http://dx.doi.org/10.1890/13-2334.1 ***Ecological Archives*** **M084-020-A-E**
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APPENDICES

Appendix A. Hierarchy Revisions Working Group

Appendix B. Growth Form Names, Codes, and Definitions

Appendix C. Formation Units - Level 1 to Level 3

Appendix D.   Examples of Other Formation-Level Classifications

Appendix E. Alliance Concept, Guidelines and Literature Review

Appendix A. Hierarchy Revisions Working Group

Members shown below have been active on the working group since 2003-2004, unless otherwise indicated.

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Ecological Archives M084-020-A2

Don Faber-Langendoen, Todd Keeler-Wolf, Del Meidinger, Dave Tart, Bruce Hoagland, Carmen Josse, Gonzalo Navarro, Serguei Ponomarenko, Jean-Pierre Saucier, Alan Weakley, and Patrick Comer. 2014. EcoVeg: a new approach to vegetation description and classification. *Ecological Monographs* 84:533–561. http://dx.doi.org/10.1890/13-2334.1

APPENDIX B. Growth form names, codes, and definitions.

Names, definitions and codes for growth forms for use in collecting vegetation plot data (from Table E.1 of FGDC (2008) (see also Whittaker 1975:359, Tart et al. 2005, Box and Fujiwara 2005).

TABLE B1. General growth forms.

Growth Form Code	Name and Definition
T	**Tree** - A woody plant that generally has a single main stem and a more or less definite crown. In instances where growth form cannot be readily determined, woody plants equal to or greater than 5 m in height at maturity are to be considered trees (adapted from FGDC 1997). Excludes krummholz (wind-stunted trees), but includes small trees or "treelets" (Box 1981). Tall multistemmed woody plants with strong canopy structure and which well exceed 5 m would be included here (e.g., mature, multi-stemmed *Quercus ellipsoidalis* in the United States or some Australian mallee eucalypts). ;
S	**Shrub** - A woody plant that generally has several erect, spreading, or prostrate stems which give it a bushy appearance. In instances where growth form cannot be readily determined, woody plants less than 5 m in height at maturity are to be considered shrubs [even if monopodial?] (adapted from FGDC 1997). Includes krummholz (wind-stunted trees), but excludes small trees (Box 1981). Includes dwarf-shrubs (less than 30 cm), low or short woody vines, and arborescents (woody plants that branch at or near ground-level but grow to low tree heights). (Box 1981). Some multi-stemmed, bushy woody species ("scrub") that reach up to 10m may be included here, such as Australian mallee comprised of *Eucalyptus viridis* and *Eucalyptus dumosa*).
H	**Herb** - A vascular, non-woody plant without perennial aboveground woody stems, with perennating buds borne at or below the ground surface. (Whittaker 1975, FGDC 1997). Includes forbs (both flowering forbs and spore-bearing vascular plants), graminoids, and herbaceous vines.
N	**Nonvascular** - A plant or plant-like organism without specialized water or fluid conductive tissue (xylem and phloem). Includes mosses, liverworts,

	hornworts, lichens, and algae (adapted from FGDC 1997). Also called thallophytes or "nonvascular cryptogams," (that is, excluding the vascular cryptogams; see Herb) (Box 1981).
E	**Epiphyte** - A vascular or nonvascular plant that grows by germinating and rooting on other plants or other perched structures, and does not root in the ground (adapted from FGDC 1997).
L	**Liana** - A woody, climbing plant that begins life as terrestrial seedlings but relies on external structural support for height growth during some part of its life (Gerwing 2004), typically exceeding 5 m in height or length at maturity. Non-woody climbers are treated as "Herb."

TABLE B2. Specific growth forms.

General Growth Form Code	Specific Growth Form Code	Name and Definition
T	TBD	**Broad-leaved deciduous tree** - *A tree with a branching crown, leaves that have well-defined leaf blades that are generally of at least microphyll size (≥225 mm2, or 0.35 in2)* and which seasonally loses all of its leaves and becomes temporarily bare-stemmed* (adapted from FGDC 1997, Box 1981; Includes monopodial and sympodial growth forms.
	TBE	**Broad-leaved evergreen tree** - *A tree with a branching crown, leaves that have well-defined leaf blades that are generally of at least microphyll sized (≥225 mm2 or 0.35 in2) and which has green leaves all year round*. (FGDC 1997, Box 1981). Includes monopodial and sympodial growth forms, and woody-like bananas (*Musa* spp.).
	TBES	**Sclerophyllous tree** - *A type of broad-leaved evergreen tree with leaves that are stiff and firm, and retain their stiffness even when wilted*. The leaves are typically relatively small (microphyll to small mesophyll in size) and sometimes rather linear , (FGDC 1997, Whittaker 1975, Box 1981)
	TN	**Needle-leaved tree** - *A tree with slender, often cylindrical, elongated leaves or with small overlapping leaves.* Includes scale-leaved and needle-leaved trees, deciduous and evergreen, needle-leaved trees. such as *Abies, Larix, Picea,*

		Pinus, *Thuja*. (FGDC 1997, Box 1981).
	TU	**Succulent tree –** *A tree or arborescent plant with fleshy stems or leaves with specialized tissue for the conservation of water* (FGDC 1997). Includes Cactaceae, *Yucca brevifolia* (Joshua trees), euphorbias, and others over 5 meters in height at maturity. An "arborescent stem-succulent" (Box 1981) Some Dracaenaceae may fit here.
	TM	**Small-leaved tree** - *A tree with very small leaves (<225 mm2, or 0.35 in2)*, or even leafless, sometimes armed with spines*. Includes both evergreen and deciduous small-leaved trees, such as *Acacia greggii*, *Mimosa* spp. (adapted from "thorn tree" by Whittaker 1975)
	TP	**Palm tree** - *An evergreen, broad-leaved, flowering, (non-sporing, tree, typically with a simple, unbranched stem and terminal, rosulate crown of large, pinnate or fan-shaped leaves. A type of rosette tree*. Palms are the primary taxa, but see Dracaenaceae, some Pandanaceae, etc. (Box 1981). *Hyphaene thebaica is an example of a branched palm tree*
	TF	**Tree fern** - *An evergreen, broad-leaved, spore-bearing tree (or arborescent fern) with a simple, unbranched stem and terminal, rosulate crown of large fronds.* A type of rosette tree, including taxa from Cyatheaceae (Box 1981).
	TG	**Bamboo tree**- *A woody-stemmed, arborescent grass that is equal to or greater than 5 m in height at maturity.* Only applies to woody-stemmed bamboos. Includes the "Arborescent grasses" (Box 1981). Other more typically woody grasses, such as *Arundo, Saccharum*, currently excluded, and treated as Herb-graminoid.
S	SD	**Dwarf-shrub –** *A mature caespitose, creeping, matted, or cushion-forming shrub that is generally small-leaved and is typically less than 30 cm tall at maturity due to genetic and/or environmental constraints* (adapted from Mueller-Dombois and Ellenberg 1974).
	SBD	**Broad-leaved deciduous shrub** - *A shrub that is typically more than 30 cm tall at maturity with leaves that have well-defined leaf blades that are generally of at least microphyll size (≥225 mm2, or 0.35 in2* and seasonally loses all of its leaves and becomes temporarily bare-stemmed* (FGDC

