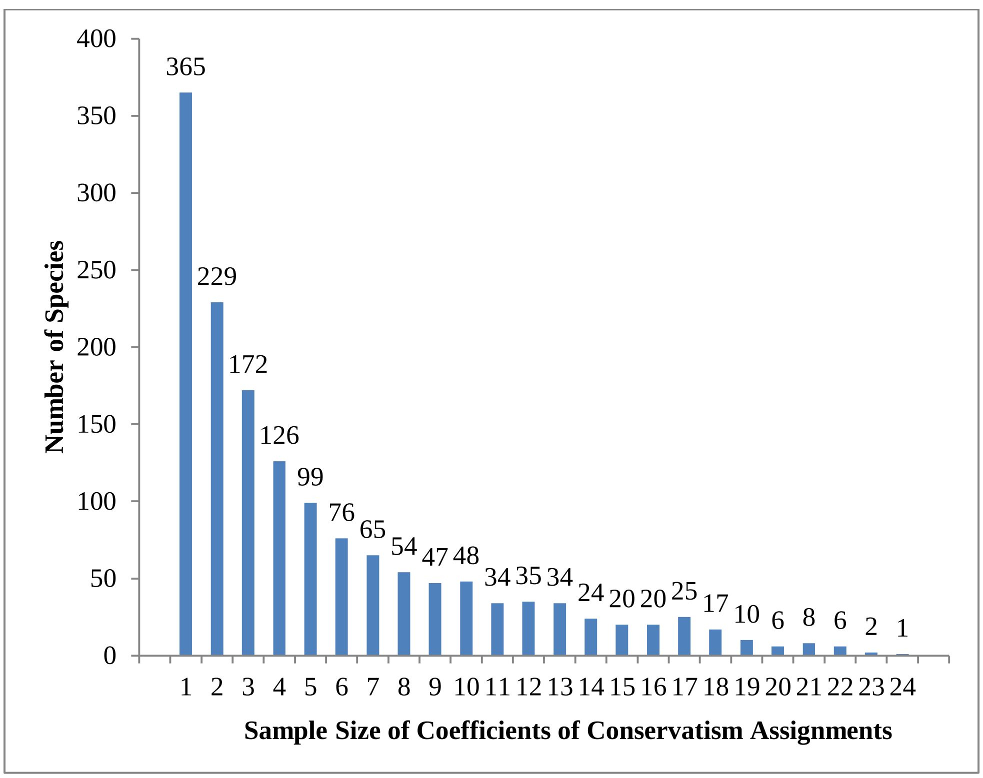


Figure 3. Sample Size for Panel C value Assignments for Western Washington

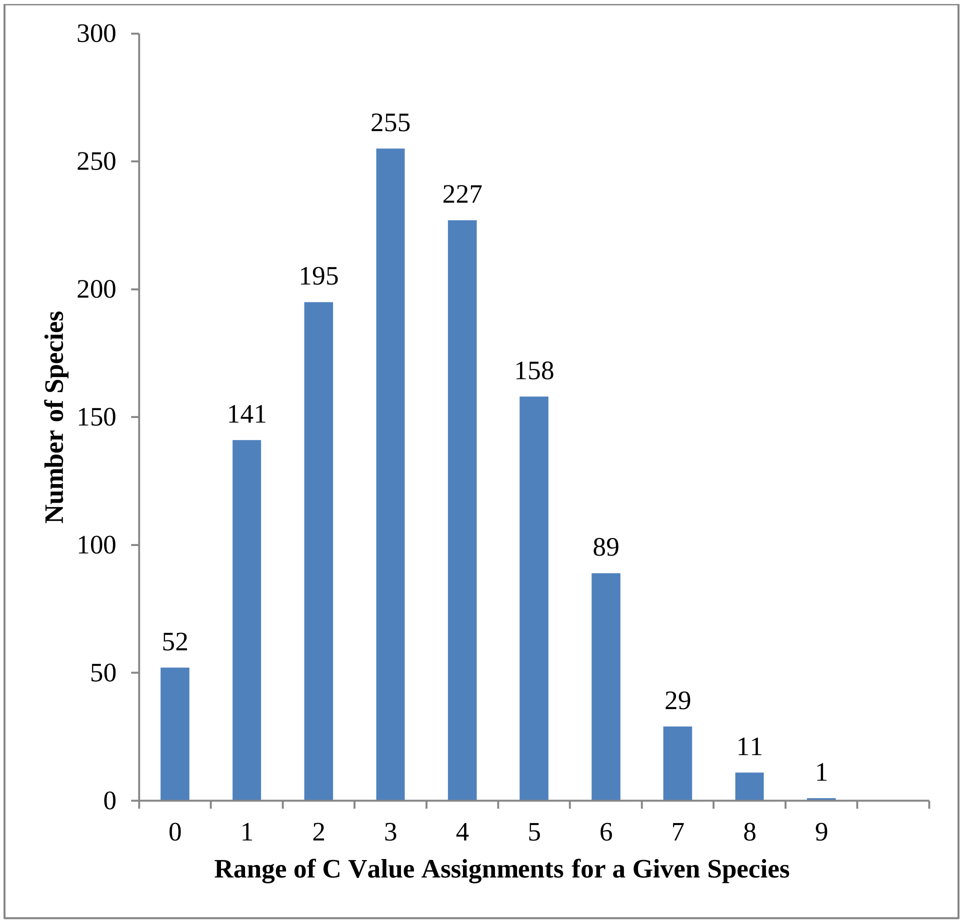


Figure 4. Range of Panel C value Assignments for Western Washington

3.2 Eastern Washington Results

The total number of species occurring in eastern Washington, as recorded in the database, is 3,445 of which 81% are native species (Table 4). Of the 2,794 native species in the flora, 2,085 (75%) were assigned C values by the Panel (Table 4). The Panel was not able to assign C values to 709 native species (25% of native species). The 651 non-native species, which do not receive a C value assignment (they default to 0 in any conservatism-based index which includes nonnative species), comprise 19% of the flora. The C value assignments are stored in the Eastern Washington Floristic Quality Assessment Database and Calculators (http://www1.dnr.wa.gov/nhp/refdesk/communities/fqa/fqa_calculator_cb.xls and http://www1.dnr.wa.gov/nhp/refdesk/communities/fqa/fqa_calculator_e_mtn.xls).

A histogram of the assigned C values is shown in Figure 5. The distribution is normal but skewed toward higher values (Figure 5). Species assigned C value ≤3 constituted 16% (331) of the flora while 28% (585 species) was assigned a C value ≥ 7 species (Figure 5). Species assigned a C value of 4-6 comprised 56% (1,169 species) (Figure 5).

Table 4. Results of C value Assignments for Eastern Washington

Total Species in Database (native + nonnative)	**3,445**
Total native species	2,794 (81%)
Total non-native species	651 (19%)
Native Species Assigned C values	**2,085 (75%)**
Species with assigned C value range ≤ 3	1,449 (69%)
Species with assigned C value range ≥ 4	636 (31%)
Native Species Not Assigned C value	**709 (25%)**

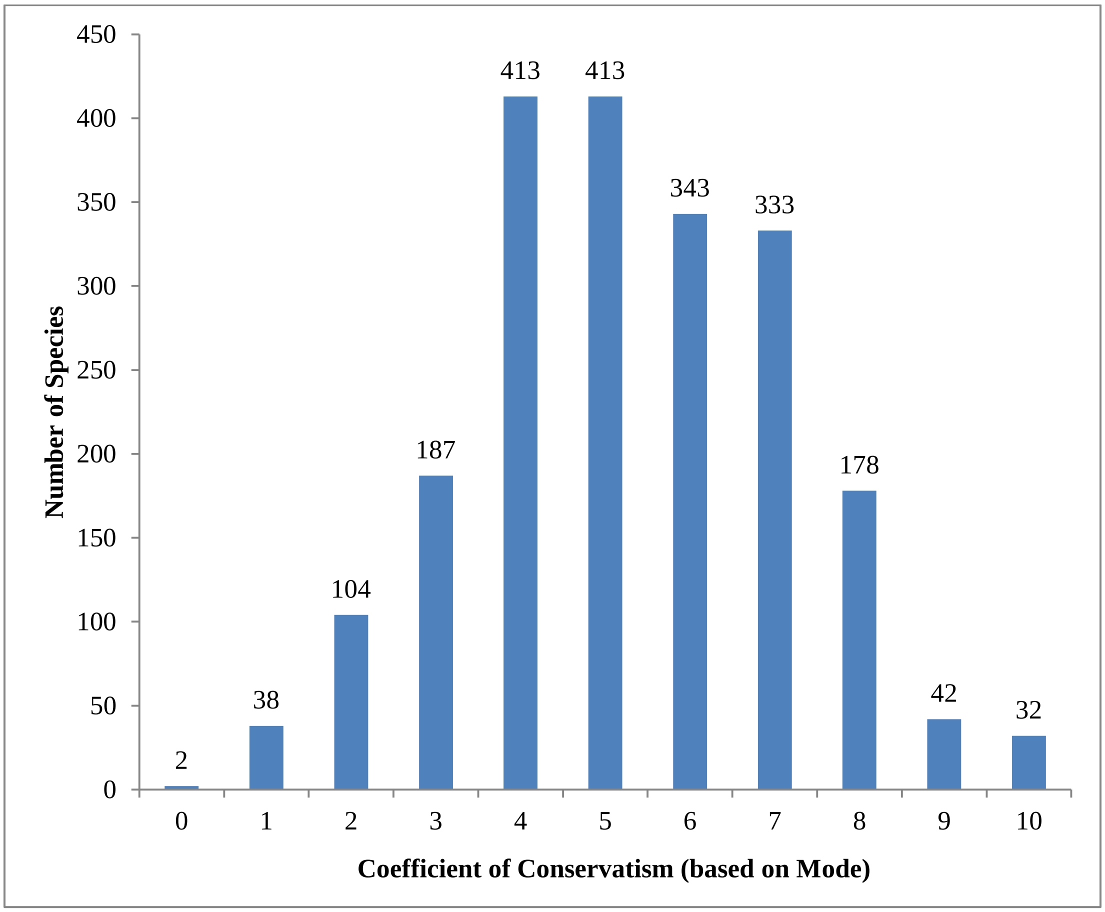


Figure 5. Distribution of Coefficients of Conservatism for Native Species for Eastern Washington

