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U.S. National Vegetation Classification 3.0: The Revisions Process

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Cover photos:

Top left: Great Plains workshop, Ardmore, Oklahoma. Feb 20, 2019. D. Faber-Langendoen

Top right: G887 Cross Timbers Woodland. Wichita Mountains Wildlife Refuge, Oklahoma. Oct. 17, 2015. D. Faber-Langendoen

Bottom right: G889 Northern Great Plains Sand Prairie. Montana, Steve Cooper, Montana Natural Heritage Program.

Bottom left: G888 Southern Great Plains Sand Prairie. Cimmaron National Grassland, Kansas, June 14, 2024. Colorado Natural Heritage Program.

USNVC PROC-7

PROCEEDINGS OF THE U.S. NATIONAL VEGETATION CLASSIFIATION

Ecological Society of America

The USNVC Partnership and the Federal Geographic Data Committee Vegetation Subcommittee

https://www.fgdc.gov/organization/working-groups-subcommittees/vsc/index_html

The USNVC is a partnership through the Federal Geographic Data Committee Vegetation Subcommittee, chaired by the USFS (Carol Spurrier, Joanne Baggs, chairs). Partners include federal agencies, NatureServe and the Ecological Society of America.

The USNVC is published on usnvc.org, which is hosted by the U.S. Geological Survey.

Contents

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Producing a revision of the USNVC is both a daunting and exhilarating task, especially as our work spanned almost a decade, from 2016-2025. We are grateful for the opportunity to spend time working together as editors on the USNVC Peer Review Board, comparing notes, inviting colleagues to weigh in on our ideas, and sorting through ideas to reach a decision. Our work gave us new appreciation for the wide diversity of ecosystems found in the U.S. We thank our individual institutions for their support of our work as editors. We thank our many colleagues and workshop participants for taking the time to help develop this new version. A perusal of this document, including where we highlight the various peer review meetings held over the last nine years to produce 3.0, shines a little light on the extensive network of ecologists, including many from state Natural Heritage Programs and federal agencies, who weighed in on the merits of our proposed revisions. We are grateful that they have persisted with us through the many turns that we've taken to improve the USNVC.

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We thank colleagues who have served on the Editorial Board in the past, especially Lesley Sneddon, whose work in the northeast at the association level was instrumental in guiding alliance and group concepts.

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U.S. National Vegetation Classification 3.0: The Revisions Process

EXECUTIVE SUMMARY

INTRODUCTION

Purpose: The U.S. National Vegetation Classification Vegetation (USNVC) is to classify all terrestrial ecosystems of the U.S, both natural and anthropogenic. It is maintained as a partnership among U.S. federal agencies, the Ecological Society of America (ESA), and NatureServe. It has strong engagement from federal partners, because it is a federal standard, and from NatureServe, who uses it as a standard across the Network of 50 state programs. Here we describe the peer review process for revising USNVC 2.0, released in 2016. The focus of revisions to USNVC 3.0 included 1) a reworked set of upper levels based on biome concepts; 2) a systematically peer reviewed set of mid- and lower-level units, with a focus on group and alliances, and 3) engagement with state programs and federal partners.

PEER REVIEW BOARD

The USNVC Peer Review Board: The USNVC is maintained by the USNVC Peer Review Board (hereafter "Review Board"), with an Editor-in-Chief (EIC) and 36 Regional and Associate Editors, representing expertise from across the entire U.S. and adjacent Canada. The Review Board is overseen by the ESA Vegetation Classification Panel (hereafter "Panel"), which was authorized by the Federal Geographic Data Committee (FGDC) Vegetation Subcommittee (FGDC) to maintain a Review Board.

METHODS: PEER REVIEW PROCESS

Upper Formation Levels: The Review Board took, under consideration, recommendations from an International Revisions Work Group to adopt the Realms and Biomes approach of the Global Ecosystem Typology (GET, https://global-ecosystems.org/).

Mid and Lower Levels: The Board developed a peer review process that included 18 regional meetings covering all 50 states over a five year period (2019-2023). The Board worked closely with State partners, especially from the Natural Heritage Network, and with federal agencies, including the National Park Service, the U.S. Forest Service (especially the Forest Inventory and Analysis Program), U.S. Geological Survey, and the LANDFIRE program to actively integrate USVC 3.0 into their products.

At each meeting, attendees systematically evaluated all alliances (level 7), as well as groups (level 6) and association (level 8) concepts where needed (see table below). Particular attention was paid to the ecological gradients shaping vegetation patterns.

Data Management: The entire review process and products were managed in Biotics by the NatureServe Ecology Data Management Committee. A standard template was used to describe all types, as needed. A full lineage tracking report was generated that summarizes all changes made between v2.0 and v3.0.

RESULTS AND DISCUSSION

Upper Levels: From Formations to Biomes: The Review Board, in consultation with the Panel, adopted biome concepts for defining levels 1 to 3. Biome-based (large-scale ecosystem) concepts better integrate vegetation with ecological processes, expand the properties of vegetation beyond physiognomy and growth forms to include functional traits, life-history strategies, and productivity, and includes the potential role of animals as drivers of ecosystem patterns. The Board also adopted the "realms" framework of the GET, thereby focusing the USNVC more clearly on all terrestrial and transitional wetland ecosystems. The upper level revisions were substantial because of the revisions from formation to biome concepts.

Revised Hierarchy of USNVC 3.0 after incorporating biome concepts.

Hierarchy	Example
Upper	
L1 – Biome	Temperate-Boreal Grassland & Shrubland
L2 – Subbiome	Temperate Grassland & Shrubland
L3 – Ecobiome	Temperate Lowland-Montane Grassland & Shrubland
Mid	
L4 – Division	Central North American Grassland & Shrubland
L5 – Macrogroup	Central Lowlands Tallgrass Prairie
L6 – Group	Northern Tallgrass Prairie
Lower	
L7 – Alliance	Northern Mesic Tallgrass Prairie
L8 – Association	Northern Mesic Big Bluestem Prairie

Mid to Lower Levels

The definitions of the mid to lower levels were unchanged from USNVC 2.0. Revisions to the types at mid-levels were relatively modest (+6% for divisions, -6% for macrogroups, and +3% for groups). Alliance types changed the most (+19%), largely because in USNVC 2.0, they (and the association units) were only complete for the lower 48, whereas now alliances extend across all 50 states. Associations are still incomplete, and they did not receive extensive examination in the revisions process, except to ensure that they were properly nested within the correct alliance. Many associations are not tracked by state or federal partners, making it difficult to resolve their concepts.

Summary

For USNVC 3.0, the biome to alliance levels are now comprehensive for all 50 states and represent a substantial upgrade from USNVC 2.0 to 3.0.

Comparison of the Number of Natural/Semi-natural Vegetation Types in USNVC for all 50 states between USNVC 2.0 and 3.0.

Hierarchy	2.0	3.0
Upper		
L1 – Biome	6	11
L2 – Subbiome	13	25
L3 – Ecobiome	36	41
Mid		
L4 – Division	71	77
L5 – Macrogroup	184	178
L6 – Group	427	441
Lower		
L7 – Alliance	1282*	1520
L8 – Association	6054*	6975

*in 2.0, alliances and associations were not yet reported for Hawaii and Alaska, hence the large percentage increase for these levels.

All types were named using standard nomenclature, with both a scientific and common name, and have a primary concept source. Descriptions were based on range-wide input from U.S., Canadian, and other international sources, and were compiled using a standard template. At this time 29% (455) of the alliances and 20% (1,420) of the associations still lack descriptions; however, information for completing these alliances is available and ready for compilation.

The USNVC 3.0 Catalog: A full accounting of all vegetation types developed for USNVC 3.0, from biome to association, is provided in the USNVC Catalog. The catalog is a readily accessible tool for exploring the hierarchy, used alongside the USNVC databases, including that of the U.S. Geological Survey (accessible at usnvc.org), and through NatureServe's International Vegetation Classification (IVC), which is hosted on NatureServe Explorer (explorer.natureserve.org).

A critical benefit of generating the catalog and publishing USNVC 3.0 is that, as with a botanical flora, it represents a stable version (especially from biome to alliance) that can used for years to come as a reference for vegetation-type concepts in the U.S.

Distribution Maps: NatureServe staff developed distribution maps for 308 USNVC groups and eight anthropogenic biome types across the lower 48 states and adjacent areas in Mexico and Canada. The maps were based on a previous map of ecosystems that was developed in collaboration between NatureServe and LANDFIRE. The map units can be aggregated from group up to biome, and the distribution of each ecosystem type can be displayed at a variety of spatial scales based on NatureServe's standard Nested Hexagon Framework.

CONCLUSIONS

The USNVC 3.0 is the first multi-scaled terrestrial ecosystem-based vegetation classification of the United States that systematically lists and describes types at each level, from biome to association. The ecosystem-based approach of the USNVC advances our understanding of not just the floristic and physiognomic composition of the ecosystems but identifies the patterns and processes along environmental gradients that shape these ecosystems. An ongoing goal is to bolster our understanding of these patterns by compiling quantitative field plot data that detail the vegetation and ecological properties of each type.

With the publication of USNVC 3.0, the USNVC partners provide both an authoritative and stable version that serves as a reference for inventory, monitoring, and restoration of ecosystems. The goal is not to suggest that there is only one authoritative system for ecosystem classification but to build reliable (inter-operable) relationships between various global to local classifications that facilitate information exchanges at multiple scales. There is still much to learn, and by working closely with state and federal partners, the classification can become a living document, whereby new information on the status, distribution, and management of these ecosystems within states and across the nation can be constantly gathered and compiled, periodically leading to new versions.

INTRODUCTION

The United States encompasses a wide diversity of vegetation, from tropical rainforests to arctic tundra, from coastal freshwater and marine shorelines to alpine vegetation. While a few broad narratives had previously been provided, in the early 1990s scientists recognized the need for a comprehensive national classification of vegetation in the United States. A partnership soon formed that led to the development of the U.S. National Vegetation Classification (USNVC), with two versions to date: the first version (USNVC 1.0) was developed from 1997 to 1998 (FGDC 1997, Grossman et al. 1998), and the second version (USNVC 2.0) was developed between 2008 and 2016 (FGDC 2008, Franklin et al. 2012, USNVC 2.0 2016) (See Appendix A for a brief historical summary).

Throughout the process, the goal of the USNVC was to produce an authoritative classification based on vegetation and ecological processes (FGDC 2008, Jennings et al. 2009). Vegetation is a critical component of terrestrial ecosystems, given its role in energy capture, biomass production, nutrient and water cycling, and trophic webs, as well as its contribution to niche diversity. Thus, vegetation types are best defined based on the integration of vegetation growth form, structure, biogeography, and floristics with ecological drivers. Unlike many previous vegetation classifications, the goal of the USNVC was to describe all vegetation: natural, semi-natural/ruderal, and intensively managed lands (i.e., cultural vegetation *sensu* Küchler 1969).

As summarized in what became the EcoVeg approach (Faber-Langendoen et al. 2014), the USNVC developed a multi-level hierarchy to fully classify and describe the diversity of ecosystems, from large-scale global formations to local plant communities. Large-scale formation types were described based on synthetic interpretations of ecological and vegetation patterns (Faber-Langendoen et al. 2016), and types at mid and local scales were more often based on regional data, field surveys, plots, and mapping (Peet and Roberts 2013).

USNVC 2.0 was developed by members of the ESA Vegetation Classification Panel (hereafter "Panel") with the focus primarily on the new mid-levels of the USNVC (division, macrogroup, and group; FGDC 2008, Faber-Langendoen et al. 2014). A key innovation in USNVC 2.0 was the decision that the USNVC be maintained as a dynamic content standard, subject to ongoing peer review. To continue improving USNVC 2.0, the Panel in 2016 created an independent USNVC Peer Review Board (hereafter "Review Board") and in 2018, the Panel charged the USNVC Review Board to implement a review process.

Here we describe the revisions process taken by the Review Board. It first assessed the limitations of USNVC 2.0 and then focused on three main goals: 1) conduct a review of the upper level formation levels in light of proposals to use biome concepts; 2) conduct a peer review of the mid- and lower-level units, with a focus on groups and alliances not fully reviewed when USNVC 2.0 was published, and 3) engage as many state programs and federal partners directly in the peer review process.

PREPARATIONS FOR REVISING THE USNVC

Assessing the limits of USNVC 2.0

Completion of USNVC 2.0 in 2016 was a critical step in implementing the vision of the FGDC (2008) standard, which simplified the upper formation levels from five to three, developed a more ecological coherent set of types, and introduced three new mid-level units (division, macrogroup, and group). That version provided a comprehensive set of the new mid-levels, which were integrated under the revised formations; alliances and association units were placed under these new mid-levels (Box 1).

Box 1. USNVC Hierarchy 2.0

Upper
L1 – Formation
L2 – Subformation
L3 – Formation

Mid
L4 – Division
L5 – Macrogroup
L6 – Group

Lower
L7 – Alliance
L8 – Association

Concepts for USNVC 2.0 types were also partly informed by the existing vegetation type concepts of NatureServe's Ecological Systems classification (Comer et al. 2003). That classification was developed, in part, as an interim solution for mid-level units not available in USNVC 1.0 (Grossman et al. 1998).

However, there were four major limitations with USNVC 2.0:

1) <u>Need for a Permanent Peer Review Board</u>: Peer review of USNVC 2.0 was largely handled by the ESA Panel, which together with the Hierarchy Revisions Work Group, served as the Peer Review Board, along with many invited experts at workshops. Ongoing revision of the USNVC required a more permanent Peer Review Board comprised of regional vegetation ecology experts.

2) <u>Upper Level Revisions:</u> The USNVC has been committed to ongoing collaboration with international scientists. Publication of USNVC 2.0 and the EcoVeg approach led to invitations in 2017 to contribute to a global ecosystem classification effort sponsored by the International Union for Conservation and Nature (IUCN). That effort produced the Global Ecosystem Typology (GET; Keith et al. 2022), which developed biome and functional ecosystem concepts for all terrestrial, freshwater, marine, and subterranean ecosystems. The results of that work suggested that the terrestrial formation level concepts of the USNVC would benefit from a more consistent use of biome concepts (Faber-Langendoen et al. 2014, 2020).

3) Additional Review of Mid and Lower Levels: Alliance Concepts: The steps needed to revise alliance concepts developed in USNVC 1.0 from a strongly dominance-based to a more ecological-based vegetation concept were not fully completed (although substantial progress was made in USNVC 2.0, including reducing the number of alliances from 1502 to 1220 in the conterminous U.S.). At the same time, in international publications, there was increasing importance given to the alliance concept as a key lower-level of vegetation classification, highlighting the need for greater confidence for units at that level (Faber-Langendoen et al. 2014, Willner 2020).

4) Engagement of State and Federal Partners. USNVC 2.0 was completed in the conterminous U.S., with a range of state partner engagement, but more was needed to better integrate state concepts, where appropriate, into the USNVC and to encourage adoption of USNVC concepts by states. In addition, in USNVC 2.0, neither Alaska nor Hawaii were part of the process.

The Peer Review Board

The Review Board was formed in 2018, with an Editor-in-Chief (EIC) and selected Regional Editors (REs) with expertise in the major vegetation regions of the United States. Associate Editors (AEs) were added to assist the Regional Editors in their work. By 2025, the Board had 36 Regional and Associated Editors (Table 1). Editors from Canada were included because the USNVC standard (FGDC 2008) mandates that types be described across their "total range (present and historic)" and because the CNVC shares the same hierarchy as the USNVC. Range-wide information elsewhere is drawn from the International Vegetation Classification (Faber-Langendoen et al. 2018).

Working within the scientific framework of the FGDC (2008) standard and the EcoVeg approach, the Review Board began the revision process to USNVC 2.0. Lessons learned from initial pilots of the peer review process in Alaska in 2017-2018 helped shape the process.

Upper Level Revisions – Scope of the Classification

The USNVC 2.0 used two "supra-classification" categories to define the scope of the USNVC. 1) A vegetated/non-vegetated category was defined, whereby ecosystems with <1% cover were not treated. As a result, not all terrestrial ecosystems were classified, and this distinction forced a rather precise measurement of a very difficult-to-measure parameter (<1% versus 1% cover). 2) natural versus cultural vegetation. A key aspect of the USNVC is that it accounts for both natural and cultural (anthropogenic) vegetation, such as farmland and plantations. USNVC 2.0 separated all cultural vegetation from natural vegetation at the outset, and even provided two separate hierarchies, each with their own independent set of criteria. Lost in this use of categories is that the USNVC is, foremost, a terrestrially focused classification.

Table 1. USNVC Peer Review Board. Role: EIC = Editor-in-Chief, RE = Regional Editor, AE = Associate Editor, ME= Managing Editor; Nation US-C = US Territory in Caribbean; CAN = Canada.

