# 54th Symposium of the International Association for Vegetation Science

Vegetation in and around water:
patterns, processes and threats

# ABSTRACTS

**June 20 – 24, 2011**
**Lyon, France**

IAVS

cnrs

Université Claude Bernard Lyon 1

# Schedule Overview

| Schedule | Theatre B *Berula erecta* | Theatre C *Callitriche platycarpa* | Room 105 *Potamogeton coloratus* | Room 204 *Baldellia ranunculoïdes* | Room 208 *Samolus valerandi* | Room 209 *Marsilea quadrifolia* | |
|---|---|---|---|---|---|---|---|
| **Monday 20 June** | | | | | | | |
| 9h00 opening ceremony | opening ceremony | | | | | | 9h00 opening ceremony |
| 10h00 Plenary session | Plenary session: P.A. Keddy | | | | | | 10h00 Plenary session |
| 11h00 coffee break | | | | | | | 11h00 coffee break |
| 11h30 parallel sessions | | Biological invasions: towards general models and increased predictability | Anthropogenic impacts on vegetation | Computational Vegetation Science: Structure and dynamics of plant assemblages in silico | | | 11h30 parallel sessions |
| 12h10 lunch | | | | | | | 12h10 lunch |
| 14h00 parallel sessions | | Biological invasions: towards general models and increased predictability | Anthropogenic impacts on vegetation | Computational Vegetation Science: Structure and dynamics of plant assemblages in silico | Plant communities in aquatic ecosystems | Biodiversity and functioning of riparian habitats: indicators of change | 14h00 parallel sessions |
| 15h40 coffee break | | | | | | | 15h40 coffee break |
| 16h30 parallel sessions | | Biological invasions: towards general models and increased predictability | Conservation and restoration of plant communities | Climate change experiments in temperate grasslands | Plant communities in aquatic ecosystems | Biodiversity and functioning of riparian habitats: indicators of change | 16h30 parallel sessions |
| 18h30 | | | | | | | 18h30 |
| 19h30 welcome reception | | | | | | | 19h30 welcomme reception |
| **Tuesday 21 June** | | | | | | | |
| 8h30 ceremony new honorary members | ceremony new honorary | | | | | | 8h30 ceremony new honorary members |
| 9h00 Plenary session | Plenary session: J.P. Grime | | | | | | 9h00 Plenary session |
| 10h00 | Plenary session: J.S. Rodwell | | | | | | 10h00 |
| 11h00 coffee break | | | | | | | 11h00 coffee break |
| 11h30 parallel sessions | | Describing biodiversity patterns: trait-based analyses of plant communities | Conservation and restoration of plant communities | Climate change experiments in temperate grasslands | Clonal growth in plant communities: patterns and role in community dynamics | Biodiversity and functioning of riparian habitats : indicators of change | 11h30 parallel sessions |
| 12h30 lunch | | | | | | | 12h30 lunch |
| 14h30 parallel sessions | | Describing biodiversity patterns: trait-based analyses of plant communities | Conservation and restoration of plant communities | Climate change experiments in temperate grasslands | Clonal growth in plant communities: patterns and role in community dynamics | | 14h30 parallel sessions |
| 16h10 coffee break | | | | | | | 16h30 coffee break |
| 17h00 poster session | | | | | | | 17h00 poster session |
| 18h30 | | | | | | | 18h30 |
| **Thursday 23 June** | | | | | | | |
| 9h00 Plenary session | Plenary session: E. Garnier | | | | | | 9h00 Plenary session |
| 10h00 parallel sessions | | Biogeochemical approaches for understanding plant communities and ecosystem functioning | Warm-temperate deciduous forests in Southern Europe, East Asia and elsewhere around the Northern | New insights in descriptive vegetation science | Dispersal in space and time | Describing biodiversity patterns at multiple scales | 10h00 parallel sessions |
| 11h00 coffee break | | | | | | | 11h00 coffee break |
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| 12h30 lunch | | | | | | | 12h30 lunch |
| 14h30 parallel sessions | | Biogeochemical approaches for understanding plant communities and ecosystem functioning | Warm-temperate deciduous forests in Southern Europe, East Asia and elsewhere around the Northern hemisphere | New insights in descriptive vegetation science | Dispersal in space and time | Describing biodiversity patterns at multiple scales | 14h30 parallel sessions |
| 16h10 coffee break | | | | | | | 16h30 coffee break |
| 17h00 poster session | | | | | | | 17h00 poster session |
| 18h30 | | | | | | | 18h30 |
| 20h00 Symposium dinner | | | | | | | 20h00 Symposium dinner |
| **Friday 24 June** | | | | | | | |
| 9h00 Plenary session | Plenary session: C. Körner | | | | | | 9h00 Plenary session |
| 10h00 parallel sessions | | Alpine vegetation : threats in a changing world | Landscape dynamics in result of anthropogenic disturbance | New insights in descriptive vegetation science | Wetland biodiversity and functioning | | 10h00 parallel sessions |
| 11h00 coffee break | | | | | | | 11h00 coffee break |
| 11h30 parallel sessions | | Alpine vegetation : threats in a changing world | Landscape dynamics in result of anthropogenic disturbance | Vegetation responses to disturbances | Wetland biodiversity and functioning | | 11h30 parallel sessions |
| 13h10 lunch | | | | | | | 13h30 lunch |
| 14h30 General assembly | | | | | | | 14h30 General assembly |
| 16h00 Closing ceremony | | | | | | | 16h00 Closing ceremony |

# 54th Symposium of the International Association for Vegetation Science

## Vegetation in and around water: patterns, processes and threats

## EDITED BY :

**Gudrun BORNETTE and Sara PUIJALON**

Université Lyon 1, UMR CNRS 5023 “Ecologie des Hydrosystèmes Naturels et Anthropisés”, Villeurbanne, France

## IN COLLABORATION WITH :

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solange.perrel@univ-lyon1.fr
Université Lyon 1, FOCAL, Bât. Condorcet, 69622 Villeurbanne Cedex, France

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# MONDAY, 20 JUNE

## Theatre B — *Berula erecta*

**9h00** opening ceremony — opening ceremony

**10h00** Plenary session — Plenary session: P.A. Keddy

**11h00** coffee break

**11h30** parallel sessions

**12h30** lunch

**14h00** parallel sessions

**16h00** coffee break

**16h30** parallel sessions

**19h30** welcome reception at the Hotel de Ville

## Theatre C — *Callitriche platycarpa*

**Biological invasions: towards general models and increased predictability**

| | | | |
|---|---|---|---|
| 11h30 | 1 | M. Chytrý | CURRENT PATTERN AND FUTURE PROJECTIONS OF THE LEVEL OF INVASION BY ALIEN PLANTS IN EUROPE |
| 11h50 | 2 | Z. Lososová | BIOTIC HOMOGENIZATION OF CENTRAL EUROPEAN URBAN FLORAS DEPENDS ON RESIDENCE TIME OF ALIEN SPECIES AND HABITAT TYPES |
| 12h10 | 3 | P. Gerhold | PHYLOGENETICALLY POOR PLANT COMMUNITIES RECEIVE MORE ALIEN SPECIES, WHICH MORE EASILY COEXIST WITH NATIVES |

**Biological invasions: towards general models and increased predictability**

| | | | |
|---|---|---|---|
| 14h00 | 4 | F. Jansen | HOW TO USE VEGETATION DATABASES AND MEAN PLANT TRAITS - ECOLOGICAL PREFERENCES OF ALIEN PLANT SPECIES IN NORTH-EASTERN GERMANY |
| 14h20 | 5 | S. White | USING STRUCTURAL EQUATION MODELLING TO TEST THE PASSENGER-DRIVER HYPOTHESIS: RESULTS FROM A NORTHERN GRASSLAND |
| 14h40 | 6 | M. Carboni | DEALING WITH SPARSE DATA TO MODEL HOW NATURAL GRADIENTS AND PROPAGULE PRESSURE SHAPE FINE SCALE ALIEN PATTERNS ON SANDY SHORES |
| 15h00 | 7 | J. Thiele | ARE INVASIVE SPECIES DRIVERS OR PASSENGERS OF SUCCESSION? |
| 15h20 | 8 | N. Gross | UNDERSTANDING THE IMPACT OF BIOLOGICAL INVASION ON COMMUNITY DYNAMICS AND ECOSYSTEM FUNCTIONING USING PLANT FUNCTIONAL TRAITS |
| 15h40 | 9 | M. Cruz Díaz-Barradas | PHYSIOLOGICAL TRAITS TO ASSESS *HIERACIUM PILOSELLA* INVASION IN THE MAGELLANIC STEPPE OF TIERRA DEL FUEGO ISLAND (ARGENTINA) |

**Biological invasions: towards general models and increased predictability**

| | | | |
|---|---|---|---|
| 16h30 | 10 | J.M. Kalwij | UPWARD SHIFTS IN ALTITUDINAL LIMITS OF EXOTIC PLANTS IN A MONTANE GRASSLAND |
| 16h50 | 11 | P. Saccone | *ACER NEGUNDO* INVASION ALONG A SUCCESSIONAL GRADIENT |
| 17h10 | 12 | S. Rouifed | DO SIMILAR WEAPONS BETWEEN SPECIES LIMIT COLONIZATION BY BOHEMIAN KNOTWEED? |
| 17h30 | 13 | M. Shimoda | ETHNOBOTANY AND HABITATS OF JAPANESE KNOTWEED (*FALLOPIA JAPONICA*) IN JAPAN |
| 17h50 | 14 | R.G. Gavilán | ARE *SPARTIUM JUNCEUM* RESTORATIONS A PROBLEM FOR CONSERVATION AREAS OF CENTRAL SPAIN? |

## Room 105 — *Potamogeton coloratus*

**Anthropogenic impacts on vegetation**

| | | | |
|---|---|---|---|
| 11h30 | 1 | H. Daniel | WOODLAND PLANT RESPONSE TO URBANIZATION AND MANAGEMENT INTENSITY – OPPORTUNITIES TO MAINTAIN AND RESTORE BIODIVERSITY IN URBAN AREAS |
| 11h50 | 2 | L. Kutnar | WHAT ARE THE POSSIBLE EFFECTS OF GLOBAL WARMING ON THE SLOVENIAN FORESTS IN THE FUTURE? |
| 12h10 | 3 | M.D. Bejarano | GEOMORPHIC CONTROLS OF WOODY VEGETATION RESPONSES TO FLOW ALTERATION IN A MEDITERRANEAN STREAM IN CENTRAL-WESTERN SPAIN |

**Anthropogenic impacts on vegetation**

| | | | |
|---|---|---|---|
| 14h00 | 4 | G.M. Davies | PATTERNS AND DRIVERS OF LONG-TERM CHANGE IN SAGEBRUSH-STEPPE VEGETATION COMMUNITIES |
| 14h20 | 5 | V.M. Dos Santos | INFLUENCE OF NUTRIENT ENRICHMENT, SEDIMENTATION AND HERBICIDE RESIDUES ON SEAGRASS IN TWO CONTRASTING NEW ZEALAND HARBOUR |
| 14h40 | 6 | T. Baumberger | HUMAN DISTURBANCE EFFECTS ON PLANT POPULATIONS: A CASE STUDY OF *LIMONIUM GIRARDIANUM*, A PROTECTED ENDEMIC SPECIES IN COASTAL SALT MARSHES |
| 15h00 | 7 | J. Hsu | THE SENSITIVITY OF PRIMARY PRODUCTION TO PRECIPITATION |
| 15h20 | 8 | M. Saulais | VEGETATION PATTERNS EVOLUTION OF AN ARTIFICIALLY VEGETALIZED STORMWATER INFILTRATION BASIN |
| 15h40 | 9 | M. Koch | SEVERE CHANGES AND SUCCESSION IN THE VEGETATION COMPOSITION FOLLOWING DRAINAGE OF A LOWLAND PERCOLATION MIRE COMPLEX |

**Conservation and restoration of plant communities**

| | | | |
|---|---|---|---|
| 16h30 | 1 | W. Wamelink | ESTIMATION OF SOIL QUALITY FOR NATURA-2000 AREAS; AN APPLICATION OF BIO-INDICATION |
| 16h50 | 2 | N. Hölzel | THE IMPORTANCE OF ENVIRONMENTAL FILTERS AND FOUNDER EFFECTS IN GRASSLAND RESTORATION – EVIDENCE FROM A LONG-TERM STUDY |
| 17h10 | 3 | J. Mantilla-Contreras | INFLUENCE OF SOIL AND MICROCLIMATE ON SPECIES COMPOSITION AND GRASS ENCROACHMENT IN COASTAL HEATH SUCCESSION |
| 17h30 | 4 | P. Stroh | RELATIONSHIPS BETWEEN SOIL POROSITY, HYDROLOGY AND VEGETATION AT A LANDSCAPE SCALE WETLAND RESTORATION SITE |
| 17h50 | 5 | R. Jaunatre | IMPACTS OF A MULTI-TREATMENT RESTORATION EXPERIMENT ON THE VEGETATION, SOIL AND SEED BANK OF A MEDITERRANEAN STEPPE |
| 18h10 | 6 | S. Bechar | CONSEQUENCES OF RESTORATION ON THE ECOLOGICAL FUNCTIONING OF RIVERINE WETLANDS |
| 18h30 | 7 | M. Sammul | BIOMASS ACCUMULATION DURING REED ENCROACHMENT REDUCES THE EFFICIENCY OF THE RESTORATION OF BALTIC COASTAL GRASSLANDS |

## Room 204 — *Baldellia ranunculoïdes*

**Computational Vegetation Science: Structure and dynamics of plant assemblages in silico**

| | | | |
|---|---|---|---|
| 11h30 | 1 | M. Garbey | LARGE SCALE SIMULATION OF VIRTUAL PRAIRIES WITH VOLUNTEER COMPUTING |
| 11h50 | 2 | D.E. Goldberg | THE ROLE OF CLONAL PLANT SIZE AND LITTER PRODUCTION IN COMPETITIVE DYNAMICS ALONG NUTRIENT GRADIENTS |
| 12h10 | 3 | S. Schmidtlein | A BRUTE-FORCE APPROACH TO VEGETATION CLASSIFICATION |

**Computational Vegetation Science: Structure and dynamics of plant assemblages in silico**

| | | | |
|---|---|---|---|
| 14h00 | 4 | W.S. Currie | INTERWOVEN CAUSE AND EFFECT IN NUTRIENT CYCLING, PLANT SIZE, AND INVASION SUCCESS IN A SIMULATED CLONAL WETLAND ECOSYSTEM |
| 14h20 | 5 | T. Herben | TESTING TRAIT CONVERGENCE/DIVERGENCE IN A GRASSLAND COMMUNITY IN SILICO |
| 14h40 | 6 | J.-S. Pierre | OPTIMAL FORAGING IN CLONAL PLANTS. THE BLIND PROSPECTOR MODEL |
| 15h00 | 7 | F. Campillo | MONTE CARLO SIMULATION AND MATHEMATICAL ANALYSIS OF AN INDIVIDUAL-BASED MODEL FOR CLONAL PLANT DYNAMICS |
| 15h20 | 8 | F-H. Yu | CONTEXT-DEPENDENT EFFECTS OF PLANT TRAITS ON FITNESS |

**Climate change experiments in temperate grasslands**

| | | | |
|---|---|---|---|
| 16h30 | 1 | C.N. Carlyle | CLIMATE CHANGE EXPERIMENTS IN TEMPERATE GRASSLANDS: SESSION INTRODUCTION |
| 16h50 | 2 | L.H. Fraser | INTERACTING EFFECTS OF CLIMATE CHANGE AND GRAZING ON GRASSLAND PLANT COMMUNITIES ALONG A NATURAL PRODUCTIVITY GRADIENT |
| 17h10 | 3 | J. Cahill | COMPLEX RESPONSES TO ALTERED WARMING, WATER, AND DEFOLIATION: RESULTS FROM A FIELD EXPERIMENT IN THREE NORTHERN GRASSLANDS |
| 17h30 | 4 | S.L. Collins | RAINFALL VARIABILITY AND COMMUNITY DYNAMICS IN CHIHUAHUAN DESERT VEGETATION |
| 17h50 | 5 | A. Knapp | GRASSLAND ECOSYSTEM RESPONSES TO EXPERIMENTAL MANIPULATIONS OF THE PRECIPITATION REGIME |
| 18h10 | 6 | M. Smith | IMPACTS OF CLIMATE EXTREMES ON A MESIC GRASSLAND |
| 18h30 | 7 | J. Fridley | THE BASIS OF COMMUNITY RESISTANCE TO CLIMATE CHANGE IN A LIMESTONE GRASSLAND, AND WHY IT MAY NOT LAST |

## Room 208 — *Samolus valerandi*

**Plant communities in aquatic ecosystems**

| | | | |
|---|---|---|---|
| 14h00 | 1 | U. Peterson | A RETROSPECTIVE SERIES OF SATELLITE IMAGES FOR STUDYING MACROPHYTIC VEGETATION DYNAMICS IN THE COASTAL ZONES OF LARGE LAKES |
| 14h20 | 2 | A. Cunha | MACROPHYTE'S IN AZOREAN LAKES |
| 14h40 | 3 | J.A. Molina | VERNAL POOL ECOSYSTEMS ON BOTH SIDES OF THE STRAIT OF GIBRALTAR: HABITAT AND FLORISTIC VARIATION |
| 15h00 | 4 | M. Gioria | PATTERNS OF PLANT DIVERSITY IN FARMLAND PONDS: DRIVERS AND FUNCTIONS |
| 15h20 | 5 | F. Arthaud | SPECIES RICHNESS AND FUNCTIONAL GROUPS IN RESPONSE TO ANTHROPOGENIC STRESS AND DISTURBANCES IN SHALLOW LAKES |
| 15h40 | 6 | E. Hamann | RESPONSES OF FRESHWATER PLANTS TO DEWATERING: BIOMECHANICAL PROPERTIES AND MORPHO-ANATOMICAL DETERMINISM |

**Plant communities in aquatic ecosystems**

| | | | |
|---|---|---|---|
| 16h30 | 7 | G. Cavalli | THE ROLE OF SPECIES FUNCTIONAL TRAITS FOR DISTRIBUTIONAL PATTERNS IN LOWLAND STREAM VEGETATION |
| 16h50 | 8 | P. Michel | BRYOPHYTES AND WATER: SPECIES ASSEMBLAGES DRIVE HYDROLOGICAL PROCESSES AT CUSHION AND CATCHMENT SCALE |
| 17h10 | 9 | K. Szoszkiewicz | THE IMPACT OF AQUATIC VEGETATION ON THE DIVERSITY OF A RIVER ECOSYSTEM |
| 17h30 | 10 | R. Bolpagni | HOW DO HYDRO-MORPHOLOGICAL AND PHYSICO-CHEMICAL FEATURES GOVERN MACROPHYTE COMPLEXITY IN A HYPEREUTROPHIC AND IMPACTED RIVER? |
| 17h50 | 11 | A. Keruzoré | THE ROLE OF DISTURBANCE IN THE MAINTENANCE OF MACROPHYTE DIVERSITY IN LARGE RIVER FLOODPLAINS |
| 18h10 | 12 | C. Coutris | CAN WE PREDICT THE COMMUNITY-WIDE EFFECTS OF HERBICIDES FROM TOXICITY TESTS ON PLANT SPECIES? A CASE STUDY ON FRESHWATER MACROPHYTES |

## Room 209 — *Marsilea quadrifolia*

**Biodiversity and functioning of riparian habitats: indicators of change**

| | | | |
|---|---|---|---|
| 14h00 | 1 | R. Fernández-Lo Faso | A PROJECTION OF TEMPORARY STREAMS UNDER SEMI-ARID CLIMATE SCENARIOS. EVIDENCE FROM AN EPHEMERAL MEDITERRANEAN STREAM |
| 14h20 | 2 | C. Carreau | TAKING THE SPATIAL STRUCTURE OF THE HEDGE NETWORKS INTO ACCOUNT FOR THE RIPARIAN ECOLOGICAL RESTORATION |
| 14h40 | 3 | S. Dufour | USING MULTI -SOURCE DATA FOR ASSESSING RIPARIAN VEGETATION STATUS AT LARGE SCALE |
| 15h00 | 4 | T. Tormos | REMOTELY SENSED RIPARIAN CORRIDOR INDICATORS IN RELATION TO ECOLOGICAL STATUS OF RIVERS |
| 15h20 | 5 | N. Clerici | PAN-EUROPEAN MODELLING OF RIPARIAN ZONES BASED ON REMOTE SENSING AND GIS |
| 15h40 | 6 | M.R. Fernandes | IMAGE-BASED METHODS TO CHARACTERIZE DEGRADATION PATTERNS OF MEDITERRANEAN RIPARIAN FORESTS |

