Long Database Report

BERGWALD – the vegetation database of mountain forests in the Bavarian Alps

Jörg Ewald

Abstract: The database BERGWALD (GIVD ID EU-DE-002), an electronic repository for vegetation plot data from forests and related vegetation in the Bavarian Alps (Germany), is presented. Created in 1995, the database has been intensively used for the classification and mapping of vegetation and site types, for calibrating and evaluating plant indicator values, and for analysing patterns of plant species richness. Hosted at the University of Applied Sciences in Freising, Bavaria, the data are available for collaborative research.

Keywords: ecoinformatics; forest site classification; indicator plant.

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Basic facts

The Bavarian Alps are situated at the Northern edge of the Eastern Alps and, together with the neighbouring regions in Austria, comprise substantial portions of the Northern Calcareous Alps (Fig. 1). 63% of the region's 4,600 km² are covered with mountain forests. Geomorphological and geological complexity make it a biodiversity hotspot for forest plants (Ewald 2008b), and forest management has to balance timber production, hazard protection and biodiversity conservation. To meet these requirements existing data on vegetation and site conditions were collected systematically. BERGWALD (German for "mountain forest") was compiled from 1995-2000 at the Forestry Faculty of the Technical University of Munich (Ewald 1995). The relational data model comprising 12 essential tables was first realised in Paradox for Windows and later migrated to MS-Access. The taxon list was adopted from the Fortran-program BSVEG (Storch 1985) and completed to include all vascular (n = 2,951), byrophyte (n = 1,427) and lichen taxa (n = 468) listed in the electronic version of indicator values (Ellenberg et al. 1991). While the latter list is still used as the taxon reference, a translation to valid names of the reference list GermanSL (Jansen & Dengler 2008) is under construction.

All available relevés made in the reference region were gathered from published sources, dissertations and private archives (4.1%). However, search and capture were largely restricted to forest, scrub and related vegetation types. Relevés of non-forest vegetation types were unsystematically captured.

Data were captured from BSVEG formats generated in dissertations and reports at the Forestry Faculty and by manually entering printed tables from all other sources. While BSVEG-data were consistent with the taxonomical concepts of Ellenberg et al. (1991), plant names from external sources were interpreted prior to data entry, i.e. original names were lost and there is no option to manage multiple concepts.

All available header data were acquired, notably elevation, aspect, slope, relevé area and total cover of vegetation layers. Geographical coordinates were available for 1,997 relevés from more recent dissertations. For the dissertations of Feldner (1978) 341 and Frankl (2001) 110 relevé positions were digitised from field maps, yielding a total of 49.6% relevés with coordinates. For 510 relevés (10.3%) only the map sheet 1:25,000, and for additional 1,239 relevés (25.1%) the quarter of the map sheet could be retrieved from original data. For 690 relevés (13.9%) only the forest growth region (Foerst & Kreutzer 1977) is known, and for 47 relevés (1%) the location within the Bavarian Alps is unknown.

The method of relevé placement was recorded, with 4,170 relevés (84.5%) selected subjectively and 764 (15.5%) arranged in fixed grids. Original relevé identifiers and, for published vegetation tables, table and column ids were stored. Original assignment to vegetation types was stored and vegetation types were tentatively assigned to the higher syntaxa presented in Ellenberg et al. (1991). Relevés were from the following alliances: Fagion (49,7%), Linnaeo-Piceion (15.9%), Erico-Pinion (13.1%), Tilio-Acerion (6.3%), Alno-Ulmion (3.4%), Seslerion albicantis (1.8%), Adenostylion alliariae (1.2%) and 16 other non-forest alliances.

Presently, BERGWALD relevés cover records of 966 vascular plant (the most frequent being *Picea abies* 83.7%, *Oxalis acetosella* 66%, *Acer pseudoplatanus* 63%, *Vaccinium myrtillus* 53% and *Sorbus aucuparia* 51.5%), 374 bryophyte (*Dicranum scoparium* 52%, *Hylocomium splendens* 49.6%, *Ctenidium molluscum* 44%, *Tortella tortuosa* 40.6%, *Polytrichum formosum* 37.8%) and 56 lichen taxa (*Cladonia pyxidata* 3.5%, *Cladonia furcata* 2.8%, *Peltigera leucophlebia* 2.3%, *Cetraria islandica* 1.8%, *Peltigera praetextata* 1.8%).