Region	Subregion	Editor	Nation	Role
		Don Faber-Langendoen	US	**EIC**
WEST	Warm Desert	Este Muldavin	US	**RE**
		Patrick McIntyre	US	AE
	Californian	Rachelle Boul	US	**RE**
		Jamie Rachford	US	**RE**
		Julie Evens	US	**RE**
	Cool Semi-Desert	Marion Reid	US	**RE**
		Patrick McIntyre	US	**RE**
		Keith Schulz	US	AE
	Pacific	Joe Rocchio	US	**RE**
		Del Meidinger	CAN	**RE**
		Kitty Labounty	US	**RE**
		Tynan Ramm-Granberg	US	AE
	Rocky Mountains	Jack Triepke	US	**RE**
		Tynan Ramm-Granberg	US	AE
		Scott Franklin	US	AE
		Chris Murphy	US	AE
		Mary Manning	US	AE
	Western Wetlands	Gwen Kittel	US	**RE**
GREAT PLAINS	Great Plains	Bruce Hoagland	US	**RE**
		Scott Franklin	US	AE
		Keith Schulz	US	AE
EAST	Laurentian-Acadian	Don Faber-Langendoen	US	**RE**
	Central Interior-Midwest	Don Faber-Langendoen	US	**RE**
	Appalachian-Northeast	Ephraim Zimmerman	US	**RE**
	South-Central	Milo Pyne	US	**RE**
		Martina Hines	US	AE
	Southeast Coastal Plain	Alan Weakley	US	**RE**
		Kyle Palmquist	US	**RE**
CARIBBEAN	Caribbean - Puerto Rico	Humfredo (Fito) Marcano	US -C	**RE**
		Eileen Helmer	US -C	**RE**
BOREAL & ARCTIC	Boreal	Torre Jorgenson	US	**RE**
	Arctic	Aaron Wells	US	**RE**
	Boreal & Arctic	Timm Nawrocki	US	AE
		Lindsey Flagstad	US	AE
		Tina Boucher	US	AE
OCEANIA	Hawaiian Islands	TBD	US	
NatureServe	Data Mgmt Committee	Kristin Snow	US	
		Mary Harkness	US	
Ecological Society of America (ESA)	Proceedings of USNVC	Alexis Conley	US	ME
	ESA Panel Chair	Este Muldavin	US	

Upper Level Revisions – Formation Concepts

In USNVC 2.0 the upper levels of the USNVC used the physiognomic-ecological formation concept to define types. This approach has long been a primary basis for terrestrial ecosystem typologies (Whittaker 1975, Box and Fujiwara 2005, Moncrief et al. 2016a, Mucina et al. 2018, Sayre et al. 2020). The ecologically-based formation concept allowed for physiognomic variability within formation concepts (e.g., by defining a formation as comprised of specified growth form combinations, rather than a single criterion), making them more meaningful in terms of their relationship to macroclimate and other global ecological drivers (Faber-Langendoen et al. 2016). As such, the concept of formation in USNVC 2.0 already overlapped with that of biome (Whittaker (1975).

However, there were limitations to the formation concepts as part of a full terrestrial ecosystem classification, including (as noted above) that these concepts did not address non-vegetated (or extremely sparsely vegetated) terrestrial ecosystems, such as desert bedrock, rocky shores, and even glaciers. Equally important, the physiognomic-ecological approach relies strongly on growth forms and structure, excluding non-physiognomically expressed functional traits of the vegetation, such as wetland hydrophytic traits in water-logged soils or C3/C4 photosynthetic pathways. In addition the role of animals is not considered relevant.

Mid- and Lower-level Units: The Focus on Alliances

To revise USNVC 2.0, the Review Board was tasked to focus on alliance units. Alliance units had not been systematically reviewed in USNVC 2.0 because the focus was on the development of the new mid-level units: division, macrogroup, and group (Franklin et al. 2012). The alliance concept in 2.0 was considered sound; an alliance is "*a vegetation classification unit containing one or more associations, and defined by a characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation. Alliances reflect regional to subregional climate, substrate, hydrology, and moisture/nutrient factors, and disturbance regimes*." (FGDC 2008, Jennings et al. 2009, Faber-Langendoen et al. 2014).

The expectation of the alliance units is that they should be well separated from other alliances by multiple diagnostic species (either by one or more character species or several strong differential species) and broadly distinct ecological factors sorted along environmental gradients over large geographic areas (Mueller-Dombois and Ellenberg 1974, Faber-Langendoen et al. 2014, Willner 2021) (See definition of terms in Appendix B). Similarly, the alliance aggregates a specific set of associations and is a nested unit within an even more inclusive group concept (Table 2). The diagnostic features of these levels are often assessed through gradient analyses, ordination, and cluster techniques (Peet and Roberts 2013). However, systematic field plot data were still lacking for these levels, which limited the Review Board's ability to use analytical assessments of floristic composition and environmental gradients.

Table 2. Guidelines for Group, Alliance and Association concepts (from FGDC 2008, Faber-Langendoen et al. 2014). These are "typical" criteria, and the role of factors may vary across biomes.

Level	Group	Alliance	Association
Definition	A vegetation unit that is defined by a relatively narrow set of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect regional mesoclimate, geology, substrates, hydrology, and disturbance regimes.	A vegetation classification unit defined by a characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation. Alliances reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	A vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy. Associations reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.
Biogeography / Overall Composition	Regional ecological gradient segment (often broadly topo-edaphic) reflected by a set of moderately diagnostic species (at least a few species' ranges fully contained); overall composition broadly distinct from other units.	Regional to sub-regional gradient segment (often more narrowly topo-edaphic or biogeographic), reflected by at least several moderate diagnostic species, including from the dominant strata; overall composition moderately distinct from other units.	Subregional to local ecological gradient segment reflected in several diagnostic species, including differential species and constant dominants across strata; overall composition not well separated from other units.
Diagnostic and Constant Species	A set of moderately strong diagnostic species, preferably with several strong differentials or character species. Constancy of at least 25% expected for some species.	Several moderate diagnostic species, preferably including at least one strong differential (character species may be absent). Constant species more important for defining type, with at least 40% constancy expected.	A few diagnostic species, preferably including at least one moderate differential (character species often absent). Constancy very important for defining type, with at least 60% constancy expected.
Dominants and Growth Forms	Moderately uniform growth forms and canopy closure, (e.g., varying from evergreen to deciduous and open to closed canopy).	Moderately uniform growth forms and canopy closure, at least in the dominant layer (e.g., conifer + mixed hardwood, other layers may vary from shrub to herb or moss-dominated ground layers with either open or closed canopy).	Strongly uniform growth forms, in both dominant and other layers and degree of canopy closure (e.g. closed canopy evergreen dominated shrubland with a primary understory growth form dominant (sedge, forb).
Climate	Regional mesoclimate – could indicate secondary regional gradients (depends upon selected primary gradient for macrogroup).	Regional to sub-regional topo-edaphic factors, sometimes reflective of biogeography and climate.	Climate rarely a driver; rather often a narrow range of topo-edaphic factors.
Disturbance regime / Succession	Moderately consistent disturbance regime; may incorporate successional stages that are otherwise floristically similar.	Moderately specific disturbance regime – may group successionally related associations.	Narrow range of disturbance regime – may have disturbance or successional relationships to other local associations.
Edaphic/ Hydrology	Moderate range of variation in specific topo-edaphic or hydrologic conditions.	Moderately specific edaphic or hydrologic conditions, e.g., dry, dry-mesic, mesic, wet-mesic, wet moisture conditions, and poor, moderate, moderately rich, rich nutrient conditions.	Narrow range of edaphic or hydrologic conditions, indicative of locally significant factors, e.g., soil moisture/nutrient regimes, soil depth and texture. Site-scale drivers of structural variation (e.g., dry acidic woodlands).

Ruderal Vegetation

Describing ruderal vegetation posed another challenge (Appendix C). Ruderal vegetation typically encompasses types where the species composition and/or vegetation growth forms have been altered through anthropogenic disturbances such that no clear natural analogue is identifiable, but it is still a largely spontaneous set of plants shaped by ecological processes. Ruderal vegetation had been incompletely addressed in USNVC 2.0, mostly because many treatments of vegetation only focus on natural/native vegetation. Curtis's (1959) description of ruderal vegetation in Wisconsin is a remarkable exception. A more complete accounting was needed for USNVC 3.0.

State and Federal Engagement

The USNVC serves as both a federal standard for federal agencies, who are expected to link their agency classifications to it, and as a NatureServe Network standard, where the 50 state Natural Heritage programs in the U.S. collaborate with USNVC partners to develop the USNVC, either to directly use the USNVC as the basis for the state classification or alongside their own state vegetation or natural community classification. Development of USNVC 2.0 did engage state partners, but because the focus was on the mid-level units, which are at thematic scales of lesser concern to the states, the engagement was limited. With the focus on the mid- to lower-level units of group, alliance, and association, input of state programs was critical to ensure the USNVC would be operational within and across states. Similarly, federal agencies with land ownership in multiple states valued this interoperability.

METHODS

To develop USNVC 3.0, the Review Board addressed the three major limitations of USNVC 2.0: 1) the limitations of the formation concept; 2) incomplete review of mid- and lower-level units, especially for groups and alliances, and 3) limited engagement with state programs and federal partners.

Peer Review of Upper Levels - Formations

Opportunities to review the formation-level concepts (levels 1-3) initially occurred in the context of the development of a Global Ecosystem Typology (Keith et al. 2022), where NatureServe staff were part of the team. Following the success of that work, NatureServe invited an international team of terrestrial ecologists to join the International Vegetation Classification (IVC) Revisions Work Group to consider revisions to the formation concepts. The USNVC shares the same hierarchy approach as the IVC (Faber-Langendoen et al. 2018). A summary of the Work Group process between 2022 and 2023 is provided in Faber-Langendoen et al. (2025, Appendix S1; IVC Revisions Work Group Process). Given the substantial changes that were being considered, all proposed revisions to the IVC were submitted for review in 2023 to the -Review Board and to the ESA Panel.

Peer Review of Mid and Lower Levels – Lower 48 States

Peer Review Meetings

From 2017-2023, the Review Board systematically evaluated all alliances and groups (also addressing associations where needed to coordinate concepts with alliances). Eighteen major meetings (physical and virtual) were held at which the EIC and Review Board editors met with state and local experts from the region (Appendix D). At each meeting, a set of types from USNVC 2.0 were provided in a spreadsheet form with links to the existing descriptions. Proposed changes to types were documented using spreadsheet tools suitable for use by the NatureServe Ecology Data Management Committee (DMC).

Sources of Information - General

Without a full set of plot data across the approximately 1200+ alliances, the Review Board provided information for each meeting from a variety of sources, including previously analyzed vegetation plot data (e.g. Palmquist et al. 2013, Ramm- Granberg et al. 2021), local or state publications that describe alliances or comparable units (often based on plot data) (e.g. Curtis, 1959, Comer et al. 2003, Minnesota DNR 2003, Sawyer et al. 2009, Thompson et al. 2019), literature references to existing vegetation type descriptions, and experts at the meeting with field knowledge and experience in vegetation mapping. The challenge was to synthesize concepts across publications and jurisdictions using the guiding criteria for the different levels of the hierarchy). We often used geographic regions and floristic/vegetation zones as guides for interpreting regional scale turnover in species composition and changes in ecological gradients (Curtis 1959, Minnesota DNR 2003, Faber-Langendoen et al. 2014 - Appendix E, MacKenzie and Meidinger 2018), but there are limits to how well these guides serve as proxies for maximizing diagnostic species criteria (Willner et al. 2017).

Sources of Information - Ecological Systems

NatureServe's Ecological System types (Comer et al. 2003) were an important source of information for assessing group and alliance concepts. The classification was developed to address the lack of ecologically meaningful mid-level units in USNVC 1.0 (FGDC 1997, Grossman et al. 1998). A terrestrial ecological system was defined as "*a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients.*" Ecological Systems addressed native/natural vegetation but did not include ruderal or intensively managed/cultural vegetation. Sets of associations were used to help define the classification limits of the Ecological System types (though never fully linked), but the ability to map the units especially using various environmental and remotely sensed spatial data was also important. Units were typically described in terms of diagnostic classifiers, including biogeography and bioclimate, environment, ecological dynamics, landscape juxtaposition, vegetation structure, and vegetation composition and species' abundances. Lessons learned from the Ecological Systems effort had already influenced the concepts for the types above association (USNVC 2016). For example, whereas the definition of the alliance in USNVC 1.0 (Grossman et al. (1998) was strongly physiognomic-floristic; i.e., "*a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation,*" the revised definition in USNVC 2.0 was reworked as an ecological vegetation concept (see Table 2 and FGDC 2008). Although Ecological System types are no longer being revised, their high complementarity with USNVC units led NatureServe staff and the USNVC Review Board to crosswalk them to groups and alliances. Where concepts were similar or identical, Ecological Systems information was integrated into USNVC 3.0 group and alliance descriptions.(Note that the role of Ecological Systems in guiding LANDFIRE's Biophysical Setting and potential vegetation concepts is a separate application; see La Puma 2023).

State Collaboration

Lower 48 states

The USNVC serves as both a federal standard for federal agencies, who are expected to link their agency classifications to it, and as a NatureServe Network standard, whereby the 50 state programs in the U.S. collaborate with USNVC partners to develop the USNVC. At the regional review meetings, we reviewed all existing types listed for a state, and where a state had alternative classifications, we reviewed the types to see if they might inform revisions to the USNVC. If so, the revisions enhanced the relationship between the USNVC and state classification; but if not, we developed a crosswalk that accounted for the difference in concept between the two classifications.

Alaska

Of particular importance to the Board was to include ecologists with expertise in Alaskan vegetation. That partnership quickly emerged (see Alaska meetings in Appendix D) and initially led to a comprehensive review of all USNVC types in Alaska from formations (now biomes) down to group, and a partial review of alliances (Faber-Langendoen et al. 2020). Continued engagement by Alaskan ecologists and their participation on the USNVC Board led to further proposals for revising Alaskan macrogroups and groups (Nawrocki et al. 2025).

Hawaii

Progress in Hawaii has been more challenging, and formal engagement with ecologists on the islands is still needed. Previously, substantive work on Hawaii vegetation types had been completed through National Park Service vegetation mapping projects and a comprehensive list of Ecological Systems (Comer et al. 2003). These publications served as primary guides for alliance revisions by the Review Board but need a formal review.

U.S. Territories

Considerable information has been compiled on USNVC types in the U.S. Territories, particularly through extensive vegetation mapping conducted by the National Park Service. A formal review from experts is still needed.

Classification Data Management

Classification data management was handled by the NatureServe Ecology Data Management Committee (DMC) in NatureServe's Biotics database (NatureServe 2025).

Documentation of Revisions and Lineage Tracking

A key requirement for maintaining an authoritative list of types for the U.S. is to document the basis for changes through the creation of a lineage tracking process. The Lineage Tracking information should explain how and why types are removed and added to the classification as a result of concept splits, lumps, and other reconfigurations, as well as simple additions of missing concepts. To meet this need, the Editor-in-Chief worked with the DMC to record the basis for the change in any USNVC type. In addition, the DMC tracked name changes and moves of types to a different higher-level type (e.g., an alliance placed in one group being moved to a different group).

Type Description Template

The Review Board engaged editors and other experts to write descriptions for each type, whether revising an existing type description or writing a new type description. Types were described using a standard description template. The template is provided in Jennings et al. (2009, Box 2) (see also FGDC 2008, Section 3.2.3, and ESA Vegetation Classification Panel 2025 Appendix A). See Appendix E for an example.

Mapping the USNVC

In an ancillary project, NatureServe staff developed range-wide distribution maps for most USNVC groups guided by the type descriptions. The methods are detailed in Faber-Langendoen et al. (2025b), but essentially, staff worked closely with LANDFIRE map products to build a linkage (crosswalk) between the USNVC groups and Ecological System map units that LANDFIRE used to map the existing vegetation of the U.S. Staff then used expert review to revise the map based on jurisdictional and geographic distribution information described for each group. The staff accessed equivalent spatial information available for adjacent areas in northern Mexico and adjacent Canada (Comer et al. 2022).

RESULTS AND DISCUSSION

Upper Level Revisions – Realms

We adopted the "realms" framework of the GET (Keith et al. 2022) (see Table 3). Realms are defined as one of the major components of the biosphere that differ fundamentally in ecosystem organization and function: terrestrial, freshwater, marine, and subterranean (Fig. 1). The terrestrial realm includes all dry lands, the vegetation, substrate (soils, rock) to the rooting depth of the plants, and associated animals and microbes. Water and nutrients are the primary resource drivers in terrestrial ecosystems, with energy, oxygen, and carbon rarely limiting.