**Biodiversity and functioning of riparian habitats: indicators of change**

| | | | |
|---|---|---|---|
| 16h30 | 7 | V. Kalusová | RIPARIAN AND COASTAL HABITATS ARE THE MOST IMPORTANT DONORS OF INVASIVE PLANTS OF EUROPEAN ORIGIN |
| 16h50 | 8 | E. Araujo Calçada | LOCAL *VS.* REGIONAL PROCESSES EXPLAINING PLANT COMMUNITY ASSEMBLY ALONG FOREST STREAMS |
| 17h10 | 9 | F. C. Aguiar | SPECIES COMPOSITIONAL AND FUNCTIONAL VARIATION OF RIPARIAN FORESTS: DISPERSION INDICATORS |
| 17h30 | 10 | S. Škornik | VEGETATION OF RIPARIAN WOODED MEADOWS (SLOVENIA) IN RELATION TO LIGHT CONDITIONS AND ABANDONMENT |
| 17h50 | 11 | S.L. Stoffella | HYDROLOGY, SUBSTRATE TYPE AND DENSITY EFFECTS ON SPECIES GROWTH AND SURVIVAL IN EVERGLADES TREE ISLANDS |
| 18h10 | 12 | S. Greulich | VULNERABILITY OF ALLUVIAL VEGETATION OF THE LOIRE RIVER (FRANCE) IN RELATION TO CLIMATE CHANGE |

# TUESDAY, 21 JUNE

| | | Theatre B *Berula erecta* | Theatre C *Callitriche platycarpa* | Room 105 *Potamogeton coloratus* | Room 204 *Baldellia ranunculoïdes* | Room 208 *Samolus valerandi* | Room 209 *Marsilea quadrifolia* | |
|---|---|---|---|---|---|---|---|---|
| 8h30 | ceremony new honorary members | opening ceremony | | | | | | 8h30 |
| 8h40 | | | | | | | | 8h40 |
| 9h00 | Plenary session | Plenary session: J.P. Grime | | | | | | 9h00 |
| 10h00 | | Plenary session: J.S. Rodwell | | | | | | 10h00 |
| 11h00 | coffee break | | | | | | | 11h00 |
| 11h30 | parallel sessions | | **Describing biodiversity patterns: trait-based analyses of plant communities**<br>1 P. Chanteloup — FUNCTIONAL COMPLEMENTARITY IN A WET GRASSLAND AND ITS IMPACT ON ECOSYSTEM SERVICES | **Conservation and restoration of plant communities**<br>8 O. Chabrerie — DRIVERS OF PLANT SPECIES DIVERSITY AT FOREST EDGES | **Climate change experiments in temperate grasslands**<br>8 E. Cleland — COMMUNITY TRAIT COMPOSITION AND ECOSYSTEM FEEDBACKS TO GLOBAL CHANGE: INTER- *VS.* INTRA-SPECIFIC VARIABILITY AND TEMPORAL SCALE | **Clonal growth in plant communities: patterns and role in community dynamics**<br>1 R. Tamme — RELATIONSHIP BETWEEN CLONAL AND SEED DISPERSAL DISTANCES | **Biodiversity and functioning of riparian habitats : indicators of change**<br>13 P.M. Rodríguez-González — USING TREE GROWTH AS A PROXY FOR RECENT HYDROLOGICAL CHANGES IN SOUTHERN EUROPEAN FORESTED WETLANDS | 11h30 |
| 11h50 | | | 2 M.C. Cobo — RAUNKIAER'S LIFE-FORMS AND INTER-SPECIFIC RELATIONS IN PATTERN FORMATION UNDER VARYING LAND USES IN SEMIARID SE SPAIN | 9 F. Coates — SPRING WETLANDS ON A GRANITE PLATEAU IN SOUTH-EASTERN AUSTRALIA - SPECIES DOMINANCE IN AN AGRICULTURAL LANDSCAPE | 9 J.M.H. Knops — BIODIVERSITY IS NOT AT EQUILIBRIUM BUT REFLECTS THE GHOST OF ECOLOGICAL PROCESSES PAST | 2 Š. Janeček — CARBOHYDRATE STORAGE IN MEADOW PLANTS AND ITS DEPLETION AFTER DISTURBANCE: DO THE ROLES OF SHOOT AND ROOT DERIVED ORGANS DIFFER? | 14 J. White — REGENERATION OF FLOODPLAIN TREE SPECIES MAY NOT BE SUFFICIENT TO PREVENT SPECIES LOSS DUE TO HYDROLOGIC ALTERATION | 11h50 |
| 12h10 | | | 3 L. Götzenberger — ASSEMBLY RULES IN THE UNDERSTORY OF A TEMPERATE FOREST | 10 J.-A. Metsoja — VEGETATION CHANGES AND MANAGEMENT INDICATORS IN THE RESTORED FLOODED MEADOWS OF THE ALAM-PEDJA NATURE RESERVE, ESTONIA | 10 H. Henry — PLANT AND SOIL RESPONSES TO FOUR YEARS OF WARMING AND NITROGEN ADDITION IN A GRASS-DOMINATED, NORTHERN TEMPERATE OLD FIELD | 3 M. Sosnová — DISTRIBUTION OF CLONAL TRAITS AMONG WETLAND HABITATS | 15 J.C. Stella — DENDROECOLOGY AS AN INDICATOR OF RIPARIAN FUNCTION AND A DRIVER OF MESO-SCALE ECOSYSTEM IMPACTS | 12h10 |
| 12h30 | | | 4 J. Leathem — TRAIT-BASED ANALYSIS AND COMMUNITY ASSEMBLY OF NATIVE AND EXOTIC SPECIES ON SUBARCTIC ROADSIDES | | 11 J.-F. Soussana — ASSESSING THE IMPACTS OF CLIMATE CHANGE, ELEVATED $CO_2$ AND EXTREME EVENTS ON MESIC AND ALPINE GRASSLANDS | 4 A.-K. Bittebiere — EFFECT OF CLONAL COLONIZATION STRATEGY ON PRODUCTIVITY IN PLANT COMMUNITIES: A WIDE-SCALE MESOCOSM EXPERIMENT | 16 D. Marage — TYPICAL, DIAGNOSTIC OR CHARACTERISTIC SPECIES: WHAT IS WRONG WITH IT? A METHODOLOGICAL FRAMEWORK TO DEFINE "TYPICAL" SPECIES FOR ASSESSING THE CONSERVATION STATUS IN RIPARIAN FORESTS | 12h30 |
| 12h50 | lunch | | | | | | | 12h50 |
| 14h30 | parallel sessions | | **Describing biodiversity patterns: trait-based analyses of plant communities**<br>5 U. Jandt — FUNCTIONAL CHANGES IN CALCAREOUS DRY GRASSLANDS IN GERMANY OVER TIME | **Conservation and restoration of plant communities**<br>11 J. Oudot-Canaff — SHORT-TERM CONSEQUENCES OF WETLAND RESTORATION ON THE GENETIC DIVERSITY OF A CLONAL PLANT SPECIES | **Climate change experiments in temperate grasslands**<br>12 C. Beierkuhnlein — SENSITIVITY OF PLANT SPECIES TO CLIMATIC EXTREMES DURING GRASSLAND SUCCESSION | **Clonal growth in plant communities: patterns and role in community dynamics**<br>5 C. Wellstein — MOLECULAR GENETIC EVIDENCE FOR CLONAL STANDS OF *QUERCUS PUBESCENS*? | | 14h30 |
| 14h50 | | | 6 J. Price — DO ABOVE-GROUND ASSEMBLY RULES APPLY BELOW-GROUND? | 12 T. Aavik — GENETIC CONSEQUENCES OF USING WILDFLOWER SEED MIXTURES IN ECOLOGICAL RESTORATION | 13 A. Jentsch — EFFECTS OF RECURRENT SEVERE DROUGHT ON MULTIPLE ECOSYSTEM FUNCTIONS IN TEMPERATE GRASSLAND | 6 S. Bell — IS CLONALITY A CRITICAL DIMENSION OF CO-EXISTENCE IN TEMPORARY WETLANDS? | | 14h50 |
| 15h10 | | | 7 N.W.H. Mason — FUNCTIONAL DIVERSITY INDICES REVEAL COMMUNITY ASSEMBLY PROCESSES ALONG A SOIL CHRONOSEQUENCE | 13 Z. Akasbi — EFFECTS OF GRAZING EXCLUSION ON INTERANNUAL CHANGES OF DWARF SHRUB BIOMASS IN A MOROCCAN SAGEBRUSH STEPPE | 14 J.-P. Maalouf — ADAPTING ECOSYSTEM CONSERVATION MANAGEMENTS TO CLIMATE CHANGE: THE CASE OF CALCAREOUS GRASSLANDS SUBJECT TO SIMULATED DROUGHT | 7 L.C. de Witte — AFLP MARKERS REVEAL HIGH CLONAL DIVERSITY AND EXTREME LONGEVITY IN FOUR ARCTIC-ALPINE KEY SPECIES | | 15h10 |
| 15h30 | | | 8 M. Bernard-Verdier — DETECTING COMMUNITY ASSEMBLY PATTERNS ALONG A SOIL DEPTH GRADIENT IN A MEDITERRANEAN RANGELAND | 14 M. Isermann — PLANT BIODIVERSITY MAINTAINED BY SCRUB REMOVAL IN COASTAL DUNES | 15 P. Mariotte — SUBORDINATE PLANT SPECIES PROMOTE RESISTANCE OF PLANT COMMUNITY DURING SUMMER DROUGHT | 8 J. Klimešová — SPACE OCCUPANCY STRATEGIES AND SPECIES DIVERSITY ON SMALL SCALE IN A TEMPERATE MEADOW | | 15h30 |
| 15h50 | | | 9 S. Vanderplank — CHANGES IN PHENOLOGY AND PHYSIOGNOMY ALONG A PRECIPITATION GRADIENT IN BAJA CALIFORNIA | 15 E.-M. Bauer — THE INCREASING IMPORTANCE OF REED HARVEST IN THE WESER ESTUARY AND ITS INFLUENCE ON THE VITALITY OF THE COMMON REED (*PHRAGMITES AUSTRALIS*) | 16 T. Dutoit — DISCRIMINATING CLIMATE CHANGES FROM LAND-USE CHANGES TO EXPLAIN THE ABSENCE OF SHRUB COLONIZATION IN A MEDITERRANEAN STEPPE | 9 M. Carboni — SPECIES COEXISTENCE ALONG A PRODUCTIVITY GRADIENT IN WET MEADOWS: ASSESSING THE ROLE OF CLONAL AND LHS TRAITS | | 15h50 |
| 16h10 | | | 10 C. Wellstein — INTRASPECIFIC VARIABILITY IN CLONAL GROWTH IN RESPONSE TO EXTREME CLIMATIC EVENTS | | | 10 Y. Zhang — CLONAL INTEGRATION AMELIORATES PHYSIOLOGICAL EFFECTS OF DROUGHT STRESS | | 16h10 |
| 16h30 | coffee break | | | | | | | 16h30 |
| 17h00 | poster session | | | | | | | 17h00 |
| 18h30 | | | | | | | | 18h30 |

# THURSDAY, 23 JUNE

| | | Theatre B *Berula erecta* | Theatre C *Callitriche platycarpa* | Room 105 *Potamogeton coloratus* | Room 204 *Baldellia ranunculoïdes* | Room 208 *Samolus valerandi* | Room 209 *Marsilea quadrifolia* | |
|---|---|---|---|---|---|---|---|---|
| 9h00 | Plenary session | Plenary session: E. Garnier | | | | | | 9h00 |
| 10h00 | parallel sessions | | **Biogeochemical approaches for understanding plant communities and ecosystem functioning**<br>1 T. Riis — NITROGEN CYCLING IN A LOWLAND MACROPHYTE STREAM<br>2 D. Kim — FLUVIAL-GEOMORPHIC PROCESSES OF SALT MARSH CREEKS SHAPE SPATIAL TRENDS IN VEGETATION ACROSS ENVIRONMENTAL STRESS GRADIENTS<br>3 M. Ilomets — EFFECTS OF WATER LEVEL SEASONAL FLUCTUATION ON SUBSTRATE CHEMISTRY AND COMMUNITY STRUCTURE OF A CALCAREOUS FEN | **Warm-temperate deciduous forests in Southern Europe, East Asia and elsewhere around the Northern hemisphere**<br>1 K. Fujiwara — CHARACTER OF WARM-TEMPERATE FORESTS IN ASIA<br>2 J. Loidi — THE TEMPERATE FORESTS OF THE IBERIAN PENINSULA<br>3 P. Bingre — WARM-TEMPERATE FORESTS OF CENTRAL PORTUGAL : A MOSAIC OF SYNTAXA | **New insights in descriptive vegetation science**<br>1 P.R. Minchin — NEW TOOLS FOR THE ANALYSIS OF COMMUNITY CHANGE WITH APPLICATIONS IN CONSERVATION, MANAGEMENT AND RESTORATION<br>2 M. Manthey — TESTING THE CONTINUUM – A NEW PERMUTATION-BASED APPROACH TO EVALUATE SPECIES TURNOVER ALONG ENVIRONMENTAL GRADIENTS<br>3 O. Semboli — HEISENBERG'S UNCERTAINTY PRINCIPLE APPLIES TO LONG-TERM MONITORING OF TROPICAL FOREST PLANT COMMUNITIES | **Dispersal in space and time**<br>1 D. Zelený — BETTER DISPERSAL MEANS A WIDER REALIZED SPECIES NICHE<br>2 J. Lenoir — SPATIAL PATTERNS IN ARCTIC PLANT COMMUNITIES ACROSS EURASIA: THE EFFECT OF PLANT DISPERSAL ABILITIES<br>3 E. Buisson — ROLE OF THE SEED BANK AND SEED RAIN IN THE REGENERATION OF A TRANSITION FOREST NEAR ANDOHAHELA NATIONAL PARK, MADAGASCAR | **Describing biodiversity patterns at multiple scales**<br>1 M. Barbour — PATTERNS OF DOMINANCE BY NEEDLE-LEAF AND BROAD-LEAF EVERGREEN TREES IN NORTHERN CALIFORNIA<br>2 L. Kadik Achoubi — DIVERSITY IN THE VEGETATION OF THE LOW MOUNTAINS IN THE BLIDA ATLAS (SUBHUMID STAGE)<br>3 S.D. Jelaska — PLANT DIVERSITY OF CLIMATOGENIC SILVER FIR – BEECH FOREST IN THE DINARIC KARST ACROSS SEVERAL MESOSCALE GRADIENTS | 10h00 |
| 11h00 | coffee break | | | | | | | 11h00 |
| 11h30 | parallel sessions | | **Biogeochemical approaches for understanding plant communities and ecosystem functioning**<br>4 E.-S. Tuittila — CARBON DYNAMICS AND VEGETATION SUCCESSION DURING MIRE DEVELOPMENT | **Warm-temperate deciduous forests in Southern Europe, East Asia and elsewhere around the Northern hemisphere**<br>4 R. Guarino — DOWNY OAK-WOODS OF ITALY: PHYTOGEOGRAPHICAL REMARKS ON A CONTROVERSIAL TAXONOMIC AND ECOLOGICAL ISSUE | **New insights in descriptive vegetation science**<br>4 R. Peet — CLASSIFICATION, DIVERSITY AND ENVIRONMENTAL RELATIONSHIPS OF PLANT COMMUNITIES OF THE SOUTHERN APPALACHIAN MOUNTAINS | **Dispersal in space and time**<br>4 A. Jamoneau — WHY DO SPECIES ASSEMBLAGES DIFFER BETWEEN ANCIENT AND RECENT FORESTS? AN EXPERIMENT | **Describing biodiversity patterns at multiple scales**<br>4 M. Pärtel — TRUE, DARK AND PSEUDODIVERSITY: RE-CONCEPTUALIZATION OF BIODIVERSITY | 11h30 |
| 11h50 | | | 5 R. Gerdol — PHOSPHOROUS AVAILABILITY LIMITS BOTH PRIMARY PRODUCTION AND DECOMPOSITION AT INCREASING LEVELS OF ATMOSPHERIC NITROGEN DEPOSITION IN BOG ECOSYSTEMS | 5 A. Čarni — DISTRIBUTION OF THERMOPHILOUS, DECIDUOUS FORESTS IN THE CENTRAL AND WESTERN PART OF THE BALKAN PENINSULA AND THEIR STRUCTURAL FEATURES | 5 R. Lawrence-Lodge — AN EXPLORATION IN TO INTRINSIC GUILD MEMBERSHIP | 5 G. Arellano — MEDITERRANEAN GRASSLAND SEEDLING ESTABLISHMENT: THE ROLE OF SEED SIZE UNDER DIFFERENT AUTUMN MOISTURE CONDITIONS | 5 D. Rocchini — CALCULATING GENERALIZED ENTROPY AS A MEASURE OF LANDSCAPE DIVERSITY IN AN OPEN SOURCE SPACE | 11h50 |
| 12h10 | | | 6 M.R. Wong — MICROBIAL COMMUNITY FUNCTIONAL GROUPS: LINKS TO VEGETATION AND ECOSYSTEM PROPERTIES OF SEMI ARID GRASSLANDS, SOUTHEASTERN AUSTRALIA | 6 E. Uğurlu — NUMERICAL CLASSIFICATION AND ECOLOGICAL CHARACTERIZATION OF WARM-TEMPERATE OAK FORESTS OF TURKEY | 6 K.J. Zanini — PATTERNS OF CONVERGENCE AND DIVERGENCE OF TRAITS IN FOREST COMMUNITIES ALONG A SUCCESSIONAL GRADIENT | 6 A. Baattrup-Pedersen — SEED GERMINATION FROM DEPOSITED SEDIMENTS DURING HIGH WINTER FLOW IN RIPARIAN AREAS | 6 I. Hiiesalu — ROOT SEQUENCING DOUBLES SMALL-SCALE PLANT RICHNESS MEASURES AND ALTERS DIVERSITY PATTERNS | 12h10 |
| 12h30 | | | 7 V.H. Klaus — NUTRIENT CONCENTRATIONS IN PLANT COMMUNITY BIOMASS REFLECT SPECIES RICHNESS PATTERNS IN A BROAD RANGE OF AGRICULTURAL GRASSLANDS | 7 C.Q. Tang — PERSISTENCE OF THE TERTIARY RELICT DECIDUOUS TREE TETRACENTRON SINENSE IN SUBTROPICAL SW CHINA | 7 E. Paradis — THE BOG/UPLAND TRANSITION INSIDE RAISED BOGS OF NORTH-EASTERN AMERICA : CHARACTERIZATION OF ECOTONAL COMMUNITIES | 7 A. Bischoff — DISPERSAL AND MICROSITE LIMITATION IN FLOODPLAIN GRASSLAND RESTORATION | 7 F. Bioret — A NATIONAL SYNSYTEM OF THE FRENCH VEGETATIONS | 12h30 |
| 12h50 | lunch | | | | | | | 12h50 |
| 13h10 | | | | | | | | 13h10 |
| 14h30 | parallel sessions | | **Biogeochemical approaches for understanding plant communities and ecosystem functioning**<br>8 P. Saccone — EFFECTS OF SNOW DEPTH ON LITTER DECOMPOSITION RATES FROM CONTRASTED PLANT SPECIES IN SUBALPINE MEADOWS | **Warm-temperate deciduous forests in Southern Europe, East Asia and elsewhere around the Northern hemisphere**<br>8 Y. Hoshino — SPECIES COMPOSITION OF SEMI-NATURAL OAK FORESTS IN THE WARM-TEMPERATE DECIDUOUS FOREST ZONE IN JAPAN | **New insights in descriptive vegetation science**<br>8 N. Sajna — SEPARATED OCCURRENCE ACROSS A SALT MARSH TIDAL GRADIENT ENABLES THE COEXISTENCE OF TWO SYMPATRIC *SALICORNIA* SPECIES | **Dispersal in space and time**<br>8 M. Diekmann — QUANTIFYING THE IMPORTANCE OF SHORT-DISTANCE DISPERSAL FOR PATCH OCCUPANCY PATTERNS OF AQUATIC PLANT SPECIES IN A DITCH NETWORK | **Describing biodiversity patterns at multiple scales**<br>8 A. Nalian — PYROSEQUENCING-BASED ASSESSMENT OF TEMPORAL DYNAMICS OF FUNGAL COMMUNITIES IN THE RHIZOSPHERE OF PLANTS | 14h30 |
| 14h50 | | | 9 A. Aan — INDICES OF LIGHT AND NITROGEN RESOURCE USE AND CHANGES IN THE ALLOCATION PATTERN ALONG A PRODUCTIVITY GRADIENT OF GRASSLAND | 9 M.A. Blumler — DECIDUOUS WOODLANDS IN MEDITERRANEAN CALIFORNIA AND THE NEAR EAST | 9 C. Damgaard — COMPETITIVE INTERACTIONS *OF CALLUNA VULGARIS AND* DESCHAMPSIA FLEXUOSA IN DRY HEATHLANDS | 9 K. Kiehl — PRE-RESTORATION SEED BANK ANALYSES IN A BACKWATER SYSTEM OF THE DANUBE FLOODPLAIN NEAR INGOLSTADT (GERMANY) | 9 E. Buisson — DISTURBANCE REGIMES AND TROPHIC RESSOURCES CHANGE BIOTIC INTERACTIONS IN HERBACEOUS PLANT COMMUNITIES | 14h50 |
| 15h10 | | | 10 A. Fidelis — ABOVE- AND BELOWGROUND BIOMASS AND CARBON DYNAMICS IN TROPICAL WET GRASSLANDS | 10 B. Vilches de la Serna — BROAD-LEAVED OAK FOREST IN NORTHEASTERN SPAIN: A CASE STUDY OF *QUERCUS PYRENAICA* COMMUNITIES USING THE MULTIPATT APPLICATION | 10 M. De Cáceres — CLASSIFICATION OF VEGETATION: SOME CONCEPTS AND PITFALLS | 10 T. Riis — DISPERSAL AND COLONIZATION OF PLANTS IN LOWLAND STREAMS | 10 S.C. Pennings — DOES LATITUDINAL VARIATION IN PLANT QUALITY MATTER FOR HERBIVORES? | 15h10 |
| 15h30 | | | 11 M. Moretti — TOWARDS AN UNDERSTANDING OF THE TROPHIC RELATIONSHIPS BETWEEN PLANTS AND HERBIVOROUS INVERTEBRATES | 11 M. Olvera Vargas — TREE MORTALITY, RECRUITMENT AND POPULATION STRUCTURE DYNAMICS IN MIXED-OAK DOMINATED FORESTS IN WESTERN MEXICO | 11 L. Tichý — STABILITY AND NUMBER OF DIAGNOSTIC SPECIES: TWO IMPORTANT PROPERTIES OF COMMUNITY CLASSIFICATIONS | 11 K. Šumberová — POSSIBILITIES OF PLANT PROPAGULE DISPERSAL VIA FISH IN EUROPEAN POND SYSTEMS | 11 L. Strazdina — BRYOPHYTE COMMUNITY RESPONSE TO NATURAL FOREST SUCCESSION IN THE MORICSALA ISLAND RESERVE, LATVIA | 15h30 |
| 15h50 | | | 12 J. Valera-Burgos — THE IMPORTANCE OF A HEMIPARASITIC SHRUB IN THE NUTRIENT CYCLING OF A SAND DUNE ECOSYSTEM IN THE SOUTHWEST OF SPAIN | 12 E.O. Box — WARM-TEMPERATE DECIDUOUS FORESTS OF EASTERN NORTH AMERICA, IN GLOBAL PERSPECTIVE | 12 D. Duncan — CAN REVEREND BAYES HELP REDEEM CATEGORICAL VEGETATION ASSESSMENTS TO MONITOR CHANGE OVER TIME? | | | 15h50 |
| 16h10 | | | 13 N. Rossignol — GRAZING CONTROLS THE NET NITROGEN MINERALIZATION RATE THROUGH LITTER QUANTITY IN A WET GRASSLAND | | 13 S.K. Wiser — EXTENDING AND UPDATING CLASSIFICATIONS: AN EXAMPLE WITH NEW ZEALAND'S WOODY VEGETATION | | | 16h10 |
| 16h30 | coffee break | | | | | | | 16h30 |
| 17h00 | poster session | | | | | | | 17h00 |
| 18h30 | | | | | | | | 18h30 |
| 20h00 | Symposium dinner | | | | | | | 20h00 |