		1997).
	SBE	**Broad-leaved evergreen shrub** - *A shrub that is typically more than 30 cm tall at maturity with leaves that are generally of at least microphyll sized (≥225 mm2, or 0.35 in2 * and has green leaves all year round* (adapted from FGDC 1997, Box 1981).
	SBES	**Sclerophyllous shrub** - *A type of broad-leaved evergreen shrub, typically with relatively small, leaves that are stiff and firm, and retain their stiffness even when wilted* (FGDC 1997, Whittaker 1975).
	SN	**Needle-leaved shrub** - *A shrub that is typically more than 30 cm tall at maturity with slender, elongated leaves or with small overlapping leaves that usually lie flat on the stem (*FGDC 1997). Includes scale-leaved as well as needle-leaved shrubs, and deciduous as well as evergreen.
	SU	**Succulent shrub** – *A fleshy shrub that is typically more than 30 cm tall at maturity with specialized tissue for the conservation of water* (adapted from FGDC 1997 and the Thorn shrub of Whittaker 1975). Includes cacti less than 5 meters in height at maturity. Includes both the "Typical Stem succulents" and "Bush succulents" (Box 1981). Includes Aloe, Agave.
	SM	**Small-leaved shrub** - *A shrub that is typically more than 30 cm tall at maturity with very small leaves (<225 mm², or 0.35 in2)*, or even leafless, sometimes armed with spines, usually having compound, deciduous leaves that are often reduced in size*. Includes *Larrea tridentata, Prosopis glandulosa, Acacia neovernicosa, Senna, Calliandra* (Whittaker 1975)
		Bamboo shrub- *A woody-stemmed, shrubby grass that is less than 5 m in height at maturity.* Only applies to woody-stemmed bamboos. Includes *Arundo, Saccharum, Sinarundinaria* spp (=*Yushania* spp.).
	SP	**Palm shrub** - *An evergreen, broad-leaved, typically unbranched shrub that is typically more than 30 cm tall at maturity with a simple stem and terminal, rosulate crown of large, pinnate or fan-shaped leaves*. Includes palms and palm-like plants, such as espeletia.

H	HA	**Aquatic herb** - *A flowering or non-flowering herb structurally adapted to live floating or submerged in an aquatic environment*. Does not include emergent plants such as cattails and sedges. (FGDC 1997). Includes flowering and non-flowering, and forb and graminoid aquatic herbs. Further subdivision may be warranted if ecologically meaningful.
	HF	**Forb** - *A non-aquatic, flowering or spore-bearing, non-graminoid herb.*
	HFF	**Flowering forb** - *A forb with relatively broad leaves and showy flowers*. Does not include graminoids, ferns, or fern-allies. Includes herbaceous vines.
	HFE	**Spore-bearing forb** - *A non-flowering, spore-bearing forb.* Includes non-aquatic, non-woody ferns, clubmosses, spikemosses, horsetails, and quillworts.
	HFS	**Succulent forb** - *A flowering forb with a fleshy stem and often with reduced leaves.* Includes *Salicornia* and others.
	HG	**Graminoid** - *A non-aquatic, flowering herb with relatively long, narrow leaves and inconspicuous, reduced flowers.* Includes grasses, sedges, rushes, and arrow-grasses. Aquatic graminoids are treated with aquatic herbs.
N	NB	**Bryophyte** - *A nonvascular, non-flowering, photosynthetic plant that bears leaf-like appendages or lobes and attaches to substrates by rhizoids.* Includes mosses, liverworts, and hornworts (Abercrombie et al. 1966).
	NA	**Alga** - *A nonvascular, photosynthetic plant with a simple form ranging from single- or multi-celled to a filamentous or ribbon-like thallus with relatively complex internal organization* (Abercrombie et al. 1966).
	NL	**Lichen** - *An organism generally recognized as a single plant that consists of a fungus and an alga or cyanobacterium living in symbiotic association* (FGDC 1997). Technically, lichen is not a plant, but is often treated together with moss as a type of nonvascular growth form.

E	E	**Epiphyte** - *A vascular or nonvascular plant that grows by germinating and rooting on other plants or other perched structures, and does not root in the ground* (adapted from FGDC 1997). This growth form may be used as a modifier of other growth forms. For example, HFF(Flowering forb) - -E
L	L	**Liana** - *A woody, climbing plant that begins life as terrestrial seedlings but relies on external structural support for height growth during some part of its life* (Gerwing 2004), typically exceeding 5 m in height or length at maturity. Non-woody climbers are treated as a type of "Herb."

cf. Gillison (2013, Table 12.3), who defines microphylls as 225–2025 mm², and nanophylls as 25–225 mm²

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***Ecological Archives* M084-020-A3**
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Appendix C. Formation Units - Level 1 to Level 3

	LEVEL 1– FORMATION CLASS	LEVEL 2 – FORMATION SUBCLASS	LEVEL 3 – FORMATION Wetland and aquatic formations marked with *
	1. Forest & Woodland [Mesomorphic Tree Vegetation]	1.A. Tropical Forest & Woodland	1.A.1. Tropical Dry Forest & Woodland
			1.A.2. Tropical Lowland Humid Forest
			1.A.3. Tropical Montane Humid Forest
			1.A.4. Tropical Flooded & Swamp Forest *
			1.A.5. Mangrove*
		1.B. Temperate & Boreal Forest & Woodland	1.B.1. Warm Temperate Forest & Woodland
			1.B.2. Cool Temperate Forest & Woodland
			1.B.3. Temperate Flooded & Swamp Forest *
			1.B.4. Boreal Forest & Woodland
			1.B.5. Boreal Flooded & Swamp Forest *
	2. Shrub & Herb Vegetation [Mesomorphic Shrub & Herb Vegetation]	2.A. Tropical Grassland, Savanna & Shrubland	2.A.1. Tropical Lowland Grassland, Savanna & Shrubland
			2.A.2. Tropical Montane Grassland & Shrubland
			2.A.3. Tropical Scrub & Herb Coastal Vegetation