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GIVD Database ID: EU-DE-002			**Last update:** 2012-04-28
BERGWALD			
Scope: A database of mountain forests and related vegetation types in the Bavarian Alps (Germany)			
Status: completed and continuing	**Period:** 1938-1997		
Database manager(s): Jörg Ewald (joerg.ewald@hswt.de)			
Owner: Jörg Ewald			
Web address: [NA]			
Availability: free upon request	**Online upload:** no	**Online search:** no	
Database format(s): MS Access	**Export format(s):** [NA]		
Publication: Ewald, J. (1995): Hoppea 56: 453–465.			
Plot type(s): normal plots	**Plot-size range:** 5-2600 m²		
Non-overlapping plots: 4,934	**Estimate of existing plots:** 7,000	**Completeness:** 70%	
Total plot observations: 4,934	**Number of sources:** 37	**Valid taxa:** 1,396	
Countries: AT: 3.3%; DE: 96.7%			
Forest: [NA] — **Non-forest:** [NA]			
Guilds: all vascular plants: 100%			
Environmental data: altitude: 96%; slope aspect: 91%; slope inclination: 90%; soil pH: 9%; other soil attributes: 9%; land use categories: 9%			
Performance measure(s): cover: 100%			
Geographic localisation: point coordinates less precise than GPS, up to 1 km: 40%; small grid (not coarser than 10 km): 85%; political units or only on a coarser scale (>10 km): 87%			
Sampling periods: 1930-1939: 0.1%; 1940-1949: 0.5%; 1950-1959: 1.3%; 1960-1969: 11.2%; 1970-1979: 23.1%; 1980-1989: 23.9%; 1990-1999: 34.0%			
Information as of 2012-07-19; further details and future updates available from http://www.givd.info/ID/EU-DE-002			

Scientific output

BERGWALD was originally compiled as a basis for the classification of forest site types. Thus, for 373 relevés from Ewald (1997) and for 96 relevés from Ewald (2005) extensive soil chemical and soil morphological data are available and were used for direct ordination (Ewald 2000a, 2000b), calibration of indicator values (Ewald 2003, 2009, 2008) and study of plant species richness (Ewald 2002, 2008).

Since its foundation BERGWALD has continuously delivered analyses and products to regional site classification. Relevés and vegetation tables have served as a reference for local site maps (Ewald 1999), for descriptions of natural vegetation in forest regions (Gauer & Aldinger 2005), for developing field classification keys as well as prescriptions for rule-based classification (Ewald & Binner 2007). By intersecting georeferenced relevés with a geological map Binner et al. (2005) defined substrate groups for GIS-based modelling of Natura 2000 habitat types (Ewald et al. 2009). BERGWALD is a crucial component in the establishment of the forest information system for the Northern Alps WINALP (Ewald 2009b, Reger et al. 2010), where relevés and soil profiles are intersected with GIS layers of terrain, geology, soils and climate to calibrate indices of thermal climate, moisture and soil acidity, and ultimately map potential forest types at scale 1:25,000 for the whole Bavarian Alps.

Syntaxonomical treatments of grassland in avalanche tracks (Ewald 1996), montane mixed *Fagus-Abies-Picea* (Ewald 1997) and subalpine *Picea* forests (Ewald 1999b) were based on the database. Shade tolerance of tree species was studied using Ellenberg values for light (Ewald 2004, 2007a). BERGWALD served as a data source for compiling a list of vascular species tied to forest habitats in the German Alps (Schmidt et al. 2003) and is currently used in creating a corresponding list of bryophytes. Ewald (2007b) compared frequency spectra of nutrient values in Erico-Pinion relevés in the database to those of pine forests from the Central European lowlands. Currently, BERGWALD relevés serve as an important data source for modelling thermal niches of tree species and elevation belts (Ewald 2010). Ewald & Kölling (2009) showed that relevés in the database exceeded the known altitudinal limits (Oberdorfer 2001) of 13 out of 30 tree species.

Data flow

The BERGWALD relevés formed one of two founding data sets in the German national vegetation database VegetWeb (Ewald et al. 2006, 2010), which has made them available for online queries and downloads. It has also been a prototype of a vegetation database connected to the Global Biodiversity Facility (GBIF), where relevé records were joined to worldwide data from herbarium collections. All georeferenced species occurrence records from BERGWALD were delivered to the floristic database of Bavaria (Zentralstelle für die Floristische Kartierung in Bayern). Relevés with concurrent soil data were delivered to the Alterra laboratory in the Netherlands (Wamelink et al. 2005). Data selections were delivered for syntaxonomic treatments of *Mulgedio-Adenostyletea* in Europe (Michl & Dengler 2010), Pinus mugo-communities (Europe) and *Vaccinio-Piceetea* in Germany (Heinken 2008). Relevés were delivered for a study of the ecology of *Lathraea squamaria* in Bavaria (Klotz & Rüther 2007).