# FRIDAY, 24 JUNE

| | | Theatre B *Berula erecta* | Theatre C *Callitriche platycarpa* | Room 105 *Potamogeton coloratus* | Room 204 *Baldellia ranunculoïdes* | Room 208 *Samolus valerandi* | Room 209 *Marsilea quadrifolia* | |
|---|---|---|---|---|---|---|---|---|
| 9h00 | Plenary session | Plenary session: C. Körner | | | | | | 9h00 |
| 10h00 | parallel sessions | | **Alpine vegetation : threats in a changing world**<br>1 G.P. Malanson — ALPINE BIOGEOGRAPHIC CONTEXTS FOR CLIMATE IMPACTS<br>2 G. Jurasinski — HOMOGENIZATION OF EUROPEAN SUMMIT FLORAS UNDER GLOBAL WARMING<br>3 M.-L. Benot — RESISTANCE OF A SUBALPINE MEADOW AFTER TWO YEARS OF SEASONAL CLIMATE CHANGE AND AN EXTREME EVENT | **Landscape dynamics in result of anthropogenic disturbance**<br>1 J. Liira — OLD MANOR PARKS – FROM CULTURAL HERITAGE TO BIODIVERSITY CONSERVATION<br>2 A. Gazol — LANDSCAPE HETEROGENEITY AND MICROSITE CONDITIONS: WHAT DRIVES LOCAL SPECIES RICHNESS?<br>3 A. Jamoneau — NICHE *VS.* NEUTRAL PROCESSES PATTERNING SPECIES ASSEMBLAGES WITHIN FOREST METACOMMUNITIES: A CHRONOSEQUENCE APPROACH | **New insights in descriptive vegetation science**<br>14 M.W. Palmer — EFFECTS OF THE MODE OF PUBLICATION AND CHOICE OF STUDY AREA ON THE NUMBER OF SPECIES IN NORTH AMERICAN FLORAS<br>15 J. Plue — SEED BANKING IN ANCIENT FOREST SPECIES: WHY TOTAL SURFACE AREA REALLY MATTERS!<br>16 F. de Bello — THE MEMORY OF SOIL: DNA BARCODING FROM SOIL MIRRORS PRESENT, BUT ALSO PAST, PLANT DIVERSITY | **Wetland biodiversity and functioning**<br>1 G.L. Rapson — EPHEMERAL DUNE WETLANDS OF THE MANAWATU COAST, NEW ZEALAND - A REVIEW OF TWO DECADES OF CHANGE<br>2 W. Kotowski — ASSEMBLY RULES IN WETLANDS: SHIFTING IMPORTANCE OF CANOPY, WATERLOGGING AND MANAGEMENT DURING 3-YEAR MESOCOSM EXPERIMENT<br>3 U. Deil — ARE WETLANDS AZONAL ECOSYSTEMS? - SPATIAL PATTERNS IN SEASONAL WETLAND VEGETATION IN EXTRATROPICAL AND OROTROPICAL SOUTH AMERICA | | 10h00<br>10h20<br>10h40 |
| 11h00 | coffee break | | | | | | | 11h00 |
| 11h30 | parallel sessions | | **Alpine vegetation : threats in a changing world**<br>4 B. Casper — FLOWERING IN THE MONGOLIAN STEPPE: EFFECTS OF THE TOPOGRAPHY, YEAR, AND CLIMATE MANIPULATION<br>5 D. Urrutia Guevara — THE RESPONSES OF ALPINE PLANT AND SOIL COMPOSITION TO CHANGES IN SNOW COVER IN THE OLD MAN RANGE, NEW ZEALAND<br>6 A. Gutiérrez-Girón — ENVIRONMENTAL VARIABLES AND FUNCTIONAL TRAITS RELATIONSHIPS IN MEDITERRANEAN HIGH MOUNTAIN GRASSLANDS IN CENTRAL SPAIN: A DIRECT APPROACH<br>7 A. Korsten — DO PLANT FUNCTIONAL TRAITS SHIFT ALONG SNOWMELT GRADIENTS? – A MECHANISTIC APPROACH TO DESCRIBE THE TRANS-TRASMAN ALPINE RELATIONSHIP<br>8 B. Cranston — FACILITATION IN THE ALPINE ZONE : IS FACILITATION BY AN ALPINE CUSHION DEPENDENT ON STRESS OR GENDER?<br>9 J. Doležal — NO FACILITATIVE EFFECT OF CUSHION PLANTS: A SURPRISE FROM THE ROOF OF THE WORLD? | **Landscape dynamics in result of anthropogenic disturbance**<br>4 T. Reitalu — RESPONSES OF GRASSLAND SPECIES RICHNESS TO LOCAL AND LANDSCAPE FACTORS DEPEND ON SPATIAL SCALE AND HABITAT SPECIALISATION<br>5 F. Gutierres — LANDSCAPE STRUCTURE AND DYNAMICS OF THE SADO ESTUARY AND COMPORTA-GALÉ NATURA 2000 SITES<br>6 W. Kotowski — DIVERGENCE OF ECOSYSTEM PATHWAYS IN A LARGE FEN SYSTEM AS A RESULT OF REGIONAL DRAINAGE – CASE OF THE RED BOG (BIEBRZA VALLEY, POLAND) | **Vegetation responses to disturbances**<br>1 S.T. Alvarado — VARIATION OF PLANT PHENOLOGY AMONG FIRE REGIMES ON IBITY MOUNTAIN (MADAGASCAR)<br>2 R. de Gouvenain — VARIATION IN POPULATION DEMOGRAPHY AND LIFE HISTORY TRAITS OF TECATE CYPRESS SUGGESTS A PRE-HISTORICAL FIRE REGIME DIFFERENCE ACROSS THE USA-MEXICO BORDER<br>3 L. Battaglia — EFFECTS OF AN EXPERIMENTAL STORM SURGE AND SEDIMENT DEPOSITION ALONG AN ESTUARINE GRADIENT IN NORTHWESTERN FLORIDA, USA<br>4 I. Jüriado — FACTORS CONTROLLING THE DIVERSITY OF GROUND-LAYER LICHENS ON ALVARS OF WESTERN ESTONIAN ISLANDS<br>5 G. Wardell-Johnson — LANDSCAPE AGE, CLIMATE STABILITY AND FIRE REGIME PREDICTABILITY: DEVELOPING AN UNDERSTANDING OF BIODIVERSITY IN OLD STABLE LANDSCAPES | **Wetland biodiversity and functioning**<br>4 M. Alvarez — WEED, GRASSLAND AND SEMI-NATURAL VEGETATION OF EAST AFRICAN SMALL WETLANDS<br>5 F. Landucci — FORMALIZED PHYTOSOCIOLOGICAL CLASSIFICATION OF CENTRAL ITALY WETLAND VEGETATION: SUITABILITY, RESULTS AND OPEN QUESTIONS<br>6 N. Mogha — IMPACT OF LAND USE ON VEGETATION COMMUNITIES AND THEIR FLORISTIC COMPOSITION IN THE SMALL WETLANDS OF EAST AFRICA<br>7 S. Güsewell — SPECIES POOLS AND SMALL-SCALE SPECIES RICHNESS IN WETLANDS: A RELATIONSHIP DRIVEN BY RECRUITMENT LIMITATION?<br>8 T.A. Hodges — *EMPODISMA MINUS* ENGINEERS THE FEN-BOG TRANSITION IN NEW ZEALAND MIRES | | 11h30<br>11h50<br>12h10<br>12h30<br>12h50<br>13h10 |
| 13h30 | lunch | | | | | | | 13h30 |
| 14h30 | General assembly | | | | | | | 14h30 |
| 16h00 | Closing ceremony | | | | | | | 16h00 |
| 17h00 | | | | | | | | 17h00 |

# POSTER SESSION

### Biogeochemical approaches for understanding plant communities and ecosystem functioning

**1** J. Mládek — GRASSLAND RESPONSE TO LONG-TERM MANAGEMENT AND LEVELS OF NUTRIENTS IN STANDING BIOMASS

**2** Y. Goto — EFFECTS OF ELEVATION ON THE NUTRIENT LIMITATIONS OF SOME TREE SPECIES TO PLANT GROWTH ON MT FUJI

**3** P. Merilä — N2 FIXATION ALONG A MIRE CHRONOSEQUENCE

**4** L. Biederman — THE EFFECTS OF BIOCHAR ALONG AN AGRICULTURAL GRADIENT: FERTILITY AND PLANT PRODUCTIVITY

**5** S. Chelli — VARIABILITY IN LEAF FUNCTIONAL TRAITS IN CONTRASTING MOUNTAIN GRASSLANDS IN THE CENTRAL APENNINES OF ITALY

### New insights in descriptive vegetation science

**6** D. Martí Pino — ZAMIADROID: FIELD REGISTRATION OF BIOLOGICAL DATA USING MOBILE DEVICES

**7** A. Zegrar — USING REMOTE SENSING FOR FOREST MAPPING IN A SEMI ARID AREA IN THE NORTH WEST OF ALGERIA

**8** I. Biurrun — ANALYSIS AND CLASSIFICATION OF RIVERINE FORESTS: CHANGES OF THE FLORISTIC COMPOSITION ALONG CLIMATIC GRADIENTS

**9** L. Körmöczi — NEW PERSPECTIVES IN MEASUREMENTS OF MICROCLIMATE OF EDAPHIC COMMUNITIES: WIRELESS SENSOR NETWORKS

**10** N.A. Laskurain — THE INDIVIDUAL RESPONSE OF TREES TO CLIMATE IN A MIXED FOREST IS CONDITIONED BY COMPETITION AND NEIGHBORHOOD COMPOSITION

**11** F. Jansen — THE GLOBAL INDEX OF VEGETATION-PLOT DATABASES (GIVD): A NEW RESOURCE FOR VEGETATION SCIENCE

**12** A. Gastón — HISPAVEG: A NEW ONLINE VEGETATION PLOT DATABASE FOR SPAIN

**13** A. Fukamachi — SPATIAL DISTRIBUTION AND HABITAT CHARACTERISTICS OF FIVE *CHRYSOSPLENIUM* L. SPECIES IN THE *FRAXINUS PLATYPODA* FOREST

**14** J. Sawtschuk — A MICRO-DATA TRANSITION MATRIX MODEL TO IMPROVE SUCCESSION DESCRIPTION FOR RESTORATION.

**15** L. Casella — CAUSALISTIC ANALYSIS OF THE RANGE OF *STYRAX OFFICINALIS* IN ITALY

**16** M. Kaligarič — TO WHAT EXTEND DOES FUNCTIONAL CLASSIFICATION MATCH WITH PHYTOSOCIOLOGICAL SCHEME? A CASE OF HALOPHYTE VEGETATION

**17** H. Feilhauer — COMBINING ORDINATION AND REMOTE SENSING TECHNIQUES TO MAP ECOTONES IN A HETEROGENEOUS LANDSCAPE

**18** M. Saulais — SURVEY OF PLANT COLONIZATION OF A STORMWATER INFILTRATION BASIN THROUGH STATIC AND DYNAMIC APPROACHES

### Biological invasions: towards general models and increased predictability

**19** S.M. Koontz — PLANT COMMUNITIES AND SUCCESSIONAL PROCESSES IN A SECOND-GROWTH EASTERN DECIDUOUS FOREST, BALTIMORE MD

**20** G.P. Sharma — ECO-PHYSIOLOGICAL PERFORMANCE OF FIVE INVADERS WITH DIFFERENT LIFE SPANS: IMPLICATION FOR MANAGEMENT

**21** E. Carli — THE SPREAD OF *AMORPHA FRUTICOSA* L. ALONG THE RIVERS: THE CASE STUDY OF THE BIFERNO RIVER (MOLISE, CENTRAL ITALY).

**22** S. Masson — ORIGIN AND IMPACT OF BRAMBLE COLONIZATION ON THE BIODIVERSITY OF A XERIC STEPPE: WHICH TYPE OF ECOLOGICAL RESTORATION?

**23** S. Landi — DO COMMON AND ALIEN SPECIES FOLLOW ANALOGOUS TRENDS? AN APPROACH TO MINIMIZE THE ALIEN SPECIES DIFFUSION

**24** C. Rodriguez — A PHYTOMETRIC ASSESSMENT OF WETLAND VULNERABILITY TO INVASIONS

**25** S.P. Bako — THREATS AND POTENTIALS OF INVASIVE MACROPHYTE SPECIES TO INLAND FRESHWATERS IN RELATION TO CHANGING CLIMATE IN NORTHERN NIGERIA

**26** J.R. Arévalo — HERBICIDES AND MECHANICAL CONTROL OF *OPUNTIA DILLENII* AND *AGAVE AMERICANA* IN THE RURAL PARK OF TENO

### Conservation and restoration of plant communities

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# Plenary lectures

## Monday, 20 June

### Dr. Paul KEDDY
Ontario, Canada

***Vegetation In and Around Water—Two Perspectives on Wetlands: Special Features and General Rules for Vegetation Science***

In this presentation, Dr. Paul Keddy (www.drpaulkeddy.com) will begin with some special features of vegetation in wet places, such as plant traits that allow flood-tolerance, and striking zonation patterns. The majority of the talk will then focus on general principles from wetlands that can be applied to all plant communities. These principles will include (1) competitive hierarchies, (2) zonation patterns, (3) stress-tolerant plant communities, and (4) assembly rules from traits and filters. He will draw upon examples from his two recent books, Plants and Vegetation: Origins, Processes Consequences and Wetland Ecology: Principles and Conservation – and include mention of the Camargue and its flamingos, which are only a short drive south from Lyon.

## Tuesday, 21 June

### Prof. John S. RODWELL
Lancaster, United Kingdom

***A Place for Ecology***

The UK National Vegetation Classification has made a great difference to the way in which all manner of environmental professionals do business with the natural world, as well as illuminating the spectrum of scepticism, uncertainty and trust with which practitioners and customers variously regard science. Results from some of its many applications also reveal attitudes and practices that subvert the benefits of ecological research. On the one hand, spurious notions of the 'wild' minimise legitimate cultural claims to relationships with place while much conservation and landscape planning works to obliterate the fuzziness and dynamism of green infrastructure and creative interactions between nature and humankind. The policy frames to which many of us now work also exert a particular twist, imposing unrealistic targets for landscape management and inflexible measures of environmental condition. For some, the ethical implications of ecological endeavour are not a legitimate part of our professional integrity, yet the notion of ecosystem services, widely welcomed, presses such moral decisions upon us – or provides an opportunity for negotiating a more imaginative relationship to the natural world. Ecology has a place in relating environmental value and condition to human well-being in ways that neither enslave the natural nor fail to liberate human resourcefulness to find its place in a sustainable world among other creatures.

### Emer. Prof. J. Philip GRIME
University of Sheffield, Sheffield, United Kingdom

***The twin-filter model of plant community assembly and ecosystem functioning***

This talk will summarise arguments and evidence that address an old conundrum in plant ecology "How similar must two organisms be to exploit the same environment and how different to coexist?"

## Thursday, 23 June

### Dr. Eric GARNIER

Centre d'Ecologie Fonctionnelle et Evolutive, Montpellier, France

### *A framework to scale-up from species to ecosystem functioning using species traits and abundance*

One pending question in ecology is to understand how species influence ecosystem functioning (EF). It is now admitted that functional diversity, defined as the value, range and relative abundance of functional traits present in a community, is one of the major factors affecting this functioning. In particular, some specific traits of the dominant species, called effect traits, are thought to strongly influence EF, which is often referred to as the "biomass ratio hypothesis". In parallel with these questions, the current development of standardized protocols for the measurement of plant traits and data bases centralizing the wealth of information on species traits and relevés makes it possible to predict EF on a unprecedented scale, within the range of applicability of the biomass ratio hypothesis. This will be possible if (i) the trait(s) relevant to the ecosystem function of interest is (are) clearly identified, and (ii) the trait value(s) extracted from the data bases can be used in the situations where the relevés are available. This will depend on whether the differences in environmental conditions between the location of the relevé and that where the trait was initially measured are large, and whether the intraspecific variability of the trait is substantial. Here, I will present a framework that articulates the different steps involved in the approach presented above, and apply it to the case of litter decomposition. Community-level decomposition of leaf litter measured in a Mediterranean old-field succession in Southern France was significantly related to the community weight mean leaf dry matter content (LDMC), calculated from species abundance and LDMC of individual species measured in situ. I will show here community-level decomposition can also be successfully predicted when species LDMC data are taken either from an experiment conducted in an experimental garden or from the LEDA data base, in which trait data are available for populations from the North-Western part of Europe. These findings validate the general framework proposed in the case of a particular process for which a relevant trait can be identified.

## Friday, 24 June

### Prof. Dr. Christian Körner

University of Basel, Basel, Switzerland

### *Alpine vegetation under environmental change*

Environmental change has many facets and alpine vegetation may respond to all of them, though to variable degree. I will address responses to 5 categories of change: (1) rise in temperature, (2) associated likelihood of drought, (3) rising CO2 concentration, (4) enhanced soluble nitrogen deposition and (5) change in land use. With temperature, we are dealing with a rather curious situation. While the cold climate at high elevation had been traded as a major constraint to life, it is now believed that warming is a threat. Obviously, it cannot be both at the same time. The conflict emerged from a wide spread misconception about the nature of 'stress', which will be the starting issue of this lecture. Climatic warming will interact with plant phenology (which is often controlled by photoperiod rather than temperature) and with topography effects on microclimate. Although, the water balance improves with elevation in most temperate mountains, extreme drought events are likely to affect also alpine biota, and these affects may be enhanced by fire in low latitude alpine vegetation. As far as we know from in situ experiments, elevated CO2 has no direct effect on alpine plants (yet some long-term, species specific responses cannot be excluded), but even minor increases in soluble nitrogen loading exert a major impact in a species specific way. Changes in landuse, though often forgotten in the global change debate, are of paramount significance and associated effects may overrun any other global change influence, although effects may be absent in the uppermost alpine and nival belt, but can become overruling at the treeline interface. I will close by discussing the likelihood of an advance of the alpine treeline and the consequences for alpine land area, should treeline position track climatic warming. It will be concluded that mountain biota in general are in a better position than many lowland biota when environmental conditions change, because topography offers a mosaik of alternative microhabitats at short distance. Not surprinsingly mountains have always been refugia in a changing climate. Yet the areal extent of certain types of vegetation and distributional ranges of some species will shrink, while others will expand.