Each Panel member suggested C values for those species they were most familiar with. Consequently, some species had more input than others. The number of individual suggestions (sample size) for those 2,085 species which were assigned C values is shown in Figure 6. Approximately 18% (380 species) are based on one individual suggestion. Of the 1,705 species which had more than one suggested C value, the majority of the Panel was in agreement regarding the individual assignment of C values. For example, 190 species (11%) had a range of

0 indicating that the Panel was in complete agreement about those species' C value assignment (Figure 7). The Panel was in close agreement (range of assigned C values was 1 - 3) for 52%

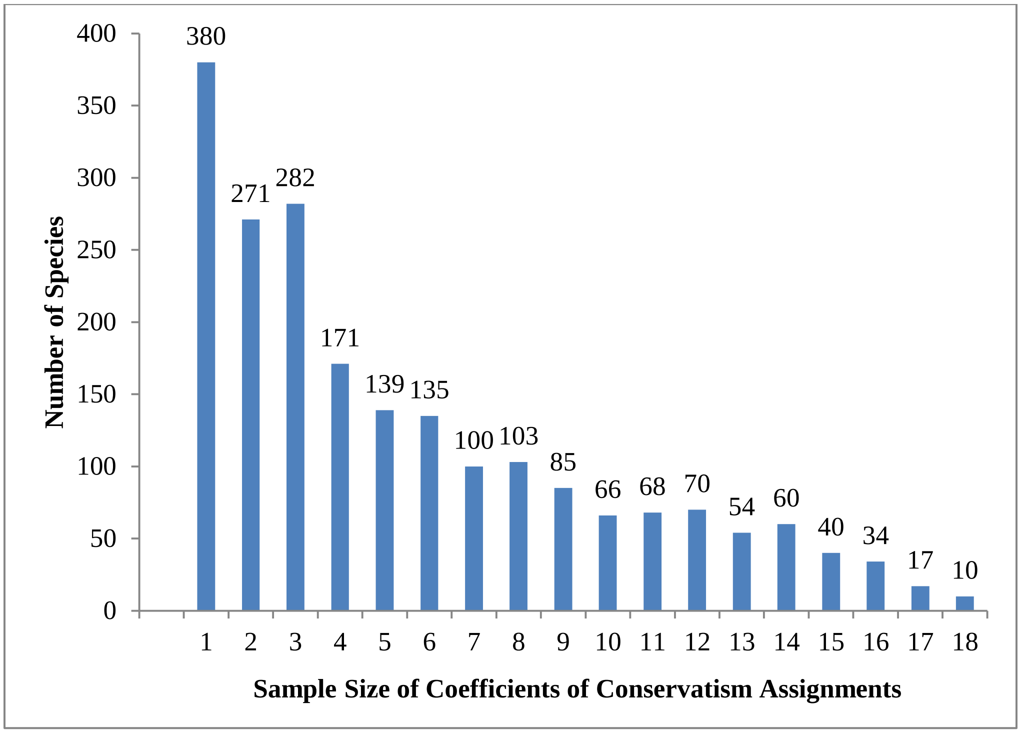


Figure 6. Sample Size for Panel C value Assignments for Eastern Washington

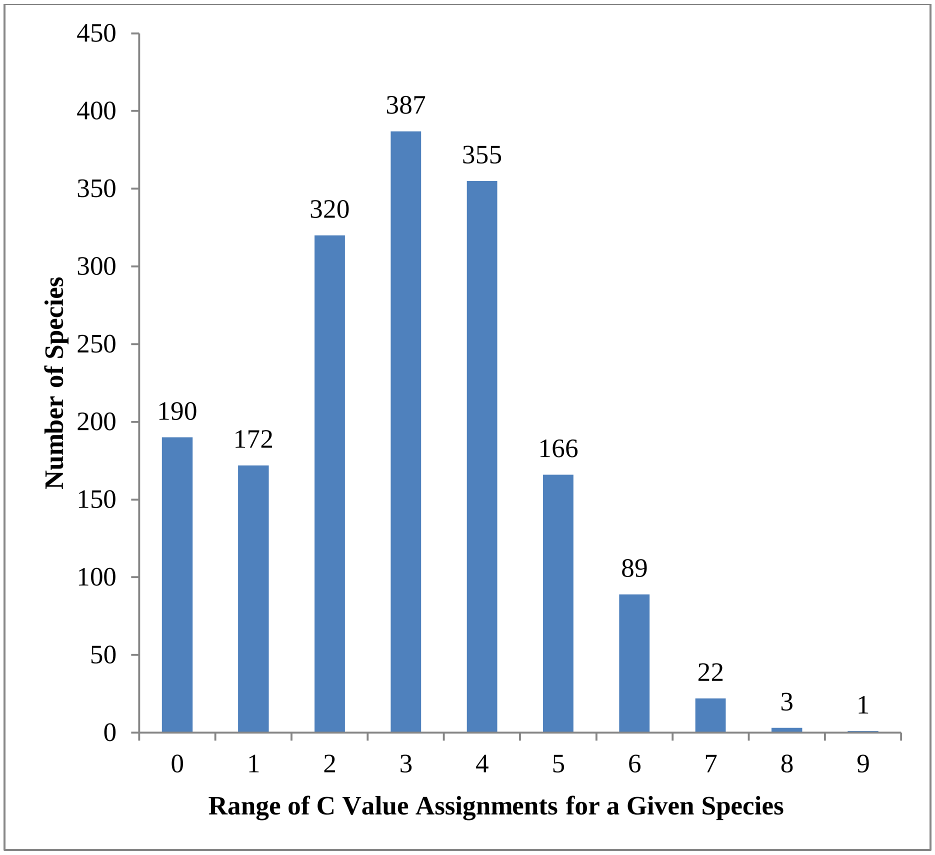


Figure 7. Range of Panel C value Assignments for Eastern Washington

(879) of those species receiving more than one C value assignment (Figure 7). Thus, the panel was in relative agreement (i.e., range of assigned values was ≤ 3) for 63% of the total species assigned. The remaining 37% (636) had a range ≥ 4, but the majority of those were within the 4 range (Figure 7).

4.0 DISCUSSION

4.1 Coefficients of Conservatism Assignments

Seventy five percent of both the eastern and western Washington native flora has been assigned a C value. The C value assignments had a normal distribution however were skewed toward the right of the peak of 4 (Figure 2 and Figure 5), a pattern also exhibited in other FQA efforts (Herman et al. 1996; Taft et al. 1997, Andreas et al. 2004; Rocchio 2007b). However, the concentration of C value assignments for Washington was more clustered in the middle ranges (C values of 4-6) than other FQA efforts (Table 5). The percentage of species with low C values (i.e., ≤ 3) was relatively similar among these FQA efforts. Typically the proportion of species with C values ≤ 3 is less than 12% of a flora (Gerould Wilhelm, personal communication). The proportion of eastern and western Washington C values within the 7-10 range was lower than other states (Table 5).

Because of differences in landscapes, both in terms of ecosystem types and the level of fragmentation, agriculture, and development patterns, the proportion of conservative species in particular region might be expected to vary although this has not been empirically demonstrated. In addition, slight variation in conservative definitions could result in variation across different regions.

Because the intent of using the C values is to assess site condition relative to a reference standard or monitor changes of ecological condition over time, the distribution of assigned C values is not as important as the sensitivity of conservatism-based indices. Thus, the true measure of the utility of the assigned C values will be whether they result in a large enough spread of average C values between an intact (or reference standard) and highly disturbed site sufficient to detect differences in ecological quality. Such an analysis was not performed for this project. However, as resources permit, WNHP intends to calculate FQA indices for existing plot data in order to calculate reference values for intact ecosystem types.

Table 5. Distribution of Washington Coefficients of Conservatism Relative to other States.

Range of Coefficients of Conservatism	Eastern Washington	Western Washington	Colorado[1]	Illinois[2]	Michigan[3]	Ohio[4]
0-3	16%	18%	8%	17%	15%	11%
4-6	56%	58%	46%	34%	36%	48%
7-10	28%	24%	46%	49%	49%	41%

[1]Rocchio (2007b); [2]Taft et al. (1997); [3]Herman et al. 1996; [4]Andreas et al. (2004)

4.2. FQA Databases and Calculators

The Washington Natural Heritage Program has also developed Microsoft Excel-based calculators for eastern and western Washington (see http://www1.dnr.wa.gov/nhp/refdesk/communities/fqa.html). The calculators include the final FQA database for each region. The calculator will automatically compute index values for a given dataset. Many different metrics are calculated including conservatism-based indices as well as more commonly used metrics such as % non-natives, % annuals, etc. (Table 6).

Species data can be entered into Column A of the "Calculator" worksheet by using the drop down list or typing directly into the cell. If you choose to type, the name **must** be synonymized with the USDA PLANTS name (column B of the "FQA Database" worksheet.). You can also paste a species list into Column A but species names MUST be synonymized with the USDA PLANTS name (column B of the "FQA Database" worksheet). Metrics are automatically calculated as you enter data. You do not need to take any other action.