Prospects

At present, 85% of the relevés are from the period 1975 to 2000, and there has been no recent capturing of new relevés. However, the WINALP project (Ewald 2009b; http://www.winalp.info) has delivered 1,505 new forest relevés with soil profile descriptions placed systematically throughout the whole region (Reger et al. 2012). Chiefly designed to verify GIS-mapping of potential forest types, this new data set will be suitable for direct gradient analysis and modelling across the larger region.

Plate: Vegetation types featured by the vegetation-plot database GIVD EU-DE-002.

A: Timberline mosaics of subalpine spruce forest (*Adenostylo glabrae-Piceetum*) and krummholz (*Rhododendro-Pinetum mughi*) on karstic limestone (Photo: H.-W. Rose).

B: Highly productive montane forests on Flysch sandstone (*Luzulo-Fagetum* with *Abies alba* and *Picea abies*) (Photo: J. Ewald).

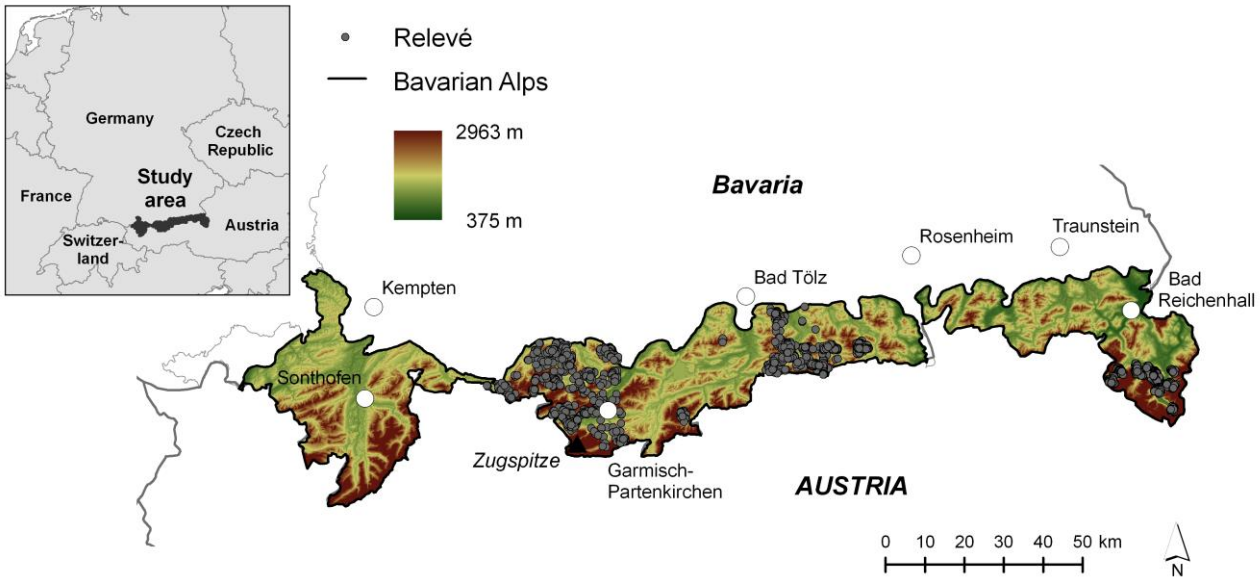

Fig. 1: Map of the Bavarian alps, the study area of the BERGWALD database; only relevés with precise georeference plotted; digital elevation model used by courtesy of the Bavarian Surveying Administration (LVG).

BERGWALD offers many pathways for further investigation. Proposals to repeat georeferenced relevés in order to detect responses to climate warming have so far not been successful, but should be pursued. The database is particularly suited to collaborative data pooling with respect to species-community-soil relationships and to altitudinal, thermal and moisture gradients. Collaborators are invited to use BERGWALD data for their own research and design new studies jointly.

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References

Binner, S., Ewald, J., Rogg, S. (2005): Die ökologische Interpretation geologischer Karten mit Hilfe der Datenbank bayerischer Bergwälder und terrestrisch kartierter Standortskarten. – Waldökologie Online **2**: 114–123.

Ellenberg, H., Weber, H.E., Düll, R., Wirth, V., Werner, W., Paulißen, D. (1991): Zeigerwerte von Pflanzen in Mitteleuropa. – Scripta Geobotanica **18**: 1–248.