# ABSTRACTS OF PRESENTATIONS

# Biogeochemical approaches for understanding plant communities and ecosystem functioning

Session ‘Ecosystem functioning’ / ORAL

## NITROGEN CYCLING IN A LOWLAND MACROPHYTE STREAM

**Tenna Riis[1], Walter K. Dodds[2], Peter B. Kristensen[1], Annette Baisner[1]**

*[1] Aarhus University, Dept. of Biological Sciences, Aarhus, Denmark; [2] Kansas State University, Division of Biology, Manhattan KS, USA*

Keywords: stream ecosystems, macrophytes, nitrogen cycling, $^{15}$N-release

Understanding nitrogen (N) cycling, retention and transformation in streams is important for improving predictions of the effect of increased N inputs to the biosphere. The release of $^{15}$N-labeled ammonium has been used to study N cycling in a range of stream types, but until now, it has never been used to study this process in a lowland, macrophyte-rich stream. We conducted a 12-day $^{15}$N-ammonium release in a 63 Liter.s$^{-1}$ Danish lowland stream that is dominated by *Ranunculus aquatica* and *Callitriche* sp. to assess the N-flux pathways in a macrophyte-dominated stream. Macrophyte-dominated streams are expected to function differently in N cycling compared to forested headwater streams and open streams with no macrophytes. We expected that macrophyte-dominated streams would have more nitrogen retention and flux into the food web because the water exchange rate is slowed, and there is a larger biologically active surface area. Macrophytes stayed labeled with $^{15}$N up to 100 days after enrichment. The epiphytes on the macrophytes were highly active, reflecting the water nitrogen content. The uptake length for ammonium was 303 m, indicating that the ammonium pool was turning over rapidly. These results will be compared to earlier $^{15}$N-ammonium release studies in other stream types, and the effect of macrophytes on nitrogen cycling in streams will be discussed.

Session ‘Ecosystem functioning’ / ORAL

## FLUVIAL-GEOMORPHIC PROCESSES OF SALT MARSH CREEKS SHAPE SPATIAL TRENDS IN VEGETATION ACROSS ENVIRONMENTAL STRESS GRADIENTS

**Daehyun Kim [1], David M. Cairns [2], Jesper Bartholdy [3]**

*[1] Department of Geography, University of Kentucky, Lexington, USA; [2] Department of Geography, Texas A&M University, College Station, USA; [3] Department of Geography & Geology, University of Copenhagen, Copenhagen, Denmark (corresponding author: biogeokim@uky.edu)*

Keywords: salt marsh vegetation, tidal creek processes, waterlogging, salinity, biogeomorphology

The zonal patterns of plants and physical conditions of salt marsh have been addressed across the elevation gradient from the coastline to inland areas, but they have rarely been addressed across tidal creeks in relation to their hydrogeomorphic processes. Therefore, the role of such processes in salt marsh ecology is unclear. To evaluate this role, we investigated cross-creek trends in physical stresses and vegetation at a Danish salt marsh. The results showed that creek meandering concentrated fine sediments on marsh interiors and coarse grains on high levees near the streams. Consequently, in poorly drained interiors, saline water could remain after inundation to evaporate and accumulate salts, while the well-drained levees experienced reduced salinity. The occurrence of the highest salinity at these mid-elevation interiors, not at the lowest point bars with frequent waterlogging, is at odds with conventional expectations. This finding suggests that, based solely on surface elevation, it is difficult to define a single, overriding stress gradient around tidal channels. The levees showed high diversity due to the competitive exclusion of inferior low-marsh plants by dominant high-marsh competitors. The saline interiors exhibited the coexistence of many low-marsh plants, whereas in the anoxic bars, very high evenness of pioneers was observed. The unexpectedly high diversity at stressful interiors and bars is hypothesized to result from niche differentiation and resource partitioning. By shaping major geomorphic features and providing sediments to the adjacent sites, fluvial geomorphic processes in tidal creeks exert fundamental controls on the cross-channel distribution of abiotic and biotic factors. These results point to a need for more empirical studies that explicitly include such biogeomorphic aspects of salt marsh ecology.

Session 'Ecosystem functioning' / ORAL

## EFFECTS OF WATER LEVEL SEASONAL FLUCTUATION ON SUBSTRATE CHEMISTRY AND COMMUNITY STRUCTURE OF A CALCAREOUS FEN

**Mati Ilomets, Laimdota Truus, Raimo Pajula, Kairi Sepp**

*Institute of Ecology at Tallinn University, Tallinn, Estonia; e-mail: ilomets@tlu.ee*

Key words: calcareous fen, water level, substrate chemistry, plant species

Calcareous fens, which are under severe threat worldwide, are characterized by a nutrient-pure environment and permanently near-surface water level and are inhabited with communities consisting of many rare and endangered plant species. The main aim of this study was to assess the response of plant assemblages and species to changes in peat substrate chemistry as controlled by the amplitude of the water level seasonal fluctuation (AWLSF). On the Paraspõllu calcareous fen (approx. 40 ha) in northern Estonia, the coverage of vascular and moss species, tot-N, tot-P, tot-S and metal concentrations (Ca, Mg, Fe, Na, and K) of the surface peat and mire water were studied at 34 locations. The mire water level, pH and electric conductivity (EC) were monitored for 3 years. Two groups of analyses were distinguished by AWLSF less than 10 cm (undrained) and AWLSF over 30 cm (weakly drained), which were divided thereafter into two plant assemblages: *Menyanthes trifoliata-Campylium stellatum+Scorpidium cossonii+Calliergonella cuspidata, Schoenus ferrugineus+Molinia caerulea-Sc.cossonii and M. caerulea+ Sch. ferrugineus, M. caerulea*, respectively. The first assemblage differed significantly from others by higher Na, Mg, Fe, tot-P, and lower tot-N concentrations in the peat and a higher Ca concentration in the mire water. With increasing AWLSF, the N but not P concentration in the peat substrate increased. The coverage of vascular plant species was well correlated with small changes in AWLSF in the undrained part of the fen. This finding indicates that species inhabiting the undrained calcareous fen site are very sensitive to even small differences in the AWLSF. The Mantel test indicated a weak but significant relationship in the species composition and coverage between the field and surface layers. The most important driver of the habitat conditions is AWLSF, but the vascular plant species distribution was well correlated with N, Mg, and Fe concentrations in the peat and the Ca concentration in the mire water. Weakly interrelated N and P concentrations in the substrate divided the moss species into groups with low N and high P, high N concentration and high N/P ratio, respectively.

Session 'Ecosystem functioning' / ORAL

## CARBON DYNAMICS AND VEGETATION SUCCESSION DURING MIRE DEVELOPMENT

**Eeva-Stiina Tuittila[1], Mirva Leppälä[1,2], Anna Laine[1]**

*[1]University of Helsinki, Department of Forest Sciences, Helsinki, Finland, [2]Metsähallitus, Natural Heritage Services Pohjanmaa, Oulu, Finland (corresponding author: eevastiina.tuittila@helsinki.fi)*

Keywords: Peatland, $CO_2$, $CH_4$, water level, Sphagnum

With peat accumulation during mire development, the conditions for plants and microbes change; consequently, there are changes in mire functions, including changes in carbon dynamics. Along the Finnish coast, uplift continues to take place, and primary mire paludification occurs. Therefore, a primary successional series of mire ecosystems can be found from the coast to inland areas. We used the spatial continua of pristine mires to link the succession of plant communities to changes in carbon dynamics.

We measured carbon dioxide ($CO_2$) and methane ($CH_4$) dynamics from seven sites over a ten-km transect located from the coast to an inland area. The transect covered successional stages from a first step of primary paludification to a bog stage, with terrestrial ages from 50 to 3,000 years. In each site, sampling covered characteristic variations in the vegetation composition and water table (WT) level.

Plant community structure and hydrology appeared to be the key factors in regulating both $CO_2$ and $CH_4$ dynamics. Plant functional types differed in their abilities to photosynthesize. As a consequence, during a normal growing season, younger sites that are dominated by grasses and sedges were larger $CO_2$ sinks than older sites with dwarf shrubs and *Sphagnum* mosses. In these conditions, the younger sites with sedges also had larger $CH_4$ emissions than older sites. However, during a dry year, the dynamics changed. At young sites, the WT collapsed, while in older sites, it stayed close to the mire surface. The stability of the WT, which results from an increase in the *Sphagnum* cover and peat layer thickness, appeared to increase during succession. The lowered WT resulted in a decreased leaf area, which was reflected in decreased photosynthesis, respiration and methane emissions in young sites during a dry year. By contrast, in older sites, there was no significant difference in the leaf area and ecosystem carbon gas exchange between years. Our results indicate that the stability of ecosystem function increases during succession.

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## PHOSPHORUS AVAILABILITY LIMITS BOTH PRIMARY PRODUCTION AND DECOMPOSITION AT INCREASING LEVELS OF ATMOSPHERIC NITROGEN DEPOSITION IN BOG ECOSYSTEMS

**Renato Gerdol[1*], Laura Bombonato[1], Luca Bragazza[1,2], Lisa Brancaleoni[1]**

*[1] University of Ferrara, Department of Biology and Evolution, Corso Ercole I d'Este 32, I-44121 Ferrara, Italy; [2] École Polytechnique Fédérale de Lausanne (EPFL), School of Architecture, Civil and Environmental Engineering (ENAC), Laboratory of Ecological Systems (ECOS), Batiment GR, Station 2, CH-1015 Lausanne, Switzerland; * grn@unife.it*

Keywords: Carbon balance, Litter decomposition, N:P ratio, Peatland

In this presentation, we summarize the results of three studies, showing that under increasing levels of atmospheric nitrogen (N) deposition, both primary production and organic-matter decomposition in bog ecosystems are limited by phosphorus (P) deficiency.
1. After eight years of experimental fertilization in an alpine bog, N addition caused a strong reduction in the primary production of *Sphagnum* mosses and a concomitant increase in the cover of vascular plants (especially graminoids and, to a lesser extent, evergreen shrubs). However, the increase in vascular cover at the expense of *Sphagnum* mosses was much less evident when P was applied in combination with N.
2. At a number of European bog sites that are located across a natural gradient of bulk atmospheric N deposition (0.1-2 g $m^{-2}$ $yr^{-1}$), we observed a saturating trend in the N:P ratio of living *Sphagnum* tissues in regions where atmospheric N deposition is >1 g $m^{-2}$ $yr^{-1}$. Hence, high atmospheric N deposition rates result in a stoichiometric imbalance in *Sphagnum* tissues, which prevents excess N from being absorbed by the mosses. This in turn enhances N availability in the root layer, stimulating the growth of vascular plants.
3. Experimental assessments of litter decomposition rates in two peatlands in the southeastern Alps of Italy showed that litter decomposability principally depends on the chemical nature of the decaying plant material, with the percentage of mass lost ranked as follows: forbs > shrubs = graminoids > *Sphagnum* mosses. However, the litter decomposition rates of all litter types were consistently higher at lower N:P ratios. A companion study revealed a consistent increase in phosphatase activity, which suggests that P availability plays a primary role in controlling litter peat decay by exerting a nutritional constraint on the activity of soil microbes.

Session 'Ecosystem functioning' / ORAL

## MICROBIAL COMMUNITY FUNCTIONAL GROUPS: LINKS TO VEGETATION AND ECOSYSTEM PROPERTIES OF SEMI-ARID GRASSLANDS IN SOUTHEASTERN AUSTRALIA

**M.R Wong[1,2], J.W Morgan [3], N.K Wong [3], T.C Cavagnaro [1,2]**

*[1] Monash University, School of Biological Sciences and [2] Australian Centre for Biodiversity, Clayton, Australia; [3] LaTrobe University, Department of Botany, Bundoora, Australia*

Key words: Microbial community, functional groups, ecosystem properties, semi-arid grasslands

Given the key role of soil microbes in nutrient cycling, the functional classification of microbial communities can provide insight into the mechanistic links between community change, ecosystem properties and ecosystem function. For example, a higher ratio of fungi relative to bacteria (F:B) is often associated with low fertility or levels of disturbance. Plant growth and nutrient recycling is generally slower in such habitats and more rapid in fertile or disturbed habitats. This study tests the association of F:B with ecosystem properties in the semi-arid perennial tussock grasslands of the Riverine Plains in southeastern Australia.
This grassland system is shaped largely by land abandonment and prior agricultural use, so sites were selected in the context of a state and transition model that was previously developed for this system. The 24 sites included a range of native vegetation qualities and land use histories, from never-cultivated native remnants to exotic pastures that are still in production. Plant cover was estimated using point transects, soil physiochemical properties were analyzed, and phospholipid fatty acids were measured for F:B.
As the level of fungi relative to bacteria increased, the cover of native (predominantly perennial) plant species also increased. This finding was correlated with a decrease in the levels of carbon (total C and total Organic C) and nutrients (N, P and K). It is predicted that with this increase in F:B, the C-S-R functional signature of plant communities will shift toward higher stress coordinates, the results of which will be discussed. F:B ratios were not associated with soil carbon-to-nitrogen ratios or the amount of nitrogen available for mineralization by microbes under anaerobic incubation (potentially mineralizable N).
The association of F:B ratios with a number of key ecosystem properties demonstrates that in this grassland system, microbial functional groups may be a useful tool for understanding the links between community change and ecosystem properties and ultimately ecosystem functions relating to nutrient cycling.

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## NUTRIENT CONCENTRATIONS IN PLANT COMMUNITY BIOMASS REFLECT SPECIES RICHNESS PATTERNS IN A BROAD RANGE OF AGRICULTURAL GRASSLANDS

**Valentin H. Klaus [1]*, Till Kleinebecker [1], Norbert Hölzel [1], Steffen Boch [2], Jörg Müller [3], Stephanie A. Socher [2], Daniel Prati [2], Markus Fischer [2,3]**

*[1] University of Münster, Institute of Landscape Ecology, Robert-Koch-Str. 28, D-48149 Münster, Germany; [2] University of Bern, Institute of Plant Sciences, Altenbergrain 21, CH-3013 Bern, Switzerland; [3] University of Potsdam, Institute of Biochemistry and Biology, Maulbeerallee 1, D-14469 Potsdam, Germany; * Corresponding author, Tel +49 251 8339770, E-Mail address v.klaus@uni-muenster.de*

Keywords: biodiversity explorations, land use, nitrogen, nutrient limitation, phosphorus

Understanding the changes in biodiversity in agricultural landscapes in relation to land use is a major issue in current plant ecological research. In this context, enrichment of nutrients by land-use intensification has been identified as a key mechanism inducing species loss in Central European grassland ecosystems. Insights into the linkage of nutrient status and plant diversity are crucial for both fundamental research and biodiversity conservation. Based on 145 grassland plots arranged along a broad gradient of land-use intensities in three regions in Central Europe, we present a comprehensive study on the relationship between vascular plant species richness and nutrient concentrations in the aboveground biomass. We found the nutrient composition in the aboveground community biomass to be closely linked to plant species richness and land use. Whereas phosphorus concentrations strongly increased with land-use intensity and decreased with plant species richness, nitrogen and potassium concentrations exhibited less clear patterns. High N:P ratios indicating a shift from N to NP or P limitation were strongly correlated with the number of particularly endangered plant species. Thus, we suggest that the N:P ratio of the aboveground biomass is a useful indicator of the conservation value of grasslands. However, these relationships differed strongly among land-use types and study regions, highlighting the importance of regionally replicated studies incorporating a broad range of land-use intensities.

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## EFFECTS OF SNOW DEPTH ON LITTER DECOMPOSITION RATES FROM CONTRASTED PLANT SPECIES IN SUBALPINE MEADOWS

**Patrick Saccone[1], Charlotte Collomb[1], Roberto Geremia[1], Jean-Marc Bonneville[1], Florent Domine[2], Franck Poly[3], Jean-Christophe Clement[1]**

*[1] Laboratoire d'Ecologie Alpine, Université Joseph Fourier, Grenoble, France; [2] Laboratoire de Glaciologie et Geophysique de l'environnement, Université Joseph Fourier, Grenoble, France; [3] Laboratoire d'Ecologie Microbienne, Université Lyon 1, Lyon, France*

Keywords: Litter decomposition, Snow cover, Nitrogen cycle, Subalpine meadows

The expected warming of frozen soils and the resulting biogeochemical activities raise strong questions about potential feedback with global changes. For instance, while the activation of microbial activities in unfrozen soils could release greenhouse gases, global warming could also induce a decrease in the snow cover and indirectly increase the duration of soil freezing. At a local scale, the complex web of interactions among snow, plant (litter), soil and microorganisms needs to be more deeply investigated. For this purpose, we explored some of these relationships during the winter by monitoring litter decomposition, the physical and chemical properties of snow, soil parameters and soil N mineralization potential in subalpine meadows of the French Alps. We set up a litter bag experiment at two contrasting elevations along a snow depth gradient using two species that differed in plant strategy: one was exploitative (*Dactylis glomerata),* and one was conservative (*Festuca paniculata).* We monitored the temperature at the snow/soil interface during the entire season. Our results showed better litter decomposition under a deeper snow pack and that the species strategy was the determinant of the litter decomposition rate. Soil chemical analyses showed similar potential nitrogen mineralization rates under both snow depths, but higher nitrate exportation was found under thin snow cover. In a context of a synergic effect between climate changes and land-use changes, these results could indicate deep changes in subalpine biogeochemical cycles.

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## INDICES OF LIGHT AND NITROGEN RESOURCE USE AND CHANGES IN THE ALLOCATION PATTERN ALONG A PRODUCTIVITY GRADIENT OF GRASSLAND

**Anne Aan[1,2], Olevi Kull[1], Krista Lõhmus[1], Arne Sellin[1]**

*[1] University of Tartu, Institute of Ecology and Earth Sciences, Tartu, Estonia; [2] Natural History Museum of Tartu University, Tartu, Estonia*

Keywords: coexistence, light partitioning, nitrogen, allocation pattern, plasticity

Patterns of light and nitrogen use indices were studied in two contrasting types of herbaceous vegetation. The first community (wet, W) is characterized by smaller productivity gradient, with an aboveground biomass that ranges from 341 to 503 g $m^{-2}$. It is dominated by one species *Molinia caerulea*. The other community (dry, D) exhibits a biomass gradient from 248 to 682 g $m^{-2}$ and has several dominant species: *Filipendula ulmaria*, *Elymus repens*, and *Brachypodium pinnatum,* which replace each other. Both biomass gradients are formed by soil humidity and nitrogen gradients. The leaf area ratio (LAR) increases in the monodominant community (W) with increased soil fertility but decreases in the co-dominated community (D). Competition is more asymmetric in the monodominant community (with higher LAR and leaf area index, LAI) in site W compared to site D, which had a lower LAR. More asymmetric light competition is probably caused by similar shoot architectures and leaf arrangements in large and small individuals of the same dominant species. Light absorption per biomass ($\Phi_M$) decreased linearly in site D with increasing community productivity, revealing that index $\Phi_M$ is strongly influenced by increased light use efficiency (LUE). As the species differed little in their aboveground nitrogen use efficiency (aNUE), species replacement along the productivity gradient did not cause an increase in community aNUE and light absorption per leaf nitrogen ($\Phi_N$) because a ratio of NUE/LUE decreased monotonously with increasing community productivity. In the W site, the decrease was not significant. A trade-off between foliar nitrogen content ($N_A$) and LAR was established: large LAR and low NA characterized the monodominant community, while the co-dominated community had low LAR and high $N_A$. There exist two contrasting types of plastic responses. The first type of plant responds to increases in soil fertility and light competition with increasing LAR, and the second type of plants reduces their LAR. The high-LAR community indicated a tendency toward lower NUE compared to the low-LAR vegetation.

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## ABOVE- AND BELOWGROUND BIOMASS AND CARBON DYNAMICS IN TROPICAL WET GRASSLANDS

**Alessandra Fidelis[1,2], Maria Fernanda di Santi Lyra [1], Vânia Regina Pivello [1]**

*[1] Universidade de São Paulo, Department of Ecology, São Paulo, Brazil; [2] (corresponding author: fidelis@usp.br)*

Keywords: fire, seasonality, Cerrado, root:shoot ratio, allocation

Grassland ecosystems dominate large areas around the world and potentially influence global carbon reserves. However, limited data about carbon stocks and biomass are available for these ecosystems. The Brazilian Cerrado comprises a gradient of different types of grassy ecosystems (grasslands and savannas) where fire is a key factor influencing the vegetation physiognomy and dynamics. Studies on Cerrado carbon stocks usually consider only the aboveground biomass, while most of the biomass in such ecosystems is accumulated below the ground. In this study, we aimed to evaluate above- and below-ground biomass and carbon dynamics in Cerrado wet grasslands according to different fire histories (burned every two years, B2, and excluded from fire for four years, B4) and seasons (dry and rainy). In three wet grassland sites, we sampled eight plots (0.25 x 0.25 x 0.2 m) with different fire histories (B2 and B4, 48 samples) during the dry season (end of September), and additional eight plots during the rainy season (B2, 24 samples). We separated both above- and below-ground biomass into different categories: dead, graminoids, forbs, belowground organs and roots. All material was dried (60°C for five days) and weighed. The biomass was multiplied by 0.45 to calculate the carbon values. To verify the statistical differences in biomass among the different seasons and fire histories, we performed ANOVA applied to randomization tests. There was no significant difference in the total biomass according to fire history. However, dead biomass was greater at B4 ($P=0.01$). We found significantly higher accumulation of below-ground biomass during the dry season ($P=0.003$), and the dead biomass increased from the dry season to the rainy season ($p=0.02$). The greatest percentage of carbon, approx. 40%, was found below the ground, and approx. 35% was found in the graminoids biomass. Our study is the first to estimate above- and below-ground biomass and carbon contents according to fire history and season in Cerrado grasslands. Moreover, this study shows that these grasslands are potential carbon pools; therefore, they should be considered in further studies about the effects of climate change in carbon pools.

