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A Habitat-Based Strategy for Delimiting Plant Element Occurrences: Guidance from the 2004 Working Group

The "Element Occurrence" (EO) is a fundamental unit of information in the NatureServe Natural Heritage methodology. NatureServe's Element Occurrence Data Standard[1] (hereafter, EO Data Standard) defines an Element Occurrence (EO) as "an area of land and/or water in which a species or natural community is, or was present." *SubEOs* can be used for tracking information on more localized areas that are part of a single EO.

While EOs are often self-evident for vascular plants, two fundamental questions regularly arise in developing botanical EO data:

a. *Minimum criteria* for an EO – whether an observation, collection, or other report of a plant at a particular place can be considered to be sufficient basis for an EO record.

b. *Separation distances* for nearby EOs – whether two (or more) observations in different but nearby places should be considered different EOs, or combined into a single EO.

The EO Data Standard provides for use of Element Occurrence Specifications ("EO specs") to delineate and differentiate EOs, including both minimum criteria and separation distances. Individually written ("custom") EO specs are of two general kinds. *Element-specific EO Specs* are written for a particular, generally well-known element, drawing on element-specific information on ecology, species biology, threats/vulnerabilities, management needs, etc. *Group EO Specs* are written for a group of related or ecologically similar elements (specified by a list or by a scoping definition), drawing on various considerations broadly applicable to the particular group. Custom EO specs may also be developed to address unusual population structures or dispersal dynamics. Note that custom EO specs may specify shorter as well as longer separation distances when considered appropriate in particular cases.

Minimum EO criteria usually follow generally accepted (although not well-documented) criteria, considering such evidence as successful or potentially successful establishment, presumed naturalness (including deliberate restorations and reintroductions within the element's historical range), and review of reliability of identification and locality information. A single well-established individual plant is often considered to meet the minimum criteria for an EO. The issue of minimum EO criteria is addressed more extensively in the EO Data Standard, and is

[1]NatureServe. 2002. Element Occurrence Data Standard, 6 February 2002. NatureServe, Arlington, Virginia. Accessed at http://whiteoak.natureserve.org/eodraft/index.htm, September 2004.

not further considered here. When necessary, custom EO specifications can be written to identify minimum EO criteria for a particular taxon.

I. The 2004 Plant EO Specs Working Group

For the many thousands of vascular plant species with Element Occurrences tracked by Heritage Programs or Conservation Data Centers, relatively few have individual or group element-occurrence specifications (custom EO specs). However, the default 1 km minimum separation distance provided by the EO Data Standard has often been considered inappropriately small, particularly for riparian plants, plants found in dynamic landscape mosaics such as fire systems or sand dunes, and plants scattered in large areas of apparently suitable habitat. Indeed, the EO Data Standard encourages the use of larger separation distances in such cases.

A working group of Heritage and NatureServe botanists[2] convened in March 2004 to help advance production of EO Specifications (EO specs) for plants. They developed the general strategy presented here for using commonly encountered habitat and landscape situations for delimiting EOs of vascular plants that lack custom EO specs. In this novel strategy, pairs or groups of observations of the element are reviewed to determine whether they are better treated within the same EO or as separate EOs. Since plant taxa may show different habitat relations or distribution patterns in different portions of their geographical ranges, this method can result in different separation distances being applied in different places for the same taxon, and perhaps even within the same EO.

In effect, the group's strategy provides a single, interim alternative separation procedure available for use for any plant element for which more focused individual or group EO specs have not been developed. The group's guidelines should promote standardization across the NatureServe network in the process of thinking through the appropriate occurrence delimitation for particular EOs, as an alternative to use of individually specified range-wide separation distances for elements or groups of elements (as usually provided in custom EO specs) or rigid use of the default 1 km minimum EO separation distance specified in the EO Data Standard.

The group's strategy was developed primarily to provide general guidance for EO separation distances for native North American vascular plants, but can be applied to other plants or regions as well. Of course, element-specific or group specs may always be developed for elements for which these recommendations clearly do not apply, or for which other separation distances based on particular circumstances are more appropriate. Given the group members' limited familiarity with tropical, polar, ocean-island, and marine systems, these guidelines should be used with caution in such circumstances, and more appropriate EO separation distances should be applied (and documented) if necessary.

The working group's draft was circulated broadly to Heritage botanists, data managers, and others for review, discussion, and refinement, resulting in the guidance presented here. This report[3] presents the group's strategy as a decision tree (Figure 1), and provides instructions for its

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[3] Prepared for the group by Larry Morse, Jim Morefield, and Florence Caplow.

use, along with pertinent background material on botanical and ecological considerations and EO methodology.

The group thanks Kat Maybury (NatureServe's Director of Botany) for convening the March meeting, providing ongoing encouragement, promoting Network-wide discussion, and exploring implementation issues; Geoff Hammerson (NatureServe) for his presentation on zoological EO specs; Jennifer Nichols (NatureServe) for guidance on various methodological questions; Larry Master for coordinating a needed adjustment to the EO Data Standard; and the numerous reviewers whose questions and suggestions have led to improvements and refinements in this presentation.