Ewald, J. (1995): Eine vegetationskundliche Datenbank bayerischer Bergwälder. – Hoppea **56**: 453–465.

Ewald, J. (1996): Graslahner - Rasengesellschaften in der montanen Waldstufe der Tegernseer Kalkalpen. – Berichte der Bayrischen Botanischen Gesellschaft **66**: 121–134.

Ewald, J. (1997): Die Bergmischwälder der Bayerischen Alpen – Soziologie, Standortbindung und Verbreitung. – Dissertationes Botanicae **290**. Berlin: Cramer.

Ewald, J. (1999a): Die standortsökologisch fundierte Pflanzensoziologie als Erkenntnisquelle für den naturnahen Waldbau - das Beispiel der Standortsgliederung für das bayerische Hochgebirge. – Freiburger Forstliche Forschung Berichte **16**: 27–38.

Ewald, J. (1999b): Soziologie und Standortbindung subalpiner Fichtenwälder in den Bayerischen Alpen. – Tuexenia **19**: 107–125.

Ewald, J. (2000a): The influence of coniferous canopies on understorey vegetation and soils in mountain forests of the Northern Calcareous Alps. – Applied Vegetation Science **3**: 123–134. CrossRef

Ewald, J. (2000b): Long-term impact of forest pasture on the understorey of mountain forests in the Tegernsee Alps (Bavaria). – Zeitschrift für Ökologie und Naturschutz **9**: 161–171.

Ewald, J. (2002): Multiple controls of understorey plant richness in mountain forests of the Bavarian Alps. – Phytocoenologia **32**: 85–100. CrossRef

Ewald, J. (2003): The sensitivity of Ellenberg indicator values to the completeness of vegetation relevés. – Basic and Applied Ecology **4**: 507–513. CrossRef

Ewald, J. (2004): Ökologie der Weißtanne (Abies alba Mill.) im bayerischen Alpenraum. – Forum Geobotanicum **2**: 1–12.

Ewald, J. (2005): Schlusswaldgesellschaften des Werdenfelser Landes (Bayerische Alpen). – Hoppea **66**: 377–406.

Ewald, J. (2007a): Ein pflanzensoziologisches Modell der Schattentoleranz von Baumarten in den Bayerischen Alpen. – Forum Geobotanicum **3**: 11–19.

Ewald, J. (2007b): Bimodal spectra of nutrient indicators reveal abrupt eutrophication of pine forests. – Preslia **79**: 391–400.

Ewald, J. (2008a): Comparing indicator values of bryophyte and vascular understorey in mountain forests. – Mitteilungen der Arbeitsgemeinschaft Geobotanik Schleswig-Holstein **65**: 17–126.

Ewald, J. (2008b): Plant species richness in mountain forests of the Bavarian Alps. – Plant Biosystems **142**: 594–603. CrossRef

Ewald, J. (2009a): Epigeic bryophytes do not improve bioindication by Ellenberg values in mountain forests. – Basic and Applied Ecology **10**: 420–426. CrossRef

Ewald, J. (2009b): Waldinformationssystem Nordalpen - WINALP sammelt Wissen zum Schutz der Bergwälder. – Waldforschung aktuell **30**: 45–46.

Ewald, J. (2012): Vegetation databases provide a close-up on altitudinal tree species distribution in the Bavarian Alps. – In: Dengler, J., Oldeland, J., Jansen, F., Chytrý, M., Ewald, J., Finckh, M., Glöckler, F., Lopez-Gonzalez, G., Peet,

R.K., Schaminée, J.H.J. [Eds.]: Vegetation databases for the 21st century. – Biodiversity & Ecology **4**: 41–48. Hamburg: Biocentre Klein Flottbek and Botanical Garden. CrossRef

Ewald, J., Binner, S. (2007): Werkzeuge zur Bestimmung der Waldtypen im bayerischen Hochgebirge. – Waldökologie online **5**: 25–77.

Ewald, J., Kölling, C. (2009): Wo der Wald an Grenzen stößt - Höhenverbreitung der Baumarten in den Nordalpen. – LWF aktuell **71**: 34–36.

Ewald, J., May, R., Kleikamp, M. (2006): VegetWeb - die pflanzensoziologische Online-Datenbank unter www.floraWeb.de. In: Berg, C., Bergmeier, E., Hövelmann, T. & Ristow, M. (Bearb.): Ein Netzwerk für den botanischen Artenschutz. – BfN-Skripten **178**: 127–131.