The following modifications were made for metric calculations (all original data remain in the FQA database):

- the following 'duration' designations found the PLANTS data were lumped as Annual: annual / annual, biennial / annual, biennial, perennial / annual, perennial
- the following 'duration' designations found the PLANTS data were lumped as Perennial: biennial / biennial, perennial / perennial / perennial, annual
- the following 'nativity' designations were lumped as Native: N, N?
- the following 'nativity' designations were lumped as Exotic: I, I?
- lifeform designations were reduced to Tree, Shrub, and Herbaceous for the purpose of Mean C calculations. The original lifeform designation (from USDA PLANTS) is found in the FQA Database worksheet.

As noted above, Panel members were encouraged to assign C values to infraspecific taxa when possible but to default to the species level if that is how they know a species. Consequently, some species with multiple infraspecific taxa have various permutations: (1) only the species record was assigned a C value; (2) the species records and one or more infraspecific taxa were assigned C values; or (3) only the infraspecific taxa were assigned a C value. Users should use the C value for the finest level taxa they are familiar with. For example, if the user only identified a taxa to the species level but C values only exist for infraspecific taxa then no C value should be used in the calculation for that taxa unless all infraspecific taxa have the same C value. If a C value exists for the species record and the infraspecific taxa, users should use C values for the latter if they are confident which is included in their dataset.

Table 6. Indices Included in the Western Washington FQA Calculator

Metric	Notation	Definition
Mean C (native species)	$\bar{C}n$	$\sum Ci \div N$
Mean C (all species)	$\bar{C}all$	$\sum Cj \div S$
Mean C (native trees)	$\bar{C}ntrees$	Same as $\bar{C}n$ except limited to native tree species
Mean C (native shrubs)	$\bar{C}nshrubs$	Same as $\bar{C}n$ except limited to native shrub species
Mean C (native herbaceous)	$\bar{C}nherbs$	Same as $\bar{C}n$ except limited to native herbaceous species
FQAI (native species)	FQI*n*	$\bar{C}n * \sqrt{N}$
FQAI (all species	FQI*all*	$\bar{C}all * \sqrt{S}$
Adjusted FQAI*	AFQI	$\left\{\frac{\bar{C}n}{10} * \frac{\sqrt{N}}{\sqrt{S}}\right\} * 100$
% intolerant (C value ≥ 7)	$\bar{C}n \geq 7$	Same as $\bar{C}n$ except limited to species with C values ≥ 7
% tolerant (C value ≤ 3)	$\bar{C}n \leq 3$	Same as $\bar{C}n$ except limited to species with C values $n \leq 3$
Species richness (all species)	S	Total number of all (native + nonnative) vascular plant species
Species richness (native species)	N	Total number of native vascular plant species
% nonnative		Percentage of nonnative species relative to S
Wet Indicator (all species)	$\overline{WI}all$	$\sum WIj \div S$
Wet Indicator (native species)	$\overline{WI}n$	$\sum WIi \div N$
% hydrophytes		% of species with wetland indicator status of OBL or FACW relative to S
% native perennial		% of native perennial species relative to S
% native annual		% of native annual species relative to S
% annual		% of annual species relative to S
% perennial		% of perennial species relative to S
# of moderate fidelity prairie species		number of species with moderate fidelity to **western Washington/Willamette valley prairies**
# of high fidelity prairie species		number of species with high fidelity to **western Washington/Willamette valley prairies**
% native forbs		% of native forb species relative to S
% native graminoids		% of native graminoid species relative to S

Notation: i = individual native species; j = individual species (native or nonnative); N = native species richness; S = total species richness (native and nonnative); WI = numeric wetland indicator status as follows: OBL/OBL*(-5), FACW+(-4), FACW*(-3), FACW(-3), FACW-(-2), FAC+(-1), FAC*(0), FAC(0), FAC-1(+1), FACU+(+2), FACU*(+3), FACU(+3), FACU-(-4), UPL (5)

*** (Adjusted FQAI citation)**: Miller, S.J. and D.H. Wardrop. 2006. Adapting the floristic quality assessment index to indicate anthropogenic disturbance in central Pennsylvania wetlands. Ecological Indicators 6(2): 313-326.

****Prairie fidelity assigned by:** (1) Alverson, E. 2009. Vascular Plants of the Prairies and associated habitats of the Willamette Valley-Puget Trough-Georgia Basin ecoregion. Excel Spreadsheet which includes fidelity values. The Nature Conservancy, Eugene, Oregon; and (2) Chappell, C., E. Alverson, and W. Erickson. 2004. Ecologic and geographic variation in species composition of prairies, herbaceous balds, and oak woodlands of the Willamette Valley-Puget Trough-Georgia Basin Ecoregion. Paper Presented at the Ecological Society of America Annual Conference. Portland, Oregon.

4.3 Use and Application of the Floristic Quality Assessment Method

Some of the more common questions asked by managers regarding floristic quality are (Wilhelm and Masters 1996): (1) What is the overall floristic quality of a site/plant community; (2) How does floristic quality spatially vary throughout a site; and (3) How does management, restoration, or protection efforts affect floristic quality of a site? There are many interrelated considerations when applying FQA indices to answer such questions including methods of data collection, classification concerns, metric choice, and interpretation of FQA index scores, etc. As such, the following discussion may be redundant from one section to the next.

4.3.1 Data Requirements and Sampling Methods

The most critical aspect of data quality for FQA application is how well data reflect a comprehensive species list from a given site. Sampling methods and observer error are the two critical variables to consider.

Taft et al. (1997) noted that conservatism-based index calculations are most accurate when relatively comprehensive species lists (~80% complete inventory) and similar data collection methods are used since the presence of a just a few conservative species could affect the index value. Many researchers have noted that conservatism-based indices assume data was collected by botanically proficient observers (Rooney and Rogers 2002; Lemly and Rocchio 2009). However, Bourdoughs (2011) found that Mean C was relatively unaffected when obscure and difficult to identify species were removed from index calculations. Nonetheless, many other metrics included in the Washington FQA Calculators have been shown to be contingent on a comprehensive species list (Rocchio 2006; Lemly and Rocchio 2009). Until a similar study as Bourdoughs' (2011) is conducted in Washington, comprehensive species lists (collected by proficient botanists) should be used.

Species lists can be collected from releve plots, transects, or even plotless methods such as a site walk-through inventory. When possible, standardized plots or transects are recommended. However, site walk-through inventories can suffice for rapid assessments or categorization/planning efforts. For example, Lemly and Rocchio (2009) found that Mean C values calculated from a plotless data collection method was strongly correlated (r = 0.86) to Mean C values calculated from a fixed 10 x 20 m releve plot in the same area.

The type of sampling method may be dictated by project objectives. For example, collecting species data from quadrats distributed along multiple transects is ideal to determine spatial variability of floristic quality across a large site. In this case, FQA index scores can then be calculated for both the entire area (species data compiled from all quadrats) as well as individual quadrats or transects (Wilhelm and Masters 1996) to provide a multi-scaled assessment of floristic quality. FQA index scores from individual quadrats can identify and focus management toward more sensitive areas. Both quadrat and overall floristic quality data can be used to measure the extent to which management is having a positive or negative effect on floristic quality. For example, Mean C (natives) can be calculated based on two averages: (1) average Mean C of all species observed in a transect ($\overline{C}$t) or (2) individual quadrat $\overline{C}$ values averaged across the transect ($\overline{C}$q). The ratio of these two values provides valuable information. For example, if $\overline{C}$q is less than $\overline{C}$t, it would suggest that conservative species are not well represented in any given location within the area of interest whereas the reverse would suggest that non-conservative species, while present, are not abundant in the system (Wilhelm and Masters 1996). Another useful comparison would be to use an analysis of variance or the standard deviation among the $\overline{C}$ for individual quadrats, to determine how variable the quality is across a transect or site. Long-term monitoring of this statistic would provide some indication whether ecological quality is equilibrating across the site (Wilhelm and Masters 1996).

4.3.2 Ecological Classification and Sampling Area Concerns

There are many considerations to keep in mind when deciding how big of an area to sample, what the effects of sample area have on FQA index scores, and whether to constrain the sampling area to similar habitats (i.e. classification concerns).

How much area should be sampled?
Sample area is related to: (1) the adequate area to sample your target and (2) the effect sample area has on FQA-indices. The former is a consideration related to project objectives—Does a single releve plot encompass the internal variability of the target (e.g., small wetland vs. large prairie)? Is the target sufficiently large to require multiple, randomly placed releve plots or quadrats along multiple transects? Whether a single $100m^2$ releve plot or 10 transects each with 50 $1m^2$ quadrats are employed, the important consideration is that use of the method remains consistent and reflects the variability of the target area. Comparing FQA index values from different sized sample areas (e.g., comparing values derived from a single 100 m^2 releve plot to those averaged from 10 transects each with 50 $1m^2$ quadrats can be problematic for FQA indices which are sensitive to sample area size.

Area Effects on FQA Index Values
Sample area has been shown to have varying effects on FQA indices. For example, some researchers have found that the size of the assessment area has a strong effect on species richness and FQI (Francis et al. 2000; Matthews 2003; and Matthews et al. 2005) but an insignificant effect on Mean C (Francis et al. 2000; Rooney and Rogers 2002; Matthews et al. 2005; Bourdaghs et al. 2006).

The original FQI was used to distinguish sites, regardless of their size or the number or types of ecosystems occurring there (Swink and Wilhelm 1994; Taft et al. 1997). To account for cases when a large and a small area share the same Mean C value, Taft et al. (1997) created the FQI metric by multiplying the square root of species richness with the Mean C value. They argued that incorporating species richness into the equation accounted for potential variation in the size of the sample area among sites. Because habitat heterogeneity and the presence of anthropogenic patches can also have an impact on species richness, they use the square root of species richness to minimize the effect of area alone on the index score (Swink and Wilhelm 1994; Wilhelm and Masters 1996; Taft et al. 1997). As such, FQI is suggested to be a discriminating index when comparing sites of varying ecological complexity and size to prioritize for their value as a conservation target. However, in this scenario careful interpretation of various indices needs to occur. For example, because the FQI index is the arithmetic product of Mean C and the square root of species richness, FQI scores are often skewed by sites with high species richness even though their Mean C values might be low. Taft et al. (1997) provide an example where a relatively degraded site could theoretically have a similar or greater FQI score than a high-quality site if species richness is higher in the degrade sites. Thus, despite its intention of accounting for the effect of area and habitat heterogeneity, FQI doesn't necessarily reduce noise associated with comparing sites of varying size and ecological complexity.