		2.B. Temperate & Boreal Grassland & Shrubland	2.B.1. Mediterranean Scrub & Grassland
			2.B.2. Temperate Grassland & Shrubland
			2.B.3. Boreal Grassland & Shrubland
			2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation
		2.C. Shrub & Herb Wetland	2.C.1. Tropical Bog & Fen *
			2.C.2. Temperate to Polar Bog & Fen*
			2.C.3. Tropical Freshwater Marsh, Wet Meadow & Shrubland*
			2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland*
			2.C.5. Salt Marsh*
	3. Desert & Semi-Desert [Xeromorphic Woodland, Scrub & Herb Vegetation]	3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland	3.A.1. Tropical Thorn Woodland
			3.A.2. Warm Desert & Semi-Desert Scrub & Grassland
		3.B. Cool Semi-Desert Scrub & Grassland	3.B.1. Cool Semi-Desert Scrub & Grassland
	4. Polar & High Montane Scrub, Grassland & Barrens [Cryomorphic Scrub, Herb & Cryptogam Vegetation]	4.A. Tropical High Montane Scrub & Grassland	4.A.1. Tropical High Montane Scrub & Grassland
		4.B. Temperate to Polar Alpine & Tundra Vegetation -	4.B.1. Temperate & Boreal Alpine Dwarf-shrub & Grassland
			4.B.2. Polar Tundra & Barrens
	5. Aquatic Vegetation [Hydromorphic Vegetation]	5.A. Saltwater Aquatic Vegetation	5.A.1. Floating & Suspended Macroalgae Saltwater Vegetation*
			5.A.2. Benthic Macroalgae Saltwater Vegetation*
			5.A.3. Benthic Vascular Saltwater Vegetation*
			5.A.4. Benthic Lichen Saltwater Vegetation*
		5.B. Freshwater Aquatic Vegetation	5.B.1. Tropical Freshwater Aquatic Vegetation*
			5.B.2. Temperate to Polar Freshwater Aquatic Vegetation*

	6. Open Rock Vegetation [Cryptogam - Open Mesomorphic Vegetation]	6.A. Tropical Open Rock Vegetation	6.A.1. Tropical Cliff, Scree & Other Rock Vegetation
		6.B. Temperate & Boreal Open Rock Vegetation	6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation
	7. Agricultural & Developed Vegetation [Anthromorphic Vegetation]	7.A. Woody Agricultural Vegetation	7.A.1. Woody Horticultural Crop
			7.A.2. Forest Plantation & Agroforestry Crop
			7.A.3. Woody Wetland Horticultural Crop*
		7.B. Herbaceous Agricultural Vegetation	7.B.1. Row & Close Grain Crop
			7.B.2. Pasture & Hay Field Crop
			7.B.3. Herbaceous Horticultural Crop
			7.B.4. Fallow Field & Weed Vegetation
			7.B.5. Herbaceous Wetland Agricultural Crop*
		7.C Herbaceous & Woody Developed Vegetation	7.C.1. Lawn, Garden & Recreational Vegetation
			7.C.2. Other Developed Vegetation
			7.C.3. Developed Wetland Vegetation*
		7.D. Agricultural & Developed Aquatic Vegetation	7.D.1. Agricultural Pond Vegetation*
			7.D.2. Urban & Recreational Pond Vegetation*
	6 natural classes	*13 natural subclasses*	*37 natural formations*
	1 cultural subclass	*4 cultural subclasses*	*13 cultural formations*
Non-vegetated Classes (non - NVC)	8. Natural Open Fresh Water	Lake	
		River	
		Subterranean Freshwater	
	9. Natural Open Salt Water	Estuary and Ocean	
	10. Cultural Open Water	Reservoir and Canal (etc.)	

	11. Perennial Snow / Ice	Perennial Snowfield
		Ice Sheet
		Glacier
	12. Natural Surface Bare Area	Consolidated Bare Area (Rock, etc)
		Unconsolidated Bare Area (Sand, Gravel, etc)
	13. Natural Subterranean	Cave (etc).
	14. Cultural Surface Bare Area	Developed, Low Intensity
		Developed, Medium Intensity
		Developed, High Intensity
	15. Cultural Subterranean	Mine Shaft (etc.)

APPENDIX D. EXAMPLES OF OTHER FORMATION-LEVEL CLASSIFICATIONS

Main World Terrestrial Biome Types (Box and Fujiwara 2005, Table 4.4,)

The authors provide 18 major biome types recognized by most modern treatments of world vegetation. For example, they recognize the following forest biomes:

Tropical rain forest (including montane and cloud forests)
Tropical deciduous forest, woodland, and thorn scrub
Temperate forests
Deciduous broad-leaved forest
Evergreen broad-leaved forest (incl. laurel forest, warm-temperate mixed forest)
Temperate rain forest
Conifer forests
Boreal (including deciduous)
Montane conifer forest (temperate montane and subalpine)

From. Box, E. O., and K. Fujiwara. 2005. Vegetation types and their broad-scale distribution. Pp. 106–128 *in* van der Maarel, E. Vegetation ecology. Blackwell Publishing. Malden, Massachussets, USA.

World Wildlife Fund Major Habitat Types (Olson 2001)

MAJOR HABITAT TYPES
Tropical & Subtropical Moist Broadleaf Forests
Tropical & Subtropical Dry Broadleaf Forests
Tropical & Subtropical Coniferous Forests
Temperate Broadleaf & Mixed Forests
Temperate Coniferous Forests
Boreal Forests/Taiga
Tropical & Subtropical Grasslands, Savannas, & Shrublands
Temperate Grasslands, Savannas, & Shrublands
Flooded Grassland and Savannas [temperate and tropical]
Montane Grassland and Savannas [temperate and tropical]
Polar
Mediterranean Forests, Woodlands, & Shrub
Deserts & Xeric Shrublands
Mangroves
Lake
Rock and Ice

David M. Olson, Eric Dinerstein, Eric D. Wikramanayake, et al. 2001. Terrestrial ecoregions of the world: a new map of life on earth. BioScience 51(11):933–938.

Formations (Biomes) - (Whittaker 1975)

FORMATIONS (BIOMES)
FORESTS AND WOODLANDS
1. Tropical rain forest
2. Tropical seasonal forest
3. Temperate rain forest
4. Temperate deciduous forest
5a. Temperate evergreen forest --broadleaf
5b. Temp. evergreen forest--needleleaf
5c. Temperate evergreen forest--sclerophyll [Mediterranean]
6 Taiga & subarctic-subalpine needle-leaved forest
7. Elfin woodland
8. Tropical broadleaf woodland
9a. Thornwood--woodland
9b. Thornwood--scrub
10a. Temperate woodland --needleleaf
10b. Temperate woodland--sclerophyll
10c. Temperate woodland--deciduous broadleaf
SHRUBLANDS
11a. Temperate shrubland--deciduous
11b. Temperate shrubland--heath
11c. Temperate shrubland--sclerophyll [Mediterranean]
11d. Temperate shrubland--subalpine, needleleaf
11e. Temperate shrubland--subalpine, broadleaf
GRASSLANDS AND ALPINE VEGETATION
12. Savanna [tropical grassland]
13. Temperate grassland
14. Alpine shrubland
15. Alpine grassland
COLD AND WARM DESERTS and TUNDRA
16. Tundra
17. Warm semidesert scrub
18a. Cool semidesert--open scrub
18b. Cool semidesert--dry grassland
19. Arctic-alpine semidesert

20. True desert
21. Arctic-alpine desert
SWAMPS, MARSHES AND BOGS
22. Cool temperate bog
23. Tropical freshwater swamp forest
24. Temperate freshwater swamp forest
25. Mangrove swamp
25. Saltmarsh
MARINE AND AQUATIC
[26-29 are aquatic]
29. Marine rocky shores
30. Marine sandy beaches
31. Marine mudflats

Whittaker, R. H. 1975. Communities and ecosystems. Second edition. MacMillan, New York. (pp. 135–161).