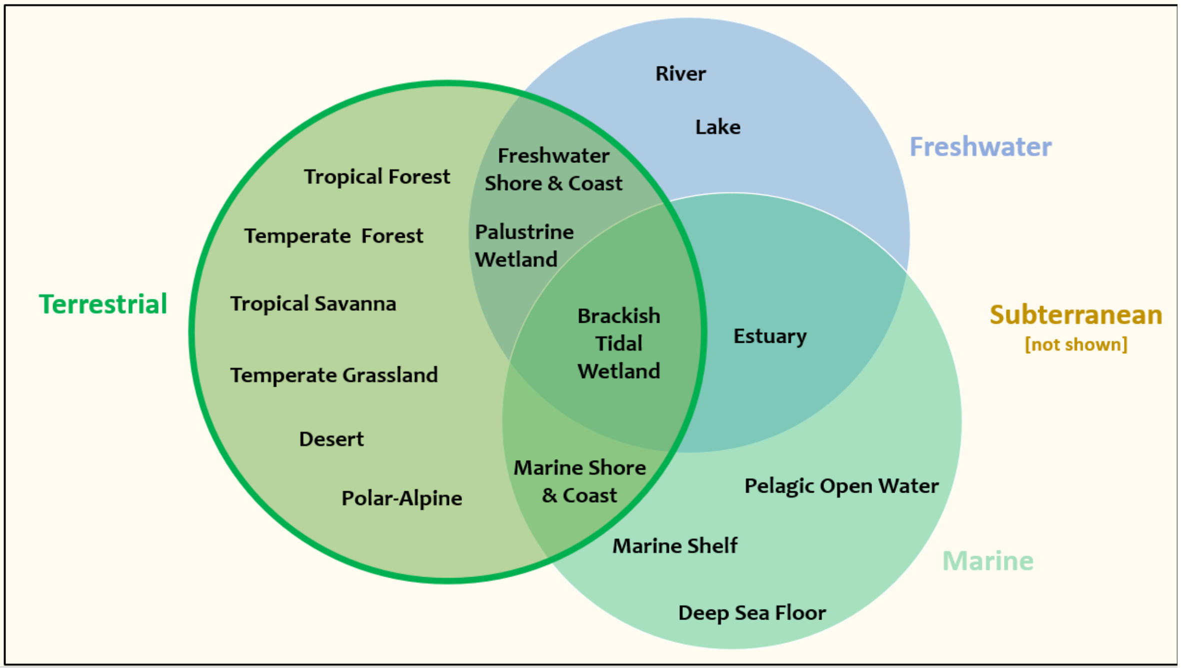

Figure 1. The scope of the USNVC as defined by the Terrestrial Realm and Transitional Realms. The dark green circle includes both the core "upland/dryland" biomes and the transitional wetland biomes (names abbreviated from Figure 2). Anthropogenic biomes in each realm are not shown. Figure adapted from Keith et al. (2022), including names of biomes in the Freshwater and Marine realms. The Subterranean realm is not shown for clarity.

Temperature and its variability on interannual, seasonal, and diurnal time scales is a major ambient driver, with ecosystem function and structure responding to global latitudinal and altitudinal climatic gradients. Fire is a major ecosystem driver, essentially unique to the terrestrial realm. Human activity is a key driver of ecosystem processes (Keith et al. 2022). The framework had been previously articulated by Ellenberg (in Mueller-Dombois and Ellenberg (1974), in what he termed "mega-ecosystems": Marine, Limnic (freshwater), Semi-terrestrial (wetlands), Terrestrial, and Urban-Industrial.

In adopting the realms approach, we removed the "supra-classification" categories of the USNVC (Table 3). The first was the distinction between **Vegetated/Non-vegetated**, such that the scope of USNVC 3.0 is defined not by wherever vegetation occurs (including aquatic beds), but by its terrestrial focus. To complete that terrestrial focus, we extended the USNVC to include all terrestrial ecosystems, including non-vegetated ecosystems such as beaches and glaciers. Despite the absence (or near-absence) of vegetation in these ecosystem types, they can be classified based on the overlap in abiotic properties with closely related ecosystems that have sparse to dense vegetation. The second was the distinction between **Natural/Cultural**. Requiring a distinction between natural and cultural as a "supra-classification" category is not satisfactory, as it would then need to identify all such cultural vegetation types at the outset, whether farms, orchards, or sea-walls, a rather heterogenous mix. Instead we moved the

Table 3. Revisions to the USNVC Hierarchy. 3a) Revised upper level (Level 1 - 3) structure of the USNVC 3.0, showing the realm and terrestrial biome levels compared with USNVC 2.0 categories and formation levels. Biome to ecobiome definitions with text in italics indicate the slight modifications made to the formation concepts to reflect their redefinition as biome concepts

USNVC 3.0 (Faber-Langendoen et al. 2025a)	USNVC 2.0 (FGDC 2008)
Realm and Transitional Realm. A realm is one of four core components of the biosphere that differ fundamentally in ecosystem organisation and function: terrestrial, freshwater, marine, subterranean. Transitional Realms describe overlaps among the realms.	**Category 1. Vegetated/Non-vegetated:** All terrestrial areas are classified as vegetated that have ≥1% surface coverage by live vascular and/or non-vascular plant species, including wetland and aquatic vegetation (rooted emergent, rooted submergent and floating aquatic vegetation). **Category 2: Natural/Cultural:** Natural (including semi-natural) vegetation is defined as *vegetation where ecological processes primarily determine species and site characteristics; that is, vegetation comprised of a largely spontaneously growing set of plant species that are shaped by both site and biotic processes.* **Cultural vegetation** is defined *as vegetation with a distinctive structure, composition, and development determined by regular human activity.*
L1. Biome. A broad combination of dominant general growth forms and structure *regulated by common major ecological drivers*, including basic moisture, temperature, substrate, and/or disturbance regimes.	**L1. Formation Class**. Broad combinations of dominant general growth forms adapted to basic moisture, temperature, and/or substrate or aquatic conditions.
L2. Subbiome. A combination of general dominant and diagnostic growth forms *and structure that are regulated by global ecological drivers*, such as mega- or macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate and disturbance regimes.	**L2. Formation Subclass.** Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.
L3. Ecobiome. A combination of *ecosystem properties* (especially dominant and diagnostic growth forms and structure) *that share common ecological drivers,* such as global macroclimatic conditions (modified by altitude and seasonality of precipitation), substrates, hydrologic, and disturbance regimes.	**L3. Formation.** Combinations of dominant and diagnostic growth forms that reflect global macroclimatic conditions as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.

distinction within the hierarchy, letting the degree of distinctive ecosystem characteristics generated by human activity within the realms determine how ecosystems are placed. Thus anthropogenic seawalls are identified in the context of marine shorelines, and forest plantations and agricultural fields are distinguished from tropical and temperate-boreal forests and grasslands. We choose not to use the term cultural for those anthropogenic units as indigenous influences on the landscape are often referred to as cultural practices, even when extensive and largely integrated with natural processes.

The wetland transitional realms (including both freshwater and marine wetlands) are part of the USNVC and account for the variation and overlap of the terrestrial realm with other realms (Fig. 1). The interface between terrestrial and freshwater realms contains palustrine (freshwater) wetlands, and the interface between the terrestrial, freshwater, and marine realms contains brackish tidal wetlands.

We exclude aquatic vegetation that was previously considered part of the USNVC; that is, aquatic vegetation in riverbed and lakebeds are better treated as part of the freshwater realm and the subtidal aquatic beds as part of the marine realm (Fig. 2). Doing so has the advantage of clarifying and enhancing the relationship of the USNVC to other U.S. federal classifications, such as the wetland and freshwater aquatic standard (Cowardin 1985) that guides the National Wetland Inventory and the marine standard of the Coastal Marine Ecological Classification System (CMECS, FGDC 2012). Together, these federal standards now cover nearly all ecosystems of the U.S. with only the subterranean realm lacking a standard.

Upper Level Revisions – From Formations to Biomes

We replaced the formation concepts of level 1 – 3 with biome concepts because the biome concept more firmly grounds vegetation concepts in ecological relationships; that is, biomes are large-scale ecosystem concepts that integrate biotic and abiotic processes and properties (Box 2, from Mucina 2018) (Table 4). Using biome concepts expands the properties of vegetation beyond physiognomy and growth forms to include non-physiognomic functional traits, such as life-history strategies and productivity, and recognizes, where needed, the role of animals as drivers of ecosystem patterns. In the terrestrial realm, formations and biomes are closely related because vegetation is a primary characteristic of terrestrial ecosystems (Whittaker 1975).

Box 2. Consensus on Biome Concepts
(Mucina 2018)

(1) A biome is a large-scale ecosystem occupying large spaces at least at the (sub)continental scale, or found in the form of a complex of small-scale, isolated patches scattered across those large spaces.

(2) A biome incorporates a complex of fine-scale biotic communities; it has its characteristic flora and fauna, and it is home to characteristic vegetation types and animal communities.

(3) Biome patterns are driven by coarse-scale (macroclimate) and meso-scale (soil, water, disturbance) drivers, and the biome structures impose feedbacks on the environment.

(4) A biome is generally characterized by a typical physiognomy (combination of plant and animal life forms), yet ecological feedback processes and disturbance may produce multiple stable states coexisting in the same geographic space.

Table 4. The revised hierarchy for USNVC 3.0 with Example.

USNVC 3.0 Hierarchy	Example
Upper	
L1 – Biome	Temperate-Boreal Grassland & Shrubland
L2 – Subbiome	Temperate Grassland & Shrubland
L3 – Ecobiome	Temperate Lowland-Montane Grassland & Shrubland
Mid	
L4 – Division	Central North American Grassland & Shrubland
L5 – Macrogroup	Central Lowlands Tallgrass Prairie
L6 – Group	Northern Tallgrass Prairie
Lower	
L7 – Alliance	Northern Mesic Tallgrass Prairie
L8 – Association	Northern Mesic Big Bluestem Prairie

We aligned the Level 1 formation class concepts with the Level 2 biome units of the GET (Keith et al. 2022), a process fully described in Faber-Langendoen et al. (2025a). The process of revising the formation class units of USNVC 2.0 (Faber-Langendoen et al. 2016) is shown in Figure 2. Key changes included a) initially moving all wetland types together, regardless of physiognomy, then separating them by freshwater versus marine wetland transitional realms, and b) combining temperate and tropical open rock types with grasslands and shrublands (a process already implemented in USNVC 2.0 for desert, polar, and alpine rock). After revising Level 1, most other Level 2 and 3 formation subclasses and formations were moved and revised as needed into the new biome structure.

All formation descriptions were revised, as were a few division (Level 4) units affected by these upper level revisions. Nomenclatural rules for the three biome levels were refined slightly to clarify that only a single name would serve as both scientific and common name. Previously, in USNVC 2.0, the Level 1 formation class had a modestly distinct scientific name from the common name, but Levels 2 and 3 did not.

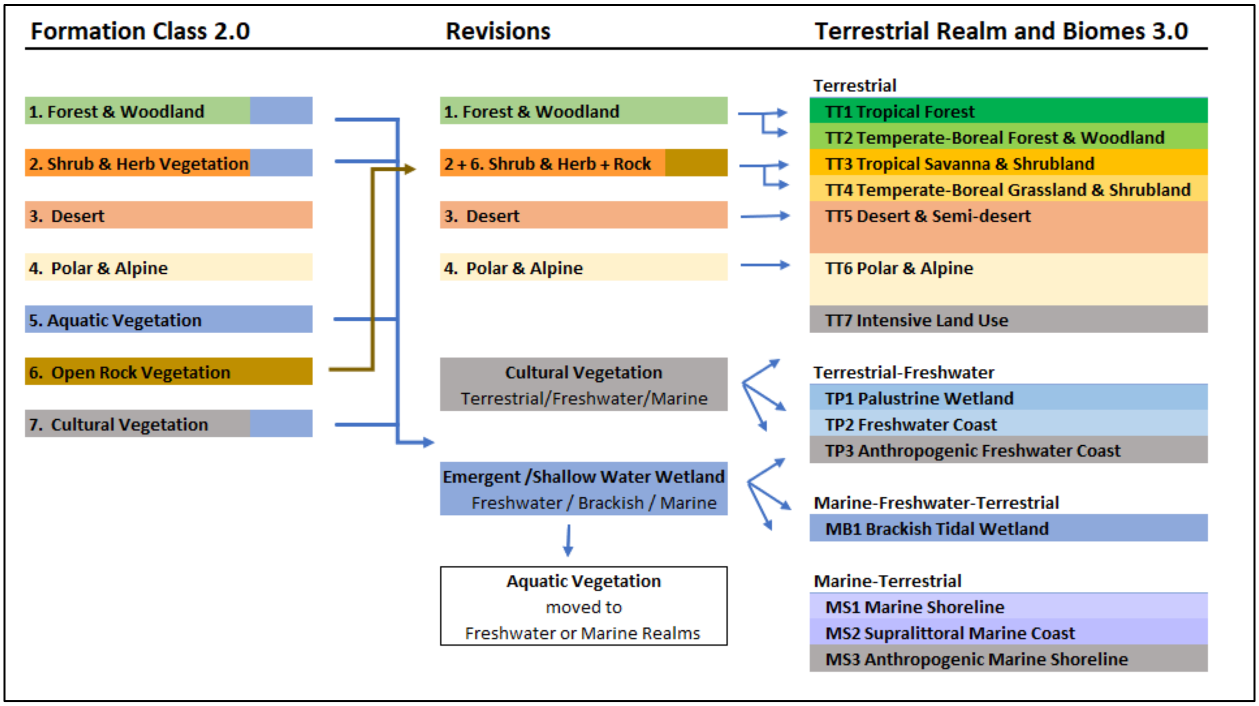

Figure 2. The revision of the formation class units of USNVC 2.0 to the biome units of USNVC 3.0. In the first left column the seven formation class units of 2016 are shown with the wetland components of formation class 1, 2, and 7 shown in blue. The second column shows the movement of the wetland components into a composite wetland unit and the integration of temperate and tropical rock types (formation class 6) with temperate and tropical grassland and shrubland types. The right-hand column shows the completed biome units organized by the terrestrial (including transition terrestrial) realm as published in Faber-Langendoen et al (2025a).

Mid-level Revisions – Division and Macrogroup

The mid-levels of division and macrogroup were relatively unchanged by the upper level realm and biome divisions; that is, the units could be moved directly under the revised ecobiome units at L3 with minimal revision. The number of divisions increased from 71 types in USNVC 2.0 to 77 in 3.0 (8% change). The number of macrogroups decreased from 184 types to 178 types (-3% change). These relatively modest changes in numbers reflected the merits of the extended review that occurred for those two levels in USNVC 2.0 (Franklin et al. 2012).

Because the macrogroup level is used for wildlife habitat and forest monitoring and because it has value as a broad unit for comprehensively describing ecosystems of the U.S., we developed a factsheet for each macrogroup, including a photo, mapped distribution, and summary text (see Faber-Langendoen et al. in prep).

Nomenclatural rules for the division and macrogroup were revised by the Review Board:

- Division. As with the biome levels, a single name serves as both scientific and common name for the division. In USNVC 2.0, the division had a formal scientific name that included up to three species names, physiognomy, and biogeography, separate from the common name. But identifying three characteristic species at this level was judged too obscure and out of step with current practices for naming types at this level (e.g., Willner and Faber-Langendoen 2021, Mucina 2023, Mucina et al. 2024). A common name was developed using biogeographic and physiognomic terms, supplemented by ecological terms if needed for clarity.

- Macrogroup. As with division, the macrogroup in USNVC 2.0 had a formal scientific name that included up to three species names, physiognomy, and biogeography, distinct from a common name. After discussion, it was agreed that, although providing up to three species in the name was helpful, their diagnostic role was much clearer if the biogeographic term associated with the concept was the primary term. Thus for naming macrogroups, the first term is the biogeographic region, followed by up to three species names, then physiognomy.

Mid to Lower-level Revisions – Group and Alliance

Starting from the 427 groups in the 50 states and territories in USNVC 2.0, the peer review process led to 441 groups, a 3% increase. Alliances were only addressed in the lower 48 states in USNVC 2.0, and from the original 1262 alliances the peer review process generated 1327 alliances for the lower 48 states (+5%). With the additional work done in Alaska and Hawaii for USNVC 3.0, the number of alliances increased to 1520 (+18%) for all 50 states.

The basis for revisions to each level varied by geography and ecology. In many cases, the alliance concepts are drawn from published types. We demonstrate the results of the process with an example from Minnesota and Wisconsin, followed by more general results.

Minnesota and Wisconsin - example

Information for the revisions to the alliances and groups in Wisconsin and Minnesota was taken from the historic work of Curtis (1959), the Wisconsin DNR (2025), and the plot-based publications of the Minnesota DNR (e.g. MNDNR 2003). Curtis (1959, p. 478) noted that his types were comparable to European alliances, and indeed some are now equivalent to USNVC alliances, others to groups (Table 5). The MNDNR publications provided a rich source of field plot-based information for revising the USNVC types within Minnesota and across the region. Minnesota state ecologists worked with the Review Board ecologists to improve the alliance concepts based on published state level information at the Minnesota “class” level. Decisions on how the state types were linked together through USNVC alliances and groups were guided by the degree of shared floristics and comparable ecological gradients (Fig. 3).

Table 5. Development of alliance concepts based on integrating state-level classifications within a region. Minnesota types (Native Plant Community Classes) are taken from MNDNR (2003). Wisconsin types are from Curtis (1959) and Wisconsin DNR (2025). Ecological System concepts are from Comer et al. (2003). Within each group, only the alliances found in these two states are shown. "+" indicates that the state type or Ecological System type is crosswalked to more than one alliance; in the case of Ecological Systems, those alliances may be in other regions (i.e. Acadian region). Figure 3 shows the relationship between Minnesota classes and NVC alliances along an ecological gradient.