II. Methodological Considerations for EOs for Plants

The EO Data Standard notes that "An EO should have *practical conservation value* for the Element." Also, an EO should have *biological merit* and *conservation merit* and be *stable* and *practical.* When feasible, EOs should be actual biological populations, with plants within an EO interacting with each other or being be more closely related to each other than with plants in other EOs. (However, for most plant species, there is relatively little information on actual dispersal rates and distances and other aspects of their population or metapopulation dynamics.) In addition, EO separations should be on scales reasonable for conservation; neither immensely large EOs nor numerous tiny nearby EOs would meet this test. EOs should also involve areas and boundaries that are reasonably stable on the landscape over decades on average, and almost certainly over any given 25-year period, without need for frequent remapping and reallocation of data. Finally, for data comparability, EOs for a particular element should be developed by the same criteria throughout the element's distributional range. The degree of aggregation of observations into EOs particularly affects EO ranks, since larger EOs will often have higher EO ranks. Aggregation also focuses attention on the resulting EOs as overall assemblages in conservation planning, habitat management, or environmental review.

The informal term "EO Feature" is used here for any place (from point locality to large area) where a particular plant element has been observed or otherwise documented as being present (currently or historically) with sufficient evidence of naturalness, persistence, etc., to meet the pertinent minimum EO criteria outlined in the EO Data Standard. As discussed in the EO Data Standard, the areal representation of such a Feature is expanded by an appropriate buffer to address any locational uncertainty in the original information. An Element Occurrence (EO) includes one or more such EO Features. In the EO Data Standard and in this guidance, separation distances are always applied to the Basic Feature of the Biotics EO methodology. Note, however, that the differences between Basic Features and final Procedural Features are negligible for these purposes, so Procedural Features may be considered in EO delimitation if already developed.

EO Features based on historical information, including EOs with a rank of "H" (historical), "F" (failed to find), or "X" (extirpated), especially if they have good locational information, may be used to link extant EO Features that would otherwise be considered to belong to different EOs. Use of such historical information may lead to more appropriate EOs since dispersal patterns, habitat dynamics, and metapopulation phenomena may be better represented. The resulting EO may also be a more appropriate unit for EO ranking and for data use. However, many historical observations have poor locational information (i.e., a very high

degree of locational uncertainty), and in that case may be inappropriate for linking otherwise distinct EOs or for combining with a new, more precisely located Feature. Determining whether a new observation is or is not the same as an historical EO is a matter of judgment and generally involves a consideration of the original historical description (often an herbarium specimen label), habitat for the element, and historical and current extent of the habitat within the area of the historical EO, including its estimated locational uncertainty.

Many habitats have experienced fragmentation as a result of human activity (such as clear-cut patches, mined areas, residential development, roads, agricultural development). In general, EO separation distances should not be based on consequences of anthropogenic habitat fragmentation, on differences in ownership or management, or on utility in conservation planning. This is because such factors can differ widely across the range of an element and could lead to very inconsistent EOs; such factors are generally not intrinsic to the element itself. EO specs are intended to result in more consistent EO delimitation despite such spatial variation. For habitat fragmentation in particular (whether new or historical), this should be reflected as a decrease in quality (EO Rank) of one or more formerly less-fragmented EOs, and perhaps also as sub-EOs where management or other conservation factors vary widely between fragments, but not as an increase in the number of EOs.

In many cases, a program may want to maintain EO data at a sub-EO level, based on the individual Features that make up the EO. When previously processed EOs are combined, several sub-EOs may need to be created. Whether or not sub-EOs are used, the original polygons that have been combined into one EO should be maintained.

III. Separation Distances for Vascular Plant EOs

Separation distances are a key component to Element Occurrence Specifications (EO specs). The EO Data Standard provides a *Default Separation Distance* of 1 km (~0.62 miles) or greater for plant and animal elements that lack EO specs, noting that situations involving dispersal barriers could involve even shorter distances. When areas (rather than point locations) are known, separations are measured edge-to-edge, not center-to-center, after any locational uncertainty is addressed. While gene flow declines over distance at different rates for different elements, the minimum default EO separation distance of 1 km has been accepted by the Network as the most suitable round-number metric-system approximation broadly applicable to many (but not all) situations.

Some heritage programs use other separation-distance guidance (such as ¼ mile, about 0.4 km) that was developed under a previous EO methodology that did not provide a capability for sub-EOs. These older guidelines tended to encourage use of more numerous but smaller EOs to maintain separate mapped Features and data records for information that can now be tracked at the sub-EO level.

Narrow dispersal barriers are important for many animals, but for vascular plants, there seem to be few cases in which narrow barriers would justify treatment of quite nearby plants in different EOs. Such situations may be addressed in custom EO specs if necessary. However, for most plants, the contrast of suitable and unsuitable habitat is usually more important, with the latter being crossable only in single-generation dispersal events.