Formations of Australia (Specht and Specht 2001)

FORMATIONS[1,2]
Closed forests (rainforests) - tropical north-eastern Australia
Closed forests (rainforests) - subtropical eastern Australia
Closed forests (rainforests) - temperate south-eastern Australia
Semi-deciduous closed forests - monsoonal northern Australia
Semi-deciduous closed forests - subtropical eastern Australia
Eucalypt open forests and woodlands - monsoonal northern Australia
Eucalypt open forests and woodlands - subtropical eastern Australia
Eucalypt open forests and woodlands - temperate south-eastern Australia
Eucalypt open forests and woodlands - montane south-eastern Australia
Eucalypt open forests and woodlands - temperate south-western Australia
Eucalypt open forests and woodlands - Australia wetland forests
Mallee eucalypt open-scrubs - monsoonal northern Australia
Mallee eucalypt open-scrubs - subtropical eastern Australia
Mallee eucalypt open-scrubs - temperate south-eastern Australia
Mallee eucalypt open-scrubs - temperate south-western Australia
Heathlands and related shrublands - monsoonal northern Australia
Heathlands and related shrublands - subtropical eastern Australia
Heathlands and related shrublands - temperate south-eastern Australia
Heathlands and related shrublands - montane south-eastern Australia
Heathlands and related shrublands - temperate south-western Australia
Tussock grasslands
Acacia vegetation - subhumid, subtropical eastern Australia
Acacia vegetation - Australian Arid Zone
Hummock grasslands - Australian Arid Zone
Chenopod low shrublands - southern Australia Arid Zone

Aquatic vegetation - tropical and subtropical northern Australia
Aquatic vegetation - temperate southern Australia
Coastal dune vegetation
Coastal wetland vegetation (mangroves, salt marshes, and brackish wetlands)

1. Specht, R. L., and A. Specht. 2001. Australia, ecosystems of. Pp. 307–324,

in S. A. Levin, editor. Encyclopedia of Biodiversity, Vol. 1. Academic Press, New York, New York, USA.

2. Within each formation, Specht and Specht (2001) also provide a set of Floristic Groups.

Australian Native Vegetation (NWLRA 2001)

Vegetation profile fact sheets were developed for each type listed below:

MAJOR VEGETATION GROUP
Rain forest and vine thickets
Eucalypt and tall open forests
Eucalypt open forests
Eucalypt low open forests
Eucalypt woodlands
Acacia forests and woodlands
Callitris forests and woodlands
Casuarina forests and woodlands
Melaleuca forests and woodlands
Other forests and woodlands
Eucalypt open woodlands
Tropical Eucalypt woodlands/grasslands
Acacia open woodlands
Mallee woodlands and shrublands
Low closed forests and closed shrublands
Acacia shrublands
Other shrublands
Heath
Tussock grasslands
Hummock grasslands
Other grasslands, herblands, sedgelands and rushlands
Chenopod shrublands, samphire shrubs and forblands
Mangroves, tidal mudflats, samphires, claypans, sand, rock, salt lakes, lagoons and freshwater lakes

NWLRA (National Land and Water Resources Audit). 2001. Australian Native Vegetation Assessment 2001. National Land And Water Resources Audit. Canberra, Australia.

EUROPEAN VEGETATION SURVEY (2002)

FORMATIONS

A. Coastal mud-flats and brackish waters
B. Saltmarsh, sand-dune and sea-cliff vegetation
C. Rock crevice, scree and boulderfield vegetation
D. Freshwater aquatic vegetation
E. Springs, shoreline, and swamp [marsh] vegetation
F. Bogs and fens
G. Temperate grasslands, heaths, and fringe vegetation
H. Dry grasslands and semi-deserts
I. Oromediterranean grasslands and scrub
J. Montane tall-herb, grassland, fell-field and snowbed vegetation
K. Mediterranean garrigue, maquis, mattoral, tomillar and phyrygna
L. Temperate broadleaved forests and scrub
M. Montane heaths and coniferous forests
N. Weed communities

Rodwell, J. S., J. H. J. Schamineé, L. Mucian, S. Pignatti, J. Dring, and D. Moss. 2002. The diversity of European vegetation. An overview of phytosociological alliances and their relationships to EUNIS habitats. Wageningen, NL. EC-LNV. Report EC-LNV nr. 2002/054. 168 p.

APPENDIX E.
ALLIANCE CONCEPT, GUIDELINES AND LITERATURE REVIEW

1. ALLIANCE DEFINITION

The 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).

2. ALLIANCE CONCEPT

[words in bold are defined in the glossary]

The **alliance** is a classification unit defined primarily by **floristic composition** (including **diagnostic, constant** and **dominant** species) and **physiognomy**, with consideration given to the relation of these vegetation parameters to ecological (**habitat and biogeographic**) factors. The alliance is placed between the **association** and **group** levels in EcoVeg and the association and order levels of Braun-Blanquet.

The alliance is a more inclusive (or taxonomically higher scaled) concept than the association; as such, it should be well separated floristically from other alliances by multiple diagnostic species (either by one or more **character** species or many **differential** species) that have diagnostic value over **large geographic areas** (Mueller-Dombois and Ellenberg 1974). The alliance aggregates vegetation and habitat factors at somewhat broader biogeographic and ecologic scales than the association. That is, whereas the association contains vegetation characteristics that emphasize more local and narrowly defined environmental and biotic relationships, the alliance emphasizes somewhat larger environmental gradients and biogeographic regions (Table 5 in Faber-Langendoen et al. 2014).

In EcoVeg, the alliance concept is constrained by some moderate level of both floristic and physiognomic variation, in the context of ecologic and biogeographic factors. For example, alliances do not (or only rarely) span woodland and shrub physiognomy, or shrub and herb physiognomy (unless shrubs are creeping or share the dominant layer with herbs), or even purely evergreen and purely deciduous tree physiognomy. Moreover, floristic composition includes recognition of the importance of dominants and diagnostic species. That is, rarely are associations united if they do not share similar or overlapping dominants. In this way, an integration of floristics with physiognomy, as typically expressed through the dominants species, is maintained.

Assessing the acceptable range of floristic variation in a vegetation unit proposed as an alliance is judged both by diagnostic and dominant species and by overall composition. It is a challenge to analytically balance these criteria, but at minimum both should be considered. In some applications, diagnostic species identified through vegetation analyses receive more ‘weight’ in determining a type when they also have clearly understood site **indicator** interpretations with respect to specific ranges of soil moisture and/or nutrient regimes, or to disturbance regimes (e.g., frequent flooding). Overall composition is often assessed through ordination and cluster analyses. These analyses may be used as either the primary tools to identify types, from which the number of diagnostic species can be extracted, or as secondary tools that provide important insights into the degree to which types identified through diagnostic and dominant species methods are reflective of overall composition and environmental factors. A hybrid of the two methods may also be used (e.g., cluster criteria are partly judged by the number of diagnostic species present in those clusters).