USNVC Types			Minnesota (class level)	Wisconsin	Ecological Systems
M159 Laurentian Dry Forest & Woodland					
G907	**Laurentian Pine - Oak Forest & Woodland**				
	A3238	Laurentian Jack Pine - Red Pine - Oak Forest & Woodland	FDc24. Central Rich Dry Pine Woodland; FDc25. Central Dry Oak-Aspen (Pine) Woodland	Northern Dry Forest	Laurentian Jack Pine-Red Pine Forest
	A4127	Laurentian White Pine - Red Pine - Oak Forest & Woodland	FDc34. Central Dry-Mesic Pine-Hardwood Forest	Northern Dry-mesic Forest	Laurentian-Acadian Northern Pine-(Oak) Forest +
G160	**Laurentian Pine Barrens**				
	A1499	Laurentian Pine-Oak Barrens	FDc12. Central Poor Dry Pine Woodland FDc23. Central Dry Pine Woodland	Pine Barrens	Laurentian Pine-Oak Barrens
G999	**Laurentian Subboreal Pine - Spruce Woodland**			**Boreal Forest**	
	A3838	Subboreal Jack Pine - Black Spruce Forest	FDn32. Northern Poor Dry-Mesic Mixed Woodland		Laurentian-Acadian Sub-boreal Dry-Mesic Pine-Black Spruce-Hardwood Forest
	A3839	Subboreal Jack Pine - Red Pine - Oak Rocky Woodland	FDn22. Northern Dry-Bedrock Pine (Oak) Woodland		Northern Dry Jack Pine-Red Pine-Hardwood Woodland+
	A3840	Subboreal Jack Pine - Red Pine Sand Woodland	FDn12. Northern Dry-Sand Pine Woodland		
	A4130	Subboreal Red Pine - White Pine Forest	FDn33. Northern Dry-Mesic Mixed Woodland+		
	A3837	Subboreal Rocky Aspen - Spruce Woodland			
G921	**Laurentian Hardwood Forest**				**Laurentian-Acadian Northern Hardwood Forest +**
	A4444	Laurentian Aspen-Birch-Hardwood Forest	MHn44. Northern Wet-Mesic Boreal Hardwood-Conifer Forest	Northern Mesic Forest	
	A4448	Laurentian Rich Mesic Hardwood Forest	MHn46. Northern Wet-Mesic Hardwood Forest Class	Northern Mesic Forest	

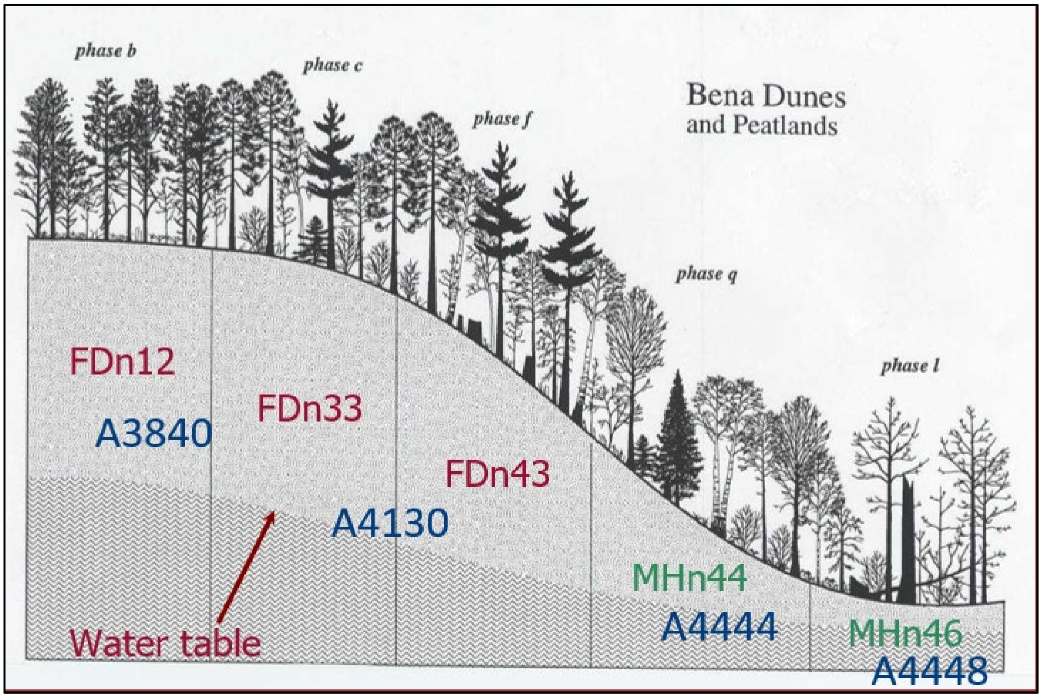

Figure 3. Development of alliance concepts in relation to ecological gradients – temperate forests. The Native Plant Community Classes of the MNDNR (2003) and the equivalent USNVC alliances in USNVC 3.0 are strongly correlated with local environmental conditions, especially gradients of moisture and nutrients (see Table 5 for names of vegetation types for each Minnesota and NVC code). Profile taken from the Bena Dunes near Lake Winnibigoshish, MN. Figure is adapted with permission from an unpublished figure created by the Minnesota DNR.

The Minnesota and Wisconsin state types did not explicitly incorporate range-wide patterns, including across the U.S. - Canadian border, and the Review Board used expert review to integrate multiple sources into a coherent set of alliances. However, the Minnesota ecologists did examine how the floristic tension zone defined by Curtis (1959) is readily apparent in central Minnesota (Fig. 4a). In turn the northern region above the tension zone, called the Laurentian Mixed Forest Province by the Minnesota DNR (2003), is part of a larger geographic concept (Fig. 4b) that is widely recognized in various publications, including as an ecoregional concept (CEC 2006), a forest regions concept (Braun 1950, Rowe 1972), and as a Vegetation Zone concept (Baldwin et al. 2021). Its boundaries eastward in the eastern Great Lakes and St. Lawrence are still under review as they are more challenging to resolve in relation to the Acadian and mountainous northern Appalachian regions. Nonetheless, the distinctive ecological processes and diagnostic floristic characteristics that are reflected in this region helped to guide alliance and group concepts. Review is ongoing on how to resolve boreal versus Laurentian/subboreal distinctions in the region (cf. Brandt 2009, Chapman et al. 2020).

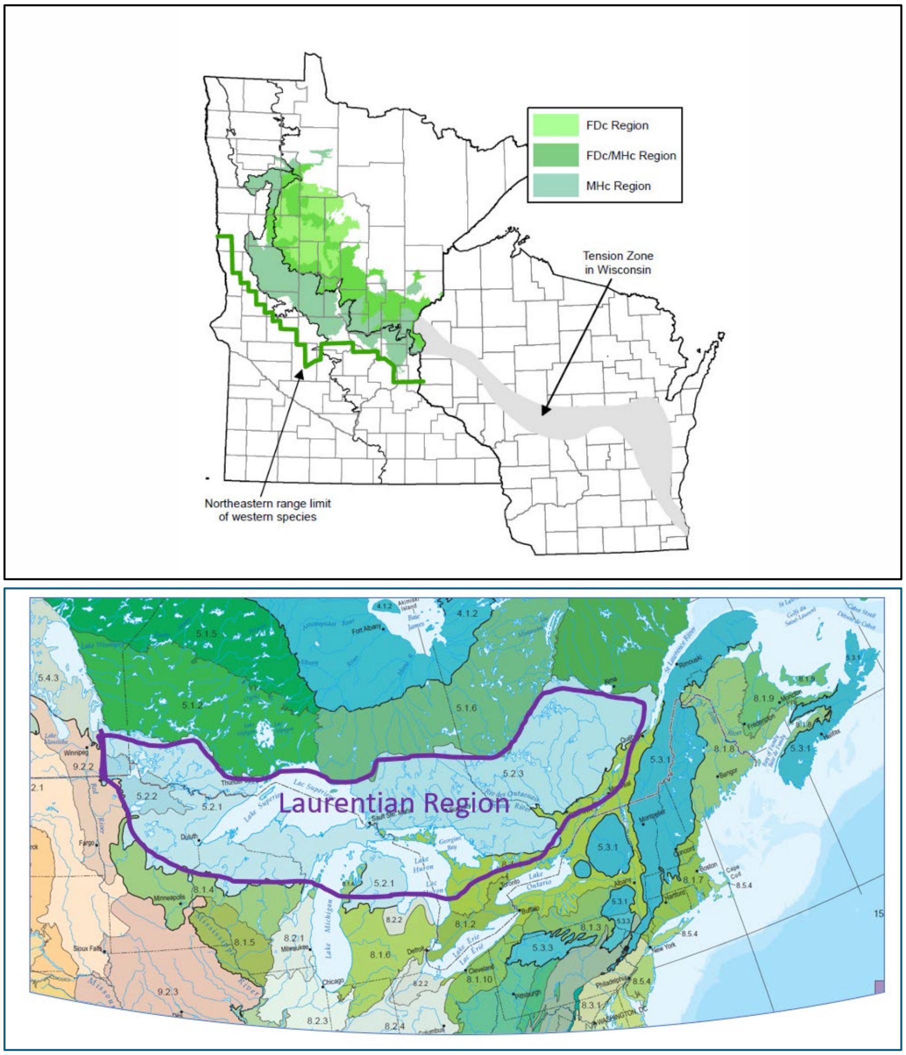

Figure 4. Illustration of the use of geographic gradients among types to guide the USNVC.

a) In Minnesota, the Laurentian Mixed Forest province reaches its southern limits in the Central Floristic region, where Fire Dependent Forest and Woodland Central types (FDc) and Mesic Hardwood central (MHc) types are shown in relation to the tension zone extended from Wisconsin as described by Curtis (1959). Also plotted is the collective northeastern range limit of selected western plant species in Minnesota; this limit approximates the southern boundary of the tension zone in Minnesota (Aaseng et al. 2011). Alliances are generally developed separately for types north and south of the tension zone (figure from Aaseng et al. 2011, used with permission from the Minnesota DNR).

b) The region north of the floristic tension zone in Wisconsin and Minnesota (there termed the Laurentian Mixed Forest Province) is part of a larger Laurentian ecoregional unit, the 5.2 Mixed Wood Shield of CEC (2006).

The Revisions Process – Lower 48

The process of linking alliances to published well-documented types that expressed the concept of the alliance continued throughout the five-year review process across all 48 states. As with the Minnesota and Wisconsin example, the review process relied on documented knowledge of species turnover along ecological and biogeographic gradients. This ecological gradient process is illustrated for salt marshes (Figure 5). The use of biogeographic considerations is illustrated by the use of Peet's (2000) description of four Rocky Mountain floristic regions where tree species turnover is high. These regions were used to guide macrogroup, group, and alliance concept decisions, and associations were redescribed as needed to reflect the corresponding ecological and floristic gradients (Triepke et al. 2025).

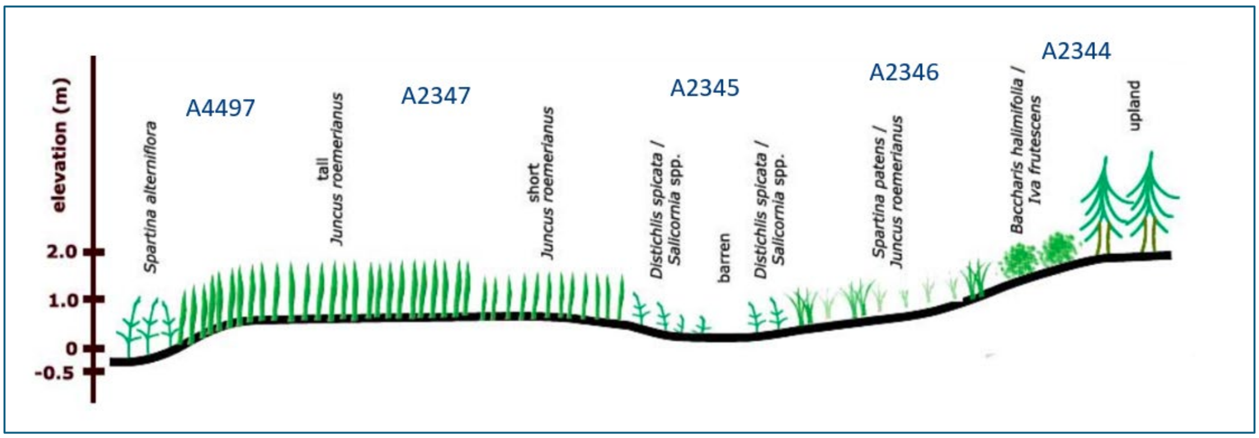

Figure 5. Developing alliance concepts in relation to ecological gradients – salt marshes. Generalized diagram of Gulf Coast salt marshes on protected low energy shorelines, showing alliance patterns of the South Atlantic & Gulf Coast Salt Marsh (G982). Alliance codes and names are as follows: A4497 Spartina alterniflora South Atlantic-Gulf Low Salt Marsh Alliance; A2347 S*partina patens - Spartina bakeri - Juncus roemerianus* Brackish Salt Marsh Alliance; A2345 *Batis maritima - Sarcocornia pacifica - Distichlis spicata* Salt Panne Marsh Alliance; A2346 *Spartina spartinae - Juncus roemerianus* High Salt Marsh Alliance; *A2344 Iva frutescens - Borrichia arborescens - Baccharis halimifolia* Salt Marsh Scrub Alliance. [from https://soils.ifas.ufl.edu/florida-wetlands-extension-program/about-wetlands/types-of-wetlands/tidal-salt-marshes/].

The documentation of USNVC associations by programs invested in that level were foundational in helping shape alliance concepts, as demonstrated by engagement with programs in the northeast, where state natural community types were used to guide association concepts and then aggregated into an alliance unit that smoothed over differences among state (Table 6). In the Mid-Atlantic region (Maryland, North Carolina, Pennsylvania, Virginia, West Virginia), individual hardpan woodland associations defined through a collaborative peer review process with those states then facilitated development of the alliance (Table 7). In California, the Manual of California Vegetation provided published descriptions of alliances (Sawyer et al, 2009), and these descriptions were indispensable in improving the USNVC in that ecologically diverse state (Table 8). Other western states, such as Washington (Ramm-Granberg et al. 2021), Colorado, and New Mexico have long invested in documenting associations, and state ecologists provided the expertise to integrate that information into improved alliance concepts.

Table 6. Alliance level revisions and associations. Aggregation of associations into a USNVC alliance and group, with corresponding published units from the New York (Edinger et al. 2014), Vermont (Thompson et al. 2019), and New Hampshire (Sperduto and Nichols 2012) Natural Heritage Programs. State types are synonymous with (=) the association. State conservation ranks (S#) and Granks (G#) are also provided (Master et al. 2012). A4443 is also equivalent to the Acadian-Appalachian Montane Spruce-Fir Forest (CES201.566) ecological system (Comer et al. 2003).

USNVC Name and Code			State Community Type		
Group	Alliance	Association	New York	Vermont	New Hampshire
Acadian-Appalachian Red Spruce -Fir Hardwood Forest (G744) [G5]					
	Montane Red Pruce – Fir – Yellow Birch Forest (A4443) [GNR]				
		Montane Balsam Fir – Birch Forest (CEGL006112) [GNR]	Mountain Fir Forest = (S2)	Montane Fir Forest = (S3)	High-elevation balsam fir forest = (S3S4)
		Montane Red Spruce – Fir Forest (CEGL006128) [G4]	Mountain Spruce-Fir Forest = (S2S3)	Montane Spruce-Fir Forest = (S3)	High-elevation spruce – fir forest = (S4)
		Montane Yellow Birch – Red Spruce Forest (CEGL008721) [G4]	?	Montane Yellow Birch-Red Spruce Forest = (S3)	?

The process of revision in the lower 48 has been detailed in some publications of the Proceedings of the USNVC, including for the Great Plains (Hoagland and Faber-Langendoen 2021) and the Rocky Mountains (Triepke et al. 2025). Recent work in the Canadian Prairie Provinces engaged ecologists on both sides of the border to revise and improve temperate grassland, forest, and wetland types in the northern Great Plains (Vinge-Mazer et al. 2025).

Table 7. Example of an alliance concept based on closely related associations in a geographic area: the mid-Atlantic hardpan woodland types.

USNVC Type: Code / Common Name		Scientific Name	Distribution
A4434 Piedmont Oak-Hickory Hardpan Woodland		**Quercus stellata - Carya carolinae-septentrionalis - Carya glabra Hardpan Woodland Alliance**	US: GA, MD, NC, SC, VA
CEGL006209	Potomac River Bedrock Terrace Oak - Hickory Forest	Carya glabra - Quercus (rubra, montana) - Fraxinus americana / Viburnum rafinesqueanum Forest	US: MD, VA
CEGL006216	Northern Piedmont Hardpan Basic Oak - Hickory Forest	Quercus alba - Carya glabra - Fraxinus americana / Muhlenbergia sobolifera - Elymus hystrix Forest	US: MD, VA
CEGL004037	Piedmont Mixed Moisture Hardpan Forest	Quercus phellos - Quercus (alba, stellata) - Carya carolinae-septentrionalis Hardpan Wet Forest	US: NC, SC?, VA
CEGL003558	Piedmont Dry Post Oak - Hickory - Pine Woodland	Quercus stellata - (Pinus echinata) / Schizachyrium scoparium - Echinacea laevigata - Oligoneuron album Woodland	US: NC
CEGL003711	Piedmont Basic Hardpan Woodland (Southern Type)	Quercus stellata - (Pinus echinata) / Schizachyrium scoparium - Symphyotrichum georgianum Woodland	US: NC, SC
CEGL004413	Piedmont Acidic Hardpan Woodland	Quercus stellata - (Quercus marilandica) / Gaylussacia frondosa Acidic Hardpan Woodland	US: NC
CEGL003713	Piedmont Basic Hardpan Forest (Rocky Type)	Quercus stellata - Carya carolinae-septentrionalis / Acer leucoderme / Piptochaetium avenaceum - Danthonia spicata Woodland	US: GA?, NC, SC?
CEGL003714	Piedmont Montmorillonite Woodland	Quercus stellata - Quercus marilandica - Carya (carolinae-septentrionalis, glabra) / Schizachyrium scoparium Woodland	US: GA, NC, SC, VA

Table 8. Example of building an alliance concept from published alliances: The Manual of California Vegetation (Sawyer et al. 2009). All alliances are directly equivalent between the two classifications, apart from A3677, which is uncertain in California and A3673, which is equivalent to two California alliances.