Ewald, J., May, R., Kleikamp, M. (2012): VegetWeb, the national online-repository of vegetation plots from Germany. – In: Dengler, J., Oldeland, J., Jansen, F., Chytrý, M., Ewald, J., Finckh, M., Glöckler, F., Lopez-Gonzalez, G., Peet, R.K., Schaminée, J.H.J. [Eds.]: Vegetation databases for the 21st century. – Biodiversity & Ecology **4**: 173–175. Hamburg: Biocentre Klein Flottbek and Botanical Garden. CrossRef

Ewald, J., Seitz, R., Binner, S. (2009): Monitoring der Waldlebensräume in den Bayerischen Alpen mit GIS und Fernerkundung – In: Graef, F., Bilo, M., Weddeling, K., Hölzl; N. [Eds.]: Einsatz von Fernerkundung im Rahmen des FFH-Monitorings in Deutschland: 64–75. Bonn: Bundesamt für Naturschutz.

Feldner, R. 1978. Waldgesellschaften, Wald- und Forstgeschichte und Schlußfolgerungen für die waldbauliche Planung im N.S.G. Ammergauer Berge. – Wien: Universität für Bodenkultur.

Foerst, K., Kreutzer, K. (1977): Regionale natürliche Waldzusammensetzung und Forstliche Wuchsgebietesgliederung Bayerns. – München: Forstliche Versuchs- und Forschungsanstalt.

Frankl, R. (2001): Die Bergkiefer (Pinus mugo Turra) in den Tannheimer Bergen - ein Beitrag zur Kenntnis nordalpiner Latschengebüsche. – Berichte der Bayrischen Botanischen Gesellschaft **71**: 123–158.

Gauer, J., Aldinger, E., (editors) (2005): Waldökologische Naturräume Deutschlands - Forstliche Wuchsgebiete und Wuchsbezirke - mit Karte 1:10000. – Mitteilungen des Vereins für Forstliche Standortskunde und Forstpflanzenzüchtung **43**: 1–324.

Heinken, T. (2008): *Dicrano-Pinion* – Sand- und Silikat-Kiefernwälder. – Synopsis der Pflanzengesellschaften Deutschlands **10**.

Jansen, F., Dengler, J. (2008): Eine universelle taxonomische Referenzliste für Vegetationsdatenbanken in Deutschland. – Tuexenia **28**: 239–253.

Klotz, J., Rüther, C. (2007): Lathraea squamaria im Raum Regensburg: Zur Verbreitung einer kartierungskritischen Art. – Hoppea, Denkschriften der Regensburgischen Botanischen Gesellschaft **68**: 201–218.

Michl, T., Dengler, J. (2010): Montane-subalpine tall-herb vegetation (Mulgedio-Aconitetea) in central Europe: large-scale synthesis and comparison with northern Europe. – Phytocoenologia **40:** 117–154. CrossRef

Oberdorfer, E. (2001): Pflanzensoziologische Exkursionsflora. 8th ed. – Stuttgart: Ulmer.

Reger, B., Schüpferling, R., Beck, J., Dietz, E., Morovitz, D., Schaller, R., Wilhelm, G., Ewald, J. (2012): WINALPecobase – Ecological database of mountain forests in the Bavarian Alps. – – In: Dengler, J., Oldeland, J., Jansen, F., Chytrý, M., Ewald, J., Finckh, M., Glöckler, F., Lopez-Gonzalez, G., Peet, R.K., Schaminée, J.H.J. [Eds.]: Vegetation databases for the 21st century. – Biodiversity & Ecology **4**: 167–171. Hamburg: Biocentre Klein Flottbek and Botanical Garden. CrossRef

Schmidt, M., Ewald, J., Fischer, A., von Oheimb, G., Kriebitzsch, W.-U., Schmidt, W., Ellenberg, H. (2003): Liste der in Deutschland typischen Waldgefäßpflanzen. – Mitteilungen der Bundesforschungsanstalt für Forst- und Holzwirtschaft **212**: 1–33.

Storch, M. (1985): Fortran-Programm zur Bearbeitung von Vegetationstabellen - Ergänzungen zu Streng/Schönfelder. – Hoppea **44**: 379–392.

Wamelink, G.W.W., Goedhart, P.W., van Dobben, H.F., Berendse, F. (2005): Plant species as predictors of soil pH: replacing expert judgement with measurements. – Journal of Vegetation Science **16**: 461–470. CrossRef

Jörg Ewald (joerg.ewald@hswt.de)
University of Applied Sciences
Weihenstephan-Triesdorf
Hans-Carl-von-Carlowitz-Platz 3
85354 Freising, GERMANY