While the 1 km default separation distance is generally accepted as a suitable minimum, it has long been recognized by many Network botanists that a standardized 1 km separation distance for all vascular plant EOs lacking custom EO specs seemed inappropriately small in many cases, particularly those in three broad patterns:

- *Riparian corridors*, in which water currents (or at least occasional floods) focus dispersal substantial distances in the water-flow direction. Riparian corridors, seashores, and shores of other large water bodies that have big storm waves often show linear distribution patterns, with a plant species occurring in various places along the water's edge, or in adjacent habitat affected by floods, storm waves, or other high waters, but not far inland.
- *Dynamic landscape mosaics*, in which particular patches of habitat actively occupied by the element appear and fade on a scale of several years to a few decades, yet the overall habitat area remains relatively fixed in place. Some habitats, for example active sand dunes, fire-dominated systems, and beaver-influenced systems, are mosaic in nature, with the same particular place on the ground unlikely to have the same ecological characteristics over a 50-year period, with recurrent processes continuing to create new habitat patches that subsequently fade.
- *Continuous apparently suitable habitat* in which an irregularly distributed plant is likely to be present (perhaps in a seed bank), or likely to disperse, in places between the currently known observations.

While all such cases could in principle be addressed by custom EO specs, few such specs have been developed to date. Apart from the lack of appropriate information on dispersal and population biology for many elements, custom EO specs can prove difficult to write for wide-ranging plants, since a variety of habitats, dispersal vectors, and population structures may be involved. This is particularly the case for globally common elements that are of conservation concern in only small portions of their range (usually peripheral or disjunct sites).

IV. Novel Strategy: Pairwise Consideration of EO Features Based on Habitat

The working group initially planned to develop various specs groups, based on such factors as habitat characteristics, life history, pollination biology, or seed dispersal strategies. This system would be parallel to the specs groups developed for many animal taxa. However, with discussion, the group encountered three major barriers to the development of specs groups: 1) a lack of knowledge of life history, pollination biology, or seed dispersal strategies for many elements, 2) habitat characteristics that can vary across the elements' ranges, and 3) multiple pollination and dispersal vectors for many elements. For example, seeds of cottonwood *(Populus* spp.) may be mostly wind dispersed, but can also be water dispersed or bird dispersed, and these vectors are going to vary across the range of the element and even among or within populations.

The group soon realized that the practical question at hand instead involves the selection of appropriate separation criteria for nearby observations of the same element, taken as pairs (or groups), not necessarily using a single criterion for an element throughout its entire geographical range. The group's remaining discussion, and the recommendations presented here, follow that

novel track, focusing on the possible role of various familiar habitat and landscape patterns in providing useful guidance on EO delimitation.

This resulting strategy recognizes that while there is need for an objective process in implementing scientifically credible EO separations, there is no real need that the same separation be used throughout the range of a particular element, so long as there is a process for deciding whether any given pair of observations are sufficiently far apart (in their habitat/landscape context) to be treated as separate EOs.

Particular attention was given to the contrast in the EO Data Standard between unsuitable and apparently suitable habitat, and to the special cases of dynamic landscape mosaics and riparian/shore systems. The group identified pertinent combinations and recommended guidance for general EO separation distances for each case, using diverse species with which group members had personal expertise as test cases in refining these recommendations. The overall recommendation is presented as a decision tree (Figure 1), defining cases in which separation distances of 1 km, 2 km, 3 km, and 10 km are suitable for general use in delimiting vascular plant EOs that lack custom individual or group specs.

The group agreed that, if custom EO specs are lacking, EO Features over 10 km apart should be separate (if not bridged by intervening EO Features), and those less than 1 km apart should be combined. While these numbers are somewhat arbitrary, they address an overriding need for consistency in delimiting EOs (EO Data Standard), and are in keeping with informal standards already in use.

The group's recommendation, as revised following review, are:

1. The minimum default separation distance is 1 km, as specified in the EO Data Standard, when no other EO specification or guidance applies.
2. Custom EO specs are needed to justify any separation distances <1 km or >10 km that are not otherwise in compliance with the guidance herein.
3. When custom EO specs are available, they should be used if available information permits.
4. *Additional guidance* is provided here for selected general cases involving nearby pairs/groups of EO Features, with separation distances of 1 km, 2 km, 3 km, or 10 km as appropriate to the situation.
    a. Within **stable, apparently suitable habitat not known to be occupied**, two EO Features separated by up to **2 km** are included in the same EO, unless there is a gap of persistently unsuitable habitat 1 km or more wide.
    b. In **dynamic landscape mosaics**, two EO Features separated by up to **3 km** are included in the same EO, unless there is a gap of persistently unsuitable habitat 1 km or more wide.
    c. In certain **riparian/shore water-dispersal systems,** two EO Features separated by up to **10 km** are included in the same EO, unless there is a gap of persistently unsuitable habitat of 3 km or more, with distances measured along the path of water flow.
5. If EOs exceed 20 km in any direction, they may be broken into two or more EOs for practicality if desired.

For convenience, definitions of key terms, with related notes, are presented together as an appendix. The distinction between suitable and unsuitable habitat, and the three special habitat-based cases, are considered further below.