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## TOWARD AN UNDERSTANDING OF THE TROPHIC RELATIONSHIPS BETWEEN PLANTS AND HERBIVOROUS INVERTEBRATES

**Marco Moretti [1], Sébastian Ibanez [1,2], Francesco de Bello [3], Christian Rixen [4], Sandra Lavorel [2]**

*[1] Swiss Federal Research Institute WSL, Community Ecology, Bellinzona, Switzerland; [2] Laboratoire d'Ecologie Alpine CNRS UMR 5553, Université Joseph Fourier, Grenoble Cedex 9, France; [3] Institute of Botany, Czech Academy of Sciences, Department of Functional Ecology, Třeboň, Czech Republic; 4 Swiss Federal Institute for Snow and Avalanche Research SLF, Davos, Switzerland (corresponding author: marco.moretti@wsl.ch)*

Keywords: plant-herbivore interaction, trophic trait cascade, herbivory, grasshoppers, functional traits

Understanding how multi-trophic interactions affect plant community composition and distribution and their possible effects on ecosystem processes and resulting ecosystem services is a key challenge in functional ecology. In particular, it has been suggested that herbivore feeding strategies and feeding traits should combine to shape plant traits, plant community composition and ecosystem functions such as production, decomposition, and elemental cycling. We quantified the functional trait relationships between grasshoppers and plants and their effects on fodder production under five different management regimes in a subalpine grassland ecosystem from the Central French Alps. We used a recently developed conceptual framework of a trophic cascade based on the Holy Grail hypothesis, which considers the response and effect traits at multiple trophic levels. The covariations of selected plant and grasshopper traits across management regimes were analyzed using Community weight mean traits (CWM) and trait dispersion (Rao's quadratic diversity). Co-intertia Analyses showed that grasshopper and plant CWMs and Rao coefficients have a common structure under different management regimes. Partial univariate and multivariate RDAs provided evidence about the relative importance of response and effect traits that are involved in the trophic cascade. Our study showed that the management regime affects both plant and grasshopper traits, with effects on trophic interactions between the two guilds but without a clear link to fodder production through the trophic cascade. Cafeteria experiments with 24 plant species and 1 grasshopper species suggest that the grasshopper species distribution is influenced by factors other than preferred food dominance or diversity, such as management and habitat conditions. The diversity of plant traits in the communities might be sufficient to provide adequate food for grasshoppers, which is therefore not a limiting factor for grasshopper abundance. Analyses of multi-trophic systems provide a powerful and promising tool to quantify how these trophic interactions influence ecosystem service delivery.

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## THE IMPORTANCE OF A HEMIPARASITIC SHRUB IN THE NUTRIENT CYCLING OF A SAND DUNE ECOSYSTEM IN THE SOUTHWEST OF SPAIN

**Javier Valera-Burgos[1], Elena Kazakou[2], Eric Garnier [2], M. Cruz Díaz Barradas [1], María Zunzunegui [1]**

*[1] Department of Plant Biology and Ecology, University of Seville. Seville (Spain); [2] Centre d´Écologie Fonctionnelle et Évolutive, Montpellier (France)*

Keywords: Decomposition, Mediterranean, NIRS, Hemiparasitic

In terrestrial ecosystems, more than 90% of the net above-ground production returns to the soil as litter, so litter decomposition is a key process in the nutrient cycling of most terrestrial ecosystems. Mediterranean ecosystems are nutrient-poor systems with low-fertility soils. Studies have described the important roles of some hemiparasitic species in poor ecosystems, including increasing the soil fertility and enhancing plant growth. The aim of this study was to determine the role of the hemiparasitic dioecious shrub *Osyris lanceolata Hocht. & Steud.* in a Mediterranean sand dune ecosystem located in the southwest of the Iberian Peninsula, mainly associated with the Stone pine (*Pinus pinea L.*). We studied some traits (SLA, LDMC, LNC, LCC) of the living leaves of 4 representative woody species at the study site (*P. pinea*, *Cistus salvifolius L.*, *Halimium halimifolium (L.) Willk*. and *O. lanceolata*) and the decomposition rates of the same four species, developing two methods: 1) litter-bag experiments (in the field and under microcosm conditions) and 2) the near-infrared reflectance (NIR) spectral characteristics of litters from these four species. Our results confirm that *O. lanceolata* litter has a higher nitrogen concentration in senescent leaves than the other woody species (approx. twice as high), which is a limiting resource in poor ecosystems, and releases nutrients to the soil; this hemiparasitic species also has a high decomposition rate. Therefore, NIRS is a powerful tool to predict litter decomposability.

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# GRAZING CONTROLS THE NET NITROGEN MINERALIZATION RATE THROUGH LITTER QUANTITY IN A WET GRASSLAND

**Nicolas Rossignol, Anne Bonis**

*UMR CNRS 6553, ECOBIO, Université de Rennes 1, Campus de Beaulieu, 35042 Rennes Cedex, France (corresponding author: anne.bonis@univ-rennes1.fr)*

Keywords: Heterogeneous grazing, N mineralization rate, N immobilization, plant litter quality and quantity, soil microbial biomass

Herbivores influence nutrient cycling, mainly by driving vegetation composition, litter accumulation on the soil and deposition of excreta. Focusing on the changes in vegetation quality and quantity resulting from a grazing gradient, this study intends to disentangle the respective effects of reduced litter quantity and enhanced litter quality on the net nitrogen (N) mineralization rate.

The rates of net N mineralization in the soil and both the quantity and quality of litters were characterized in various plant patches occurring within an area of grazed grassland. Soil incubations were also performed in controlled conditions to assess the respective role of litter quantity and quality on N mineralization.

In laboratory incubations, the effect of litter quantity on net N mineralization rates was found to depend on litter quality. High inputs of litter produced by grazing-promoted species (C/N 11) stimulated the net N mineralization rates, while high inputs of litter produced by grazing-reduced species (C/N 46) decreased the rates of net N mineralization. The intensity of either the negative or positive effects of litter was then regulated by litter quantity. In the field, litter quality only varied within a limited range. Litter with the highest quality in the field (C/N 22) had the same negative effect on N mineralization than the lowest quality litter (C/N 46). Grazing-induced variations in litter quality, monitored in the field, appeared unlikely to cause the measured variations in the net N mineralization rates. Litter with C/N ratios of 46 and 22 stimulated N immobilization, and reduction of their inputs increased the rate of N mineralization due to decreased microbial N immobilization. Intra-grassland variations in litter quantity were large and negatively correlated with net N mineralization rates. Our results support the hypothesis that grazing influences net N mineralization rates by controlling microbial N immobilization, mainly through changes in the quantity of litter-Carbon supplied to the soil. Finally, we discussed the consequences of grazing-induced vegetation patchiness and long-term floristic changes with grazing on the functions of grassland.

Session 'Ecosystem functioning' / POSTER 1

## GRASSLAND RESPONSE TO LONG-TERM MANAGEMENT AND LEVELS OF NUTRIENTS IN STANDING BIOMASS

**Jan Mládek[1], Pavla Mládková[2], Michal Hejcman[2,3], Stanislav Hejduk[4], Vilém Pavlů[2,3], Martin Duchoslav[1]**

*[1] Palacký University, Department of Botany, Olomouc, Czech Republic; [2] Czech University of Life Sciences, Department of Ecology, Prague, Czech Republic; [3] Crop Research Institute, Prague, Czech Republic; [4] Mendel University, Department of Animal Nutrition and Forage Production, Czech Republic (corresponding author: jan.mladek@upol.cz)*

Keywords: Grazing, Fallow, Leaf dry matter content, Mowing, Standing biomass.

On a large scale, it is recognized that community-weighted leaf dry matter content (community LDMC) is negatively related to grassland productivity and N, P and K concentrations in biomass. Hence, higher total levels of nutrients in above-ground standing biomass should be linked to lower community LDMC. However, current research has provided evidence that community LDMC is substantially modified by a defoliation regime. We asked whether management supporting vegetation with the lowest community LDMC also provides the highest amount of standing biomass and highest total levels of N, P and K. We used three long-term management experiments (sites) with four management treatments (grazing with spring burning, grazing, mowing in mid-July and fallow), which were set up in *Bromion erecti*, *Cynosurion cristati* and *Violion caninae* in the grasslands of the White Carpathian Mountains (Czech Republic) in 2004. At each site, twenty management plots (each five m × five m in size) were arranged in five blocks. During 2010, the first growth biomass was sampled at the end of May, in mid-June and in mid-July, each time from one randomly allocated one $m^2$ subplot within each plot. The total levels of N, P and K in a sample were calculated from dry matter standing biomass and laboratory analyses of nutrient concentrations. Community LDMC was calculated from the sample proportions of species biomass and LEDA database values. All analyses were performed with linear mixed models (REML method), where management was treated as a fixed effect, while site and date were treated as random effects. Variation in community LDMC was in 80% explained by the site; by contrast, variations in standing biomass and the total levels of N, P and K were explained by the site only up to twenty five %. Filtering out the random effects, all characteristics were significantly affected by management. We found, consistent with current studies, that community LDMC was significantly the lowest under mowing, but, unexpectedly, the total levels of N, P and K were also significantly the lowest under mowing. In summary, higher total levels of N, P and K in standing biomass may not be expected for vegetation with lower LDMC when analyzing grasslands under different management regimes.

Session 'Ecosystem functioning' / POSTER 2

## EFFECTS OF ELEVATION ON THE NUTRIENT LIMITATIONS OF SOME TREE SPECIES TO PLANT GROWTH ON MT. FUJI

**Yuki Goto[1], Takashi Nakano [2], Taisuke Yasuda [2], Yasuo Yamamura [1]**

*[1] Ibaraki University, Mito, Ibaraki, Japan; [2] Yamanashi Institute of Environmental Sciences, Fuji-Yoshida, Yamanashi, (Takashi Nakano: nakano@yies.pref.yamanashi.jp)*

Keywords: Nitrogen, Phosphorous, Volcanic soil, Nutrient resorption efficiency, M:P ratio

Nitrogen (N) and phosphorus (P) frequently limit plant growth in early-succession soils. The vegetation on Mt. Fuji, a young volcano in central Japan, may be affected by deficiencies of N and/or P. The limitation of soil nutrients may be more severe at higher altitudes. The aim of this study was to clarify the role of N-P limitation on the growth of tree species along an altitude gradient on the north-facing slope of Mt. Fuji. At the three sites that are characterized by different altitudes, the soil nutrient conditions were examined, and the N and P concentrations in living and dead leaves of several dominant tree species (three broadleaf trees and three conifers) were measured. The nutrient resorption efficiency (NRE, %) during leaf senescence and the N:P ratio in foliage were used as indices of nutrient limitation.
The concentration of available soil N and P tended to decrease with elevation. The NRE in deciduous trees indicated that nutrient limitation changed from N-limitation to P-limitation with elevation. On the other hand, the NRE of conifers did not indicate any change in nutrient limitation. The N:P ratio exhibited no trend along the elevation gradient regardless of the species or based on the criteria proposed by Koerseleman and Meukelman (1996) for wetland vegetation. Further studies are needed for applying the N:P ratio to forest ecosystems.

Session 'Ecosystem functioning' / POSTER 3

## $N_2$ FIXATION ALONG A MIRE CHRONOSEQUENCE

**Päivi Merilä[1], Mirkka Kotiaho[2], Tuula Larmola[2], Sanna Leppänen[3], Tytti Sarjala[1], Aino Smolander[4], Marja Tiirola[1], Eeva-Stiina Tuittila[2]**

*[1] Finnish Forest Research Institute, Parkano Finland; [2] University of Helsinki, Department of Forest sciences, Helsinki Finland; [3] University of Jyväskylä, Department of Biological and Environmental Science, Jyväskylä Finland; [4] Finnish Forest Research Institute, Vantaa Finland (corresponding author: paivi.merila@metla.fi)*

Keywords: acetylene reduction activity, mires, $N_2$ fixation, *nifH* gene, primary succession

In this study, we explored the patterns of co-variation in mire vegetation, microbial $N_2$ fixation activity and community structure along a primary succession transect of mire ecosystems. The transect is located in Siikajoki on the land-uplift coast of the Gulf of Bothnia in Finland (64°45´N, 24°42´E). In this area, new land is continuously exposed from the sea due to ongoing post-glacial rebound. Together with conditions that are favorable for peat formation, this phenomenon provides an excellent opportunity to study the ecology and succession of mire ecosystems by producing spatial continua of mires of increasing age that run from the coast toward inland areas.
Along the study transect, the terrestrial age of mires range from approximately 50 to 3,000 years, and the thickness of peat layer on mineral soil increases from approximately 0 to 2,500 cm, respectively. The successional stage of the mires (n = 7) starts from a sandy beach and develops gradually via meadows and fens to bogs.
In August 2007, six to ten soil/peat profiles were collected with a box sampler to cover the variation of moisture and vegetation communities within each mire site. Total DNA was extracted from the uppermost 10-20-cm layer of peat/soil samples, and $N_2$ fixation communities were detected by PCR-DGGE-sequencing of an approximately 320-bp fragment of the *nifH* gene. In August 2010, the peat/soil sampling was repeated to assess the $N_2$ fixing activity of the samples using a 48-h acetylene reduction assay (ARA). Organic matter (OM) was assessed as loss on ignition.
The mean $N_2$ fixing activity varied from 0.91 to 2.1 nmol ethylene/g OM/h; it was the highest on the youngest meadow site. On the fens and bogs, the $N_2$ fixing activity tended to be higher in hollows than in hummocks. We will present the patterns of co-variation in the mire vegetation, $N_2$-fixing activity and community structures of diazotrophic bacteria based on the binary matrices from DGGE results.

Session 'Ecosystem functioning' / POSTER 4

## THE EFFECTS OF BIOCHAR ALONG AN AGRICULTURAL GRADIENT: FERTILITY AND PLANT PRODUCTIVITY

**Lori Biederman[1], W. Stanley Harpole [1], David Laird[2], Emily Heaton [2]**

*[1] Iowa State University, Department of Ecology, Evolution and Organismal Biology, Ames, Iowa, USA; [2] Iowa State University, Department of Agronomy, Ames, Iowa, USA (corresponding: lbied@iastate.edu)*

Keywords: Biochar, Restoration, Prairie, Agriculture

The production of biochar is a promising new technology that can address the multiple goals of supporting domestic and agriculture-based fuel sources while concurrently limiting negative environmental externalities, such as net carbon efflux into the atmosphere. In agricultural systems, biochar increases cation exchange capacity, nutrient availability, and productivity, but there have been few studies of its effect on natural systems. In this experiment, we use mesocosms to establish the mechanisms of interaction among the soil, plants, and biochar additions. We established three plant communities (corn monocultures, switch grass monocultures, and a diverse mix of prairie species plus an individual exotic invader) in two different soils (sand and loam) and added char (0.1 g $cm^{-2}$) to half, with the other half left as a control. Each of the twelve treatments were replicated five times and randomly assigned positions on a greenhouse bench. Each week, plant productivity is estimated by measuring corn height, switch grass tiller density, and, within the prairie communities, plant density and invader height. The rate of nutrient leaching will be estimated by collecting weekly aliquots of excess drainage from each pot and measuring nitrate concentrations. At ten weeks, a portion of soil will be sampled, and pH, soil microbial biomass, and the concentrations of inorganic nitrogen and phosphorus will be determined. The presence and density of mycorrhizal associations will also be monitored. We expect that biochar will promote plant productivity in all three community types and will be more pronounced in the sand, which initially had reduced nutrient concentrations compared to the loam. In the soil, we expect that biochar will adsorb excess nutrients and reduce nitrate leaching. Furthermore, we expect that biochar will limit the growth of the invasive species by adsorbing allelopathic chemicals that would otherwise facilitate its competitiveness. The expected increased development of mycorrhizal networks in the biochar soil will promote net positive associations between plants and soil organisms. Thus, biochar will synergistically promote productivity and, within the perennial systems, will promote complexity and biodiversity.

Session ‘Ecosystem functioning’ / POSTER 5

# VARIABILITY IN LEAF FUNCTIONAL TRAITS IN CONTRASTING MOUNTAIN GRASSLANDS IN THE CENTRAL APENNINES OF ITALY

**Stefano Chelli [1], Camilla Wellstein [2], Giandiego Campetella [1], Sándor Bartha [3], Francesco Spada [4], Roberto Canullo [1]**

*[1] University of Camerino, Department of Environmental Science, Botany & Ecology Section, Camerino, Italy; [2] University of Bayreuth, Department of Biogeography, Bayreuth, Germany; [3] Hungarian Academy of Science, Institute of Ecology & Botany, Vácrátót, Hungary; 4 University “Sapienza”, Department of Environmental Biology, Rome, Italy. (Corresponding author: stefano.chelli@gmail.com)*

Keywords: leaf traits, grassland, Apennines, functional diversity, environment-species-trait relationship

As sessile organisms, plants are renowned for their plasticity within species and within individuals. Many studies have demonstrated that such abilities have effects on different ecological processes, such as community dynamics and ecosystem functioning. In this contribution, we wanted to test how leaf traits of some selected species respond to variations in abiotic parameters. The field work was carried out in the Torricchio Nature Reserve in the central Apennines (Italy), where two contrasting grassland sites were selected: (A) a northwest-facing slope with a closed and dense grassland vegetation of the *Seslerio nitidae-Brometum erecti* association, and (B) a southeast-facing slope with eroded and open grassland vegetation with higher erosion and shallow and unstable soil, belonging to the *Asperulo purpureae-Brometum erecti* association. We selected four species with different life histories in both communities: *Sesleria nitida*, *Lotus corniculatus*, *Astragalus sempervirens* and *Thymus longicaulis.* In each site and for each species, we randomly selected 30 healthy adult individuals. The following leaf traits were measured according to standardized procedures: Specific Leaf Area (SLA), Leaf Dry Matter Content (LDMC), and Leaf Mass per Area (LMA). In the exact position of each individual, three abiotic parameters were measured: sunlight reaching the canopy (PAR), soil moisture (%), and soil temperature (C°). The results show that light is strongly correlated with SLA and LMA only in site A, where it represents a limiting factor, while soil temperature is equally correlated with SLA and LMA in both sites. The role of soil moisture in determining SLA and LMA is the most important in site B. LDMC appears to be less correlated to these abiotic parameters, with the exception of light in site B. These differences suggest that in site B, plants are characterized by slower growth rates, longer leaf turnover, thicker laminas and lower photosynthetic capacity. In conclusion, the individuals of site B make greater investments in structural strength and secondary leaf defenses, have lower herbivore palatability and are better equipped to cope with environmental stress.

# New insights in descriptive vegetation science

Session ‘Descriptive vegetation science’ / ORAL

## NEW TOOLS FOR THE ANALYSIS OF COMMUNITY CHANGE WITH APPLICATIONS IN CONSERVATION, MANAGEMENT AND RESTORATION

**Peter R. Minchin**

*Southern Illinois University Edwardsville, Department of Biological Sciences, Edwardsville USA (pminchi@siue.edu)*

Keywords: Multivariate statistics, Ordination, Permutation Tests

Patterns of community change can be visualized by plotting trajectories in ordinations of community data from the repeated sampling of permanent plots or from chronosequences, but statistical tools for testing hypotheses about apparent patterns are currently lacking. I present a general framework for hypothesis testing based on the random permutation of data within trajectories. Although these methods could be applied using any ordination method, I recommend the use of non-metric multidimensional scaling (NMDS) with the Bray-Curtis dissimilarity index, as this combination of techniques has been shown by extensive simulations to be more effective at summarizing patterns of community change than alternative methods. An appropriate statistic is first calculated from the trajectories of plots within the ordination. Statistics have been designed to test a variety of common hypotheses about rates or directions of community change. These statistics include testing for differences between control and treatment groups in rates or directions of change, testing that changes are aligned with a hypothesized direction (e.g., progress toward restoration targets) and testing for convergence or divergence of community composition over time. The null hypothesis of no systematic change in community composition is then simulated by randomly permuting the data for each species within each trajectory, repeating the ordination on the permuted data and recalculating the statistics. This process is completed many times, and a frequency distribution for the statistic under the null hypothesis is generated empirically, allowing P-values to be computed for the hypothesis of interest. Experiments using simulated community data with known structure show that the new methods are effective in detecting trends and patterns that are built into the data. I demonstrate the utility of these methods in several case studies, including the assessment of success in the revegetation of gold mine sites in southeastern Australia, an analysis of restoration success in wetland restorations in central Florida and an analysis of long-term trends in wetland communities in the Florida Everglades.