Some researchers have found that Mean C was not significantly affected by sample size and thus may be a useful measure when comparing sites or sampling areas of varying sizes (Francis et al. 2000; Rooney and Rogers 2002). Matthews et al. (2005) note that Mean C is not completely independent of area but does provide a more robust assessment than the FQI. Rooney and Rogers (2002) conclude that because the original FQI was not meant to be a stand-alone metric for prioritizing conservation areas there is no reason to combine species richness with Mean C and that Mean C should considered independently but in tandem with species richness, as well as other metrics, in the analysis.

Plotless sampling methods are especially susceptible to area-effects on FQA-indices due to the fact that the area surveyed at any given site may vary. Some of these concerns might be alleviated by constraining plotless sample methods to a certain time frame (e.g., limit surveys to 2 hours) or constraining the assessment to certain ecological types (emergent wetlands vs. shrub wetland vs. oak woodland, etc.) since ecological types often occur at similar scales at different sites (this isn't always true). As noted above, differences in sample area of fixed-area plots can also be a concern when comparing FQA index scores from sites with different types or intensities of data collection.

If sample area size varies, users are encouraged to compare multiple indices to account for variable response of FQA indices. In addition, constraining analyses to similar ecological types (e.g., bog to bog, prairie to prairie, etc.) can also help reduce the noise associated with varying ecological complexity of sites.

Ecological Classification Concerns

The application and comparison of FQA-based indices to an entire site rather than constraining the comparison to similar ecological types, has been shown to be problematic for certain objectives (Rooney and Rogers 2002; Matthews 2003; Andreas et al. 2004; and Rocchio 2007b). These studies found that classification is an important constraining variable for improving the sensitivity of the FQA indices in detecting change in ecological condition. For example, different ecosystem types can have very different reference ranges for a given index which could be important if one's objective is to identify the highest-quality example of a particular ecosystem type (Rocchio 2007a,b).

Project objective(s) may be the most important consideration of whether classification (as well as the type or level of classification) is necessary. For example, if project objectives entail monitoring ecological changes relative to regional reference values (see below), then classification is a very important consideration (i.e., comparisons would likely have a higher signal to noise ratio when compared between similar ecological types). If one is simply looking to prioritize different properties for conservation then a site-based score might be sufficient, although in such cases numerous indices need to be compared and many other considerations are often incorporated (types of ecosystems, rare species, etc.).

NatureServe's Ecological System classification (Comer et al. 2003) is recommended as a useful classification scheme to constrain FQA analysis due to the fact that it incorporates many different ecological characteristics as classification criteria, including vegetation, soils, hydrology, disturbance regime, etc. (Rocchio 2006). Rocchio and Crawford (2008) provide a key and description of Ecological Systems found in Washington State. The "*Ecological Classification of Native Freshwater Wetland & Riparian Vegetation of Washington*" recently developed by the Washington Natural Heritage Program may also be useful for applying FQA to wetlands. Within that classification, "Subsystems" may be the most practical and effective scale to compare FQA index scores.

4.3.3 Which Metric to Use?

Numerous conservatism-based metrics can be calculated using the C values (Table 6), each with purported advantages and disadvantages. For example, some researchers have found Mean C (natives) to be a stronger predictor of human stressors than other FQA indices (Rooney and Rogers 2002; Cohen et al. 2004) whereas Bowles and Jones (2006) found that FQI was a stronger measure of floristic quality due to the inclusion of species richness. Below is an overview of some pros and cons associated with the most common conservatism-based indices.

Mean C is the most basic metric and provides a simple measure of the average C value of all the native species which occur at a site or within a natural community (Rooney and Rodgers 2002; Taft et al. 1997). Rooney and Rogers (2002) note that it is also not strongly affected by sample size or species richness and does not "hide" any information by incorporating other ecological variables. However, unless Mean C is used in conjunction with other measures such as species richness or the percentage of nonnative species, etc., it may not suffice as a single measure of site differences (Wilhelm and Master 1996). For example, larger areas will typically support more species than smaller areas. Since there may be cases when a large and a small area share the same Mean C value, accounting for species richness by multiplying it with the Mean C value adds a discriminating factor to the floristic quality assessment (Taft et al. 1997). Thus, a higher FQI suggests a site with a higher conservation priority. However, many researchers have found that the FQI is overwhelmingly correlated to species richness and thus may obscure information related to aggregate conservatism (Matthews 2003, Francis et al. 2000; Rooney and Rodgers 2002). As noted above, Rooney and Rogers (2002) conclude that because the original FQI was not meant to be a stand-alone metric for prioritizing conservation areas there is no reason to combine species richness with Mean C and that Mean C should considered independently, alongside other metrics, rather than using a multi-metric index that "hides" information.

Taft et al. (1997) recommend that FQA indices should be calculated and reported using both a native species and a native+nonnative species version in order to provide a more comprehensive and detailed assessment of floristic quality. It has been suggested that the presence of non-native species will be indirectly observed by a corresponding effect on the proportion of conservative native plants at a site (Mushet et al. 2002). In other words, the same processes that lead to invasion of non-native species is assumed to have a similar effect on the proportion of conservative plants able to survive at a site. Cohen et al. (2004) found no appreciable improvement in the efficacy of Mean C or FQI indices when non-native species were included lending support to these suggestions. However, it is possible that a site dominated by an aggressive exotic species could still support a few conservative species and consequently have a misleading Mean C value thus it is recommended that both $\overline{C}_n$ and $\overline{C}_{all}$ be calculated (Matthews 2003; Table 5).

Miller and Wardrop (2006) found that Mean C was useful in distinguishing high-quality sites from degraded sites but was not very effective in detecting variation among degraded sites. They developed a single conservatism-based index, the Adjusted Floristic Quality Assessment Index (Adjusted FQI), with the intent of decreasing the sensitivity of the FQI to species richness as well as to incorporate the impact of non-native species. The Adjusted FQI is calculated as a percentage of the maximum attainable FQI score for a site by assuming that maximum attainable Mean C is 10 and all species are native (Miller and Wardrop 2006). Miller and Wardrop (2006) found that the Adjusted FQI had a stronger correlation with Mean C than FQI indicating that the inclusion of nonnative species lessened the effect of the species richness multiplier (Miller and Wardrop (2006). In other words, species poor sites with few, if any, non-native species will have a higher score than species rich sites with a substantial amount of non-native species present (Miller and Wardrop 2006).

Weighting the various indices by percent cover has been shown to lend minimal if any improvement to index performance (Cohen et al. 2004; Bourdaghs et al. 2006; Rocchio 2007b). Conservative species often never achieve great abundance at a particular site in contrast to competitive or dominant species, which typically have C value scores in the 4-6 range. Thus, cover-weighted indices would be overwhelmed by the score of competitive or dominant species. In addition, the fact that abundance can vary throughout a growing season (Wilhelm and Ladd; Swink and Wilhelm 1994) and that collecting percent cover data makes the FQA approach too intensive for rapid employment (Francis et al. 2000; Cohen et al. 2004; Bourdaghs et al. 2006) it does not appear the use of cover-weighted FQA indices is worth the extra effort to collect such data.

Each indicator has its advantages and disadvantages (Taft et al. 1997; Rooney and Rogers, Rocchio 2007a,b) and due to the complexity of vegetation across geographies and ecosystem types no single index can be recommended over the other. For example, Rocchio (2007b) tested the performance of variations of Mean C, FQI, and Adjusted FQI metrics as a means of detecting change in ecological condition or Southern Rocky Mountain wetlands. Metric modifications included using (1) using only native species; (2) using both native and nonnative species; and 3) weighting species C values by abundance. That study showed that each index varied in its effectiveness in detecting change in ecological condition across ecosystem types.

In summary, users should evaluate the performance of each indicator relative to their assessment and monitoring goals. In addition, it is probably most informative to calculate and report each index separately (Francis et al. 2000; Rocchio 2007b) as this allows the user to separate factors which may be affecting species richness but not aggregate conservatism or vice versa (Bernthal 2003).