When necessary in unusual cases, the numerical distances provided here may be adjusted upward by 1.33 (4/3) or downward to 0.75 (3/4) of the specified values, with text explanation. Examples include cases of locational uncertainty, minor outliers, or minor narrowing of otherwise substantial gaps (see Table 1 for ranges). These adjustments should be made only when the EO pattern resulting from application of the general guidelines is unreasonable, and/or when the exact distances on the landscape are uncertain. If more extreme adjustments are needed, element-specific (or group) specs should be written to explain and document the situation.

Table 1. Specified separation distances and acceptable adjustment ranges for habitat-based plant EO delimitation.

Separation (km)	*Range (km)*	*Separation (miles)*	*Range (miles)*
1	0.75–1.33	0.62	0.47–0.83
2	1.50–2.67	1.24	0.93–1.66
3	2.25–4.00	1.86	1.40–2.49
10	7.50–13.33	6.21	4.66–8.28

V. Suitable vs. Unsuitable Habitat

The EO Data Standard's distinction between "apparently suitable habitat not known to be occupied" and "unsuitable habitat" is fundamental to the guidance provided here, since the extent of any intervening persistently unsuitable habitat is considered in determining whether two EO Features should be included in the same EO or considered separate EOs. Examples of such persistently unsuitable habitats include waters or wetlands separating upland habitats, upland habitats separating riparian habitats or vernal pools, or contrasting bedrock types separating isolated areas of locally unusual bedrock (such as granite, serpentine, limestone, or shale). Note that persistently unsuitable habitat may itself be dynamic, rather than stable, so long as it persistently remains unsuitable for the element.

While areas of persistently unsuitable habitat are not necessarily barriers to single local dispersal events, the difficulty of the species surviving there precludes regular involvement of such areas as gap-bridging stepping-stones for multiple-generation incremental dispersal. Therefore, presence of significant areas of such persistently unsuitable habitat, sufficient to reduce effective dispersal, strengthens isolation between two nearby EO Features within an element's local distribution. Intervening areas of persistently unsuitable habitat, being harder for the element to bridge by dispersal, therefore require shorter separation distances between EO

Features than do comparable areas of apparently suitable habitat, in keeping with the EO Data Standard. Of course, discovery of the element in habitat previously thought unsuitable (other than as non-established propagules or as chance seedlings unlikely to survive) suggests that reassessment is needed. Failure to locate the element in the intervening habitat despite intensive searches may of course also suggest that the habitat is unsuitable, not merely unoccupied.

VI. Special Case: Continuous Stable Habitats

Most plants, including many substrate-associated rare species, require particular habitats for establishment and maintenance, as well as possible reproduction and further dispersal. In many instances, the pertinent habitat features (such as bedrock outcrops, topographic settings, hydrographic features, or soil or vegetation types) can be considered stable, being relatively permanent on the landscape, persisting on scales of centuries, millennia, or longer, with a fairly clear (and sometimes remarkably abrupt) boundary between unsuitable and apparently suitable habitat from the perspective of the (presumed) needs of a particular element. Note that habitat here called "stable" nevertheless undergoes many changes, particularly over periods longer than 50 years, and that chance events (such as tree-fall openings) of course occur occasionally within such areas. Seasonal changes and other very frequent disturbance also occur in most "stable" habitats. Examples of species occurring primarily or exclusively in stable habitat include *Trifolium stoloniferum* (running buffalo clover), *Isotria medeoloides* (small whorled pogonia), *Phacelia monoensis* (Mono County phacelia), *Aquilegia barnebyi* (Barneby's columbine), *Trifolium virginicum* (Kate's Mountain clover), *Arabis serotina* (shale-barren rockcress), *Eriogonum anemophilum* (wind-loving buckwheat), *Heuchera alba* (white alumroot), and *Actaea elata* (small bugbane).

The EO Data Standard suggests that stable EOs be delimited using a 25-year timeframe. For purposes of this guidance, habitats are considered stable when, under natural conditions, they are likely to retain their current apparent capacity (or lack of capacity) to support the element in question during any given 50 year period, and certainly so during any given 25 year period. The group accordingly considered habitat or landscape changes recurring every 5–25 years on average, and almost certain to recur within a 50-year period, to indicate the presence of unstable or dynamic habitat (rather than stable habitat) when considering patterns of EO separation distances. However, in distinguishing dynamic habitats, annual or very frequent disturbance should not be considered, nor should disturbance that would be unlikely to occur at a given point in the habitat within a period of 50 years.

For two EO Features separated by 1 km or more, but by less than 3 km (and not in a riparian/shore system), EO delimitation depends first on whether the two EO Features are separated by a substantial area of persistently unsuitable habitat (here specified as being 1 km wide or greater, and expected to lack suitable sites for the element of interest for the next 25 years or more). If the apparently suitable habitat is relatively continuous (without persisting gaps of 1 km or more), EO delimitation next depends on the temporal stability of the habitat. If the habitat is certain (under natural conditions) to remain stable during the next 25 years (for example, mature hardwood, spruce-fir forest, acidic fen, pond or lakes, or highly arid systems), 2 km is the suggested separation distance (see below for a discussion of unstable dynamic systems). This 2 km distance is reasonable because of the need for only one well-centered or

two random intervening locations to combine the same element occurrence, as opposed to needing more than one or two patches to bridge a 3 km separation distance.