Session ‘Descriptive vegetation science’ / ORAL

## TESTING THE CONTINUUM – A NEW PERMUTATION-BASED APPROACH TO EVALUATE SPECIES TURNOVER ALONG ENVIRONMENTAL GRADIENTS

**Michael Manthey[1], Florian Jansen[1], Jan Peper[2]**

*[1] Institute of Botany and Landscape Ecology, Greifswald University, Grimmer Str. 88, D-17489 Greifswald, Germany; [2] Bundesanstalt für Gewässerkunde, Am Mainzer Tor 1, 56068 Koblenz, Germany (corresponding author: manthey@uni-greifswald.de)*

Keywords: grazing gradient, Caucasus, HOF-model, biosphere, species diversity

The aim of our study was to investigate the relationships between grazing intensity and species turnover pattern in a semi-desert landscape. We studied the distribution of vascular plant species along transects of 900 m in length that are perpendicular to five farms in semi-deserts of Gobustan in the eastern Caucasus, Azerbaijan, and estimated grazing intensity as current livestock units per distance. We modeled species response curves with Huismann-Olff-Fresco (HOF) models and calculated species turnover by summing the first derivatives of all response curves. To test for potential discontinuities in the changes in vegetation composition along the grazing gradient, we developed a new null model based on the individualistic continuum concept that uses permutations of the observed pattern of species responses.
Most species show a sigmoidal negative response to grazing intensity, while only a few species respond with a unimodal pattern. The monotonic decrease in species richness with increasing grazing intensity marks a process of overgrazing that leads to the complete extirpation of plant species. Although the species turnover pattern shows a clear peak, it does not deviate significantly from the null model of individualistic continuous changes.
Our approach offers a method of differentiating between transition zones and continuous shifts in species composition along ecological gradients.

Session 'Descriptive vegetation science' / ORAL

## HEISENBERG'S UNCERTAINTY PRINCIPLE APPLIES TO LONG-TERM MONITORING OF TROPICAL FOREST PLANT COMMUNITIES

**Olivia Semboli[1], Denis Beina[1], Déborah Closset-Kopp[1], Sylvie Gourlet-Fleury[2], Guillaume Decocq[1]***

*[1] University of Picardie Jules Verne, Unité de Recherche Dynamiques des Systèmes Anthropisés AMIENS, France; [2] CIRAD Montpellier UR "Biens et Services des Ecosystèmes Forestiers tropicaux" (B&SEF), Département Environnements et Sociétés du CIRAD, *corresponding author:guillaume.decocq@u-picardie.fr*

Keywords: tropical forest, anthropogenic disturbance, long-term monitoring, permanent plots

Some general aspects of the Heisenberg uncertainty principle have transcended the field of quantum physics to be relevant in vegetation science. The fundamental question is whether seemingly benign experimental methods may themselves significantly affect the performance of experimental subjects. Long-term ecological research sites have become essential tools in the study of vegetation dynamics in tropical forests, and it is therefore of utmost importance to quantify the potential impacts of researcher activity on the system being studied to insure the validity of derived conclusions. In this study, we looked for a visitation bias in assessing long-term vegetation dynamics in a semi-deciduous tropical forest. We sampled the vegetation in three zones: along trails, in areas adjacent to trails, and in the forest interior, to assess species diversity and composition, tree growth, and tree mortality/recruitment rates in permanent plots in the forest of MBaïki (Central Africa Republic). We found no significant difference in species richness and evenness among the three zones investigated, but the species composition differed between trails and the other two zones, as reflected by MRPP and indicator species analyses. We also found significantly higher mortality and lower recruitment rates along trails than in other zones, but this finding was not species specific. There was a clear trend toward reduced tree growth along trails. We conclude that Heisenberg's uncertainty principle applies to plant community ecology: ecologists are not a benign influence on their study system, as is generally assumed, and the responses to the act of measuring plants may place fundamental limits on the questions that can be addressed.

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## CLASSIFICATION, DIVERSITY AND ENVIRONMENTAL RELATIONSHIPS OF PLANT COMMUNITIES OF THE SOUTHERN APPALACHIAN MOUNTAINS

**Robert Peet [1], Thomas Wentworth [2], Michael Lee [1], Forbes Boyle [1]**

*[1] University of North Carolina, Department of Biology, Chapel Hill, NC, USA; [2] North Carolina State University, Department of Plant Sciences, Raleigh, NC, USA and Country*

Keywords: Classification, Scale, Diversity, Vegetation, Appalachians

In his classic 1956 monograph on the vegetation of the Great Smoky Mountains, Robert Whittaker established the importance of complex gradients of elevation and topographic moisture in controlling the distributions of plant species and communities. Whittaker's model has been widely adopted to account for variations in vegetation and environment throughout the southern Appalachians. With data on vegetation and environments now available from a much wider geographical extent in the southern Appalachians, vegetation scientists have become increasingly aware of the importance of other gradients that influence regional vegetation patterns, particularly soil chemistry. To explore the vegetation-environment relationships across the region, we selected observations from 3,032 plots in the Carolina Vegetation Survey database, representing 85 forest, woodland, and shrubland associations of the U.S. National Vegetation Classification. We included in our analysis associations that occur in the mountains of North and South Carolina, although we also included plots from other states that fall within these associations. A principal component analysis of environmental data identified soil fertility as the first component, accounting for 45% of the total variation. The second component was associated with elevation, and the third component was associated with a simple index of topographic moisture. Ordinations of floristic data mapped well on this three-dimensional space, as did patterns of species richness. However, the mapping of richness onto the environment varied with the spatial scale of observation, with small scales (0.01-1 $m^2$) being more sensitive to topographic position and large scales (100-1,000 $m^2$) being more sensitive to soil chemistry. This analysis underscores the substantial variation in soil fertility across the region, reflecting variations in bedrock chemistry, and the need to incorporate soil chemistry as an important environmental gradient in broad regional interpretations of the vegetation patterns of the southern Appalachians.

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## AN EXPLORATION INTO INTRINSIC GUILD MEMBERSHIP

**Rachael Lawrence Lodge, J Bastow Wilson**

*University of Otago, Department of Botany, Dunedin, New Zealand (corresponding author: rachael.lawrencelodge@botany.otago.ac.nz)*

Keywords: intrinsic guilds, functional characters, ecophysiology

Previous studies on the Otago Botany Lawn community concerned has provided compelling evidence for two assembly rules; guild proportionality and limiting similarity. The presence of guild proportionality (constant representation from different guilds) within the community was established via the use of species occurrence data and null modeling and was further explored using competition data. These findings illustrated the operation of competitive exclusion restricting the proportions of particular species that could co-occur at a given point more often than expected at random. Two distinct assemblages of the most abundant species resulted; these assemblages are differentiated on an alpha-niche basis and are termed ‘intrinsic guilds’ (*sensu* Wilson 1999).
The intrinsic guild approach ‘interviews the plants’ by observing the actual community structure in place, i.e., intrinsic guilds are based on the behaviors of the plants, not on the ecologist's preconceptions. This approach offers a compelling alternative to the more traditional *a priori* assignment of guild membership using morphological or taxonomic classifications. We note that intrinsic guilds do not themselves provide an explanation as to which resource requirements and functional characters are driving the assemblage.
In this instance, the presence of limiting similarity also revealed that guild membership was consistent with markedly different responses to mowing, which is a key pressure operating on this community. The responses to biomass removal were suggestive of tolerance or avoidance strategies and provided a focus for further study.
Here, we seek to elucidate the actual mechanism(s) driving intrinsic guild membership and the observed patterns of species co-existence. Investigations focused on functional characteristics that potentially allow alpha-niche differentiation at a fine scale. Using 14 of the most abundant species from the 2 intrinsic guilds, we characterized species on the basis of their maximum relative growth rates, responses to light-mediated stress, growth responses to nitrogen and phosphorus depletion and the ability of species to utilize various forms of nitrogen and phosphorus that differ in their biological availability. We examine the relationship between these characteristics and intrinsic guild membership and the benefits of employing such an approach.

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## PATTERNS OF CONVERGENCE AND DIVERGENCE OF TRAITS IN FOREST COMMUNITIES ALONG A SUCCESSIONAL GRADIENT

**Kátia J. Zanini, Sandra C. Müller, Rafael E. Machado, Valério D. Pillar**

*Programa de Pós-grduação de Ecologia, Universidade Federal do Rio Grande do Sul, Brazil (Katyjz2009@gmail.com)*

Keywords: traits, convergence, divergence, functional diversity, Atlantic forest.

The expression of traits at the community level is associated with both environmental gradients and local interactions among species, leading to convergent and divergent assembly patterns. The aim of this study is to explore the species traits patterns in communities in a successional gradient. We surveyed four chronosequences in the Brazilian Atlantic Rain Forest and evaluated the traits of 52 tree species. The measured traits were leaf nitrogen (LNC) and phosphorus content, the ratio between these two parameters, leaf mass per area, leaf thickness and shape, dry matter content and leaf area (LA), maximum potential height of the species (H), maximum estimated height (EH) and wood density. We expected to find greater trait convergence in the initial and final stages of forest succession, considering the marked presence of environmental filters. To analyze these patterns, we used the method described in Pillar et al. (2009), which consists of matrix multiplication, fuzzy adjustment of species abundances and testing of matrix correlations against null models. The analysis requires three matrices: communities described by species, species described by traits and communities described by environmental variables (here, we considered the time of forest regeneration). The traits that maximized convergence along the successional gradient were LNC and EH ($\rho = 0.397$, $p = 0.031$). Linear regressions with the average values of these traits in each community were significant and demonstrated that LNC is lower in advanced stages than in initial stages, where the values ranged greatly among sites. EH, in turn, increases along the successional gradient. The traits maximizing divergence on the succession gradient were LA, EH and LNC ($\rho = 0.505$, $p = 0.003$). Exploratory analysis indicated the occurrence of taller trees with bigger leaves at advanced stages of succession. On the other hand, considering these traits, functional diversity did not increase along the successional gradient. This finding may be due the great range in values of the initial areas, and it seems to be associated with different patterns of species composition between sites, some of which are dominated by only a few species, leading to low values of functional diversity.

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## THE BOG/UPLAND TRANSITION INSIDE RAISED BOGS OF NORTHEASTERN AMERICA: CHARACTERIZATION OF ECOTONAL COMMUNITIES

**Étienne Paradis, Line Rochefort**

*Département de phytologie and Centre d'études Nordiques, Pavillon Paul-Comtois, 2425 rue de l'Agriculture, Université Laval, QC, QC G1V 0A6, Canada*

Keywords: mire, swamp, ecotone, wetland delimitation, SMWDA

Ecotones are generally recognized as biodiversity hotspots. They harbor species of adjacent ecosystems, but they can also provide a unique habitat for ecotonal species. One type of ecotone that has been relatively poorly studied in North America is the raised bog/upland transition. The goal of the present study is to fill this gap in knowledge of peatland ecosystems. Vegetation in 20 natural raised bogs in eastern Canada was inventoried using the point-intercept method at 0.5 m intervals along bog/upland transects. Split Moving Window Dissimilarity Analysis (SMWDA) was used to detect abrupt changes in community composition. Vegetation cover was then evaluated using quadrats inside identified ecotonal communities.
Our SMWDA results show that the width of the bog/upland boundary varies between 0 m (sharp bog/upland boundary without ecotonal community) and over 100 m (large swamp). In most situations, the width is between 20 and 40 m. Several types of ecotonal communities were identified: some communities are dominated by graminoids (sedges or *Calamagrostis*), some are dominated by trees, and others are dominated by shrub species (e.g., *Alnus, Ilex, Viburnum*). The most frequent tree species in ecotonal communities are *Picea mariana*, *Abies balsamea*, *Acer rubrum*, *Larix laricina*, and *Thuja occidentalis*; the total tree basal area is maximal in cedar rich-fens swamps (69 m²/ha). Ericaceous shrubs are among the dominant species in open communities, but their cover is very scarce in more shaded swamp communities. Many true ombrotrophic herbaceous species (e.g., *Drosera, Sarracenia*) are absent in the characterized swamps, but the herbaceous layer is more diversified than on the open bog. As inside the bog, *Sphagnum* mosses generally occupy an important part of the ground layer in ecotonal communities. Peat depth measurements made along the bog/upland gradient show that ecotonal communities are almost always located over 30-40 cm of peat. Therefore, they must be considered as integral parts of the peatland complex.

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## SEPARATED OCCURRENCE ACROSS A SALT MARSH TIDAL GRADIENT ENABLES THE COEXISTENCE OF TWO SYMPATRIC *SALICORNIA* SPECIES

**Nina Sajna[1], Urska Rabuza[2], Mitja Kaligaric[1]**

*[1] University of Maribor, FNM, Biology Dept., Koroška 160, 2000 Maribor, Slovenia; [2] University of Maribor, College of Nursing Studies, Žitna 15, 2000 Maribor, Slovenia (corresponding author: nina.sajna@uni-mb.si)*

Keywords: halophytes, spatial partitioning, polyploids, germination

The annual glassworts (*Salicornia* L., Chenopodiaceae) are halophytic herbs with convergent morphology that is displayed in articulated succulent stems, reduced leaves and tepaloid flowers. Three seeds develop in a cyme: one central and two lateral. Additionally, plants exhibit high phenotypic plasticity related to environmental gradients and/or inbreeding. Glassworts in the investigated area belong to two cytotypes, the diploid *S. patula* and the tetraploid *S. emerici*. Our previous results involving cpDNA and ITS analyses of *S. patula* and *S. emerici* suggest inter-cytotypic gene flow, gene flow across a ploidy barrier, which is known as introgressive hybridization or introgression. The existence of introgression has long been recognized, as has its importance for increasing the morphological variation or ecological tolerance of polyploids. However, very little evidence of this phenomenon exists in the wild. In the study presented, we investigated the ecological differences of diploids and tetraploids by recording the spatial partitioning of *S. patula* and *S. emerici* along salinity and humidity gradients in lower salt marshes, where they are found in sympatry. Our results show the separated spatial occurrence of *S. patula* and *S. emerici*, with tetraploid species being more widespread, forming monodominant stands, and tolerating frequent flooding. Diploids are found in a zone above stands of tetraploids, where they occupy ephemeral niches within the stands of perennial species (*Halimione portulacoides*, *Arthrocnemum fruticosum*). Additionally, we investigated the germination behavior of both species. Diploid *S. patula* exhibits seed dimorphism, resulting in significant differences in the germination pattern between seed morphs. In diploids, only the main seeds germinated, while in tetraploids, both seed types germinated equally well.

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## COMPETITIVE INTERACTIONS OF *CALLUNA VULGARIS* AND *DESCHAMPSIA FLEXUOSA* IN DRY HEATHLANDS

**Christian Damgaard[1], Johannes Ransijn [2], Inger K Schmidt [2]**

*[1] Aarhus University, NERI, Silkeborg, Denmark; [2] Copenhagen University, Life, Copenhagen, Denmark*

Keywords: Measuring plant competition, pinpoint method, heathland, *Calluna vulgaris*, *Deschampsia flexuosa*

A novel method for measuring plant-plant interactions in natural and semi-natural plant communities, where it is difficult to distinguish individual plants, is presented. It is assumed that the ecological success of different plant species in a plant community may be measured by plant cover and vertical density (a measure that is correlated with the 3-dimensional space occupancy and biomass). Both plant cover and vertical density are measured in a standard pinpoint analysis at the beginning and end of the growing season and modeled in a state-space model.
The presented method allows direct measurements of the competitive effects of neighboring plants on plant performance and the estimation of parameters that describe the ecological processes of plant-plant interactions during the growing season and the processes of survival and recruitment between growing seasons.
The method was applied to a dry heathland plot that is dominated by *Calluna vulgaris* and *Deschampsia flexuosa*. Significant competitive interactions were demonstrated between the two species, and using the model, it was possible to predict the expected community dynamics in dry heathlands. The predicted plant community dynamics were compared to the observed plant community structure in 5,000 Danish dry heathland plots.
The presented method is suited for testing different ecological hypotheses of competitive interactions along environmental gradients, investigating the importance of competition, and predicting different ecological scenarios. Furthermore, the method allows a meaningful investigation of the plant-plant interactions in plant communities that are dominated by perennial species of variable size and in locations where it is difficult to distinguish individual plants, such as in most grassland ecosystems.

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## CLASSIFICATION OF VEGETATION: SOME CONCEPTS AND PITFALLS

**Miquel De Cáceres[1], Susan K. Wiser [2]**

*[1] Centre Tecnològic Forestal de Catalunya, Solsona, Spain; [2] Landcare Research, Lincoln, New Zealand, (corresponding author: miquelcaceres@gmail.com)*

Keywords: Association, clustering, diagnostic species, phytosociology.

We suggest a conceptual framework to clarify how classification of vegetation based on floristic composition has been accomplished in the past and to provide direction on approaches that should be favored in the future. We start by reviewing basic classification concepts, such as the difference between *intensive* (i.e., assignment rules) and *extensive* (i.e., membership values) definitions of vegetation types. Intensive definitions are required to classify new data, and multiple intensive definitions should be avoided because they lead to ambiguity. Because vegetation classifications may need to be extended, with the requirement that existing types are conserved, a blend of supervised and unsupervised classification is unavoidable. These considerations imply that unsupervised classification methods that provide intensive definitions and that can subsequently guide supervised classifications are preferable to other approaches. We also suggest a conceptual distinction between the following tasks related to vegetation types: *definition*, *validation*, *indication* and *characterization*. The multiplicity of formal and informal approaches that have been taken in the past to classify vegetation has resulted from the fact that definitions of vegetation types (e.g., the concept of association) did not clearly separate these concepts. Therefore, we urge vegetation scientists and classification panels to more clearly specify the information required to define vegetation types and the information that should be used to carry out the other tasks. We finish by reviewing how numerical classification approaches have been compared in the past. We conclude that external and internal evaluation criteria provide inconclusive results when they are used to compare clustering approaches and that comparisons based on conceptual grounds are more suitable for classification.

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## STABILITY AND NUMBER OF DIAGNOSTIC SPECIES: TWO IMPORTANT PROPERTIES OF COMMUNITY CLASSIFICATIONS

**Lubomír Tichý, Milan Chytrý**

*Institute of Botany and Zoology, Masaryk University, Kotlarska 2, 61137 Brno, Czech Republic*

Keywords: Cluster analysis, Optimal number of clusters, Stopping rules.

The definition of plant communities is a complex process depending, to a large extent, on the expert knowledge of researchers. Unsupervised numerical classifications may partition the vegetation continuum, but their results always depend on the structure of the input data set. In most studies, such partitions are directly interpreted ecologically without any formal evaluation of their quality. An important measure of the quality of classification is its stability (repeatability, robustness), i.e., how it changes if some sites (e.g., plot samples) are deleted from or added to the input data set.
We have proposed a method for a posteriori evaluation of classification stability that compares the classification of sites in the original data set (a matrix of species by sites) with the classifications of subsets of its sites that are created by without-replacement bootstrap resampling. Site assignments to clusters of the original classification and to clusters of the classification of each subset are compared using Goodman-Kruskal's lambda index. Many resampled subsets are classified, and the mean of lambda values calculated for the classifications of these subsets is used as a measure of classification stability.
For interpretation of partitions and vegetation types, it is advantageous if each cluster in a partition can be characterized by several diagnostic species. Therefore, we propose to combine maximum classification stability with a maximum number of statistically determined diagnostic species into a single measure. A combination of these two characteristics may help to develop community classifications that are both stable and ecologically interpretable.

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## CAN REVEREND BAYES HELP TO REDEEM CATEGORICAL VEGETATION ASSESSMENTS TO MONITOR CHANGE OVER TIME?

**David Duncan[1], Peter Vesk[2]**

*[1] Arthur Rylah Institute, Department of Sustainability and Environment, Melbourne Australia; [2] University of Melbourne, School of Botany, Melbourne Australia (david.duncan@dse.vic.gov.au)*

Keywords: monitoring, Bayesian modeling, adaptive management, vegetation condition

Opportunities for monitoring ecological change due to vegetation management are typically constrained by the availability of appropriately sensitive data. A great deal of plot-based data exists that are typically collected by government agencies or NGOs to justify the choice of one site over another as a place to invest in vegetation management. This is itself an important function, but the data requirements for detecting changes over time are very different. Given that new longitudinal studies only reveal patterns in real time, is there a way that quasi-quantitative metrics, which are typically employed for conservation purposes, can contribute immediately to assessing changes over time in vegetation composition and structure? We revisited 25 sites in dry woodland and forest in southern Australia that were established under a conservation action program. Detailed quantitative assessments of vegetation composition and structure were compared against back-projected values that were informed by the initial assessments. We estimated changes over time as a function of the starting conditions and the site fertility using a Bayesian regression model with three alternative prior models. These analyses shed light on likely ecological trends; for example, the accumulation of litter and logs and a decline in weed cover, as well as likely cases of systematic estimation error. Our study highlights the valuable contribution that quantitative studies offer to the estimation and updating of benchmark or reference values. Above all, these findings underline why data collection for prioritization and allocation and for monitoring change over time should be tailored with respect to their objectives.