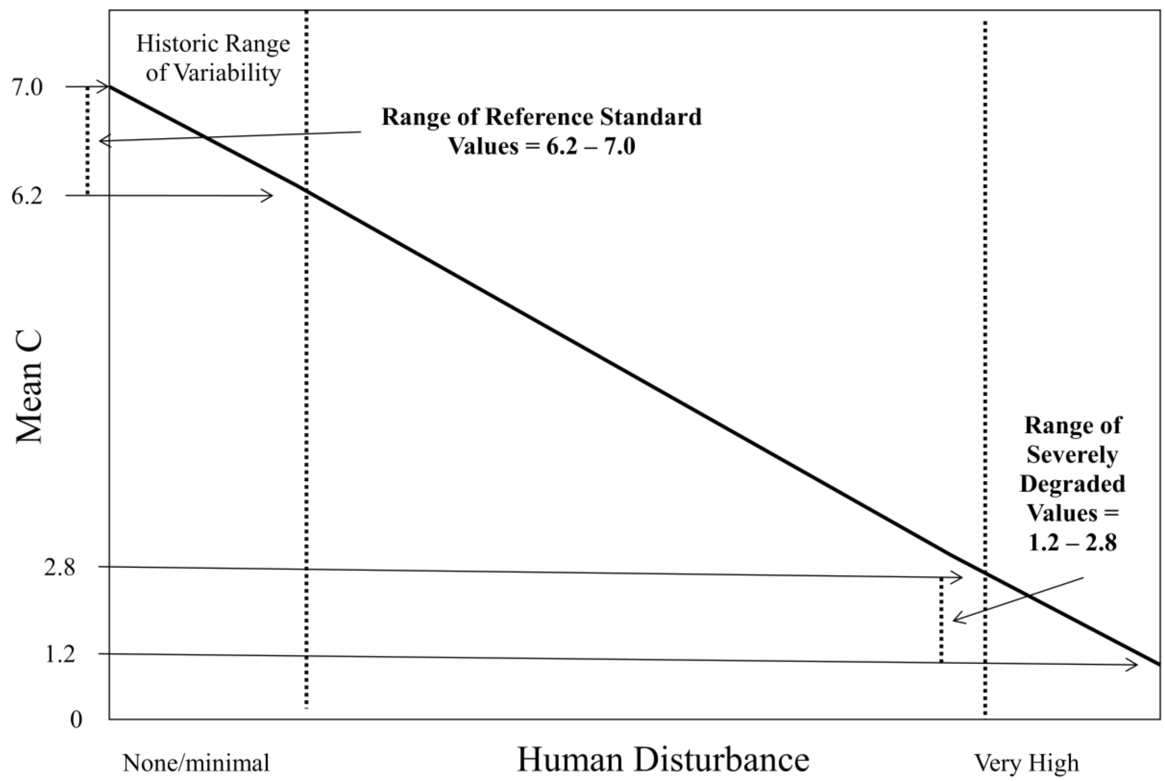
4.3.4 Baseline and Reference Standard Index Values

FQA index values are commonly used for baseline monitoring or to document ecological condition relative to regional reference values for a given ecological type.

In baseline monitoring applications, FQA index values can be compared over time at a particular site to monitor trends in ecological condition. In such cases, increasing index values suggest improvement and decreasing values suggest degradation of ecological conditions.

Alternatively, index values can be compared to a range of values for specific ecosystem types known to be functioning within their historic range of variability (Figure 8). Such sites could also be described as the highest quality sites remaining on the landscape or the “reference standard sites”. By determining what the range of variation of FQA index values are in those sites, reference standard values could be used as a baseline from which to measure deviation of any sites’ ecological condition from that expected under historic range of variability. With adequate data collection, the range of values at the other end of the continuum (i.e. severely degraded sites) could also be identified (Figure 8; Rocchio 2007a,b) thereby allowing one to place a site FQA index value along the continuum from severely degraded to relatively undisturbed.

One of the primary objectives of the Washington Natural Heritage Program (WNHP) is to identify species and ecosystem conservation priorities and to maintain a database of their locations. Because of this, WNHP has thousands of records of high-quality examples of a variety of ecological system types across Washington State. Many of those records contain comprehensive species lists from which FQA index values could be calculated. This would allow reference standard values for Washington’s Ecological System types to be calculated (Rocchio and Crawford 2008). In addition, WNHP has vegetation plot data from thousands of sites which can be used for the same purpose. As funding and time permits, WNHP will be identifying reference standard values for as many Ecological System types as our data allows. As that information is produced, it will be made available on the WNHP web page.



Graph adapted from: Davies and Jackson. 2006. Ecol. Appl. 16(4)

Figure 8. Hypothetical Relationship of Mean C to a Human Disturbance Gradient and Reference Values

4.3.5 Potential Applications of FQA

Under the assumption that plants effectively integrate spatial and temporal human impacts to ecological systems, the FQA indices provide a cost-effective means of assessing ecological condition. FQA indices provide consistent, quantitative measures of floristic integrity, can be used in any ecosystem type, do not require extensive sampling equipment (only a competent botanist), and can be applied to existing data sets. As such, FQA has been shown to be a useful stand-alone tool to assist federal and state agencies, local municipalities and other organizations to: (1) identify ecosystem protection priorities; (2) monitor and assess vegetation response to restoration, enhancement, and creation projects; (3) set mitigation performance standards; and (4) guide regulatory decisions such as wetland permitting and/or mitigation transactions.

One of the initial uses was to rapidly identify and prioritize potential natural areas (Wilhelm 1977; Ladd 1993; Taft et al. 1997; Francis et al. 2000; Nelson 2005). FQA index scores can also be used for numerous monitoring applications whether it is for long-term or ambient monitoring goals or to set and determine success in meeting performance standards of wetland restoration efforts. Mushet (2002) demonstrated the usefulness of FQA for monitoring wetland restoration projects. FQA index scores could also be used in ambient monitoring programs which seek to estimate the overall ecological condition of an ecological system within a large landscape. For example, the National Park Service has included FQA indices (within vegetation index of biotic integrity (VIBI) models) as part of their wetland vital signs monitoring protocol for Cuyahoga Valley National Park (Fraser 2005) and prairie monitoring protocols for Ebey's Landing National Historical Reserve and San Juan National Historic Park (NPS 2010; Regina Rochefort, personal communication).

FQA indices can also be used for specific regulatory needs such as informing permitting decisions associated with Section 404 of the Clean Water Act (USACE 2003, 2005, 2006). The FQI is used within a vegetation index of biotic integrity model as part of a statewide wetland regulatory program in Ohio (Lopez and Fennessy 2002; Mack 2004; Mack et al. 2004). Wilhelm (1992) notes that very few *de novo* restoration sites are able to achieve FQA index scores (i.e. FQI and Mean C) comparable to naturally diverse wetlands and thus suggested that minimum FQA index scores be used to determine permit decisions and wetland mitigation performance standards. For example, monitoring data from wetland restoration sites in the Chicago region suggest that wetlands with low floristic quality (in Chicago this was generally defined as FQI ≤ 35 and Mean C ≤ 3.5) can be compensated for via mitigation efforts whereas wetlands with high floristic quality may be irreplaceable (Wilhelm 1992). These data have been used by some regional agencies to set performance standards and set mitigation ratios. For example, Dupage County, Illinois set a minimum $\bar{C}$ value of 3.5 to identify critical wetlands and require a higher mitigation ratio for these sites (Dupage County Stormwater Management Committee 1992). The Illinois Wetland Policy Act of 1989 (20ILCS 830, 17 Ill. Adm. Code 1090) requires a 5.5:1 replacement ratio for mitigation of wetlands with a FQI index score ≥ 20 or Mean C ≥ 4.0. In Michigan, FQA index scores were used to establish mitigation performance criteria associated with endangered species impacts at the Detroit Metropolitan Wayne County Airport (Herman et al. 1997). Rooney and Rodgers (2002) note that such thresholds need to be regional defined and that baseline values should be benchmarked according to specific ecological community types.

FQA index scores could also help define regional wetland reference conditions (as described in section 4.2.4), delineating designated use categories for wetlands, and assigning biocriteria to each of these uses. Once such a framework is established, periodic monitoring of wetland FQA index scores would allow an assessment of the status and trends of wetland condition, an activity required of each State in Section 305 (b) of the Clean Water Act. It would also allow the identification of impaired wetlands meeting the definition of Waters of the U.S., as required by Section 303(d) of the Clean Water Act.

Finally, FQA or conservatism-based indices could also be used within multi-metric indices such as vegetation indices of biotic integrity (Lopez and Fennessy 2002; DeKeyser et al. 2003; Mack 2004; Rocchio 2007a) or ecological integrity assessments (Rocchio and Crawford 2011; Faber-Langendoen et al. 2006, 2008). WNHP will utilize Mean C or possibly other conservatism-based indices as one of many vegetation metrics within Ecological Integrity Assessments protocols developed for Washington's Ecological Systems (http://www1.dnr.wa.gov/nhp/refdesk/communities/eia_list.html).

5.0 Literature Cited

Adamus, P.R., T.J. Danielson, A. Gonyaw. 2001. Indicators for Monitoring Biological Integrity of Inland Freshwater Wetlands: A Survey of North American Technical Literature (1990-2000). EPA843-R-01. Office of Water, Wetlands Division, U.S. Environmental Protection Agency. Washington D.C.

Andreas, Barbara K., John J. Mack, and James S. McCormac. 2004. Floristic Quality Assessment Index (FQAI) for vascular plants and mosses for the State of Ohio. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio. 219 p.

Andreasen, J.K., R.V. O'Neill, R. Noss, and N. C. Slosser. 2001. Considerations for the development of a terrestrial index of ecological integrity. Ecological Indicators 1: 21–35.

Anthoney, R.B. 1937. Prairie plant distribution in Rock County. M.S. Thesis. University of Wisconsin.

Azous, A.L. and R.R. Horner. 2001. Wetlands and Urbanization: Implications for the Future. CRC Press, LLC. Boca Raton, FL.

Bedford, B.L., M.R. Walbridge, and A. Aldous. 1999. Patterns in Nutrient Availability and Plant Diversity of Temperate North American Wetlands. Ecology 80(7): 2151-2169.

Bernthal, T.W. 2003. Development of a Floristic Quality Assessment Methodology for Wisconsin. Unpublished report prepared for U.S. Environmental Protection Agency, Region V. Wisconsin Department of Natural Resources, Madison, WI.

Bourdaghs, M., C.A. Johnston, and R.R. Regal. 2006. Properties and Performance of the Floristic Quality Index in Great Lakes Coastal Wetlands. Wetlands 26(3): 718-735.

Bourdaghs, M. 2011. Developing a Rapid Floristic Quality Assessment. Minnesota Pollution Control Agency. St. Paul, Minnesota.

Bowles, M. and M. Jones. 2006. Testing the Efficacy of Species Richness and Floristic Quality Assessment of Quality, Temporal Change, and Fire Effects in Tallgrass Prairie Natural Areas. Natural Areas Journal 26(1): 17-30.