VII. Special Case: Dynamic Landscape Mosaics

Some plant elements occur in areas of dynamic landscape mosaics, in which patches of disturbed habitat appear and decline cyclically on timescales of several years to several decades. Examples include active sand dune systems, fire-dominated systems, and beaver-influenced systems. In such dynamic habitat mosaics, there are usually particular kinds of plants that thrive in the disturbance patches, but do not thrive as the vegetation matures. Others occur only in mature patches but not in the disturbed patches. Some of these plants can survive in-place between disturbance events as dormant seed (seed banking) or other dormant stages (spore banks, shoot banks, etc.), while other kinds of disturbance-following plants may depend on local dispersal (between different-aged patches within the habitat mosaic) for colonization of freshly opened habitat. In either of these cases, the element is persistent within the general area of the landscape mosaic, even though more transient (at least as obvious, growing plants) at any particular place. Examples of such species include *Platanthera leucophaea* (eastern prairie white-fringed orchid), *Muhlenbergia torreyana* (Torrey's dropseed), and *Astragalus columbianus* (Columbia milk-vetch).

Treating patches of plants that occur in areas of dynamic landscape mosaics as single EOs rather than the continually changing patches is generally not only more practical, reducing need for frequent re-mapping and re-delimitation of EOs, but also usually makes more sense from both an ecological and a conservation perspective. In the EO Data Standard and in this guidance, dynamic landscape mosaics are given special treatment (leading to greater separation distances) because the general area, over a relatively short time, can be expected to include habitat patches suitable for growth of the element, and may even include seed banks or other inconspicuous dormant plants. Therefore, if the element's habitat is part of a dynamic landscape system, 3 km instead of 2 km is the suggested separation distance across such apparently suitable landscape areas, unless persisting unsuitable gaps of 1 km or more intervene.

Many dynamic landscape mosaics have been altered as a result of human activity, such as increase or decrease in fire frequencies, removal of beaver, or dune stabilization. In many cases, the landscape remains dynamic despite a change in the disturbance event frequency, and so can still be considered dynamic within a 5–25 year average cycle for the purpose of EO delimitation. In other cases, the landscape processes have been halted entirely. In general, EO delimitation should be based on historic and/or potential landscape processes. In situations where the natural disturbance cycle is unlikely to ever occur again, or has been replaced by a new disturbance cycle substantially more frequent than every 5 years, however, it may be more appropriate to use the 2 km stable-habitat separation distance instead.

VIII. Special Case: Riparian/Shore Systems with Water-current Dispersal

Flowing water is a uniquely strong, directionally focused dispersal agent, generally taking quantities of propagules substantially greater distances, on average, than other dispersal agents that over time would spread the same number of propagules shorter average distances radially in many directions. Even occasional storms and floods (such as those at 10-, 30-, or

100-year intervals) can be important plant-dispersing events, considering the persistence capabilities of many kinds of plants, once established. Dispersal between nearby places in the same riparian/shore system is therefore generally more effective (in the direction of water flow) than for comparably spaced upland or quiet-water places.

One can usually assume that water dispersal plays a significant role in species biology if the plant grows somewhere in a riparian corridor (suggested to include up to the 100-year floodplain), along the seashore, or along the shore of some other water body large enough to have large storm waves (such as large lakes). Because dispersal of plant seeds and other propagules in many riparian and shoreline systems is generally relatively linear rather than radial, the effective range of dispersal is greatly elongated along the direction of water flow. Therefore, it is appropriate to include two EO Features along such a riparian or shore system in the same EO even when separated by about three times the distance that would be selected if water currents were not involved. By their nature, riparian/shore systems are usually also dynamic systems as discussed further below, and so the separation distances that apply to upland dynamic systems serve as the starting point for deriving separation distances in riparian/shore systems. By multiplying these distances by 3, then rounding, the group arrived at 10 km (instead of 3 km) along the path of water flow, with at least 3 km (rather than 1 km) of intervening persisting unsuitable habitat considered a gap. Example species of riparian/shore systems include *Rorippa columbiae* (Columbia yellow-cress), *Rorippa subumbellata* (Tahoe yellow-cress), *Lobelia dortmanna* (water lobelia), *Ptilimnium nodosum* (harperella), *Marshallia grandiflora* (large-flowered Barbara's-buttons), *Micranthemum micranthemoides* (Nuttall's micranthemum), *Plantago cordata* (heart-leaved plantain), *Amaranthus pumilus* (seabeach amaranth), and *Armoracia lacustris* (lake-cress).