	USNVC Code / Common Name		USNVC Scientific Name	MCV Name	Distribution
G344	**Californian Montane Conifer Forest & Woodland**		**Calocedrus decurrens - Pinus lambertiana - Abies lowiana Forest & Woodland Group**	**Californian Montane Conifer Forest & Woodland [same as USNVC]**	**US: CA, NV, OR; MX: BCN?**
	A0147	Bristlecone Fir Forest	Abies bracteata Forest Alliance	Abies bracteata Alliance- 88.300.00	US: CA
	A3672	White Fir - Sugar Pine Forest	Abies lowiana - Pinus lambertiana Forest Alliance	Abies concolor – Pinus lambertiana Alliance- 88.510.00	US: CA, OR
	A3677	Eastern Sierran White Fir - Ponderosa Pine Forest & Woodland	Abies lowiana - Pinus ponderosa Eastern Sierran Forest & Woodland Alliance	Pinus ponderosa / Shrub Understory Alliance- 87.125.00?	US: OR
	A3674	Coastal, Cascadian & Sierran White Fir - Douglas-fir Forest	Abies lowiana - Pseudotsuga menziesii Coastal, Cascadian & Sierran Forest Alliance	Abies concolor – Pseudotsuga menziesii Alliance - 88.530.00	US: CA, OR
	A2157	Sierra White Fir Forest	Abies lowiana Forest Alliance	Abies concolor Alliance - 88.300.00	US: CA, OR
	A2152	Baker's Cypress Volcanic Woodland	Hesperocyparis bakeri Woodland Alliance	Hesperocyparis bakeri Alliance - 81.601.00	US: CA
	A0156	Northwestern Brewer Spruce - White Fir Forest	Picea breweriana - Abies lowiana Forest Alliance	Picea breweriana Alliance - 83.300.00	US: CA, OR
	A3676	Jeffrey Pine Mixed Conifer Woodland	Pinus jeffreyi Mixed Conifer Woodland Alliance	Pinus jeffreyi Alliance - 87.020.00	US: CA, NV, OR
	A3673	Ponderosa Pine - Incense-cedar - Douglas-fir Forest	Pinus ponderosa - Calocedrus decurrens - Pseudotsuga menziesii Forest Alliance	Pinus ponderosa – Calocedrus decurrens – Pseudotsuga menziesii Alliance - 87.005.00; Pinus ponderosa Alliance - 87.010.00	US: CA, OR; MX: BCN?
	A4707	Californian-South Cascades Ponderosa Pine Woodland	Pinus ponderosa var. washoensis Forest & Woodland Alliance	Pinus ponderosa / Shrub Understory - 87.125.00	US: CA, NV, OR
	A3675	Bigcone Douglas-fir - Canyon Live Oak Forest	Pseudotsuga macrocarpa - Quercus chrysolepis Forest Alliance	Pseudotsuga macrocarpa Alliance - 82.100.00	US: CA
	A4150	Giant Sequoia Forest	Sequoiadendron giganteum Forest Alliance	Sequoiadendron giganteum Alliance - 86.200.00	US: CA

The Revisions Process – Ecological Systems and the USNVC

Ecological System concepts were consulted when revising alliance and group concepts by the regional teams. Throughout the review process, NatureServe staff maintained an ongoing crosswalk. Of the 836 ecological systems in the 50 states, there are 736 (88%) either equivalent to or nested within groups, 150 (18%) that are equivalent to an NVC group, and 222 (27%) that are equivalent to an alliance. The remaining 12% of systems had complex relationships with the group and alliance. Although direct equivalence at either level was not strong, the high percentage of equivalent or nested relationships at the group level (i.e. 88%) indicates that although ecological systems and alliances often define the finer scale relationships between vegetation and ecological gradients differently, those differences are incorporated into the broader vegetation-ecological gradients at the group level.

Alaska and the Revisions Process

The work in Alaska proceeded differently from the lower 48 states because from 2017-2020 Alaska served as a pilot for the peer review process envisioned in the FGDC (2008) standard. The result of that work led to a formal report that described the macrogroups and groups for Alaska but developed only tentative alliances (Faber-Langendoen et al. 2020). Between 2021 and 2025, the Alaska Conservation Science Center, in collaboration with partners, continued to assess the macrogroups and groups, and in 2024-2025 worked with the Review Board and the Yukon Territory ecologists to initiate a revision to the units, especially in the boreal and Arctic regions (Nawrocki et al. 2025). This work also demonstrated that Arctic and boreal alliances need more work, and future workshops are being planned. For this reason, most boreal and Arctic alliances for Alaska are considered “proposed” at this time (but see Wells et al.2022).

Hawaii and the Revisions Process

Alongside the existing set of groups and associations for Hawaii, the Review Board developed a comprehensive set of alliances, relying in part on Ecological System concepts, as described above (Comer et al. 2003). However, a peer review team is still needed to conduct a systematic review and description of these alliances.

State and Federal Collaboration

Our engagement with state and federal partners is reflected in that, alongside the Review Board members, well over 100 state and federal (as well as NGO and academic) ecologists participated in the 18 regional meetings (Appendix D). Through these regional review meetings, we were able to review all existing types listed for each state and worked to ensure that they aligned with the revised alliance and group concepts. Where states used the USNVC directly, we ensured that the state list agreed with the national list. Where state had alternative classifications, we completed crosswalks that account for the relationship between the two classifications (as shown in Tables 4, 5 and 7 above). Where needed, crosswalk information for a state is available from the NatureServe Data Management Committee.

Moving forward, for the lower 48 states, we will treat all units from biome to alliance as a definitive part of USNVC 3.0 for at least the next five years, with the caveat that some alliances, when described, may warrant revision. However, associations will remain open to revision on a regular basis. In Alaska, we will leave the alliance level open for ongoing review, and in Hawaii a full review is needed.

Documenting Alliance and Group Revisions

Lineage Tracking

To meet the requirements for maintaining an authoritative list of types that is subject to ongoing revision, we produce a full lineage table that documents all type changes between USNVC 2.0 and USNVC 3.0. An example is shown in Table 9, and the full table is provided in Appendix E.

Table 9. Example of Lineage Tracking information. See Appendix E for the full Lineage Tracking report.

Examples	Predecessors 2.0	Successors 3.0
Simple merge:	**G047** Laurentian Subboreal Dry-Mesic Pine - Black Spruce - Hardwood Forest **G347** Laurentian Subboreal Dry Jack Pine - Red Pine - Oak Woodland	**G999** Laurentian Subboreal Pine - Spruce Woodland
Simple split:	**G025** Laurentian-Acadian Pine - Oak Forest & Woodland	**G907** Laurentian Pine - Oak Forest & Woodland **G908** Acadian-Appalachian Dry Forest & Woodland
Intermediate step:	**G122** Atlantic & Gulf Coastal Low Salt Marsh	**G982** South Atlantic & Gulf Coast Salt Marsh
	G122 Atlantic & Gulf Coastal Low Salt Marsh	**G983** North Atlantic Salt Marsh
	G957 North Atlantic Salt Marsh	**G983** North Atlantic Salt Marsh
	G958 South Atlantic & Gulf Coastal Salt Marsh	**G982** South Atlantic & Gulf Coast Salt Marsh

Description Template

For each type, a description was written following the standard template (example in Appendix F). The descriptions both summarize the current knowledge of the type and the connection to previous descriptions. In addition a Classification Comments field is provided that documents any issues in the concept of the type.

The alliance description provided in Appendix F also illustrates the results of the revision and Lineage tracking process for a northern Great Plains grassland alliance (Needle-and-Thread - Northern Mixedgrass Dry Grassland, A4389) which had been described in USNVC 2.0 and was first reviewed at a Great Plains workshop in 2019 (Hoagland and Faber-Langendoen 2021). The concept was retained (then coded as A4033) with only a minor name change and some clarification of its distribution. At a later workshop (Vinge-Mazer et al. 2025), the concept was judged inadequate because the component associations were too heterogeneous and the geographic range too widely reported, resulting in the revision of the primary concept as a northern Great Plains type, which was then recoded as A4389, and with a better defined set of associations.

Full descriptions were completed for all types, from biome to group. To document the revisions to upper level types based on biome concepts, we consulted the descriptions in Keith et al. (2022) as the USNVC types were aligned with those concepts (Faber-Langendoen et al. (2025a). Division and macrogroups were little affected by the revisions, but revisions were made as needed. Groups were more substantially affected by the revisions, but all groups were revised. At the time of publication, 455 (29%) of the alliances still require descriptions. Those lacking descriptions typically have a parallel concept in an existing publication (see Table and Table 7 above), and the Review Board will engage editors to transfer that information over.

The Revised USNVC 3.0

Summary of Revisions across Biome to Alliance Levels

After the substantial revisions completed through the Review Board, USNVC 3.0 now includes 11 biomes (L1), 25 subbiomes (L2), 41 ecobiomes (L3), 77 divisions (L4), 178 macrogroups (L5), 441 groups (L6), 1520 alliances (L7), and 6975 associations (L8) (Table 10). The biome to alliance levels are comprehensive for all 50 states, though substantial review is still needed for alliances in boreal and Arctic Alaska and in Hawaii. All units were given a standard scientific and common name and a Primary Concept source. Descriptions were written based on range-wide information, and the Review Board worked with U.S., Canadian, and other non-U.S. colleagues and literature to ensure their accuracy. Descriptions are complete for biome to group units; however, 455 (29%) of alliance descriptions have not yet been written, although information is available.

Table 10. Comparison of Number of Natural/Semi-natural Vegetation Types in USNVC for all 50 states between USNVC 2.0 and USNVC 3.0. Diff. = Difference.

Hierarchy	2.0	3.0	Diff.	% change
Upper				
L1 – Biome	6	11	5	+83%
L2 – Subbiome	13	25	12	+92%
L3 – Ecobiome	36	41	5	+14%
Mid				
L4 – Division	71	77	6	+6%
L5 – Macrogroup	184	178	-6	-6%
L6 – Group	427	441	14	+3%
Lower				
L7 – Alliance	1282*	1520	238	+19%*
L8 – Association	6054*	6975	921	+15%*

*in USNVC 2.0, alliances and associations were not yet reported for Hawaii and Alaska, so percentage change largely reflects types unique to those two states.

Summary of Revisions to Associations

Association units are largely complete for the lower 48 states, except California. In Alaska they are extensively developed in the southeast coastal temperate region, but they are incomplete across much of the boreal and Arctic regions. In general, associations did not receive extensive review in this process, except to ensure that they were properly nested within the correct alliance and group. A challenge to many association units currently listed in the USNVC is that they are often based on local literature and have not been adequately verified and described across their range, making it difficult to resolve their concept. Currently 1452 (21%) of all associations have no descriptions.

USNVC 3.0 Catalog and Database

A full accounting of all vegetation types developed for USNVC 3.0, from biome to association, is provided in the USNVC Catalog (USNVC Peer Review Board 2025; https://usnvc.org/usnvc-3-0-catalog/). The catalog was generated by the NatureServe Ecology Data Management Committee. It is an easy-to-use tool, alongside the USNVC databases, for exploring the hierarchy. It contains abbreviated descriptions of the units arranged in a collapsible format, along with information of geographic distributions, comments from reviewers, and links to additional web information.

The full set of descriptions for all types is available on the Hierarchy Explorer of the USNVC web database at https://usnvc.org/explore-classification/ USNVC Database Version 3.0 2025). Information on USNVC types is also available on NatureServe Explorer, which hosts the International Vegetation Classification (IVC) (Faber-Langendoen et al. 2018).

Mapping USNVC 3.0

The Terrestrial Ecosystems of the Conterminous U.S.

The detailed map products of LANDFIRE were realigned to produce maps of 323 groups and eight additional land cover and anthropogenic land-use categories across the entire map extent (including adjacent Canada and Mexico), with 308 groups present in conterminous U.S. Results are detailed in Faber-Langendoen et al. (2025b). The map is available in the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) license as a 30m ecosystems raster dataset and as a complete series of individual ecosystem range maps mapped at five spatial scales using NatureServe's standard Nested Hexagon Framework.

Mapping U.S. Ecosystems in a Global Context

USNVC ecosystem types at biome levels are aligned with the GET. Thus, where USNVC biomes (L1) and ecobiomes (L3) are the same or congruent with GET biomes (GET L2) and ecosystem function groups (GET L3), it is possible to both integrate information from the U.S. into global maps (Faber-Langendoen et al. 2025c) and to view the distribution of these biomes across the globe. For example, the USNVC 3.0 *TT2.b2 Oceanic Cool Temperate Rainforest* is the same type as the GET *T2.3 Oceanic cool temperate rainforests*, and thereby the global distribution can be viewed through the work of the GET (see https://global-ecosystems.org/explore/groups/T2.3), whose maps are now being enhanced through the Global Ecosystem Atlas project (https://globalecosystemsatlas.org/).

Next Steps for USNVC 3.0

The next steps for development of the USNVC include the following:

Alliances

- Alliances descriptions need to be written for all that lack descriptions (29%), though all have been systematically reviewed.
- Alaskan alliances, especially in the boreal and Arctic regions, need further review.

Associations

- 20% of associations lack descriptions, and many need wider systematic review.
- Californian and Boreal and Arctic Alaska associations need to be completed.

Hawaii and the U.S. Territories

- Peer review teams need to be developed to conduct a systematic peer review of all vegetation types in Hawaii and in the U.S. Territories.

State Collaboration

- Among the 50 state NatureServe Network programs in the US, we will encourage direct use of the USNVC at association, alliance, and group levels. We will also compile all information on field locations of USNVC types, including the location of high quality occurrences of common types and location of occurrences of at-risk ecosystems.

Federal Collaboration

- We will continue to work closely with federal agencies, including the National Park Service, the U.S. Forest Service (especially the Forest Inventory and Analysis Program), the U.S. Geological Survey, and the LANDFIRE program to implement USNVC 3.0. In particular, the USFS Forest Inventory and Analysis (FIA) program is working closely with NatureServe to implement the USNVC as part of the nation's forest inventory, monitoring, and reporting program. A USNVC v2.0 key to eastern macrogroups was completed in 2017 (Menard et al. 2017), and a key to the macrogroups and groups in the western US is being prepared. These keys will allow FIA to apply USNVC labels on all FIA forest condition data in the lower 48 states and Alaska.

International Collaboration

The USNVC partners are coordinating type concepts with Canadian NVC partners, as the two countries use the same typology and review type descriptions on both sides of the border (Faber-Langendoen et al. 2018). The Review Board and the Panel will continue to engage with other international partners, especially with the GET team, and with Mexican and Caribbean colleagues.

A Guide to the USNVC 3.0

- A guide to the USNVC 3.0 is being developed by the ESA Vegetation Panel (2025).

CONCLUSIONS

The USNVC 3.0 is the first multi-scaled vegetation classification of the United States that systematically lists and describes each level, from biome to association, working in close coordination with state and federal partners and international colleagues. The revisions to the upper levels based on realms and biome concepts aligns the USNVC with the Global Ecosystem Typology, such that USNVC 3.0 now provides a comprehensive inventory of all terrestrial realm ecosystems, including terrestrial and transitional-terrestrial wetlands. The ecosystem-based (EcoVeg) approach of the USNVC advances our understanding of not just the floristic and physiognomic composition of each vegetation type but also identifies the patterns and processes along environmental gradients that shape the ecosystem. As with USNVC 2.0, USNVC 3.0 includes intensively managed (anthropogenic) ecosystems, though the focus remains on more natural ecosystems.

The revised alliance units in USNVC 3.0 provide needed rigor to the full characterization of vegetation types across the United States, parallel to continental applications of alliance concepts elsewhere (Willner 2020). Association concepts are now more effectively organized under floristic- and ecologically-based alliance concepts which help characterize the alliance's range of variation. An ongoing goal is to provide a standard summary table based on quantitative plot data that details the physiognomy, floristic, functional, environment, and location information of these and other levels. To that end, the USNVC partners plan to release a revised version of VegBank, which is a vegetation plot data archive that serves as a primary tool for managing plot data relevant to the USNVC (Peet et al. 2012).

With this version, - USNVC 3.0-, the USNVC partners provide both an authoritative and stable version that serves as a reference for ongoing applications. Ultimately, the goal is not to suggest that there is only one authoritative system for ecosystem classification but to build reliable (inter-operable) relationships among various global to local classifications to facilitate information exchanges at multiple scales. These approaches and expected outputs can strengthen efforts to implement consistent approaches to inventory, monitoring, and restoration of ecosystems. There is still much to learn, and by working closely with state and federal partners, the catalog can become a living document, whereby new information on the status, distribution, and management of these ecosystems within states and across the nation can be constantly gathered and compiled, periodically leading to new versions.