Brown, B.B. 1968. Delphi Process: A Methodology Used for the Elicitation of Opinion from Experts. RAND Corporation. Santa Monica, CA. Online: http://www.rand.org/pubs/papers/2006/P3925.pdf

Cohen, M.J., S. Carstenn, and C.R. Lane. 2004. Floristic Quality Indices for Biotic Assessment of Depressional Marsh Condition in Florida. Ecological Applications 14(3): 784-794.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, VA.

Cooper, D.J. 1990. Ecology of Wetlands in Big Meadows, Rocky Mountain National Park, Colorado. U.S. Fish and Wildlife Service, Biological Report 90(15).

Cooper, D.J. 2005. Analysis of the Strawberry Lake fen complex, Arapaho National Forest, Colorado. Unpublished Report prepared for the U.S. Forest Service, Fort Collins, CO. Dept. of Forest, Rangeland, and Watershed Stewardship, Colorado State University, Fort Collins, CO.

Crisp, M.D., M.T.K. Arroyo, L.G. Cook, M.A. Gandolfo, G.J. Jordan, M. S. McGlone, P. H. Weston, M.Westoby, P.Wilf, and H. P. Linder. 2009. Phylogenetic biome conservatism on a global scale. Nature 458: p. 754-756.

Cronk, J.K. and M.S. Fennessy. 2001. Wetland Plants: Biology and Ecology. CRC Press, LLC. Boca Raton, FL.

Curtis, J.T. 1959. The Vegetation of Wisconsin. An Ordination of Plant Communities. The University of Wisconsin Press. Madison, Wisconsin.

Davies, S.P. and S.K. Jackson. 2006. The Biological Condition Gradient: A Descriptive Model for Interpreting Change in Aquatic Ecosystems. Ecological Applications 16(4): 1251-1266.

DeKeyser, E.S., D.R. Kirby, and M.J. Ell, 2003. An index of plant community integrity: development of the methodology for assessing prairie wetland plant communities. Ecological Indicators 3, 119-133.

DuPage County Stormwater Management Committee. 1992. Appendix E. Technical guidance for the DuPage Countywide stormwater and floodplain ordinance. DuPage County Stormwater Management Division, IL. 24 pp.

Elmore, W. and B. Kauffman. 1994. Riparian and Watershed Systems: Degradation and Restoration. *In*: Ecological implications of livestock herbivory in the west. Society of Range Mgmt. Denver, Colo.

Faber-Langendoen, D., J. Rocchio, M. Shafale, C. Nordman, M. Pyne, J. Teague, and T. Foti. 2006. Ecological Integrity Assessment and Performance Measures for Wetland Mitigation. NatureServe, Arlington VA.

Faber-Langendoen, D., G. Kudray, C. Nordman, L. Sneddon, L. Vance, E. Byers, J. Rocchio, S. Gawler, G. Kittel, S. Menard, P. Comer, E. Muldavin, M. Schafale, T. Foti, C. Josse, J. Christy. 2008. Ecological Performance Standards for Wetland Mitigation based on Ecological Integrity Assessments. NatureServe, Arlington, VA. + Appendices

Flenniken, M., R.R. McEldowney, W.C. Leininger, G.W. Frasier, and M.J. Trlica. Hydrologic responses of a montane riparian ecosystem following cattle use. Journal of Range Management 54: 567-574.

Francis, C.M., M.J.W. Austen, J.M. Bowles, and W.B. Draper. 2000. Assessing Floristic Quality in Southern Ontario Woodlands. Natural Areas Journal 20(1): 66-77.

Fraser, L.H. 2005. Wetland Monitoring Protocol for the Cuyahoga Valley National Park, Ohio. Unpublished report prepared for the U.S. Department of Interior, National Park Service.

Fulton, G.W., J.L. Richardson, and W.T. Baker. 1986. Wetland Soils and Vegetation. North Dakota Research Report, Research Report #106, Fargo, ND.

Galatowitsch, S.M., D.C. Whited, R. Lehtinen, J. Husveth, and K. Schik. 2000. The vegetation of wet meadows in relation to their land use. Environmental Moniotoring and Assessment 60: 121-144.

Gould, F.W. 1937. The present status of Dane County prairie flora. M.A. Thesis. University of Wisconsin.

Grime, J.P. 2001. Plant Strategies, Vegetation Processes, and Ecosystem Properties. Second Edition. John Wiley and Sons, LTD. West Sussex, England.

Harwell, M.A., V. Myers, T. Young, A. Bartuska, N. Gassman, J. H.Gentile, C. C. Harwell, S. Appelbaum, J. Barko, B. Causey, C. Johnson, A. McLean, R. Smola, P. Templet, and S. Tosini. 1999. A framework for an ecosystem integrity report card. BioScience 49: 543-556.

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, and W.W. Brodowicz. 1996. Floristic quality assessment with wetland categories and computer application programs for the State of Michigan. Michigan Department of Natural Resources, Wildlife Division, Natural Heritage Program. In partnership with U.S. Department of Agriculture Natural Resources Conservation Service, Rose Lake Plant Materials Center, Michigan.

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, and W.W. Brodowicz. 1997. Floristic Quality Assessment: Development and Application in the State of Michigan (USA). Natural Areas Journal 17(3): 265-279.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press. Seattle, WA.

Hruby, T. 2004. Washington State Wetland Rating System for Western Washington – Annotated Version, August 2006. Washington State Department of Ecology Publication # 04-06-25.

Johnson, J.B. 1996. Environmental Function, Vegetation, and the Effects of Peat Mining on a Calcareous Fen in Park County, Colorado. Unpublished report prepared for the U.S. Environmental Protection Agency, Region VIII and Park County Department of Public Health. Department of Biology, Colorado State University, Fort Collins, CO.

Jones, W.M. 2004. Using Vegetation to Assess Wetland Condition: a multimetric approach for temporarily and seasonally flooded depressional wetlands and herbaceous-dominated intermittent and ephemeral riverine wetlands in the northwestern glaciated plains ecoregion, Montana. Report to the Montana Department of Environmental Quality and the U.S. Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT. 34 pp. plus appendices.

Jones, W. M. 2005. A vegetation index of biotic integrity for small-order streams in southwestern Montana and a floristic quality assessment for western Montana wetlands. Report to the Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Montana Natural Heritage Program, Helena, Montana. 29 pp. plus appendices.

Kauffman, J.B. and W.C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streamside Management Implications…A Review. *In*: Ecological implications of livestock herbivory in the west. Society of Range Mgmt. Denver, Colo.

Kauffman, J.B., A.S. Thorpe, and E.N.J. Brookshire. 2004. Livestock exclusion and belowground ecosystem responses in riparian meadows of eastern Oregon. Ecological Applications 14(6): 1671-1679.

Kattelmann, R. and M. Embury. 1996. Riparian Areas and Wetlands. In Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. III, Assessment and Scientific Basis for Management Options. Center for Water and Wildland Resources, University of California, Davis, CA.

Ladd, D. M. 1993. Coefficients of conservatism for Missouri vascular flora. The Nature Conservancy, St. Louis, MO, USA.

Lemly, J.M. & F.J. Rocchio. 2009. Field Testing and Validation of the Subalpine-Montane Riparian Shrublands Ecological Integrity Assessment (EIA) Scorecard in the Blue River Watershed, Colorado. Report submitted to the Colorado Division of Wildlife and US EPA Region 8 by the Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. Online: http://www.cnhp.colostate.edu/download/documents/2009/EIA_Field_Testing_Report.pdf

Lopez, R.D. and M.S. Fennessy. 2002. Testing the Floristic Quality Assessment Index as an Indicator of Wetland Condition. Ecological Applications 12(2): 487-497.

Mack, John J. 2004. Integrated Wetland Assessment Program. Part 4: Vegetation Index of Biotic Integrity (VIBI) and Tiered Aquatic Life Uses (TALUs) for Ohio wetlands. Ohio EPA Technical Report WET/2004-4. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Mack, J.J., M. Siobhan Fennessy, M. Micacchion, and D. Poreg. 2004. Part 6. Standardized Monitoring Protocols, Data Anaylsis, and Reporting Requirements for Mitigation Wetlands in Ohio, v. 1.0. Ohio EPA Technical Report W ET/2004-6. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Matthews, J.W. 2003. Assessment of the Floristic Quality Index for Use in Illinois, USA, Wetlands. Natural Areas Journal 23 (1): 53-60.

Matthews, J.W., P.A. Tessene, S.M. Wiesbrook, and B.W. Zercher. 2005. Effect of Area and Isolation on Species Richness and Indices of Floristic Quality in Illinois, USA Wetlands. Wetlands 25(3): 607-615.

Medley, L. and M. Scozzafava. 2009. Moving Toward a National Floristic Quality Assessment: Considerations for the EPA National Wetland Condition Assessment. National Wetlands Newsletter, January-February 2009. Environmental Law Institute, Washington D.C.

Miller, S.J. and D.H. Wardrop. 2006. Adapting the floristic quality assessment index to indicate anthropogenic disturbance in central Pennsylvania wetlands. Ecological Indicators 6(2): 313-326.

Mushet, D.M., N.H. Euliss, Jr., and T.L. Shaffer. 2002. Floristic quality assessment of one natural and three restored wetland complexes in North Dakota, USA.

Nelson, P.W. 2005. The Terrestrial Natural Communities of Missouri. 2nd Edition. Missouri Natural Areas Committee, Missouri Department of Natural Resources. Jefferson City, MO.

National Park Service (NPS). 2010. Prairie Monitoring Resource Brief. North Coast and Cascades Inventory and Monitoring Network. Online: http://science.nature.nps.gov/im/units/nccn/vs/prairie_vegetation/prairie_veg.cfm

Nichols, J.D., J.E. Perry, and D.A. DeBerry. 2006. Using a Floristic Quality Assessment Technique to Evaluate Plant Community Integrity of Forested Wetlands in Southeastern Virginia. Natural Areas Journal 26(4): 360-369.