3. GUIDELINES

a) *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.

b) *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.

c) *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), sometimes referred to as ecological species groups Where such diagnostics are lacking, but there are meaningful ecological or successional groupings of associations, consideration can be given to recognizing these as suballiances, or, more informally as subtypes[1]**.** Not all diagnostic species are found in all stands, but stands may still be identified as a particular alliance using overall composition and ecology.

d) *Invasive/Exotic Species*: Invasive species (typically invasive exotics) are treated as degrading elements within a native alliance or association, and 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 ruderal alliances and are placed within a

[1] Sub-alliances have not been considered a formal (or even informal) part of the USNVC hierarchy. They are occasionally used by the Braun-Blanquet tradition. They are discussed here for completeness in light of their use by others. See Chytry (2007), who recommends against using formal sub-level units, preferring instead to use “subtypes” to express internal variability within a type.

ruderal Macrogroup, separate from other natural vegetation alliances. See extended presentation in Appendix 2: "Alliance Concepts and Ruderal Vegetation (Novel Ecosystems)."

e) *Physiognomy:* alliances are typically moderately uniform in physiognomy, with consistent **layers**. For example, tree-dominated alliances will typically be primarily 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 are have either a dominant shrub or herb layer, where these otherwise have strongly overlapping composition.

f) *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.

g) *Sucessional status* : alliances 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.

h) *Wetland/upland*. Alliances 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*).

4. LITERATURE REVIEW OF ALLIANCE CONCEPT

Below are a number of articles and books that discuss the alliance concept. The goal of presenting these is both to highlight the range of views on the alliance concept (as captured through the summary observations), and from among these views, to provide some support for the guidelines presented above. Sections in quotations are direct quotes.

A. Ellenberg, H. 1988. Vegetation Ecology of Central Europe

> "Down as far as the alliances in section E III 1 the character species have been included. These are the species which appear almost exclusively, or at least preferentially, in a particular unit. In many of the alliances and some orders, and even in a few classes, the number of such species is in each case restricted. Thus a greater subdivision of the higher units is hardly possible if one is not to dispense entirely with Braun-Blanquet's 'character species principle' and work only with 'differential species' or other devices. This principle prevents the confusing splitting up of units and so should be accepted unconditionally, at least down to the level of alliance. "

> “There is some uncertainty about the classification of the Birch woods which replace Alder in wet sites where the soil is very acid (section B V 2c). Their species composition has so many similarities with the acid-soil coniferous woods (*Vaccinio-Piceetea*) that they are usually included in this class although, at least in the west of Central Europe, they rarely contain any conifers. One could include them in the unit *Vaccinio-Piceion* as a special suballiance (*Betulion pubescentis*), although their systematic classification is of little significance for the understanding of Central European vegetation since they occupy a decreasing number of small areas. We will deal with the systematic arrangement of the coniferous woodland after we have discussed the classes *Querco-Fagetea* and *Quercetea robori-petraeae*.”

Observation 1: For Ellenberg, alliance concept relies on character species, in combination with differential and constant species, whereas the association may be defined solely by differential and constant species.

Observation 2: For Ellenberg, the alliance concept, historically, could include both deciduous and evergreen acid (nutrient poor) swamp woodland associations; with a suballiance used to distinguish the different dominants and physiognomy. More recently Rodwell et al. (2002) recognized separate birch-dominated swamp woodlands (Betulion pubesentis) and pine-dominated swamp woodlands (Ledo-Pinion) as separate alliances within a Sphagno-Betuletalia order (birch and pine open bog woodlands) (see also Solomeshch et al. 1997).

<u>B. Diekmann 1997.</u> The Differentiation of Alliances in South Sweden
Folia Geobot. Phytotax. 32: 193-205, 1997
Martin Diekmann

[In deciding which level of the Braun-Blanquet hierrachy to organize the Swedish vegetation, the] "two higher-ranking units "order" and "class" were …unsuitable. Both usually have a wide geographic distribution over large parts of Europe, and both are ecologically and floristically (often also structurally) quite heterogeneous, such as *Phragmito-Magnocaricetea/Phragmitetalia, Molinio-Arrhenatheretea/Arrhenatheretalia, Vaccinio-Piceetea/Piceetalia* and *Querco-Fagetea/Fagetalia*. On this level, differences between Sweden and Central Europe would not become evident. The alliance therefore emerged as the most appropriate unit for our purposes. In contrast to the association, the alliance is often well delimited by character and differential species; unlike the higher units, it shows fairly homogeneous ecological conditions. Alliances usually also have a more restricted geographic extension than orders and classes and are therefore better suited for comparing the vegetation of different regions (ELLENBERG 1956, BRAUN-BLANQUET 1964, DIERSCHKE 1994). Orders can sometimes be split up into corresponding alliances occurring in different geographic regions, e.g., the *Androsacetalia alpinae* on siliceous screes in comprising the *Androsacion alpinae* of the mountains in Central Europe (DIERSCHKE 1994, POTT 1995) and the *Saxifrago stellaris-Oxyrion digynae* of the Scandinavian mountains (DIERSSEN 1996), or the *Thlaspietalia rotundifolii*, the equivalent order on calcareous ground, comprising the *Thlaspion rotundifolii* (POTT 1995) and *Arenarion norvegicae* (DIERSSEN 1996), respectively. "

Observation: For Diekmann, in contract to the association, the alliance is often well delimited by character and differential species. In contrast to higher levels (Braun-Blanquet class and order), it shows fairly homogeneous ecological and physiognomic conditions, and it usually has a more restricted geographic range.

Table 1. [from Diekmann 1997]. Some South Swedish vegetation classes and orders and their syntaxonomical differentiation. Orders are listed only if they include at least two alliances. For the alliances recognized the following is given: a brief description on their vegetation and ecological conditions, geographic distribution and diagnostic species (if not otherwise indicated – character species; d – differential species; N – exclusively or mainly boreal species).

Alliance	**Description**	**Distribution**	**Diagnostic species**
a) Zonal vegetation			
Coniferous forest communities (*Vaccinio-Piceetea, Piceetalia*)			
Piceion excelsae	spruce forests on mesic to moist soils	widely dominant	*Bazzania trilobata, Dicranum majus, Picea abies, Ptilium crista-castrensis, Barbilophozia lycopodioides* (N), *Listera cordata* (N), *Stellaria longifolia* (N), etc.
Dicrano--Pinion	pine forests on dry soils	common, particularly in the E	*Chimaphila umbellata, Cladonia* spp. (d), *Dicranum fuscescens* (d), *D. polysetum, Leucobryum glaucum* (d), *Monotropa hypopitys, Pyrola chlorantha, Astragalus penduliflorus* (N), *Diphasium complanatum* (N), *Pulsatilla vernalis* (N)
b) Selection of azonal vegetation types			

Swamp communities (Phragmito-Magnocariceta, Phragmitetalia)

Phragmition	reed swamps at eutrophic lakes	widespread, particularly in the S	*Acorus calamus, Butomus umbellatus, Glyceria maxima*, *Phragmites australis* (d), *Ranunculus lingua, Schoenoplectus lacustris, Typha latifolia*, etc.
Bolboschoenion maritimi	swamps at brackish water	common along the coast	*Bolboschoenus maritimus, Schoenoplectus tabernaemontani*
Magnocaricion elatae	sedge swamps at mesotrophic to eutrophic lakes	widespread	*Carex elata, C. gracilis, C. paniculata, C. riparia C. vesicaria, Cladium mariscus, Peucedanum palustre*, etc.