Ideally, for inclusion in the same EO over this extended separation distance, one should have evidence that water currents can flow from one of the two EO Features to the other, at least occasionally. However, in the usual lack of such site-specific knowledge, one may generally assume that proximity to the same water body indicates capability for sharing of water flow, for example single shores or riparian areas that are less than 1 km wide. If there is evidence that two EO Features within a riparian/shore system are not connected by water flow, even occasionally within a 50 year period, the water-current separation distances should not be used. For example, two EO Features on different upstream river tributaries, or two EO Features directly across from one another on a wide river, are not usually directly connected by water flow, and the non-riparian/shore guidance would apply to them instead. On the other hand, even on a wide river, there is likely to be propagule movement from one shoreline to the other shoreline well downstream (generally assumed when the downstream distance is at least 3 times the width of the flow).

Within riparian/shore dispersal-pattern systems, separation distance depends on whether appropriate sites for the element are continuous or discontinuous in the areas along the water-flow direction. For example, a system of gravel bars may extend for 20 km along a particular river. At any one time clusters of plants may be observed in specific portions of the gravel bars, but over the course of time one might find plants almost anywhere along the entire 20 km. This is a classic metapopulation dynamic, described for *Pedicularis furbishiae* by Menges[4]. Most

[4]Menges, E. S. 1988. Conservation biology of Furbish's lousewort: Final report to Region 5, U.S. Fish and Wildlife Service. Holcomb Research Institute, Butler Univ., Indianapolis, Indiana. 55 pp.

riparian systems will not have "continuous" habitat in any one year, but when considered over 25 years, floods and other disturbances are likely to move gravel bars and other riverine landscape components, or at least move plants among them. Such a system may still be considered continuous even if it includes persisting discontinuities (habitat that is unlikely to become suitable within 50 years, and certainly not within 25 years) less than 3 km along the path of water flow. Therefore, in a continuous riparian/shore system, EO Features may be separated as much as 10 km along the flow path and still be part of the same element occurrence. However, if there is a gap of at least 3 km of persistently unsuitable habitat along the flow path, then they will be separate element occurrences.

IX. Using the Decision Tree

The group's recommendations are summarized in a decision tree (Figure 1), used to determine whether two nearby EO Features of an element should be included in the same Element Occurrence, or treated as separate EOs. In this strategy, the size and nature of the gaps between EO Features are considered to determine the appropriate separation distance (1 km, 2 km, 3 km, or 10 km) for particular situations (approximately 0.6, 1.25, 2, and 6 miles, respectively). If custom element-specific or group EO specs exist, these should of course be applied instead when available data permit.

The tree may be used when one has two (or more) observations of the same element at different but nearby places. The EO Features being considered with the decision tree must each independently meet the minimum EO criteria for the element – the only question addressed here, and in the decision tree, is whether the two places belong to the same EO, or to two different EOs. Multiple nearby EO Features should be considered pairwise and aggregated into EOs as appropriate.

The decision tree provides an easy, readily referenced method of documenting the process for why a particular separation distance was used in assigning two (or more) EO Features to a single EO or to different EOs. While this tree is designed to be simple to use, it is based on many assumptions or inferences (patch dynamics, metapopulation dynamics, unsuitable or apparently suitable habitat, and dispersal mechanisms). When information on which to base such inferences or assumptions is completely lacking, the decision tree leads to the default 1 km separation distance.

In using the decision tree, distances between EO Features are measured edge-to-edge, if the extent of the element's presence within the EO Features is known, rather than center-to-center, after locational uncertainty has been addressed. In the context of the Biotics EO Methodology, such measurements should be made between Basic Features when available, although Procedural Features may also be used. Any two EO Features closer than 1 km would ordinarily be included in the same EO, and any EO Features more distant than 10 km would ordinarily be included in different EOs (unless additional intervening EO Features bridge the gap). As noted above, these and other distance numbers in the decision tree may be adjusted slightly in individual cases if needed (see Table 1), with an explanation of the need for the adjustment noted in the pertinent EO records.

In cases where persistently unsuitable habitat occurs as isolated patches within a relatively continuous matrix of apparently suitable habitat (whether stable or dynamic), distances

between EO Features should be measured along a path through the apparently suitable habitat that avoids or minimizes the width of intervening unsuitable habitat. For the special case of riparian or shore systems, distance measurements should follow the general path of water flow, rather than take a direct path across such areas as upland habitat, broad wetlands, or wide water bodies. In other habitats, distances should be measured along paths that minimize gaps in apparently suitable habitat, as well as along straight lines, and the two observation sites should be included in the same EO if that result is reached by either means.

Minor incidental presence of generally upland elements in riparian/shore situations may be ignored if water-current dispersal can be considered to have negligible effect on the element's overall local distribution. Similarly, for elements generally characteristic of stable habitats, minor incidental presence in adjacent dynamic landscape mosaics may be ignored if the dynamic system does not involve the element's more characteristic local habitats.

Where EOs become very large, exceeding 20 km in any direction (as might happen along major rivers), they may be split arbitrarily into two or more EOs if preferred for data management or conservation planning purposes. However, such splitting is not required, and should not change EO rank or Element rank.