Northern Great Plains Floristic Quality Assessment Panel. 2001. Floristic quality assessment for plant communities of North Dakota, South Dakota (excluding the Black Hills), and adjacent grasslands. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/2001/fqa/fqa.htm

Oldham, M.J., W.D. Bakowsky, and D.A. Sutherland. 1995. Floristic quality assessment system for southern Ontario. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario.

Parrish, J.D., D. P. Braun, and R.S. Unnasch. 2003. Are we conserving what we say we are? Measuring ecological integrity within protected areas. BioScience 53: 851-860.

Rabinowitz, D. 1981. Seven forms of rarity. Pages 205- 217 *in* H. Synge, editor. The biological aspects of rare plant conservation. Wiley, New York.

Reiss, K.C. 2006. Florida Wetland Condition Index for depressional forested wetlands. Ecological Indicators 6(2): 337-352.

Rocchio, J. 2006. Vegetation Index of Biotic Integrity for Southern Rocky Mountain Fens, Wet Meadows, and Riparian Shrublands: Phase 1 Final Report. Unpublished report prepared for Colorado Department of Natural Resources, and U.S. Environmental Protection Agency, Region VIII. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. Online: http://www.cnhp.colostate.edu/download/documents/2006/VIBI_Phase1Report.pdf

Rocchio, J. 2007a. Assessing Ecological Condition of Headwater Wetlands in the Southern Rocky Mountain Ecoregion Using a Vegetation Index of Biotic Integrity. Unpublished report prepared for Colorado Department of Natural Resources, and U.S. Environmental Protection Agency, Region VIII. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Rocchio, J. 2007b. Floristic Quality Assessment Indices of Colorado Plant Communities. Unpublished report prepared for Colorado Department of Natural Resources, and U.S. Environmental Protection Agency, Region VIII. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Rocchio, F.J. and R.C. Crawford. 2008. Draft Field Guide to Washington's Ecological Systems. Draft report prepared by the Washington Natural Heritage Program, Washington Department of Natural Resources. Olympia, WA. Online: http://www1.dnr.wa.gov/nhp/refdesk/pubs/wa_ecological_systems.pdf

Rocchio, F.J. and R.C. Crawford. 2009. Monitoring Desired Ecological Conditions on Washington State Wildlife Areas Using an Ecological Integrity Assessment Framework. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, WA.

Rocchio, F.J. and R.C. Crawford. 2011. Applying NatureServe's Ecological Integrity Assessment Methodology to Washington's Ecological Systems. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, WA. Online: http://www1.dnr.wa.gov/nhp/refdesk/communities/pdf/eia/applying_eia.pdf and http://www1.dnr.wa.gov/nhp/refdesk/communities/eia_list.html

Rooney, T.P. and D.A. Rodgers. 2002. The modified floristic quality index. Natural Areas Journal 22(4): 340-344.

Rothrock, P.E. 2004. Floristic Quality Assessment in Indiana: The Concept, Use, and Development of Coefficients of Conservatism. Unpublished report prepared for U.S. Environmental Protection Agency. Taylor University, Upland, IN.

Taft, J.B., G.S. Wilhelm, D.M. Ladd, and L.A. Masters. 1997. Floristic Quality Assessment for Vegetation in Illinois, A Method for Assessing Vegetation Integrity. Erigenia, Number 15, November 1997. The Illinois Native Plant Society Journal.

Tansley, A.G. 1935. The Use and Abuse of Vegetational Concepts and Terms. Ecology 16(3): 284-307

Thomson, J.W. 1940. Relic prairie areas in central Wisconsin. Ecological Monographs, 10: 685-717.

Tierney, G.L., D. Faber-Langendoen, B.R. Mitchell et al. 2009. Monitoring and evaluating the ecological integrity of forest ecosystems. Frontiers in Ecology and the Environment 7(6): 308-316

Swink F. and G. Wilhelm. 1979. Plants of the Chicago Region. Revised and expanded edition with keys. The Morton Aboretum, Lisle, IL.

Swink F. and G. Wilhelm. 1994. Plants of the Chicago Region. 4th Edition. Morton Arboretum, Lisle, IL.

USACE (U.S. Army Corps of Engineers). 2003. The U.S. Army Corps of Engineers' Guidance for Wetland and Stream Mitigation Banking in the Omaha District. Prepared by Karen Lawrence coordinated in consultation with the following: Dr. Robert Brumbaugh, Omaha District's field office personnel, Mike Gilbert, Dave LaGrone, Nebraska Mitigation Review Team, Mr. Jack Chowning, and many others.

USACE (U.S. Army Corps of Engineers). 2005. Chicago District Regional Permit Program. U.S. Army Corps of Engineers, Chicago District, Chicago, IL.

USACE (U.S. Army Corps of Engineers). 2006. Detroit District, U.S. Army Corps of Engineers Mitigation Guidelines and Requirements. U.S. Army Corps of Engineers, Detroit District, Detroit, MI.

USDA, PLANT Database. http://plants.usda.gov/ Accessed January 2005.

U.S. EPA. 2002a. Methods for Evaluating Wetland Condition: Introduction to Wetland Biological Assessment. Office of Water, U.S. Environmental Protection Agency, Washington D.C. EPA-822-R-02-014.

U.S. EPA. 2002b. Methods for Evaluating Wetland Condition: Study Design for Monitoring Wetlands. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-015.

Wien, J.J. 2004. The degree to which plants and animals retain their ancestral ecological traits and environmental distributions. Evolution 58(1): 193=197.

Wilhelm, G. 1977. Ecological Assessment of Open Land Areas in Kane County, Illinois. Kane County Urban Development Division, Geneva, Illinois.

Wilhelm, G. 1992. Technical Comments on the Proposed Revisions to the 1989 Wetland Delineation Manual. Erigenia 12. Pages 41-50.

Wilhelm, G. and D. Ladd. 1988. Natural area assessment in the Chicago region. Pp 361-375 in R.E. McCabe, editor, Transactions of the 53rd North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington D.C.

Wilhelm, G. and L. Masters. 1996. Floristic Quality Assessment in the Chicago Region. The Morton Arboretum, Lisle, IL.

Young, T.F. and S. Sanzone (editors). 2002. A framework for assessing and reporting on ecological condition. Prepared by the Ecological Reporting Panel, Ecological Processes and Effects Committee. EPA Science Advisory Board. Washington, DC. 142 p.

Zedler, J.B and S. Kercher. 2004. Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes. Critical Reviews in Plant Sciences 23(5): 431-452.

Appendix A. Western Washington Guidance for Assigning Coefficients of Conservatism

Coefficient of Conservatism: indicator of ecosystem condition; coefficients of conservatism range from 0 to 10 and indicate the degree to which a species is an indicator of an intact ecosystem. High C-values (9-10) indicate that the species is indicative of intact ecosystems; low C-values (0-3) suggest the species has little to no indicator value of intact ecosystems. Species coefficients are averaged to indicate site condition (e.g., Mean C of a site).

The C value is independent of rarity, fidelity to plant communities, or fidelity to climax ecosystems. When assigning C-values only consider the species niche 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 coefficient of conservatism value (C-value) ranging from 0-10. Please don't try to guess 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. The following definitions should be used for C-value assignments. Although the definitions are provided for a range of C-values, please assign a single value to each species. These definitions are intended to ensure you are in the correct part of the continuum but ultimately you will have to decide on a single value.

Definitions of Coefficients

0 -3 – Species that readily occur and persist in areas where human stressors have converted ecosystems into human-created habitats such as old fields, tilled or plowed areas, ditches, managed roadsides and utility right-of-ways. These species can also be found in a wide range of ecosystems conditions where ecological processes, functions, composition, and structure range from being intact to severely degraded/modified by human stressors. Given that they are very tolerant of a wide-range of frequency, severity, and duration of human stressors, they are not useful indicators of intact ecosystems. These species correspond to Grime's ruderal (0-1) and ruderal-competitive (2-3) species.

4-6 – Species that readily occur and persist in ecosystems where ecological processes, functions, composition, and/or structure have been moderately degraded/modified by human stressors. These species are often matrix-forming or dominant species and correspond to Grime's competitor species.

7-8 – Species that are mostly restricted to intact ecosystems but that can persist where ecological processes, functions, composition, and/or structure are slightly degraded/modified by human stressors. Good indicators of intact ecosystems.

9-10 – Species that are almost always restricted to intact ecosystems where ecological processes, functions, composition, and structure have not been (or only minimally) degraded/modified by human stressors; excellent indicators of intact ecosystems.

Definitions

Intact Ecosystem: an ecosystem in which the composition, structure, function, and ecological processes are within their historic range of variability (i.e. historic = pre-Euro-asian settlement, around 1850 in the State of Washington).