Flushes and spring communities (Montio-Cardaminetea, Montio-Cardaminetalia)

Cardamino-Montion	springs on siliceous substrates	common	*Bryum schleicheri, Epilobium obscurum, Montia* spp., *Philonotis fontana, Stellaria alsine*, etc.
Cratoneurion commutati	springs on calcareous substrates	scattered	*Catoscopium nigritum* (d), *Cratoneurum* spp., *Eucladium verticillatum, Philonotis calcarea, Saxifraga aizoides* (N), etc.

Mire communites (*Scheuchzerio-Caricetea nigrae*)

(Scheuchzerietalia palustris)

Rhynchospo-rion albae	bog margins and hollows; wet, peaty, places	widespread except in SE Sweden	*Carex limosa, Drosera intermedia, Lycopodiella inundata, Rhynchospora alba, R. fusca, Sphagnum cuspidatum, S. majus, Dactylorhiza sphagnicola* (N), *Hammarbya paludosa* (N), *Sphagnum annulatum* (N), etc.
Caricion lasiocarpae	oligotrophic to mestrophic mires	widespread	*Carex chordorrhiza, C. diandra, C. heleonastes, C. lasiocarpa, Cinclidium stygium, Eriophorum gracile, Meesia triquetra, Sphagnum obtusum, Juncus stygius* (N), etc.
(Caricetalia davallianae)			
Caricion davallianae	calcareous fens	scattered in lowland ares with calcare-ous bedrock	*Carex dioica, C. hostiana, Eriophorum latifolium, Gymnadenia odoratissima, Liparis loeselii, Orchis palustris, Primula farinosa, Schoenus ferrugineus, S. nigricans, Tofieldia calyculata, Campylium elodes* (N), etc.

Salt marsh communities (*Asteretea tripolii, Glauco-Puccinellietalia*)

Puccinellion maritimae	salt marshes at the lower geo-littoral, high salinity	common along the W-coast	*Halimione pedunculata, Puccinellia maritima, Salicornia* spp. (d), *Spergularia media, Carex paleacea* (N), *C. vacillans* (N)
Armerion maritimae	salt marshes at the upper geolittoral, low salinity	common at the W-coast and Baltic coast	*Armeria maritima, Artemisia maritima, Blysmus rufus, Carex extensa, Festuca rubra* subsp. *litoralis, Juncus gerardi, Limonium vulgare, Odontites litoralis, Deschampsia bottnica* (N)

Deciduous forest communities (*Querco-Fagetea, Fagetalia sylvaticae*)

Alnion	alder-ash forest	widespread	*Alnus incana, Carex remota, Circaea intermedia, Festuca*

incanae	on moist or wet soils	but absent in the Scandes	*gigantea, Matteuccia struthiopteris, Poa remota, Stellaria nemorum, Cinna latifolia* (N), *Equisetum pratense* (N), *Glyceria lithuanica* (N), etc.

C. Dierschke 1990

Dierschke, H. 1990. Species-rich beech woods in mesic habitats in central and western Europe: a regional classification into suballiances. Vegetatio 87:1-10.

"In this contribution for the first time an attempt is made to present a regional classification of beech woods by means of a synthetic table. The review is restricted to species-rich communities on mesic site (mesophile) beech woods….Only releves with *Fagus sylvatica* dominant were chosen….

The Fagion is the most extensive alliance of deciduous woodland in Europe due to the broad ecological range of *Fagus sylvatica.* All described beech woods of central and western Europe are combined by a high number of widespread character species of *Fagion*, *Fagetalia*, and *Querco-Fagetea…. As a good Fagion character species for the total area,* only *Galium odoratum* can be named. "

Dierschke presents 5 suballiances for central and western Europe. 1. *Endymio-Fagenion*, 2. *Scillo-Fagenion*, 3. *Galio odorati-Fagenion*, 4. *Lonicero alpigenae-Fagenion*, and 5. a transitional type of western Carpathaians, Sedetic and Bohemian mountains. In dicussing the "*Scillo-Fagenion"* he notes that it shows the clearest floristic differentiation of all suballiances, and includes both character and differential species.

"Observation 1. Dierschke uses dominance to guide the overall selection of plots, and differential species to guide the suballiance distinctions, which correspond to both ecological and biogeographic patterns.

Observation 2. All 5 suballiances were raised to the level of alliance in Rodwell et al. 2002. See also Dierschke 1997 (below).

D. Dierschke 1997

Dierschke. H. 1997. Syntaxonomical survey of European beech forests: Some general conclusions. Annali di Botanica 55:17–26

"A short overview is given about the historical development of syntaxonomy of European beech forests. Different solutions of classification have been proposed, following more or less two main approaches: Division of alliances and suballiances by ecologically or geographically orientated species groups."

"A new classification of European beech forests is proposed with 8 (or more) geographically orientated alliances, which can be further divided into suballiances by ecological species groups. For each alliance character and differential species, nomenclatural type and the area is mentioned, based on a (non published) synthetic table, including 10.006 relevés from all parts of Europe. From this table also some overlapping species groups (a–n) are given."

<u>Different approaches : ecological versus geographical species groups</u>

The history of higher syntaxa of beech forests shows different approaches and many different solutions, resulting in a series of names. In the bibliography of *Querco-Fagetea* by Tüxen *et al*. (1981) 68 names for alliances and suballiances for beech forests are mentioned. However, all syntaxonomical solutions can be reduced more or less to two main approaches:

1. Division by ecological species groups in three clusters of associations:
   - a- species-rich forests in mesic habitats (floristic center of beech woods).
   - b- species-rich forests in rather dry and warm habitats (with transitions to thermophilous forests of *Quercetalia pubescenti-petraeae*).
   - c- species-poor forests in acid habitats (with transitions to acido-tolerant forests of *Quercetalia robori-petraeae*).

   From many areas of Europe this differentiation is described with varying associations and partly also with own alliances or suballiances. Often we find the a. *Asperulo- (=Galio odorati-)-Fagion, b. Cephalanthero-Fagion* and c. *Luzulo-Fagion*.

2. Especially in species-rich areas with many own characteristic plant species,geographically orientated units have been established, e.g., the *Scillo*- and *Aremonio-Fagion* in southwestern and southeastern Europe, with further differentiation into association groups or suballiances by ecological species groups. Sometimes both approaches are mixed, e.g., geographically and ecologically orientated suballiances within the *Fagion sylvaticae*.