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## EXTENDING AND UPDATING CLASSIFICATIONS: AN EXAMPLE WITH NEW ZEALAND’S WOODY VEGETATION

**Susan K. Wiser[1], Miquel De Cáceres[2]**

*[1] Landcare Research, Lincoln, New Zealand; [2] Centre Tecnològic Forestal de Catalunya, Solsona, Spain, (corresponding author: wisers@landcareresearch.co.nz)*

Keywords: Alliance, association, community ecology, clustering, vegetation databases.

Vegetation classifications may need to be modified or extended when new plot data are collected. We consider here the extension of a classification of New Zealand’s forests and shrublands into 24 alliances, which was originally obtained using a set of 1,177 systematically located plot records. Although this classification adequately recognized and described common woody vegetation at the alliance level, it could not describe alliances that are rare on the landscape or provide sufficient resolution to define and describe associations. Here, we use a much larger data set, 11,943 plot records from New Zealand’s National Vegetation Survey (NVS) databank, to fill these gaps. In doing so, the following questions arise: (a) how can we assign new plots to existing alliances; (b) how can we detect which new plot records do not fit into the original alliances; (c) can we define new alliances while preserving the original ones; (d) does this differ substantially from rebuilding a new classification using all data; and (e) because we have more data, can we define a classification at a finer level of resolution (i.e., at the association level) and relate it to the original one? To be able to explore these issues, we first needed to re-cast the original classification into the fuzzy classification framework of Noise Clustering. We then re-sampled the new NVS plot records to remove uneven representation along floristic and geographic gradients and merged the resulting stratified data set with the original one, obtaining a data set with 5,564 plot records and 1,936 species. To extend the original classification at the alliance level, we first determined which plot records, among all 5,564, were not assigned to any of the original alliances. We then defined new alliances based on those unassigned plots but kept the original alliances as fixed elements to make the new alliances as distinct from the original alliances as possible. With the aim of extending the classification to a finer level of resolution, we defined new vegetation associations using all 5,564 plots. We related the two levels of resolution using fuzzy classification of the association centroids into alliances. In all of these steps, we demonstrate our use of complementary criteria to decide the number of new alliances and associations to recognize. We believe that our approach illustrates the application of a fuzzy classification framework at a large national scale and can serve as a model for others wishing to extend and update classifications.

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## EFFECTS OF THE MODE OF PUBLICATION AND CHOICE OF STUDY AREA ON THE NUMBER OF SPECIES IN NORTH AMERICAN FLORAS

**Michael W. Palmer**

*Oklahoma State University, Department of Botany, Stillwater, Oklahoma, USA*

Keywords: Species Richness, Biogeography, Floristics, North America, Publication bias

The number of species in a flora (a published list of species in a defined region) is a property not only of the actual number of species present but also the behaviors of botanists. Past studies that were conducted as a part of the Floras of North America Project (which attempts to compile all floras written within North America, north of Mexico) has focused primarily on the geographical determinants of vascular plant richness. In this paper, I use data from 3,301 floras to examine the relationships between the mode of publication (e.g., dissertation, journal article, book), the choice of area of study (park, political unit, physiographic definitions), and the number of species listed. While the effects of publication mode are small compared to the effects of area, latitude, elevation, and year of study, there is a tendency for books to include more species than other modes (after correcting for geographic factors). The choice of the area of study has a moderately stronger effect, with counties and states having more species listed than parks, military reservations, and arbitrarily delineated areas. The choice of area and the mode of publication have exhibited pronounced changes, with theses peaking in the 1970s, books in the 1980s, and journal articles and government documents continuing to increase in the 21st century. The choice of study area has undergone similar changes. While such trends could impact flora size in subtle ways, their effects are dwarfed by the species-area relationship and the latitudinal and elevation gradients. Contrary to the common perception that floristic publications are on the decline in North America, the total number of published floras has remained relatively constant at 60 per yr for approximately four decades.

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## SEED BANKING IN ANCIENT FOREST SPECIES: WHY TOTAL SURFACE AREA REALLY MATTERS!

**Jan Plue[1], Ken Thompson [2], Kris Verheyen [3], Martin Hermy [4]**

*[1] Stockholm University, Department of Physical Geography and Quaternary Geology, Stockholm, Sweden; [2] University of Sheffield, Department of Animal and Plant Sciences, Sheffield, United Kingdom; [3] Universiteit Gent, Department of Forest and Water Management, Gent, Belgium; [4] Katholieke Universiteit Leuven, Department of Earth and Environmental Sciences, Leuven, Belgium (jan.plue@natgeo.su.se)*

Keywords: Diversity; Methodology; Sampling guidelines; Seed bank; Temperate deciduous forest

This study questioned how various methodological aspects of seed bank sampling could affect seed bank records in temperate deciduous forests, focusing on records of ancient forest species.
Through a quantitative review of 31 seed bank studies in temperate deciduous forests, we quantified the role of sampling methodology in constraining seed bank records, notably the total species richness, average species retrieval frequency and average seed density. We specifically focused on the reported species richness of ancient forest species, which are assumed to lack a persistent seed bank; this is a hypothesis that is suspected partly due to methodological shortcomings. A major methodological trade-off was established between the sampled plot area and the number of plots: at an increased number of plots, the area sampled per plot decreased significantly. The length of the germination period significantly increased as more total surface area was sampled. The total surface area sampled in a study was the primary determinant of the total species richness, both for overall species richness and for ancient forest species richness. Furthermore, as the sampled depth increased, so did the number of (ancient forest) species. A high retrieval frequency of (ancient forest) species indicated that few plots were intensively sampled. The seed density was poorly explained by any methodological variable. Moreover, a species-pool effect was unlikely to be responsible for the ancient forest species-to-total sampled area relation, as the ancient forest species richness/total species richness ratio proved to be non-significant in relation to the methodological variables.
These results imply that the sampling methodology has a far-reaching impact on seed bank records, including total species richness, detection of ancient forest species and, ultimately, seed bank composition. This study stresses the importance of a more streamlined seed bank sampling design in the future that enhances both the quality of seed bank records and comparability among studies. We formulate a set of guidelines to improve the quality of future seed bank studies in temperate deciduous forests.

Session 'Descriptive vegetation science' / ORAL

## THE MEMORY OF SOIL: DNA BARCODING FROM SOIL MIRRORS PRESENT, BUT ALSO PAST, PLANT DIVERSITY

**Francesco de Bello, Alice Valentini, Wilfried Thuiller, Sandra Lavorel, Christian Miquel, Pierre Taberlet**

*Laboratoire d'Ecologie Alpine, CNRS UMR 5553, Université Joseph Fourier, BP 43, F-38041 Grenoble Cedex 9, France (*Corresponding author: fradebello@ctfc.es)*

Keywords: barcoding, biodiversity monitoring, land-use changes, vegetation sampling

Field surveys of plant diversity are time consuming and often seasonally restricted. We hypothesized that amplification of DNA from surface soil coupled with parallel high-throughput sequencing provides an efficient proxy for characterizing the diversity of contemporary plant communities, with a negligible signal from species that once were present in a site. We selected 14 species-rich, semi-natural meadows from the sub-alpine vegetation in the French Alps (Villar-d'Arêne; 45.04° N, 6.34 E°; between 1726 and 1847 meters above sea level). The vegetation developed on formerly cultivated terraces with a rotation of cereals and potatoes. The terraces were abandoned in different periods, in 1810, 1952, 1960, 1971 and 1986. Eight soil cores were taken using a clean steel-coring sampler. DNA extraction was carried out from 3 g of dry soil using the PowerMax Soil kit. The above-ground plant species composition was estimated, at the peak of vegetation development, with a classic Braun-Blanquet relevé approach, which is a visual estimate of species presence and cover over a plot of 10 x 10 m. The P6 loop of the plastid DNA trnL (UAA) intron was amplified to define the molecular operational taxonomic units. Approximately 70% of the species that were detected by DNA barcoding were generally found in the botanical relevés. Normally, all locally dominant species that are found in botanical relevés were detected by DNA barcoding. Some of the species that were detected by DNA barcoding but not identified in the botanical relevés are known to occur in the area or are transient plants that are difficult to detect outside of specific seasons. Most interestingly, traces of formerly cultivated crops (generally <0.3% of the total sequences found within each plot) were observable in most samples, with the number of sequences decreasing with the date of terrace abandonment. We conclude that DNA barcoding from soils can be efficiently applied to monitor contemporary plant diversity. However, in conditions when DNA degradation is slowed, e.g., by low temperatures, DNA barcoding could also provide a proxy of the history of the vegetation composition of a site.

Session 'Descriptive vegetation science' / POSTER 6

## ZAMIADROID: FIELD REGISTRATION OF BIOLOGICAL DATA USING MOBILE DEVICES

**David Martí Pino, Xavier Font, Rafael Quadrada, Gwendolyn Peyre**

*Dept. of Plant Biology, University of Barcelona, Barcelona, Spain*

Keywords: field work, mobile device, database, Android, biodiversity

Biological databases are often built based on bibliographic and/or field data. An issue with this secondary data source is the transfer of information from paper to a digital format. It requires a certain digitalization time and provides an opening for potential type errors.
We propose the use of the ZamiaDroid application to overcome these work limitations. It was designed for mobile devices running the Android operating system (version 1.6 or higher) and was programmed in Java.
The concept of ZamiaDroid allows users in the field to register georeferenced data, in form of biological citation or floristic relevés, into a personalized project. Every project allows the creation of dynamic forms of data collection using information field types like text, photos or taxon lists. All of the registered data are then georeferenced with the GPS and can be visualized through on screen cartographic programs thanks to Google Maps advanced features.
The stored information can then be exported to other systems in several formats, including spreadsheets, Biodiversity and B-VegAna (Biodiversity and Vegetation Analysis package) XML files, or vector shape GIS files. Moreover, data stored on other devices can also be imported into our system. Nonetheless, the interaction with external databases, e.g., the "Biodiversity data bank of Catalonia" (BDBC) and the "Iberian and Macaronesian Vegetation Information System" (SIVIM) do not stop at data transfer. In fact, it is possible with ZamiaDroid to access, to information relative to 1) the user's precise current location (habitat, community) and 2) a concrete taxon or community (biology, status).
We are now focusing on potential new features that we could integrate into ZamiaDroid to obtain information on 1) the probable flora in relation to mapped habitats and 2) the potential flora due to the interaction between species records and environmental parameters for a particular site.
ZamiaDroid is an open-source software package that can be freely used, studied and adapted to one's needs. We remain open to forthcoming external propositions on how to improve the ZamiaDroid design.

Session 'Descriptive vegetation science' / POSTER 7

## USING REMOTE SENSING FOR FOREST MAPPING IN A SEMI ARID AREA IN THE NORTH WEST OF ALGERIA

**Ahmed Zegrar**

*Centre of Spaces Techniques, CTS, BP 13, Arzew 31200 Algeria (corresponding author: z_ahmed65@yahoo.fr)*

Keywords: Remote sensing, SIG, cartography, forestry, semi arid

The forests in Algeria have a fairly large ecological diversity with different bioclimatic zones from arid to wet. These floors have a direct impact on forest ecosystems and determine the floristic composition of these forests and their regeneration. This ecological diversity of forests due to its constitution plays an important role in natural regeneration from natural calamities (fire, wind phenomenon, logging). The conservation of biodiversity and the sustainable development of forest ecosystems are becoming increasingly important. These ecosystems are unique to the biological wealth of forests, inland waters, agricultural lands and humid lands.
Research in ecology has advanced knowledge about the functioning of forest ecosystems and the impact of human activities (fires, logging, deforestation and land clearing). Man needs a better measure the extent of the changes it makes to its environment. Not only can it improve its practices accordingly, but it is becoming increasingly conscious of the need - and to some extent, its ability - to repair damaged areas.
In this study, the use of remote sensing images from the satellites ALSAT-1 and Landsat TM at different times allowed us to classify forest formations in the semi-arid region of Tlemcen, in northwestern Algeria. Data from images on several dates have been used and subjected to specific treatments, such as geometric correction and classifications. Supervised classification by the method of maximum likelihood is used to identify key training areas for study. Indices NDVI, MSAVI2 and Index greenness IV were used to characterize forest formations and determined the changes. This treatment has created a detailed thematic analysis of forest ecosystems and provided a vegetation map of the study area. We also used a Geographic Information System (GIS) for mapping management.

Session 'Descriptive vegetation science' / POSTER 8

## ANALYSIS AND CLASSIFICATION OF RIVERINE FORESTS: CHANGES OF THE FLORISTIC COMPOSITION ALONG CLIMATIC GRADIENTS

**Idoia Biurrun, Juan Antonio Campos, Mercedes Herrera, Javier Loidi, Itziar García-Mijangos**

*University of the Basque Country, Dept. Plant Biology and Ecology, Bilbao, Spain (corresponding author: idoia.biurrun@ehu.es)*

Keywords: Northern Iberian Peninsula, *Populetalia albae*, SIVIM, bioclimatic indices, fidelity index

Riverine forests in Europe are included by many authors in the phytosociological order *Populetalia albae* that is divided into three alliances: *Alnion incanae* (Eurosiberian riverine forests), *Populion albae* (Mediterranean riverine forests), and *Osmundo-Alnion glutinosae* (west Mediterranean *Alnus glutinosa* siliceous forests). However, the geographical and ecological definitions of these syntaxa are not totally clear.
The study area covers the northern half of the Iberian Peninsula, which includes the cantabrian, Atlantic and Mediterranean hydrographic basins and belongs to two biogeographic regions, the Eurosiberian and Mediterranean. Climate varies from temperate hyperoceanic to Mediterranean semicontinental.
Our aims were: 1) to perform a numerical classification of riverine forests in order to define their typology and set the diagnostic species at alliance level; 2) to establish the climatic features they are linked to.
A data set of 1,000 relevés belonging to 30 associations of the alliances *Populion, Alnion incanae* and *Osmundo-Alnion* was constructed with our own data and data from the Information System of the Iberian and Macaronesian vegetation (SIVIM). After removing deficient relevés and those with too small or too big sampling areas, the data set was submitted to stratified resampling. Climatic data was obtained from the Climatic Digital Atlas of the Iberian Peninsula. Three bioclimatic indices were calculated: continentality index (Ic), thermicity index (It) and the ombrothermic index of the warmest two-month period ($Ios_2$).
An agglomerative clustering analysis performed revealed the existence of three main groups of relevés, which mostly match with the phytosociological alliances. The three clusters are floristically well defined by species with high fidelity indices. Analysis of the climatic variables (annual precipitation, Ic, It, $Ios_2$) showed significant differences among clusters: *Osmundo-Alnion* was linked to the highest annual precipitation and thermicity and the lowest continentality; *Alnion incanae* was linked to the lowest mediterraneity and thermicity; and *Populion* was linked to the highest mediterraneity and continentality and the lowest annual precipitation.

Session 'Descriptive vegetation science' / POSTER 9

## NEW PERSPECTIVES IN MEASUREMENTS OF MICROCLIMATE OF EDAPHIC COMMUNITIES: WIRELESS SENSOR NETWORKS

**László Körmöczi, Zoltán Bátori, László Erdős, Mária Fehér**

*University of Szeged, Department of Ecology,Szeged, Hungary (corresponding author: kormoczi@bio.u-szeged.hu)*

Keywords: mote, wireless communication, sinkhole, sand dune, izolines

The use of wireless sensors provides a great potential for ecologists to reveal the vegetation-environment relationships both in natural and semi-natural communities. Wireless technology allows nearly unlimited installation flexibility for sensors and reduces maintenance complexity and costs. Other advantages of wireless sensors are their small size and mobility. In the measurement units, signal-conditioning sensors are integrated with radio units. This arrangement is also called "mote". In our study, we investigated the possibility of using wireless sensors in natural edaphic broad-leaved forests and sandy forest-steppe habitats of Hungary. Air temperature, air humidity and light intensity values were measured in karst and interdune depressions to test the sensitivity and precision of the programmed and calibrated SN21140CA sensors. In the experimental phase, a total of 50 sensors were used in the communication network. Data were analyzed using GIS software (surface analysis) and ecological program packages. Our results indicated that these wireless sensors are well suited for detecting the small-scale differences in the environmental variables of natural habitats.
The relevant disadvantages of motes may be the temporal loss of signals due to insufficient battery supply. Motes can be arranged not only in a systematic grid but also in random positions. This arrangement and proper modeling software should eliminate the above-stated problem.

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Session 'Descriptive vegetation science' / POSTER 10

## THE INDIVIDUAL RESPONSE OF TREES TO CLIMATE IN A MIXED FOREST IS CONDITIONED BY COMPETITION AND NEIGHBORHOOD COMPOSITION

**Nere Amaia Laskurain[1], José Miguel Olano[2], Silvia Martínez de Olcoz[1], Arantza Aldezabal [1], Adrián Escudero [3], Jesús Julio Camarero[4]**

*[1] Laboratorio de Botánica, Departamento de Biología Vegetal y Ecología, Facultad de Ciencias, UPV/EHU, Bilbao, Spain; [2] Área de Botánica, Departamento de Ciencias Agroforestales, Escuela de Ingenierías Agrarias, Soria, Spain; [3] Área de Biodiversidad y Conservación, ESCET, Universidad Rey Juan Carlos, Móstoles, Spain ; [4] ARAID, Instituto Pirenaico de Ecología (CSIC), Zaragoza, Spain. (corresponding author: nereamaia.lascurain@ehu.es)*

Keywords: Beech, birch, competition, dendroclimatology, oak.

Climate has a significant influence on spatial and temporal dynamics of forests. Dendroclimatologists have assessed the role of climatic variability on tree growth and its implications on forest dynamics. However, most studies in dendroclimatology have focused on the responses of species to climate at the population level and therefore the variability between individuals in dense forests has been rarely evaluated. Nevertheless, intraspecific and interspecific competition alter resource availability and consequently growth sensitivity to climate. The analysis of the climatic response of individual trees should take into consideration these factors. Therefore, the aim of this study was to determine if the response of individual trees to climate varied depending on the tree position in the canopy and its neighborhood, defined as tree density and composition. We tested the consistency of individual tree climate-growth responses in ring-width series of three species: birch (*Betula celtiberica*), beech (*Fagus sylvatica*) and pedunculate oak (*Q. robur*). The study site was a mixed secondary forest located in the Urkiola Natural Park (Basque Country). The climate is temperate-oceanic with a high annual rainfall (1,655 mm on average) and a mean annual temperature of 11 ºC. The results indicate that the radial growth of these three species followed a similar trend, with a steep decline starting in 1984. However, each species had characteristic climatic variables that limited growth and had contrasting sensitivity to climatic factors. Individual responses were modified by the local neighborhood and canopy position. In birch, climatic responsiveness (expressed as the growth change associated to climatic parameters) was positively related to tree size and negatively related to competition index. In contrast, beech sensitivity was negatively related to tree size. Oak sensitivity was negatively related to tree size and positively to competition index.

Session 'Descriptive vegetation science'/ POSTER 11

## THE GLOBAL INDEX OF VEGETATION-PLOT DATABASES (GIVD): A NEW RESOURCE FOR VEGETATION SCIENCE

**Florian Jansen, Milan Chytrý, Miquel De Cáceres, Jürgen Dengler, Jörg Ewald, Manfred Finckh, Falko Glöckler, Gabriela Lopez-Gonzalez, Ladislav Mucina, Jens Oldeland, Robert K. Peet, John S. Rodwell, Joop Schaminée, Nick Spencer**

Metadatabases have improved data visibility and availability to the scientific community. However, in vegetation science, where numerous databases were established on the (multi-)national, regional or local scale, no global metadatabase existed that would facilitate the communication of vegetation data. We compiled the Global Index of Vegetation-Plot Databases (GIVD; http://www.givd.info), an internet-based resource aimed to contain metadata of existing vegetation databases. For inclusion, databases need to (i) contain temporally and spatially explicit species co-occurrence data for plots of 1 ha or smaller, and (ii) be accessible to the scientific community. This poster summarizes the already registered databases in the GIVD.

Session 'Descriptive vegetation science' / POSTER 12

## HISPAVEG: A NEW ONLINE VEGETATION PLOT DATABASE FOR SPAIN

**Aitor Gastón[1], Carlos Ropero[1], Juan I. García-Viñas[1], César López-Leiva[1], Valentín Gómez-Sanz[1], Roberto Vallejo[2], Jacobo Ruiz del Castillo[1], Juan Ruiz de la Torre[3]**

*[1] Technical University of Madrid, ECOGESFOR research group, Madrid, Spain; [2] Ministry of Environment, Madrid, Spain; [3] Technical University of Madrid, ETSI Montes, Madrid, Spain.*

Keywords: Vegetation survey, Biodiversity, Ecoinformatics, Phytosociology, Relevé,

We describe a new online database, named HispaVeg, which currently holds data from 2663 vegetation plots of Spanish woodlands, scrublands and grasslands. Unlike other similar databases, a detailed description of the structure is stored with the floristic data of each plot (i.e., number and physiognomy of the vertical layers, cover values for each layer). Most of the vegetation plots are large rectangles (400 to 2000 square meters) with an average of 34 species per plot. The survey dates range from 1956 to present, with most of the records between 1964 and 1994. The elevation of the plots ranges from 0 to 2880 m, with most of the plots between 300 and 1500 m. HispaVeg is freely available to the scientific community. Users can query the online database, view printable reports for each plot and download spreadsheet-like raw data for subsets of vegetation plots.