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APPENDICES

APPENDIX A. History of Development of the USNVC

The structure of the USNVC (current version is USNVC 3.0) has evolved over time as follows:

1992-2000. Version 1. A seven-level hierarchy was developed based on the physiognomic-ecological formations of UNESCO (1973) and the floristic units of alliance and association (Grossman et al. 1998). It was initially called the International Classification of Ecological Communities (ICEC) but was renamed as IVC from the collaboration with the U.S. National Vegetation Classification (USNVC) (FGDC 1997) and the Canadian National Vegetation Classification (CNVC) (Alvo and Ponomarenko 2003). In the U.S., the Federal Geographic Data Committee Vegetation Subcommittee (FGDC 1997), the Ecological Society of America (Jennings et al. 2009), and NatureServe (Grossman et al. 1998) provided key support for its development. For details see Faber-Langendoen et al. (2018). In Version 1, each formation had separate Natural and Cultural expressions.

2000-2008/2016. **Version 2a.** Revisions leading to EcoVeg approach with an eight-level hierarchy lead to the release of the USNVC - 2.0 in 2008; release of comprehensive global formations in 2016 (levels 1-3); global grassland divisions (level 4) and macrogroups (level 5) in 2013; and macrogroups for Africa (2013) and Latin America (2018). In Version 2a, separate hierarchies were developed for Natural and Cultural Vegetation.

2017-2024. **Version 2b – Peer review and Partnerships**. Development of IVC for North America (USNVC and CNVC) using peer review processes, including through a newly established USNVC Peer Review Board overseen by the Ecological Society of America and ongoing collaboration with the CNVC Technical Committee. USNVC activities focus on development of formation to alliance types, including a five-year alliance review process (2019-2023) and expanded development of some cultural vegetation types, especially forest plantations. Collaboration with Latin American colleagues for macrogroup and group concepts (Faber-Langendoen et al. 2018). Collaboration with European (Willner and Faber-Langendoen 2021) and Australian colleagues (Muldavin et al. 2021).

2025. Version 3 – Revisions to upper levels and rigorous development of group and alliance concepts. The USNVC upper level formation units were revised as biome units, based on collaboration between USNVC, IVC, and Global Ecosystem Typology (Keith et al. 2022, Faber-Langendoen et al. 2025a). Peer Review Board completes the alliance review process and integrates all mid- and lower-level changes into the revised upper levels.

A synopsis of the versions of the USNVC is provided in Figure A1.

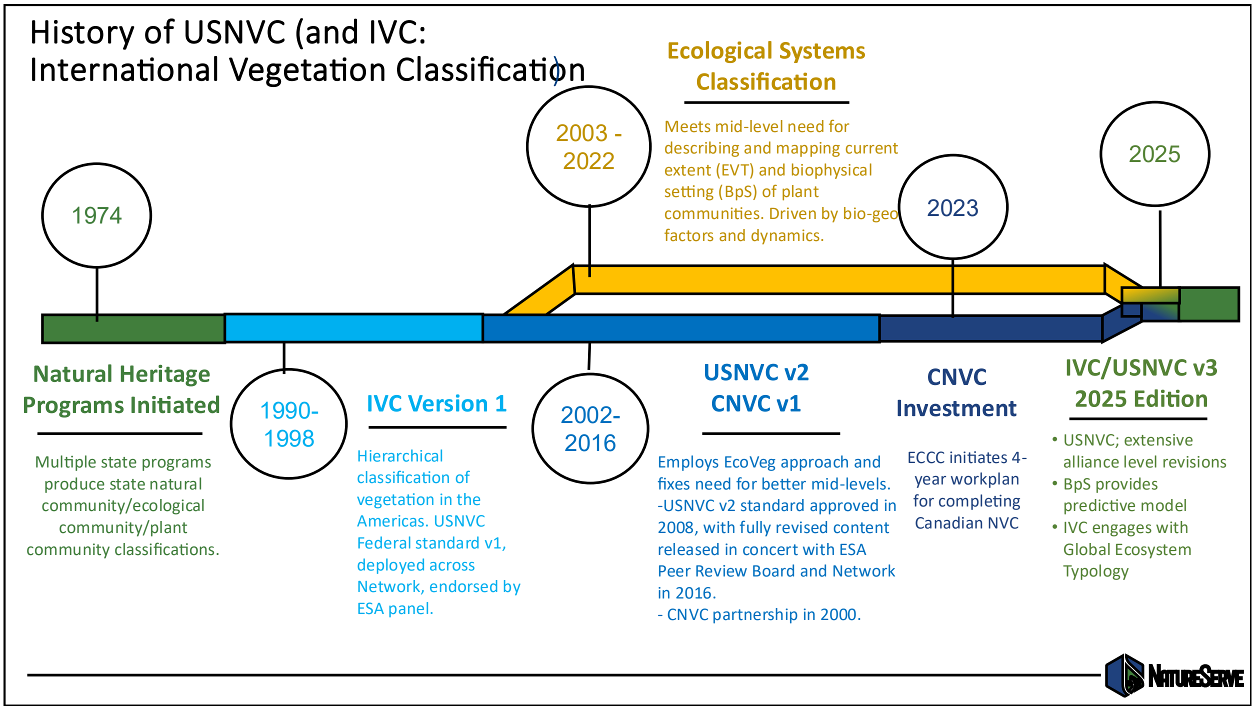

Figure A1. A brief sketch of the development of the USNVC, in relation to the International Vegetation Classification (IVC), the Canadian National Vegetation Classification (CNVC) and the Ecological Systems Classification. Figure developed by Regan Smyth.

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APPENDIX B. Guidelines for Alliance Concepts

1. SPECIFIC GUIDELINES

a. *Compositional Similarity*: The alliance concept is assessed by overall floristic composition - a measure of the similarity in the presence and abundance of plant species (and sometimes subspecies) among alliances.

b. *Characteristic Species Combination*: Typically, alliances are identified by a combination of **diagnostic** (**differential, character**), **constant,** and **dominant** species, including from the uppermost or dominant stratum, and reflective of overall **compositional similarity.** Diagnostic species should include at least one character species or multiple strong differential species (by "species" we mean taxa, thus subspecies could be used as well). Where sufficient diagnostics are lacking, but ecological or successional distinctions are strong, consideration can be given to defining the type based on those criteria. Not all diagnostic species are found in all stands, but stands may still be identified as a particular alliance using overall composition and ecology.

c. *Invasive/Exotic Species*: Invasive species (typically invasive exotics) are treated as degrading elements within a native alliance or association and vegetation containing these elements are documented as informal "**phases**" of a type, as long as some portion of the native composition remains (perhaps >10% native species cover). When invasive species overwhelmingly dominate the stand, and native diagnostics are largely to completely absent (a rough guide may be when invasives have >90% cover, but this may vary by type), they define semi-natural alliances and are placed within a semi-natural Macrogroup, separate from native alliances. See extended presentation in Appendix C: "Alliance Concepts and Ruderal Vegetation (Novel Ecosystems)."

d. *Physiognomy:* Alliances are typically moderately uniform in physiognomy, with consistent **layers**. For example, tree-dominated alliances will typically be either: forest or woodland, evergreen- mixed or deciduous–mixed. There may be considerable range in height within an alliance and variable dominance of other layers (e.g., an alliance may contain associations that have either a dominant shrub or herb layer, where these otherwise have strongly overlapping composition).

e. *Ecology*: Alliances reflect regional to subregional climate, substrate, hydrology and moisture/nutrient factors, and disturbance regimes. These patterns may also be reflective of regional biogeographic patterns.

f. *Plot data*: Alliances are best characterized through floristically comprehensive **plot** data that provide the basis for identifying diagnostic species, dominants, and overall compositional similarity. Incomplete plot data, literature, and expert judgment may still be helpful for initial development of concepts, e.g., plot data that include only species from the dominant layer or of the dominant growth forms (i.e. tree/sapling data in forests and woodlands, grass/forb data in grasslands) or species from the dominant layer along with environmental factors.

a) ALLIANCE COMMENTS. The alliance:

b) is applicable to existing, natural or semi-natural vegetation (i.e., vegetation that is not highly modified by anthropogenic activities, such as vineyards, industrial plantations, or row crops); see extended discussion of semi-natural alliances below.

c) contains diagnostic species that are typically derived through a process of aggregating associations, but in turn, alliance concepts may redefine association concepts as the role of diagnostics is re-evaluated from the top-down (Willner 2006).

d) exhibits certain environmental setting, such as parent material and soil properties, topo/edaphic range, water regime, and nutrient regime.

e) may be comparable in their order of magnitude to a variety of North American 'cover types' (forests - Eyre 1980; rangelands -Shiflet 1994), but alliances are not always dominance-type communities, because they are primarily defined by full floristic composition and diagnostic species, along with dominants. For example, a *Pinus banksiana* Eastern Boreal Woodland Alliance need not always have *Pinus banksiana* as a dominant in every plot, nor do all plots containing *Pinus banksiana* as a dominant necessarily fall into that alliance, if a strong complement of diagnostic species of another alliance are present (e.g., occasional stands of *Pinus banksiana* on a mesic site with spruce-fir regeneration and mesic shrub/herb species (Mueller-Dombois and Ellenberg 1974).

f) may include some successional stages that are floristically similar. For example, blow-downs of red spruce – fir (*Picea rubens – Abies balsamea*) stands may lead to a distinct successional stage defined as an association, with *Prunus serotina, Acer rubrum*, *Betula papyrifera*, and other light demanding species dominating the stand, along with these conifers. The more mature / old growth stage may be a separate successional stage. But the overall floristic similarity of these two associations may be such that they are placed in the same alliance. By contrast, a recently burned stand of spruce-fir, where spruce and fir are virtually absent, may be so distinctive that it is placed in a separate early successional aspen-birch *Populus tremuloides – Betula papyrifera* alliance.

g) contains associations that are typically either 'wetland' or 'upland.' But some transitional wetland types may be placed in an upland alliance (e.g., flatwoods post oak (*Quercus stellata*)) stands that exhibit xero-hydric hydrologies may be in the same alliance as other upland stands), depending on the strength of overall compositional or diagnostic features. Some species may occur in both upland and wetland types (e.g. *Thuja occidentalis*, *Acer rubrum*).

h) is often useful for mapping vegetation because of its characteristic physiognomy and the knowledge of species patterns from the dominant layer.

GLOSSARY

alliance—A group of associations with a defined range of species composition, habitat conditions, and physiognomy, and which contains one or more of a set of diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation. Alliances typically reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes (FGDC 2008, Jennings et al. 2009).

association—A vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions, and physiognomy. Associations typically reflect topo/edaphic climate, substrates, hydrology, and disturbance regimes (FGDC 2008, Jennings et al. 2009).

character species—a species that shows a distinct maximum concentration, by constancy and abundance, in one well-defined vegetation type as compared to all other types; sometimes recognized at local, regional, and general/global geographic scales (Mueller-Dombois and Ellenberg 1974, pp. 178, 208; Bruelheide 2000). Character species are often recognized from comparisons of vegetation within the same physiognomic type of a climatic or large biogeographic region, such as the NVC Division or regional formation (Dengler 2008). C*f. differential species, diagnostic species, fidelity.*

characteristic species combination—the combination of diagnostic, constant, and dominant species that characterize a type.

compositional similarity—a measure of the similarity in the presence and/or abundance of plant species (and sometimes subspecies) between two or more plots or types (cf. floristic composition). Similarity can be measured in a variety of ways, including various indices (such as Bray –Curtis, Euclidean distance, etc.)

constancy—percentage of plots in which a species is found.

constancy classes:
I – 1-20%
II – 21-40%
III – 41-60%
IV – 61-80%
V – 81-100%

constant species—“species that are present in a high percentage of the plots that define a type.” Recommended requirements for constancy at different levels of hierarchy include:

Association:	60%
Alliance:	40%
Group & Macrogroup:	25%

Constancy values change at different hierarchy levels because, as one moves up the hierarchy, the vegetation types are more heterogeneous vegetation units, with partially overlapping sets of species that comprise a meso-scale ecological gradient segment (Mueller-Dombois and Ellenberg 1974, Chytrý and Tichý 2003). Constancy is also influenced by plot size; thus, fairly constrained ranges of plot sizes (four to ten-fold range of area) are recommended for vegetation studies (Dengler et al. 2009, Peet and Roberts 2013).

cover type—a type of community defined solely on the basis of the dominance or co-dominance of one or several species

diagnostic species— any species or group of species whose relative constancy or abundance differentiates one vegetation type from another; includes ‘character’ and ‘differential’ species. Character species can be viewed as a special case of differential species, in that character species differentiate a type from all other vegetation types, whereas differential species differentiate one closely related type from another (Dengler et al. 2008). Thus, by definition, species indicated as diagnostic for a single vegetation unit can be called character species, while those indicated as diagnostic for more than one vegetation unit should be considered as differential species. However, there is a continuum in fidelity (diagnostic capacity) of species to vegetation units (Chytrý and Tichý 2003). Cf. *differential species, character species*

differential species— plant species that is distinctly more widespread or successful in one of a pair or closely related set of plant communities than in the other(s), although it may be still more successful in other communities not under discussion (Curtis 1959, Bruelheide 2000); the more limited a species is to one or a few plant community types, the stronger its differential value. c*f. character species, diagnostic species*

dominant species— species with the highest percent cover (the standard measure for vegetation classification), biomass, or density. Dominance is often assessed by strata, because taller statured species contain greater volume or biomass. At the stand or plot level a dominant has > 10% cover, thus including what may be called co-dominant species. At the type level, a dominant species is defined as a *constant species* (cf.) with at least 10% average cover, with the requirements for constancy varying by the level of the hierarchy. In sparsely vegetated habitats, such as deserts, dominance may not be a valuable criterion.

fidelity—A measure of the degree to which a species is concentrated more or less exclusively within a given vegetation type. cf. *character species*.

floristic composition—the presence and abundance of plant species (and sometimes subspecies) in a plot or type.

group — A vegetation unit defined by a relatively narrow set of diagnostic plant species, dominants and co-dominants, broadly similar composition, and diagnostic growth forms that reflect regional mesoclimate, geology, substrates, hydrology, and disturbance regimes (FGDC 2008).

growth form — the characteristic structural or functional type of plant. Growth form is usually consistent within a species but may vary under extremes of environment (Mueller-Dombois and Ellenberg 1974). Growth forms determine the visible structure or physiognomy of plant communities (Whittaker 1973).

habitat—the combination of environmental or site conditions and ecological processes influencing a plant community.

indicator species—a species whose constancy or abundance is considered to indicate certain habitat conditions, e.g., climate, soil moisture, soil nutrients, flooding regime, or disturbance history, among others.

large geographic area—a region of relatively uniform macroclimate and broadly uniform physiographic features (e.g., Great Plains-Prairie Parkland, Rocky Mountain Region, North American Boreal Region) (Bailey 1996). These areas may be on the scale of the ecoclimatic regions of Canada (Ecoregions Working Group 1989), the Ecoregional Divisions of Bailey (1997), or the floristic regions and provinces of Takhtajan (1986). As used to define the scope of alliances and associations, these areas do not provide fixed boundaries; rather they indicate the region of concentration for the units.

layer (vegetation)—a structural component of a plant community defined by (a) dominant growth form(s) of approximately the same height (e.g., tree, shrub, herb, and non-vascular layer).

natural vegetation—natural vegetation (including semi-natural, ruderal or weed) vegetation is composed predominantly of spontaneously growing sets of plant species with composition shaped by both abiotic (site) and biotic processes; these are vegetation types whose species composition is primarily determined by non-human ecological processes (Faber-Langendoen et al. 2014). See also Natural/Native vegetation, Semi-natural vegetation, and Ruderal vegetation.

natural/native vegetation—natural vegetation (excluding ruderal or weed) vegetation is composed predominantly of spontaneously growing native plant species with composition shaped by both abiotic (site) and biotic processes; (Faber-Langendoen et al. 2014).

phase—a non-standard level of the hierarchy that describes floristic variation caused by invasive species (typically invasive exotics) or other kinds of degradation to native vegetation types. The phase level may have substantial value in tracking levels of degradation caused by human impacts (see *facies* of Westhoff and van der Maarel 1973), from minimally disturbed to degraded stands. At some point, the limit of degradation of a native type is reached, after which the type is so altered that it becomes a semi-natural or ruderal type. Analyses of types may benefit from initially removing degraded phases when characterizing floristic and growth form patterns, then adding these phases back to determine their relationship to minimally disturbed types. The USNVC standard (FGDC 2008) notes that additional lower levels may be developed, if desired, but they are not formally part of the USNVC hierarchy. Phases could be developed for various floristic levels of the hierarchy but perhaps are of most value at the association and alliance levels.

physiognomy—narrowly defined as the outward appearance of a plant community as expressed by the dominant growth forms, such as their leaf appearance or deciduousness (Fosberg 1961); more broadly defined as the outward appearance and structure (i.e., spatial pattern of vegetation cover and layers) of the vegetation (Mueller-Dombois and Ellenberg 1974). Cf. structure.

plant community—a group of plant species living together and linked together by their effects on one another and their responses to the environment they share (adapted from Whittaker 1975); or more simply “the living plant species present within a defined space at a given time (adapted from

Palmer and White 1994). In the context of the USNVC, typically applied as a general term to the alliance and association levels.

plot—in the context of vegetation classification, a sampling area of defined size and shape that is intended for characterizing the vegetation and habitat of a stand.

ruderal vegetation—vegetation found on human-disturbed sites, with no apparent recent historical natural analogs, and whose current composition and structure (1) is not a function of continuous cultivation by humans and (2) includes a broadly distinctive characteristic species combination, whether tree, shrub or herb dominated. The vegetation is often comprised of invasive species, whether exotic or native, that have expanded in extent and abundance due to human disturbances (Faber-Langendoen et al. 2014). Sometimes referred to as "novel ecosystems.:

semi-natural vegetation —sometimes used as equivalent to ruderal vegetation (cf.) but also used more loosely to include a range of natural/native to near ruderal vegetation where varying levels of human/anthropogenic activities have occurred to alter the vegetation. Much natural/native vegetation in Europe is considered semi-natural because of the long history of human activity there (Faber-Langendoen et al. 2014). See also Natural, Natural/Native vegetation, Semi-natural vegetation, and Ruderal vegetation.

stand—an uninterrupted unit of vegetation, homogeneous in composition with uniform habitat conditions.

structure (vegetation)—the spatial pattern of growth forms (or life forms) in a plant community, especially with regard to their height, abundance, or coverage within the individual layers. Sometimes distinguished from physiognomy, when physiognomy is narrowly defined as the "outward appearance" of the vegetation.

vegetation—(1) the collective plant cover over an area (FGDC 1997); (2) the total of the plant communities of a region (Curtis 1959); (3) the mosaic of plant communities in the landscape (Küchler 1988).