"Now, I would suggest to classify the beech forests in Europe on the level of alliances on the basis of one criterion: ecological or geographical. Török et al. (1989) have analyzed this question for Illyrian beech forests by multivariate methods and have found a clear prevalence of geographical species groups. First my own opinion was more the ecological solution with three main alliances and geographically orientated suballiances. However, after the study of more literature, especially of southeastern areas of Europe, the geographical version seems to be more appropriate, though not all geographically orientated alliances have good character species. But in this way syntaxonomical treatment in the area of each alliance is open for more individual differentiation in an ecological sense. Also the *Abies alba* forests can be easier incorporated."

"In the meantime there is another discussion about the acidotolerant beech forests: more and more authors agree with their position within the *Quercetalia robori-petraeae*, as Müller (1991) proposed for the *Luzulo-Fagion* of central Europe. In this case the *Fagion* contains only species-rich beech forests of mesic to warmer habitats."

Observation 1. Dierschke develops geographically oriented alliances, within which ecologically-based suballiances are considered. In some cases, these more geographic alliances may lack good character species. Dierschke points to the work of Torok et al. (1989) as shaping his view (see below).

Observation 2. Acid-tolerant beech forests are treated in a different order than the mesic to somewhat dry,calcareous beech forests.

E. Török et al. 1989

Török, K., Podani, J. and Borhidi, A., 1989 - *Numerical revision of the* Fagion illyricum

***alliance*. Vegetatio 81: 169-180.**

"Another problem concerns the selection of species groups to be used in the classification. The question is whether ecological species groups of geographi cally distinct groups of character- and differential species should receive more emphasis in syntaxonomy. Moor (1952, 1960) and Tüxen (1960) are of the opinion that higher syntaxonomic units must be delimited using ecological species rather than geographically 'significant' species. However, it has been suggested over and over again that species with similar ecological requirements but occurring in different geographical regions are equally applicable, and the classifications thus obtained are of more general purpose than those considering ecological differences only. It is implicitly emphasized in numerical approaches to syntaxonomy in which no arbitrary species weights are useful in the analysis."

"The dendrogram obtained by SSQ [Sums of Square Agglomeration] (Fig. 1) provides an answer with respect to the controversy over ecologic vs geographic species groups. The four main clusters recognized on the dendrogram are formed according to geographic separation, i.e., associations from different vegetation zones of the same area rather than the vicarious associations became clustered (see the positions of OSUs [Operational Syntaxonomic Unit] 2 and 13, 3 and 14, 4 and 15, 5 and 16, 29 and 32, and 17, 27 and 31). It must be noted, however, that this is not necessarily the case in other high-level syntaxa. In the explanation of this result one must consider that the Balkan Peninsula is a relic-preserving centre with a high tendency to develop diverse floras and that the local diversity of these floras is much higher than in the central European beechwood zone. Therefore, it is not surprising that species shared by vicarious associations are apparently outnumbered by locally distributed species."

Observation 1. Overall composition similarity, as assessed by cluster analyses and ordinations, is a criterion in deciding how to aggregate associations into suballiances and alliances, and is used in combination with diagnostic species to characterize these units.

F. Dzwonko and Loster 2000.

Dzwonko, Z. & Loster, S. 2000. Syntaxonomy and phytogeographical differentiation of the *Fagus* woods in the Soutwest Balkan Peninsula. *Journal of Vegetation Science* 11: 667-678

"In consquence, the local diversity of the Balkan flora is much higher than in the central European *Fagus* wood zone, and strong floristic-geographical differentiation of the *Fagus* woodland communities in the Balkan Peninsula is observed. This creates the need to classifiy them also in regional high-rank syntaxa, on the basis of geographically different groups of characteristic and differential species. That is also true of the *Fagus* woods of the Apennine Peninsula (Feoli & Lagonegro 1982; Nimis & Bolognini 1993). The authors of earlier syntaxonomic surverys believed that the higher syntaxonomic units should be delimited using ecological rather than geographical groups of species (Moor 1960; Tuxen 1960; Zoller et al. 1977). However, a comparative survey has shown that even the associations of mesophilous *Fagus* woods of central and western Europe combine into regional suballiances (raised to alliances recently) following a climatic gradient from oceanic to subcontinental, and a floristic gradient from south to north (Dierschke 1990, 1997). Various broad comparative studies suggest that classifications based on both ecological and geographical species groups are more generally useful than those considering ecological differences only. In the classification presented here, the associations and most of their subassociations and variants within the *Doronico columnae-Fagenion* and *Doronico orientalis-Fagenion* – geographically orientated suballiances – are clearly determined ecologically by altitude and soil conditions (Bergmeier 1990; Habeck & Reif 1994; Dzwonko et al. 1999; Dzwonko & Loster 2000). The *Epimedio-Fagenion* and

Ostryo-Fagenion are ecologically orientated suballiances which comprise submontane and thermophilous woods, respectively."

Observation: For Dzwonko and Loster, geographically different groups of character and differential species define alliances, based in part on how these geographic regions reflect changing meso-climatic gradients.

G. Marinsek et al. 2013

Marinšek, A., U. Šilc & A.Čarni. 2012 Geographical and ecological differentiation of *Fagus* forest vegetation in SE Europe. Applied Vegetation Science 16:131-147

"In general, differences among *Fagus* forests are due to broad scale (historic, phytogeographic, macroclimatic and macroecological) and regional (edaphic, meso-climatic and ecological) factors (Bergmeier & Dimopoulos 2001). Soil ecology is usually considered to be the principle factor on a regional scale (Ellenberg 1996), while on a broader scale macroecological (geography and climate) differentiation has precedence (Dierschke 1990; Dierschke & Bohn 2004). Dierschke & Bohn (2004) proposed a differentiation of European Beech Forest into nine regional, geographically based alliances, with subsequent partition towards various suballiances, based on the com bination and gradual disappearance of several groups of plants species, due to changed ecological factors. "

"Which factors should be considered more important for classification is an ongoing topic among syntaxonomists dealing with the classification of European *Fagus* forests (Soo 1964; Horvat et al. 1974; Torok et al. 1989; Dierschke 1990; Dierschke & Bohn 2004). Willner (2002) and Tzonev et al. (2006) follow an approach based on ecological factors, while Dierschke (1990), Dierschke & Bohn (2004), Dzwonko & Loster (2000) and Bergmeier & Dimopoulos (2001) emphasize geographical differentiation. Various comparative studies suggest that classfications based on both ecological and geographical differentiation are generally more adequate than those that consider ecological or geographical differences alone (e.g. Dzwonko & Loster 2000). "

Observation 1: For Marinsek et al., alliance concepts should consider both ecological and geographic considerations.

H. Boublik et al. 2007

Boublík, K., Petřík, P., Sádlo, J., Hédl, R., Willner, W., Černý, T. & Kolbek, J. (2007): Calcicolous beech forests in the Czech Republic and related vegetation – a comparison of formal-ized classifi cations. – Preslia 79: 141–161.