X. Tiered Implementation

The EO separation distances used throughout the Network vary widely, and the practical conversion of plant EOs to a single standard (this habitat-based strategy when custom EO specs are not available) may take several years. To support and track the progress of member subnational programs during this process, the following tiered system of implementation will be used. Tier 3 is the goal; Tiers 1 and 2 are considered in temporary compliance only. Network members will always use the highest implementation tier practicable as their Program-wide default tier, both for new EOs and retrospectively for existing EOs, and will use tiers lower than 3 only temporarily and as a last resort, until Tier 3 can be achieved.

- **Tier 1:** Continue to use a previously adopted, single, consistent separation distance LESS THAN 1 km (such as ¼ mile [~0.4 km] for California), so that EOs can be aggregated automatically via software to generate Tier-2 implementation when necessary.
- **Tier 2:** Use a 1 km separation distance for all plant EOs.
- **Tier 3:** Use custom EO specs when available for an Element, and otherwise use full habitat-based delimitation guidance, to extent supporting information is available.

The attached decision tree (Figure 1) presents Tier 3 implementation.

For elements for which EOs are being tracked by more than one member subnational program, and especially for globally rare elements that are most likely to be the object of multijurisdicational data requests, programs should coordinate implementation levels for those elements, with the help of NatureServe if necessary, and should ideally all use the same, highest practicable implementation level for each such shared element.

The EO delimitation strategy used will be documented in Biotics at least on an element-by-element basis, and preferably at the element-occurrence level, by each subnational program.

Programs may also choose and specify the highest default tier they are able to implement program-wide at a particular point in time, but the effects of this choice must still be documented for each element or occurrence (which can be done through “batch” database updates).

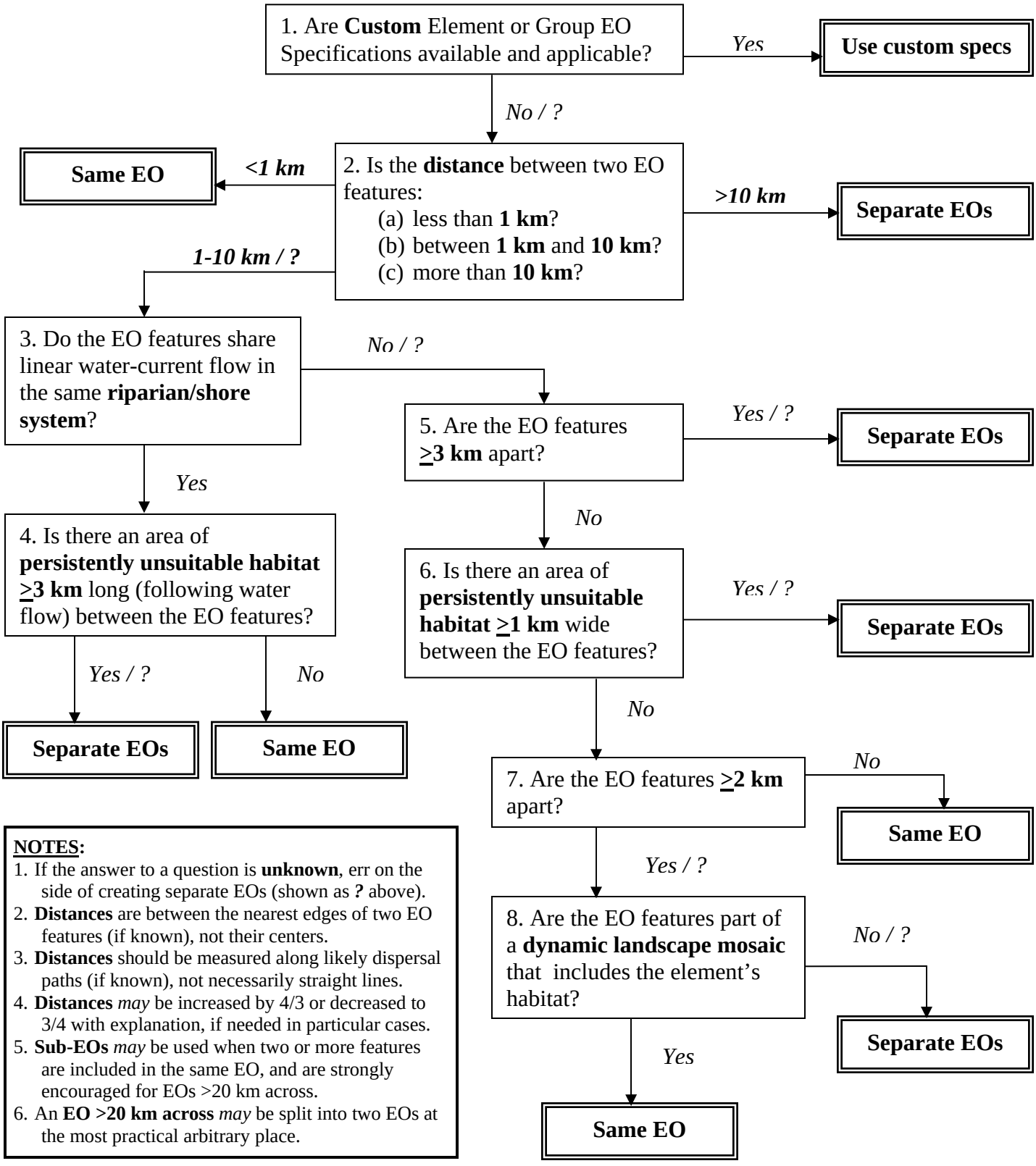
This tiered system is intended for the internal use of NatureServe and its member programs, in supporting and tracking members at various stages of implementation. Individual programs with data at Tier 1 and Tier 2 implementation levels are at least temporarily in compliance with EO specification standards and can inform external clients as such, explaining that "in accordance with data standards, we separate occurrences by .... (whatever your *default Tier 1 or Tier 2* criteria are) .... except when otherwise specified for particular taxa."