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APPENDIX C. Alliance Concepts and Ruderal Vegetation (Novel Ecosystems)

The EcoVeg approach that is the basis for the USNVC separates intensively managed biomes (lawns, orchards, row crops, vineyards, forest plantations etc.) from natural biomes at the outset, based on strong ecological and physiognomic differences between the two. For example, forest plantations have a distinct anthropogenic structure (rows, even aged) and composition (often mono-dominant, either native or exotic species, little to no ground-layer or regeneration, and intensive management). But within natural vegetation, broadly defined, we distinguish natural/native vegetation from ruderal vegetation (Fig. B1). **Natural or native vegetation** is strongly shaped by non-anthropogenic ecological processes, although human activities can influence these interactions to varying degrees, such as by logging, livestock grazing, fire, or introduced pathogens (Westhoff and van der Maarel 1973, Ellenberg 1988). By contrast **ruderal vegetation** typically encompasses types where the species composition and/or vegetation growth forms have been altered through anthropogenic disturbances such that no clear natural analogue is known, but they are still a largely spontaneous set of plants shaped by ecological processes (Fig B1). For example, studies have shown that post agricultural forests, which form spontaneously on abandoned farmland, may persist in an altered state for a full generation of trees, before sufficient native diagnostics are established to return to a natural analogue (Ellenberg 1988, Flinn and Marks 2007). We use the term "ruderal" rather than "semi-natural," as the latter term has been applied to forests with minimal human disturbance, whereas ruderal vegetation is more clearly distinct from natural/native vegetation in having anthropogenically altered site conditions and nonnative invasive species. These ruderal ecosystems have also been called "novel ecosystems" (Hobbs et al. 2006).

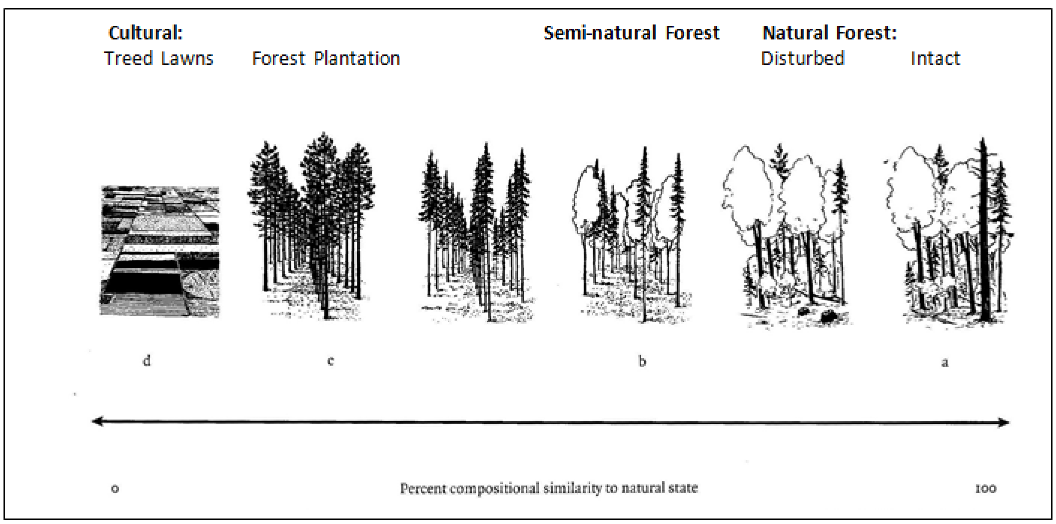

Figure B1. The disturbance gradient of a forest ecosystem, ranging from intensively managed (cultural) tree lawns and plantations to semi-natural (ruderal) and natural forests. a) Natural (native) forests are minimally disturbed (intact) by humans. Disturbed examples of native forests caused by cutting, grazing, and invasion of exotics are still recognizable as phases of native forests. b) Ruderal (semi-natural) forests may originate either on formerly planted stands where natural regeneration replaces the planted canopy or on abandoned farmlands where a mix of native and exotic species establish. c) Plantations are intensively managed in rows and exclude native regeneration (d) Treed lawns typically replace all native strata with intensively managed vegetation. Adapted from Palik and Engstrom 1999, Fig. 3.4. Used with permission from Cambridge University Press.

A critical question remains: how to address the classification of native types that are degraded through human-driven processes such as cutting, logging, grazing, and some invasion of exotics, but that have not been altered substantially enough to consider them ruderal vegetation. Our basic contention is two-fold; 1) exotics and other human-driven activities that alter and remove the native composition are a different kind of factor than the primary ecological factors that are used to sort native types. 2) Users of the classification typically have a strong interest in distinguishing near-natural or native types, at multiple levels of the hierarchy. A long treatise could be written on this topic. As this is an operational guideline, we put forth the following:

1. Rely on the characteristic combination of species (diagnostics, constants, and dominants) and their ecology and biogeography to define native types.
2. Where invasives (including at times, invasive or weedy native species) have a substantial impact, but does not displace, the diagnostic combination of native species, treat them as phases of native vegetation types. These degraded phases may be labeled by the primary invasive or set of invasives. Thus a classification type may be *Artemisia tridentata ssp. wyomingensis / Festuca idahoensis* shrub-steppe association, with a *Bromus* spp. (*tectorum*, etc.) phase. NatureServe and the Natural Heritage network have long described these phases more generally using a grading system of A, B, C, D, where A is excellent condition and D is degraded. But for the purposes of classification, we can simply label the phase and leave the grading to separate assessments of ecological condition.
3. When a type is degraded to the point where it is difficult to assign an association to it (that is, key differential species have been altered by the exotics), it may be necessary to assign a phase at the alliance level, or (more controversially) create an association that includes the combination of native and nonnative species. Two examples:
    a. In native sagebrush shrub steppe, *Bromus tectorum* is a widespread nonnative invasive species that crowds out native graminoids but not necessarily the native sagebrush (*Artemisia* spp.). Thus, while it is possible to recognize the alliance (i.e. *Artemisia tridentata ssp. wyomingensis* Dry Shrub Steppe Alliance, A2163), it may not be possible to determine the association the stand belongs to (e.g. either *Artemisia tridentata ssp. wyomingensis / Carex filifolia* Shrubland (CEGL001042) or *Artemisia tridentata ssp. wyomingensis / Hesperostipa comata* Shrubland (CEGL001051). In that case, the *Bromus tectorum* dominated stands could be assigned to a degraded phase of the alliance. Where a nonnative is widespread across an alliance, it may be most practical from a management standpoint to recognize the degraded phase as a ruderal association within a native alliance so it can be mapped, tracked, and, where feasible, flagged for restoration (i.e., *Artemisia tridentata ssp. wyomingensis / Bromus tectorum* Ruderal Shrubland (CEGL005477). Note that the association is clearly labelled as ruderal. When altered fire regimes lead to the loss of the native shrub, the stand is then reclassified as *Bromus tectorum* Ruderal Grassland (CEGL003019), placed in a *Bromus tectorum - Taeniatherum caput-medusae* Ruderal Annual Grassland Alliance (A1814), within the Great Basin-Intermountain Ruderal Dry Shrubland & Grassland (G600) and Western North American Cool Semi-desert Ruderal Scrub & Grassland macrogroup (M499).
    b. Similarly, the *Acer saccharum - Quercus muehlenbergii / Carex platyphylla* Forest (CEGL006162) (a limestone woodland type) may be dominated by the invasives *Rhamnus cathartica* and *Lonicera tartarica* in the mid-story and the invasive *Cynanchum rossicum* (pale swallowwort) in the ground layer. These can be labeled as

various phases of the native association, still recognizable by the characteristic overstory and the ecology of the type. At the point at which the native overstory is not able to reproduce and gives way to a *Rhamnus* thicket, the type may be labeled a ruderal forest type, identified as a *Rhamnus cathartica* Ruderal Shrubland (CEGL005461) within a *Northeastern Ruderal Meadow & Shrubland Group (G059)*, within an Eastern Ruderal Grassland & Shrubland (M555).

4. As a rule of thumb, where >90% of the various strata are dominated by invasives, the stand or plot may best be classified as a semi-natural or ruderal type.

In testing our approach we have found the macrogroup level to be an appropriate level at which the primary distinction between near-natural and ruderal vegetation can be made. This is because deciding whether or not a species (or even growth form) is exotic reflects historical biogeographic processes. Having defined a division concept at Level 4, based on very broad biogeographic patterns of species, it is possible to identify those species within a division that are broadly invasive in the region or being shaped more strongly by anthropogenic processes. It is also possible to identify the degree to which they form new vegetation types, often on human-disturbed sites (abandoned farmland, quarries, roadsides, etc.). Invasive exotic species often have a wide distribution and may spread across an entire division. For that reason, we create ruderal macrogroups (Table 1 below). This decision is borne out by comparisons with other classifications, such as in Europe, where the Braun-Blanquet approach recognizes distinct classes (equivalent to macrogroups) of ruderal or "weed" vegetation (see Rodwell et al. 2002). In Hungary, the MÉTA project explicitly distinguished habitats strongly dominated by "perennial alien species" from habitats containing native species, with or without some proportion of perennial aliens (Botta-Dukát 2008). The former category parallels our ruderal macrogroup.

By recognizing a continuum of naturalness (or of extensively to intensively managed human landscapes), we hope to encourage ecologists to think beyond the simple dichotomy of "pristine" nature or not. There is a long history of interactions between natural and human processes, and it is the relative strengths of those interactions that should be described (Botta-Dukát 2008).

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APPENDIX D. USNVC Peer Review Meetings 2017-2025

Revisions to USNVC 2.0 were completed by the USNVC Review Board largely by organizing state and regional meetings that brought together experts in the vegetation types found there. This Appendix documents the participants at each of the major meetings. Peer Review Board members are noted as follows: EIC – Editor-in-Chief, RE = Regional Editor, AE = Associate Editor. Attendance at the meetings were either in person (P = Present at Meeting) or remote (R = Remote Attendance). During the Covid years (2020-2022), those who regularly attended web meetings were considered Present. Meetings are arranged geographically (not by year), starting in Alaska, then from Southeast Coastal Plain to north along the coast, westward cross country to the northwest coast, south to California, and back east to Texarkana (Texas, Arkansas, Louisiana). See bottom of table for full name of the location and year when the meetings were held.

Participants			State/Regional Meetings*																	
LAST NAME	**FIRST**	**Contact**	**AK1**	**AK2**	**SEC**	**SEI**	**MAT**	**NOE**	**UGL**	**CMW**	**GPL**	**NGP**	**NRP**	**IWR**	**NCC**	**NPA**	**CA**	**SWT**	**TX**	**TAL**
Alexander	Kim	Florida Natural Areas Inventory			P															
Anderson	Marissa	U.S. Forest Service												P						
Baldvin	Tom	Colorado Natural Heritage Program												R						
Barnes	Jennifer	National Park Service	P																	
Bernard	Bonnie	Alaska Center for Conservation Science	P																	
Bezanson	Dave	The Nature Conservancy																	P	
Boucher	Tina	U.S. Forest Service	P																	
Boul (RE)	Rachelle	California Department of Fish and Wildlife														R	P			
Breen	Amy	USGS/UAF Alaska Climate Science Center	P																	
Brunner	Ray	Oregon Natural Heritage Program														R				
Carlson	Matt	Alaska Center for Conservation Science	P																	
Charnon	Betty	U.S. Forest Service	P																	
Comer	Pat	NatureServe, Boulder, CO (retired)												R						

Cooper	Steve	Montana Natural Heritage Program										R	P							
Copenhaver-Parry	Paige	Wyoming Natural Diversity Database											R							
Cox	Phil	Illinois Natural Heritage Program								P										
Crabtree	Todd	Tennessee Department of Environment and Conservation				R														
Datillo	Adam	Tennessee Department of Environment and Conservation																		
Davidson	Anne	U.S. Geological Survey											P							
Decker	Karin	Colorado Natural Heritage Program									R									
Diamond	Dave	Missouri Resource Assessment Program									P								P	
DiBenedetto	Jeff	U.S. Forest Service (retired)										R	P							
Doffit	Chris	Louisiana Department of Wildlife and Fisheries																		P
Dillman	Karen	U.S. Forest Service	P																	
Early	Brian	Louisiana Department of Wildlife and Fisheries			R															P
Edinger	Greg	New York Natural Heritage Program						P												
Elam	Caitlin	Tennessee Department of Environment and Conservation			R															
Elliott	Lee	Missouri Resource Assessment Program									P									
Estes	Dwayne	Southeast Grasslands Initiative				R														
Evens (RE)	Julie	California Native Plant Society													P	R	P			
Faber-Langendoen (EIC)	Don	NatureServe	P	P	P	R	P	P	P	P	P	R	P	P	P	P	P	P	P	P
Fagin	Todd	Oklahoma Natural Heritage Inventory									P									
Flagstad (AE)	Lindsey	Alaska Center for Conservation Science		P																
Fleming	Gary	Virginia Natural Heritage Program					P													

Fleming	Mike	Images Unlimited	P																	
Flynn	Nadele	Yukon CDC	P																	
Franklin (AE)	Scott	University of Northern Colorado									P									
Gara	Brian	The Nature Conservancy								P										
Gardner	Richard	Ohio Natural Heritage Program								P										
Gordon	Denise	Yukon Department of the Environment		R																
Gravley	Hunter	Alaska Center for Conservation Science	P																	
Grunblatt	Jess	Alaska Center for Conservation Science	P																	
Guyer	Scott	Bureau of Land Management	P																	
Hannam	Michael	National Park Service	P																	
Helmer (AE)	Eileen	U.S. Forest Service																		
Hines (AE)	Martina	Kentucky Natural Heritage Program				R				P										
Hoagland (RE)	Bruce	Oklahoma Natural Heritage Inventory									P									
Hrobak	Jennifer	National Park Service	P																	
Iosso	Chantal	Nevada Natural Heritage Program																P		
Jones	George	Wyoming Natural Diversity Database (retired)									R		P							
Jorgenson	Janet	U.S. Fish and Wildlife Service	P																	
Jorgenson (RE)	Torre	EcoScience Consulting																		
Kindscher	Kelly	Kansas Natural Heritage Inventory									P									
Kittel (RE)	Gwen	NatureServe, Boulder, CO (retired)												P				P		
Kluesner	Lisa	U.S. Forest Service								P										

Krosse	Patti	U.S. Forest Service	P																	
Labounty (RE)	Kitty	University of Alaska Southeast	R	R																
Lea	Chris	Ecology and Environment, Inc					R											R		
Leahy	Mike	Missouri Natural Heritage Program								P										
Lemly	Joanne	Colorado Natural Heritage Program												R						
Lincicome	David	Tennessee Department of Environment and Conservation				R														
Littlefield	Tara	Kentucky Natural Heritage Program				R				P										
Loehman	Rachel	U.S. Geological Survey	P																	
Lowell	Megan	U.S. Forest Service												P						
Long	Don	U.S. Forest Service	P																	
Lundgren	Julie	New York Natural Heritage Program						P												
Malusa	Jim	National Park Service (retired)																P		
Manning (AE)	Mary	U.S. Forest Service, Northern Region											P	P						
Marcano (RE)	Humfredo (Fito)	U.S. Forest Service																		
Marrugo	Jennifer	Texas Parks and Wildlife Department																	P	
Martyn	Parker	National Park Service	P																	
Maxell	Bryce	Montana Natural Heritage Program										P	P							
McCoy	Roger	Tennessee Department of Environment and Conservation																		
McIntyre (AE)	Patrick	NatureServe	P										P	P	P					
Meidinger (RE) Canada	Del	Meidinger Consulting		P										P		R				
Metzler	Ken	Connecticut Natural Heritage Program (retired)						P												