Methods

"Relevés dominated by *Fagus sylvatica* (at least 25% cover in tree layer).. were accepted regardless of the original assignment to vegetation units by the authors of these relevés (stored in the header data field 'Syntaxon code' in the database). Second, a diagnostic species group was formed of calcicolous and/or xerothermophilous species, which have high values according to Ellenberg et al. (2001) for soil reaction (most of them with values higher than7), light, or temperature. The diagnostic species group consisted of 38 species…. At least two of the 38-species diagnostic group had to be present in a relevé in order for it to be selected as calcicolous beech forest."

Discussion

"As for uniqueness (i.e. whether there are other similar vegetation units in a classification system), the calcicolous beech forests were similar to oak-hornbeam forests of the *Carpinion* alliance…The floristic affinities between *Cephalanthero-Fagenion*[1]and *Carpinion*[2] have also been discussed in the German literature (e.g.Oberdorfer1992). However, most authors agree that *Cephalanthero-Fagenion* should be included into *Fagion*, and not *Carpinion*, because of the dominance of *Fagus sylvatica."*

[1]*Cephalanthero-Fagenion* (suballiance) or full alliance (*Cephalanthero –Fagion:* Rodwell et al. 2002): warm (thermophilous) beech forests mostly on limestone.
[2]*Carpinion betuli*: broadleaved woodlands rich in hornbeam on lime-rich and neutral mull soils.

Observation 1: For Boublik et al., dominance in the dominant strata plays a role in the definition of suballiances and alliances, in combination with diagnostic species and their relation to habitat characteristics.

Observation 2: For Boublik et al., the *Fagus* association was defined using a combination of many differential species, combinations of which help define the association.

I. Sawyer et al. 2009.

Sawyer, Todd Keeler-Wolf, Julie Evens. Manual of California Vegetation. 2009.

Definitions follow the USNVC (FGDC 2008, Jennings et al. 2009).

Sawyer et al (2009) also state: "Our emphasis is at the alliance level. This level is best for considering vegetation at a regional and statewide level because it is based on a tangible number of floristic categories, defined by well-known plant species, some of which are widespread throughout the state."

Another focus of Sawyer et al 2009 is the use of the dominant and diagnostic species of alliances as indicators of fire or natural process stage e.g., (from Appendix 1): "By reviewing these traits and looking at supporting evidence from fire effects tables… and individual alliance treatments), we can begin to assess different strategies that indicator plants use to sustain themselves. These plants, as the most characteristic or indicative of each of the vegetation alliances yet described, can provide useful information on what it takes to be a successful species in the state's current array of vegetation."

Regarding ruderal or semi-natural alliances, Sawyer et al. state "…. We believe invasive plant types are not equivalent to alliances. That is why we call them "semi-natural stands." The stands replace native vegetation, and the non-native plants become dominant….In the first edition, we created a few series (alliances) for non-natives. However, we approach these types differently in this edition. In the case of alliances, the descriptions include information on ways to maintain the natives. In cases where the dominants are non-natives that form semi-natural stands, the emphasis is on wildlife/plant habitat qualities with them and on ways to restore native vegetation…we do not list associated species because so many of the naturalized types are widespread in the state and grow with a diverse set of native plants. We provide the invasive species ranking rather than the rarity ranking that is given for the alliances… "

Observation 1: For Sawyer et al., the alliance concept relies strongly on dominant and co-dominant species in the defining layer (tree, shrub or herb layer), sometimes with other characteristic species from that layer.

Observation 2: For Sawyer et al., a clear distinction is made between native alliances and semi-natural (what we call "ruderal") alliances.

J. <u>Pojar et al. 1987</u>

Pojar, J., K. Klinka, and D.V. Meidinger. 1987. Biogeoclimatic ecosystem classification in British Columbia. Forest Ecology and Management 22:119-154.

"Plant subassociations are usually distinguished by differences in one (usually dominant) or several species that indicate relatively minor climatic and/or edaphic variations among ecosystems included in the circumscribing plant association. Plant associations with similarities in floristic composition, life-form, and structure [i.e., dominance by evergreen shrubs, deciduous shrubs, ferns, graminoids, herbs, bryophytes, or lichens in conjunction with a prominent (usually climax tree) species] are grouped into alliances. A plant alliance represents a major segment of the edaphic gradient that occurs in one or several related climates. Plant alliances with physiognomically similar vegetation and general affinities in a dominant stratum are grouped into orders. A plant order signifies a broad segment of the edaphic gradient that usually occurs in many different climates and is represented by one or two prominent climax species."

(From Table 3). "The 'diagnostic (characteristic) combination of species' (DCS) that is *exclusive* to a given vegetation unit is the sole differentia for organizing ecosystems into a floristic hierarchy."

"Phytosociologists have neither precisely specified nor agreed upon the required composition of the DCS for particular categories (cf. Becking, 1957; Mueller-Dombois and Ellenberg, 1974; Westhoff and Van der Maarel, 1980). In British Columbia, our experience indicates that character-species exist for only a few plant associations, typically those of nonforested ecosystems on environmentally extreme sites. To provide suitable criteria we propose that: (1) character-species (i.e., the species that differentiate in the absolute sense) not be required in the DCS for any vegetation unit at present; (2) units be recognized by an exclusive DCS that must include at least one differential or dominant-differential species; (3) units that represent the central concept of a higher circumscribing unit also be recognized without a DCS, providing they are differentiated by the absence or low occurrence of species that characterize other units of the same category and circumscription; and (4) plant subassociations also be recognized by non-exclusive DCS's that include at least two differential or dominant-differential species. "

Observation: For Pojar et al, the requirement for character species is dropped for the association, and apparently for alliances and other upper levels of the vegetation hierarchy (which otherwise follows Braun-Banquet). Emphasis is placed on the diagnostic combination of differential and dominant-differential species. And the "central" unit of any level may lack differentials at all.

5. 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, p. 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). *cf 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% occurrence

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) 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, 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 1989). These areas may be on the scale of the ecoclimatic regions of Canada (Ecoregions Working Group 1989) the Ecoregional Divisions of Bailey (1989, 2009), 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).

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 ruderal type. Analyses of types may benefit from initially removing degraded phases when characterizing floristic and growth form patterns, then adding these phases back in 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). See also 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).

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 found on human-disturbed sites, with no apparent recent historical natural analogues, and whose current composition and structure 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 the human disturbances. (Allaby 2010). Cf. *semi-natural.*

semi-natural - vegetation in which past or present human activities significantly influence composition or structure, but do not eliminate or dominate spontaneous ecological processes (Westhoff and Van der Maarel 1973). Semi-natural vegetation may have historical analogues, even if they are "off-site" (e.g. native grasslands on historically forested sites. Semi-natural sites with strong human influences that have no recent historical analogue in terms of recognizable vegetation characteristics are referred to as *ruderal.*

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 (Gabriel and Talbot 1984). 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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