Appendix I. Decision Tree and Definitions Summary for Habitat-based Plant EO Delimitation Guidance (2004)

Figure 1. Habitat-based Plant Element Occurrence Delimitation Guidance, 1 October 2004. [Decision tree]

Notes and Definitions for Plant EO Delimitation Guidance, 1 October 2004

Figure 1. Habitat-based Plant Element Occurrence Delimitation Guidance, 1 October 2004



NOTES:

1. If the answer to a question is **unknown**, err on the side of creating separate EOs (shown as **?** above).
2. **Distances** are between the nearest edges of two EO features (if known), not their centers.
3. **Distances** should be measured along likely dispersal paths (if known), not necessarily straight lines.
4. **Distances** *may* be increased by 4/3 or decreased to 3/4 with explanation, if needed in particular cases.
5. **Sub-EOs** *may* be used when two or more features are included in the same EO, and are strongly encouraged for EOs >20 km across.
6. An **EO >20 km across** *may* be split into two EOs at the most practical arbitrary place.

Notes and Definitions for Habitat-based Plant EO Delimitation Guidance, 1 October 2004

EO Features – This Habitat-based Plant Element Occurrence (EO) Delimitation Guidance addresses whether two separate observations of the same element belong to the same EO, or to two different EOs, in the absence of more specific guidance (for example, element or group custom EO specifications). In the context of the Biotics EO Methodology, Basic Features should be compared, to assure consideration of locational uncertainty. (However, note that the differences between Basic and final Procedural Features are negligible here.) Each observation must independently meet the minimal EO criteria (see EO Data Standard) for that element prior to comparison.

Persistently unsuitable habitat – Surveyed or unsurveyed areas that, under natural conditions, are virtually certain to remain incapable of supporting viable individuals of an element during the next 25 years or more. Such areas are neither *apparently suitable habitat* nor parts of a *dynamic landscape mosaic* that includes the element (see definitions below). The potential for rare or highly irregular events (such as tornadoes, unusual hurricanes, earthquakes, 300-year floods, rare fires, or catastrophic volcanism) may be ignored. Similarly, incremental effects of long-term phenomena (such as slow erosion or deposition, climate change, or sea-level rise) may usually be ignored on the timescale of interest here; over longer times, almost everything changes.

Apparently suitable habitat – Surveyed or unsurveyed areas not known to be occupied by an element, but which appear capable (under natural conditions) of supporting viable individuals of that element, based on one or more observed or mapped factors (soils, geology, hydrology, vegetation, topography, aspect, elevation, etc.) known to delimit or predict other occurrences (current or historical) of the same element.

Dynamic landscape mosaics – Landscape or habitat mosaics (other than *linear riparian/shore systems*; see below) in which an area of potentially suitable habitat includes natural disturbance patches (or similar phenomena) which are produced and subsequently fade in various places within the area, with a natural disturbance return interval of about 5-50 years, considering both past and expected future conditions. Elements in such areas typically grow in (or are excluded from) the dynamic disturbance patches, persisting as seed (or other dormant stages) in patches not currently suitable for growth, or dispersing readily among suitable patches. Examples include many chaparral- or pine-dominated fire systems, dune blowouts, and beaverdam wetlands. Note that such habitats as intermittent wetlands, in which the conditions appropriate for growth (or exclusion) of an element may not be met every year, are still considered stable if their locations and extents remain generally constant for 25 years or more.

Linear riparian/shore systems – Systems dominated by water-current dispersal in a linear zone generally <1 km wide (riparian corridors, shores, and similar narrow systems), including those with dispersal by occasional events (major floods, storm waves, etc.) with significant potential to occur during the next 25 years. Examples include many "100-year" riparian floodplains, coastal shorelines, shorelines of big lakes with large waves, estuarine shorelines and tidal zones, and floodplains of small streams or dry drainages subject to frequent flash floods. Small, quiet ponds and lakes, as well as wide marshes or backwater swamps, generally would not be included here. EO features are assumed to share linear flow if they are aligned in a reasonable flow direction along a river, stream, shore, etc., unless contrary data exist. This is usually not the case with upstream EO features on different tributaries, or with EO features on opposite shores of rivers >1 km wide; however, such features may be indirectly connected if they each share flow with a common downstream EO feature. For an aquatic element inhabiting open water of a river, assume connection by water-current flow unless evidence suggests that this is unlikely.