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

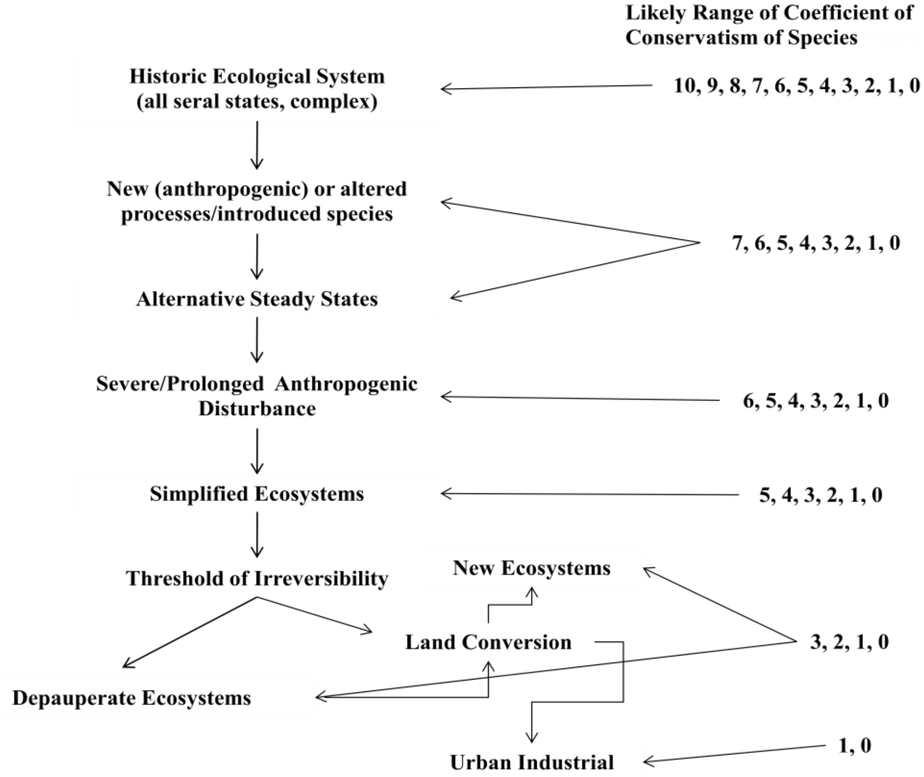
Confidence Rating: Next to the C-value column is one for indicating your confidence in each C-value assignment. Please indicate **High, Moderate,** or **Low**. This field will be helpful when it comes time to compile individual results into an overall score.

Database Notes: We have decided to use USDA PLANTS Database as the nomenclature reference. This is not because we believe PLANTS to be more accurate or in any way 'better' than others. The decision was due to the need of expediency of developing a database with synonyms (WNHP had this database on hand) and to attempt to maintain consistency with other FQA efforts across the country. We have cross-walked PLANTS name to those found in Hitchcock and to those found in the Washington Flora Checklist (although this is not complete yet). When no synonym appears in the Hitchcock column it is typically because the species was not documented in Hitchcock.

When subspecific entities are recognized in PLANTS, they often list both the species and the subspecies/variety as a unique record. When possible, please assign the C-value to the subspecific entity. However, if your knowledge is limited to the species level then you can assign C-values just to the species. For example, if you don't know any of the six varieties of *Achillea millefolium* that PLANTS recognizes, then please just provide a C-value of the species record of *Achillea millefolium*.

If you find errors in the database or if the taxonomy is confusing, please notify WNHP for clarification.

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

Example of Relationship of Mean C to Human Disturbance

Key to Coefficients of Conservatism:

Is the species almost always restricted to intact ecosystems?

YES – Assign a coefficient of 9-10

NO – Go to next question

Does the species occur and persist EITHER in areas where human stressors have converted ecosystems into human-created habitats OR in ecosystems where ecological processes, functions, composition, and/or structure have been severely degraded/modified by human stressors?

YES to either part of question – Assign a coefficient of 0-3

NO – Go to next question

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

YES – Assign a coefficient of 6-8

NO – Assign a coefficient of 4-6

Appendix B. Eastern Washington Guidance for Assigning Coefficients of Conservatism

Coefficient of Conservatism: indicator of ecosystem condition; coefficients of conservatism range from 0 to 10 and indicate the degree to which a species is an indicator of an intact ecosystem. High C-values (9-10) indicate that the species is indicative of intact ecosystems; low C-values (0-3) suggest the species has little to no indicator value of intact ecosystems. Species coefficients are averaged to indicate site condition (e.g., Mean C of a site).

The C value is independent of rarity, fidelity to plant communities, or fidelity to climax ecosystems. When assigning C-values only consider the species niche 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 coefficient of conservatism value (C-value) ranging from 0-10. Please don't try to guess 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. The following definitions should be used for C-value assignments. Although the definitions are provided for a range of C-values, please assign a single value to each species. These definitions are intended to ensure you are in the correct part of the continuum but ultimately you will have to decide on a single value.

Definitions of Coefficients

0 -3 – Species that readily occur and persist in areas where human stressors have converted ecosystems into human-created habitats such as old fields, tilled or plowed areas, ditches, managed roadsides and utility right-of-ways. These are areas where the soil has been severely disturbed. These species can also be found in a wide range of ecosystems conditions where ecological processes, functions, composition, and structure range from being intact to severely degraded/modified by human stressors. Given that they are very tolerant of a wide-range of frequency, severity, and duration of human stressors, they are not useful indicators of intact ecosystems. These species correspond to Grime's ruderal (0-1) and ruderal-competitive (2-3) species.

4-6 – Species that readily occur and persist in ecosystems where ecological processes, functions, composition, and/or structure have been moderately degraded/modified by human stressors. These species are often matrix-forming or dominant species and correspond to Grime's competitor species.

7-10 – Species that are restricted or mostly restricted to intact ecosystems where ecological processes, functions, composition, and structure have not been (or minimally so) degraded/modified by human stressors; excellent indicators of intact ecosystems.

Definitions

Intact Ecosystem: an ecosystem in which the composition, structure, function, and ecological processes are within their historic range of variability (i.e. historic = pre-Euro-asian settlement, around 1850 in the State of Washington).

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

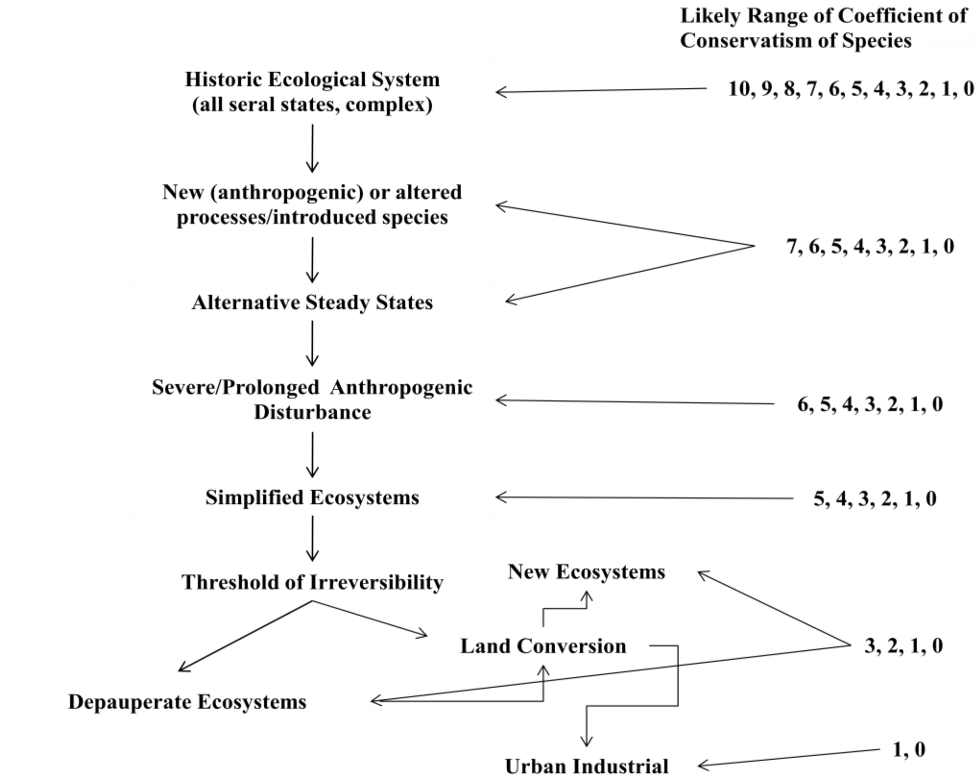
Confidence Rating: Next to the C-value column is one for indicating your confidence in each C-value assignment. Please indicate **High, Moderate,** or **Low**. This field will be helpful when it comes time to compile individual results into an overall score.

Database Notes: We have decided to use USDA PLANTs Database as the nomenclature reference. This is not because we believe PLANTs to be more accurate or in any way 'better' than others. The decision was due to the need of expediency of developing a database with synonyms (WANHP had this database on hand) and to attempt to maintain consistency with other FQA efforts across the country. We have cross-walked PLANTs name to those found in Hitchcock and to those found in the Washington Flora Checklist (although this is not complete yet). When no synonym appears in the Hitchcock column it is typically because the species was not documented in Hitchcock.

When subspecific entities are recognized in PLANTs, they often list both the species and the subspecies/variety as a unique record. When possible, please assign the C-value to the subspecific entity. However, if your knowledge is limited to the species level then you can assign C-values just to the species. For example, if you don't know any of the six varieties of *Achillea millefolium* that PLANTs recognizes, then please just provide a C-value of the species record of *Achillea millefolium*.

If you find errors in the database or if the taxonomy is confusing, please notify WANHP for clarification.

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



Exampl

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 →

Someone hand you a specimen of Species X… what does it tell you about the integrity of the site it was growing in?

- Nothing; species has such a wide amplitude that it provides no useful information about the site's integrity
  - C values 0-3

- Suggests the site is likely not a human-created habitat but can tell how intact it is
  - C values 4-6

- Strongly suggests the site is of high integrity (intact)
  - C values 7-10

Key to Coefficients of Conservatism (Version 1 Fidelity Perspective):

Is the species almost always restricted to intact ecosystems?

YES – Assign a coefficient of 7-10

NO – Go to next question

Does the species occur and persist in areas where human stressors 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 stressors.

YES – Assign a coefficient of 5-6

Otherwise – Assign a coefficient of 3-4

Key to Coefficients of Conservatism (Version 2: Colonization Perspective):

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 stressors of its natural habitat.

- Assign 5 - 6

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

- Assign 7 - 10