Miller	Amy	National Park Service	P																	
Mincemoyer	Scott	Montana Natural Heritage Program										P	P							
Mohatt	Kate	U.S. Forest Service	P																	
Muldavin (RE)	Este	Natural Heritage New Mexico		P						P	P							P		
Mullet	Tim	National Park Service	P																	
Murphy (AE)	Chris	Idaho Natural Heritage Program (retired)											R			R				
Namestnik	Scott	Indiana Natural Heritage Program								P										
Nawrocki (AE)	Timm	Alaska Center for Conservation Science																		
Nichols	William	New Hampshire Natural Heritage Program						P												
Nordman	Carl	NatureServe			P	R														
Osnas	Jeanne	Alaska Center for Conservation Science	P																	
Ott	Jeff	U.S. Forest Service											R							
Palmquist (RE)	Kyle	Marshall University			P		P													
Patterson	Karen	Virginian Natural Heritage Program					P													
Peat-Hamm	Heather	Independent Consultant										P								
Peet	Robert	University of North Carolina			P															
Pelz	Kristen	U.S. Forest Service												P						
Powers	Elizabeth	U.S. Fish and Wildlife Service	P																	
Proctor	Mike	Noble Research Institute																		
Puryear	Kristin	Maine Natural Heritage Program						P												
Pyle	Lysandra	Alberta Biodiversity Monitoring Institute										P								

Pyne (RE)	Milo	NatureServe (retired)				R	P													
Ratchford (RE)	Jamie	California Department of Fish and Wildlife													P		R			
Ramm-Granberg (AE)	Tynan	Washington Natural Heritage Program											R	P	P	P				
Raynolds	Martha	UA – Fairbanks	P																	
Rebain	Stephanie	U.S. Forest Service												P						
Reid (RE)	Marion	NatureServe, Boulder, CO (retired)		P										P						
Rideout-Hanzak	Sandra	Texas A&M Kingsville Univ																	P	
Roberts	Dave	Montana State University											P	P						
Rocchio (RE)	Joe	Washington Natural Heritage Program												P	P	P				
Rodman	Sue	Alaska Dept. of Fish and Game	P																	
Saperstein	Lisa	U.S. Fish and Wildlife Service	P																	
Schafale	Mike	North Carolina Natural Heritage Program			P		P													
Schlawin	Justin	Maine Natural Heritage Program						P												
Schotz	Al	Alabama Natural Heritage Program			P	R														
Schrader	Barb	U.S. Forest Service	P																	
Schulz	Beth	U.S. Forest Service, Anchorage Office	P												P					
Schulz (AE)	Keith	NatureServe, Boulder, CO (retired)									P		P	P	P			P		
Shappell	Laura	New York Natural Heritage Program						P												
Sikes	Kendra	California Fish and Game Department															P	R		
Singhurst	Jason	Texas Parks and Wildlife Division									P							R	P	
Smith	Jessica	Colorado Natural Heritage Program												R						

Sneddon	Lesley	NatureServe						P												
Sorenson	Eric	Vermont Natural Heritage Program						P												
Spencer	Linda	U.S. Forest Service												P						
Spurrier	Carol	U.S. Forest Service												P						
Steer	Anjanette	Alaska Center for Conservation Science	P																	
Steinauer	Gerry	Nebraska Natural Heritage Program									P									
Steuver	Mary	New Mexico State Forestry												P						
Swisher	Laurie	U.S. Forest Service												P						
Tart	Dave	U.S. Forest Service (retired)											R	P						
Tremblay	Michel	Independent Consultant										P								
Treuer-Kuehn	Amie	Texas Parks and Wildlife Division									R		R					P	P	
Triepke (RE)	Jack	U.S. Forest Service											R	P	P					
Vinge-Mazer	Sarah	Independent Consultant										P								
Wagner	Vicktoria	University of Alberta											R							
Walz	Kathleen	New Jersey Natural Heritage Program					P	P												
Weakley (RE)	Alan	University of North Carolina			P		R													
Wells (RE)	Aaron	AECOM	P	P									P							
Wentworth	Tom	North Carolina State University					P								P					
Wichmann	Brenda	Colorado Natural Heritage Program												R						
Wilker	John	Illinois Natural Heritage Program								P										
Williams	Wyatt	Indiana Natural Heritage Program								P										

Witsell	Theo	Southeast Grasslands Initiative				R														P
Keeler-Wolf	Todd	California Fish and Game Department													P					
Zaino	Robert	Vermont Natural Heritage Program						P												
Zimmerman (RE)	Ephraim	Western Pennsylvania Conservancy					R	P												

*Abbreviation for State/Regional Meeting (primary years of peer review activity)

AK1 Alaska (2017-2020)

AK2 Alaska (2024-2025)

SE Southeast Coastal Plain/Florida

SEI Southeast Interior (2022-2023)

MAT Mid-Atlantic (2020-2021)

NOE Northeast (2020-2022)

UGL Upper Great Lakes (2021-2022)

CMW Central Midwest (2021)

GPL Great Plains (2019)

NGP Northern Great Plains (2024-2025)

NRP Northern Rockies & Plains (2023)

IWR Interior West/Rockies (2021-2022)

NCC North Coast Cascades (2018)

NP North Pacific (2022)

CA California (2022)

SW Southwest (2023)

TX Texas (2023)

TA Texarkana (2023)

APPENDIX E. USNVC Lineage Tracking Report: Changes from 2.0 to 3.0

Link to spreadsheet:

https://usnvc.org/u-s-national-vegetation-classification-3-0-the-revisions-process-appendix-e/

APPENDIX F. Example of a Completed Alliance Description

TT4. Temperate-Boreal Grassland & Shrubland
TT4.b1.Nf. Central North American Grassland & Shrubland

A4389. Needle-and-Thread - Northern Mixedgrass Dry Grassland

***Type Concept Sentence:** This widespread grassland alliance is found in the northwestern Great Plains. *Hesperostipa comata* is a common dominant, with codominants of *Bouteloua gracilis, Carex filifolia, Carex inops ssp. heliophila, Elymus lanceolatus,* or *Pascopyrum smithii.* Sites are on flat to rolling uplands or hillsides with medium-textured soils.

View on NatureServe Explorer

OVERVIEW

***Hierarchy Level:** Alliance
***Placement in Hierarchy:** TT4.b1.Nf.3.c. Northern Great Plains Dry Mixedgrass Prairie (G331)

Elcode: A4389

***Scientific Name:** ***Hesperostipa comata - Pascopyrum smithii - Bouteloua gracilis* Grassland Alliance**

Common (Translated Scientific) Name [optional]: Needle-And-Thread - Western Wheatgrass - Blue Grama Grassland Alliance

***Type Concept:** This widespread grassland alliance is found in the northwestern Great Plains. Mid and short grasses and sedges dominate this dry-mesic prairie. *Hesperostipa comata* is common throughout this alliance. *Bouteloua gracilis, Carex filifolia, Carex inops ssp. heliophila, Elymus lanceolatus* and *Pascopyrum smithii* are also common. *Koeleria macrantha* increases on degraded sites. *Selaginella densa* cover may be moderate but otherwise forb cover is typically low. Forb species that are regularly found are *Antennaria parvifolia, Allium textile, Eriogonum umbellatum, Gaura coccinea, Heterotheca villosa, Liatris punctata, Opuntia polyacantha, Phlox hoodii, Packera fendleri (= Senecio fendleri)*, and *Sphaeralcea coccinea*. Shrub and dwarf-shrub cover is typically low as well. Species may include *Artemisia cana, Artemisia frigida, Elaeagnus commutata, Gutierrezia* spp., *Krascheninnikovia lanata, Prunus virginiana, Rhus trilobata (= Rhus aromatica), Rosa* spp., and *Symphoricarpos occidentalis*. Sites are on flat to rolling uplands or hillsides. If soils are sufficiently coarse-textured, this alliance can occur in valley bottoms. Soils are loamy and medium-textured or coarser and derived from sandstone or limestone.

***Diagnostic Characteristics:** This is an abundant alliance in the northwestern Great Plains and it shares some species with several others. The predominance of *Hesperostipa comata* and short grasses and sedges on loamy, medium or coarse-textured soils is characteristic.

***Classification Comments:** Two of the associations in this alliance (CEGL001700 and CEG001701) are not described. Based on their range and nominals, they may be considered for merging with CEGL002037. This alliance is generally found in the dry mixedgrass region but can also occur in xeric sites (e.g. south-facing slopes or with thin soils) in the mesic mixedgrass region.

***Similar IVC Types [if applicable]:**

Elcode	Scientific or Colloquial Name	Note
A2300	*Bouteloua gracilis - Pascopyrum smithii* Solonetzic Grassland Alliance	This alliance is found on Solonetzic soils where sites contain ~~characterstic~~characteristic burnouts.
A4031	*Pascopyrum smithii - Nassella viridula* North-Central Great Plains Grassland Alliance	This alliance occurs in more mesic grasslands where *Pascopyrum smithii* or *Nassella viridula* are dominant.

VEGETATION

Physiognomy and Structure Summary: This alliance is dominated by mid and short grass species; woody species do not regularly achieve prominence. Total vegetation cover is typically moderate and leaf litter is present but not thick. Few of the species exceed 1 m, while many do not exceed 50 cm in height. Perennial and annual forbs are common but are not abundant in most stands, with the exception of *Selaginella densa*. The ground layer of mosses and lichens may be sparse to moderate.

Floristics Summary: The most abundant species are *Hesperostipa comata (= Stipa comata), Bouteloua gracilis, Elymus lanceolatus,* or *Pascopyrum smithii*. On more mesic sites *Hesperostipa curtiseta* may be more predominant, while on areas that are drier or subject to light grazing *Bouteloua gracilis* takes precedence. Other graminoid species that are commonly found in communities of this alliance are *Aristida purpurea var. longiseta (= Aristida longiseta), Carex duriuscula (= Carex eleocharis), Carex filifolia, Carex inops ssp. heliophila, Koeleria macrantha,* and *Poa secunda. Festuca idahoensis* is generally absent but may be locally dominant in small parts of the range at higher elevations (~1200m) such as the Milk River Uplands in Alberta. Sites in the southern half of the range of this alliance may have significant amounts of *Bouteloua curtipendula. Selaginella densa* cover may be sparse to moderate, while other forbs are common but not usually abundant (<10% cover). Forb species that are regularly found are *Antennaria parvifolia, Allium textile, Eriogonum umbellatum, Gaura coccinea, Heterotheca villosa, Liatris punctata, Opuntia polyacantha, Phlox hoodii, Packera fendleri (= Senecio fendleri)*, and *Sphaeralcea coccinea*. Scattered shrubs and dwarf-shrubs are sometimes present. These may include *Artemisia cana, Artemisia frigida, Artemisia tridentata, Atriplex gardneri, Elaeagnus commutata, Gutierrezia* spp., *Krascheninnikovia lanata, Prunus virginiana, Rhus trilobata (= Rhus aromatica), Rosa* spp., and *Symphoricarpos occidentalis*. In the western and southwestern portions of its range, *Cercocarpus montanus* may be found where this alliance occurs on slopes (Hanson 1955).

Dynamics: These mixed grasslands occur in the subhumid/semi-arid steppes in the western Great Plains where high variability of precipitation, both seasonally and yearly, allows both short and mid grasses to coexist (Coupland 1992a). *Hesperostipa comata, Elymus lanceolatus,* and *Pascopyrum smithii* will decline with overgrazing, leaving the more grazing-tolerant *Bouteloua gracilis* and *Koeleria macrantha* to dominate (Smoliak 1965, Smoliak et al. 1972, Laurenroth et al. 1994a). Fire also can change the species composition of these grasslands. Burning generally kills or severely damages *Hesperostipa comata* plants. After fire, regeneration of this non-rhizomatous bunchgrass is through seed and may take many years to reach pre-fire densities (FEIS 1998). Burning *Bouteloua gracilis* during the growing season will top-kill the plant, but the rhizomes are usually unharmed and quickly regrow (FEIS 1998). *Bouteloua gracilis* is usually unharmed by fires in years with above normal winter and spring precipitation (soil moisture prevents lethal soil temperatures), but it can be severely damaged by fires that occur during drought years (FEIS 1998). Exotic species such as *Taraxacum officinale, Medicago sativa, Melilotus officinalis*, or *Salsola kali* are present in some stands.

Threats [optional NatureServe]:

ENVIRONMENT

Environmental Description: Grasslands included in this alliance are common in the west-central and northwestern Great Plains. Elevations range from 600-2350 m. Climate is temperate, continental and semi-arid to subhumid. Mean annual precipitation ranges from 25-50 cm. The year-to-year variation is great, in both total annual precipitation and the proportion of precipitation occurring in the winter and spring versus summer. Stands typically occur on upland sites in rolling plains, breaks, and plateaus. Sites are flat to moderately steep slopes on any aspect. Soils are shallow to moderately deep, non-saline, often calcareous and alkaline, with sandy loam, loam, or sometimes clay loam texture. Solonetzic sites, in the latter phases of soil development with improved drainage and without characteristic burnouts, support some stands of this alliance (Adams et al. 2013a). Parent materials often include limestone, sandstone, or shale with glacial deposits in the northern Great Plains. Adjacent stands in the plains are often grasslands dominated by *Pascopyrum smithii* in mesic bottomlands, *Bouteloua gracilis* in the xeric plains, shrublands dominated by *Artemisia tridentata, Ribes* spp., or *Rhus trilobata (= Rhus aromatica)*, and, at higher elevations, woodlands dominated by *Pinus edulis, Pinus flexilis, Pinus ponderosa*, or *Juniperus* spp.

Lower-level Units

CEGL002270	Northern Plains Blue Grama - Buffalograss Prairie	Bouteloua gracilis - Bouteloua dactyloides Northern Plains Grassland
CEGL008297	Northern Plains Needle-and-Thread - Blue Grama Prairie	Hesperostipa comata - Bouteloua gracilis - Carex filifolia Northern Grassland
CEGL001700	Needle-and-Thread - Threadleaf Sedge Grassland	Hesperostipa comata - Carex filifolia Grassland
CEGL001701	Needle-and-Thread - Sedge Mixedgrass Prairie	Hesperostipa comata - Carex inops ssp. heliophila Grassland
CEGL008298	Northwestern Great Plains Dwarf-Shrubland	Krascheninnikovia lanata / Hesperostipa comata Great Plains Dwarf-shrubland
CEGL001579	Western Wheatgrass - Blue Grama - Threadleaf Sedge Prairie	Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Grassland

DISTRIBUTION

***Geographic Range:** This alliance is found in the northwestern Great Plains from western Kansas and eastern Colorado to southern Alberta and southern Saskatchewan.

Spatial Scale & Pattern [optional NatureServe]:

Nations: Canada; United States

States/Provinces: AB, MT, ND, NE, SD, SK, WY

CONFIDENCE LEVEL

USNVC Confidence Level: Moderate

USNVC Confidence Comments [optional]:

IVC Confidence Level [optional NatureServe]: Moderate

DISCUSSION

Discussion [optional]:

CONCEPT HISTORY

***Recent Concept Lineage [if applicable]:**

Date	Predecessor	Note
2019-07-31	A4033 *Hesperostipa comata* Northwestern Great Plains Grassland Alliance	NVC125 (Great Plains)
2019-07-31	A4037 *Festuca idahoensis - Carex inops ssp. heliophila* Great Plains Grassland Alliance	NVC125 (Great Plains)

RELATED CONCEPTS

***Primary Concept Source:** Hoagland and Faber-Langendoen (2021)

Supporting Literature Concepts [optional]:

Supporting Concept Name	Relationship to A4389	Short Citation	Note
Bouteloua-Stipa Faciation	><	Coupland 1950 [A50COU01ICEC]	
Stipa comata/Carex filifolia	<	Hansen and Hoffman 1988 [G88HAN01ICEC]	*Stipa comata/Carex filifolia* and *Stipa comata/Carex heliophila* together equal this alliance.
Stipa comata/Carex heliophila	<	Hansen and Hoffman 1988 [G88HAN01ICEC]	*Stipa comata/Carex filifolia* and *Stipa comata/Carex heliophila* together equal this alliance.
Stipa-Bouteloua Faciation	><	Coupland 1950 [A50COU01ICEC]	
Central and Eastern Grasslands: 64: Grama-Needlegrass-Wheatgrass (*Bouteloua-Stipa-Agropyron*)	><	Küchler 1964 [B64KUC01ICEC]	
Central and Eastern Grasslands: 66: Wheatgrass-Needlegrass (*Agropyron-Stipa*)	><	Küchler 1964 [B64KUC01ICEC]	
Mixed Prairie climax	><	Tolstead 1942 [A42TOL01ICEC]	
Western Needlegrass, Sedge, Blue Grama community	?	Tolstead 1941 [A41TOL01ICEC]	

Related Ecological System Concepts [optional NatureServe]:

- **< CES303.674 Northwestern Great Plains Mixedgrass Prairie** System contains multiple dry mixedgrass alliances in G141 and G133.

Related Ecological Systems Summary [optional NatureServe]:

DESCRIPTION AUTHORSHIP

***Author of Description:** J. Drake, edited by S. Vinge-Mazer

Acknowledgments [optional]: Jim Drake

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