Session 'Descriptive vegetation science' / POSTER 13

## SPATIAL DISTRIBUTION AND HABITAT CHARACTERISTICS OF FIVE CHRYSOSPLENIUM L. SPECIES IN THE FRAXINUS PLATYPODA FOREST

**Atsuko Fukamachi[1], Yoshinobu Hoshino[2], Katsuhiro Naka[o3]**

*[1] United Graduate School of Agricultural science Tokyo University and Technology, Symbiotic Science of Environmental and Natural Resource, Tokyo, Japan ; [2] Tokyo University of Agriculture and Technology, Faculty of Agriculture, Tokyo, Japan ; [3] Forest and Forest Products Research Institute, Department of Plant Ecology, Ibaraki, Japan*

Keywords: mountain riparian forest floor, classification tree model, microtopography, *Chrysosplenium* L., *Fraxinus platypoda*

Genus *Chrysosplenium* L. (Saxifragaceae) has many endemic species in Japan and identification is difficult because of similar growth form and high morphological plasticity. Saxifragaceae habitats are wet shady areas, but there are few detailed reports about their habitat and information of coexistence. This study was aimed to get some basic information on the ecology of some *Chrysosplenium* species that grow on the Japanese mountain riparian forest floor.
We studied the distribution and habitat of 5 *Chrysosplenium* species (*C. echinus*,*C. macrostemon* var. *shiobarense*, *C. album* var. *stamineum*, *C. pilosom* var. *fulvum*, *C. flagelliferum*) in a *Fraxinus platypoda* forest, upstream of the Watarase river. To study distribution and habitat characteristics in detail, 722 1m$^2$ quadrants were arranged regularly within ca. 0.4 ha plot. Data were collected on the presence/absence of each species, and the environmental conditions were measured (inclination, litter mass, moss cover, surface substrate, fallen tree, raindrop erosion, canopy openness). The classification tree model and Deviance Weighted Score (DWS) were used to analyze location preferences. In addition, to compare their preference to microtopography we classified 6 microtopography units (valley-sideslope, SS; footslope, FT; landslide, LS; talus slope, TS; alluvial fan, AF; flood plain, FP).
As a result, *C. echinus* and *C. album* were distributed widely in the study plot and co-occurred with other *Chrysosplenium* species in the same quadrants. Inclination and moss cover showed a high DWS for 5 species, and litter mass showed a high DWS for 4 species, except for *C. flagelliferum*. Suitable conditions for *C. echinus* and *C. macrostemon* were slow grade condition. For *C. flagelliferum,* a rocky condition was suitable. *C. echinus* does not prefer the SS. *C. pilosum* prefers the FT and LS. *C. flagelliferum* prefers the TS and FP. All species showed no preference for the AF.
The proximate species that have similar growth form coexist in the *F. platypoda* forest floor by altering their location preferences. Multiple environment conditions in the *F. platypoda* forest floor, which originate from various ground disturbances, enable the species to coexist.

Session 'Descriptive vegetation science' / POSTER 14

## A MICRO-DATA TRANSITION MATRIX MODEL TO IMPROVE SUCCESSION DESCRIPTION FOR RESTORATION

**Jérôme Sawtschuk, Sébastien Gallet, Fréderic Bioret**

*Institution, Institut de Géoarchitecture EA 2219, Université de Bretagne Occidentale, CS 93837 29238 Brest Cedex 3, France*

Keywords: Transition matrix, Markov model, Pin–point data, Succession, Restoration

Knowledge of succession rates and pathways is important to improve ecological restoration practices and their assessment. In Brittany, many linear pin-point permanent surveys were collected over the last few decades to evaluate the restoration operation of the maritime cliff-top heathland and grassland vegetations. Frequently, successions following human disturbance were analyzed after summing pin-points and forming a species percentage macrodata. Despite being available, individual transition paths of single microdata objects that describe species composition have not yet been considered. The transition matrix Markov model is an efficient tool to quantify transitions between successive stages. This model is particularly efficient when many transitions are available, which is the case at the microdata scale where succession can be considered for each pin-point. In this study, a transition model was applied to these microdata surveys. Several statistical tests of model assumptions were performed showing succession prediction abilities. We demonstrated that stationarity of the system evolves through time, which complicates prediction robustness. A progression from a random succession towards a more predictable system with time revealed the difficulty in assessing restoration success from short vegetation monitoring.

Session 'Descriptive vegetation science' / POSTER 15

## CAUSALISTIC ANALYSIS OF THE RANGE OF *STYRAX OFFICINALIS* IN ITALY

**Laura Casella, Emiliano Agrillo, Francesco Spada, Fabio Attorre**

*University "Sapienza", Dipartimento di Biologia Ambientale, Rome, Italy; (corresponding author: francesco.spada@uniroma1.it)*

Keywords: tertiary relics, geostatistical approach, persistence, Apennines

*Styrax officinalis* L, a small deciduous tree of St*yracaceae*, is one of the crucial species of Mediterranean phytogeography and a relic of a late-Neogene's floral stock. Its range includes the regions to the south and west of Palestine, Turkey, the Aegean region, the SW Balkan Peninsula and central Italy in a very restricted enclave at around 42 degrees latitude. Populations are concentrated on the hills east of the city of Rome. This westernmost European outpost of the Aegaeo-Anatolian-Palestinian range-bulk occupies an area where the floral associates in the community exhibit a strong thermophilic character (*Hyparrhenia hirta, Ampelodesmos mauritanicus, Stipa capensis*) and a conspicuous amount of small trees (*Carpinus orientalis, Cercis siliquastrum, Pistacia terebinthus, Paliurus australis*). Here, we suggest that the relic character of the stands might be related to some outstanding features of the local environmental envelope that provides favorable conditions for the persistence of the species. To test this hypothesis, we examined the total range of the Italian outpost using descriptive statistics applied to a matrix of operational geographic units from a geographic grid in which presence/absence of the species and environmental variables were recorded. A geostatistical approach (Kriging, a set of linear regression routines used to interpolate data points) was used to obtain isolines of the environmental parameters. Multivariate analysis was applied to the same dataset to obtain a graphical overview of the relationships between species and environmental parameters. This parameterization produced a simulated "potential range", the core of the probabilistic approach of this study.

Session 'Descriptive vegetation science' / POSTER 16

## TO WHAT EXTEND DOES FUNCTIONAL CLASSIFICATION MATCH WITH PHYTOSOCIOLOGICAL SCHEME? A CASE OF HALOPHYTE VEGETATION

**Mitja Kaligarič[1], Urška Rabuza[2], Sonja Škornik[1], Nina Šajna[1]**

*[1] University of Maribor, FNM, Biology Dept., Koroška 160, 2000 Maribor, Slovenia ; [2] University of Maribor, College of Nursing Studies, Žitna 15, 2000 Maribor, Slovenia (corresponding author: mitja.kaligaric@uni-mb.si)*

Keywords: halophyte vegetation, plant traits, PCA classification

Classifying plant species into their taxonomy has strong limitations at the scale of ecosystems and landscapes. A promising way forward, to address these questions, is functional classification. However, the existing syntaxonomical classification is useful for mapping, and conservational evaluations are based thoroughly on floristic principle. Therefore, we attempted to determine to what extent the standard phytosociological classification scheme compares with functional classification, based on morphological-functional traits (MFT). We compared both approaches in 5 classes of halophytic vegetation. A total of 142 phytosociological relevés, occurring in a topographically diverse region of the Slovenian North Adriatic seacoast, were sampled according to the Braun-Blanquet procedure. For 37 species present in the relevés, we determined 16 MFT (5 regenerative and 11 vegetative). Using multivariate PCA analysis, it was shown that relevés that represent individual classes of halophyte vegetation do not mix with each other. This result suggests that there is a homogeneity of species within the 5 defined classes. When the species were classified into groups on a basis of their regenerative MFT, the seed mass and seed shape appeared to be the most relevant traits. On the basis of vegetative MFT, we could clearly identify four groups: succulents, geophytes with helomorphic leaves, middle-height rosette plants with high SLA values and scleromorphic leaves, and perennials with mesomorphic leaves. Classifying relevés on the basis of all 16 MFT yields similar groupings as species classification. Therefore, the existing classification into classes and lower syntaxa based on pure floristic principle actually corresponds to the classification based on MFT. A PCA multivariate analysis shows roughly the same divergence, regardless if the input data are species composition or MFT. The congruity between the results of classification comparing floristic and functional input data is perhaps an exception in halophyte vegetation. The structural differences of plants, characteristic of different classes of halophyte vegetation, are much higher than the differences between other classes of vegetation inhabiting less variable environmental conditions.

Session 'Descriptive vegetation science' / POSTER 17

## COMBINING ORDINATION AND REMOTE SENSING TECHNIQUES TO MAP ECOTONES IN A HETEROGENEOUS LANDSCAPE

**Hannes Feilhauer, Ulrike Faude, Sebastian Schmidtlein**

*University of Bonn, Vegetation Geography, Bonn, Germany (corresponding author: hannes@giub.uni-bonn.de)*

Keywords: floristic gradient, imaging spectroscopy, isometric feature mapping, Partial Least Squares regression

Detailed vegetation maps are required for conservation planning and management. For such maps, a meaningful generalization of the floristic pattern is of high importance and frequently attempted with classification approaches. Delineated discrete units are however often arbitrary because natural vegetation rarely exhibits sharp boundaries. These approaches may be inapt for a detailed description of these patterns. Alternatively, ordination methods can be used to extract floristic gradients, which describe the prevailing compositional variation as metric variables. The generalization abilities of ordination methods have been used previously to derive gradient maps that show floristic patterns in continuous fields.

In the present study, gradient mapping was used for the first time in a heterogeneous landscape (~30 km²) with intricate and gradually changing floristic patterns (Wahner Heide, near Cologne, Germany). We tested Isometric Feature Mapping, a promising ordination method, for its generalization ability against the established techniques such as Detrended Correspondence Analysis and Nonmetric Mulidimensional Scaling. Isomap preserved 74% of the original floristic variation (195 vegetation records) in a three-dimensional solution, which was considerably more than was achieved by the established ordination methods. The resulting floristic gradients (i.e., Isomap axes) were related to imaging-spectroscopy data (HyMap) using Partial Least Squares regression (PLSR). The regression equations (one for each dimension) were subsequently applied to the image. The PLSR models showed model fits ranging from $R^2 = 0.59$ to $R^2 = 0.73$ in calibration, and from $R^2 = 0.55$ to $R^2 = 0.69$ in tenfold cross-validation. The combination of Isomap ordination and imaging spectroscopy showed promising results for the detailed mapping of complex ecosystems. The resulting gradient map provides in-depth information on floristic vegetation patterns that can be further related to underlying environmental gradients.

Session 'Descriptive vegetation science' / POSTER 18

# SURVEY OF PLANT COLONIZATION OF A STORMWATER INFILTRATION BASIN THROUGH STATIC AND DYNAMIC APPROACHES

**Muriel Saulais[1], Xavier Marsault[2], Renato Saleri[2], Damien Lemoine[3], Delolme Cécile[1], Jean-Philippe Bedell[1]**

*[1] LEHNA-IPE, UMR 5023, University Of Lyon, ENTPE, Vaulx-en-Velin France, (corresponding author: bedell@entpe.fr); [2] MAP-ARIA, EAL, Vaulx-enVelin, France.[3] LEHNA-E3S , UMR 5023, University Of Lyon, U. Claude Bernard Lyon 1, Villeurbanne, France*

Keywords: natural colonization; aerial photos; infiltration basin; inventory; vegetal patterns

Infiltration basins are widely used to reduce stormwater volume. Wild plants that spontaneously these basins may reveal information about their edaphic characteristics. As the basins are anthropogenic environments, the description of plant biodiversity helps us determine which species are able to colonize these basins and identify the relationships between vegetation and basin functioning. We have developed a methodology that couples a classical approach using a floristic inventory (abundance dominance data) and an approach using aerial pictures taken at several dates. The aim of this study is to test if this methodology can be applied to an 8000 square meter basin and help to link vegetation colonization dynamics to the functioning of this basin. We first applied a classical approach by determining the vegetation pattern of the basin and assessing the ecological requirements of species (Ellenberg criteria). We performed this inventory within 30 areas that were sampled by construction of the minimal area of each one. We listed nearly 60 different species. According to the floristic inventory, two zones were distinguished: a zone defined as a meadow and a wetland-like zone. A low correlation was found between floristic data and some physicochemical characteristics, namely soil water content. The approach of aerial picture analysis underlined a better and more clear relationship between surface water occurrence and vegetation patterns. The first aerial shoot, taken in April 2008, allowed us to locate the surfaces covered by water, and the second shoot, taken in June 2008, underlined spatial organization of vegetation. Around 80% of the basin surface was covered by vegetation. Vegetation abundance and the organization of different vegetation patterns are correlated to water occurrence in the basin. A third picture taken in June 2009 allowed us to identify the dynamics of vegetal patterns over two years in the functioning basin. We discussed the benefits and limitations of this methodology being applied to a relatively small scale.

# Biological invasions: towards general models and increased predictability

Session 'Biological invasions' / ORAL

## CURRENT PATTERN AND FUTURE PROJECTIONS OF THE LEVEL OF INVASION BY ALIEN PLANTS IN EUROPE

**Milan Chytrý[1], Jan Wild[2,3], Petr Pyšek[2,4], Vojtěch Jarošík[4,2], Nicolas Dendoncker[5], Isabelle Reginster[6], Joan Pino[7], Lindsay C. Maskell[8], Montserrat Vilà[9], Jan Pergl[2], Ingolf Kühn[10], Joachim H. Spangenberg[10,11], Josef Settele[10]**

*[1] Masaryk University, Department of Botany and Zoology, Brno, Czech Republic; [2] Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice, Czech Republic; [3] Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Praha, Czech Republic; [4] Charles University, Department of Ecology, Praha, Czech Republic; [5] Facultés Universitaires Notre Dame de la Paix, académie Louvain, Department of Geography, Namur, Belgium; [6] Université catholique de Louvain, Department of Geography, Louvain-la-Neuve, Belgium; [7] Center for Ecological Research and Forestry Applications (CREAF) and Autonomous University of Barcelona, Department of Animal and Plant Biology and Ecology, Bellaterra, Spain; [8] Centre for Ecology and Hydrology, Bailrigg, United Kingdom; [9] Estación Biológica de Doñana (EBD-CSIC), Sevilla, Spain,[10] UFZ – Helmholtz Centre for Environmental Research, Department of Community Ecology, Halle (Saale), Germany,[11] Sustainable Europe Research Institute, Cologne, Germany*

Keywords: biological invasions, habitat types, mapping, neophytes, scenarios

Recent studies showed that habitat type is a good predictor of the level of plant invasion, expressed as the proportion of alien species to all species. Patterns of habitat invasion are consistent among contrasting European regions. We use these findings for mapping the level of plant invasion in Europe and for projecting future trends. We used 52,480 vegetation plots from Catalonia, the Czech Republic and Britain to quantify the levels of invasion by neophytes in 33 habitat types. Then, we extrapolated the measured levels of invasion to the European scale using the CORINE land-cover map. The highest levels of invasion were estimated for agricultural, urban and industrial land, especially in lowland areas of the temperate zone of western and central Europe. Low levels of invasion were estimated for grasslands and woodlands, and the lowest levels for sclerophyllous vegetation, heathlands and mires. The boreal zone and mountainous regions across the continent, as well as the Mediterranean region, except for its coastline, river corridors and areas with irrigated agricultural land were invaded to a limited extent. Subsequently, we used integrated scenarios of possible future socio-economic developments to create plausible spatially explicit scenarios of European land-use change for 21st century. We combined the data on the level of invasion with three scenarios assuming (1) deregulation and globalization, (2) continuation of current policies with standing regulations and (3) a shift towards sustainable development. Under all scenarios, an increase in the level of invasion was projected, especially for North-western Europe. However, a decrease was projected for some agricultural areas of Eastern Europe, where abandonment of agricultural land is expected. Nevertheless, a net increase in the level of invasion over Europe was projected under all scenarios. The polarization between more- and less-invaded regions is likely to increase if future policies are based on economic deregulation. However, an implementation of sustainability policies would not automatically restrict the spread of alien plants. Controlling invasions would require specific policy approaches beyond the more general ones.

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## BIOTIC HOMOGENIZATION OF CENTRAL EUROPEAN URBAN FLORAS DEPENDS ON RESIDENCE TIME OF ALIEN SPECIES AND HABITAT TYPES

**Zdeňka Lososová[1,2]*, Milan Chytrý[1], Lubomír Tichý[1], Jiří Danihelka[1,3], Karel Fajmon[1], Ondřej Hájek[1], Kateřina Kintrová[1], Deana Láníková[1,3], Zdenka Otýpková[1], Vladimír Řehořek[1]**

*[1]Department of Botany and Zoology, Masaryk University, Brno, Czech Republic; [2]Department of Biology, Masaryk University, Brno, Czech Republic; [3]Department of Vegetation Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Brno, Czech Republic (Zdeňka Lososová: lososova@ped.muni.cz)*

Keywords: Archaeophytes, biological invasions, city, native plant species, neophytes.

Human activities promote the introduction of alien species to new areas and lead to changes in biodiversity. Locally, the spread of alien species may increase biodiversity, but at a large scale, it could result in biotic homogenization, i.e., increasing similarity among floras of different areas. Here, we ask whether flora of Central European cities is being homogenized due to the spread of alien species, whether biotic homogenization depends on the residence time of aliens, and whether habitats under more intensive human pressure are more strongly homogenized.

Using floristic composition data from a standardized sample of plots of 1 ha located in 7 habitat types in 32 cities of Central Europe, Belgium and the Netherlands, we compared homogenization effects of archaeophytes (pre-1500 AD aliens) and neophytes (post-1500 AD aliens) using rarefaction curves, a Sørensen dissimilarity index, Mantel tests and a homogenization index.

In total, we recorded 1196 plant species, of which, 562 were native, 188 archaeophytes and 386 neophytes. We found that the proportions of archaeophytes and neophytes varied among urban habitats. It was found that archaeophytes contributed to homogenization and neophytes to differentiation of flora among cities. However, in general, the spread of alien species caused differentiation. Differentiation was weakest in the most disturbed urban habitats, such as city squares, boulevards or early successional sites, and it was strongest in the moderately disturbed habitats such as city parks and residential areas with open building patterns.

Our results demonstrate that biotic homogenization depends on the residence time of alien plants. Aliens introduced within the past few decades or centuries are often rare and have not yet filled their potential range in the areas of their introduction; thus they increase floristic differentiation. In contrast, species introduced more than five centuries ago had sufficient time to spread into most of the suitable habitats and sites, and they consequently contribute to homogenization.

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## PHYLOGENETICALLY POOR PLANT COMMUNITIES RECEIVE MORE ALIEN SPECIES, WHICH MORE EASILY COEXIST WITH NATIVES

**Pille Gerhold[1,7], Meelis Pärtel[1], Oliver Tackenberg[2], Stephan M. Hennekens[3], Igor Bartish[4,5], Joop H. J. Schaminée[3], Alexander J.F. Fergus[4,6], Wim Ozinga[3,7], Andreas Prinzing[3,4]**

*[1] Institute of Ecology and Earth Sciences, University of Tartu, Lai 40, 51005 Tartu, Estonia ; [2] Institute of Ecology, Evolution and Diversity, Goethe-University Frankfurt, Germany ; [3] Alterra, Centre for Ecosystem Studies, WUR, PO Box 47, 6700AA Wageningen, The Netherlands ; [4] University of Rennes 1, CNRS, Research Unit "Ecobio" Research Group "Ecology of Diversification", Campus Beaulieu, Bâtiment 14A, 35042 Rennes, France ; [5] Institute of Botany, Academy of Sciences of C. R., CZ-25243 Pruhonice 1, Czech Republic ; [6] Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland ; [7] Radboud University Nijmegen, Department Ecology, Toernooiveld 1, NL-6525 ED Nijmegen, NL (corresponding author: pille.gerhold@ut.ee)*

Keywords: Alien species, community assembly, functional traits, invasions, phylogenetic diversity

Alien species can be a major threat to ecological communities. However, we do not know why some community types allow the entry of many more alien species than others. Here, for the first time, we suggest that evolutionary diversity of the constituent species of a community may determine its present receptiveness to alien species. Using the Dutch Vegetation Database we found robust evidence that plant community types assembled from a few phylogenetic lineages (i.e., phylogenetically poor communities) are more receptive to aliens. The establishment of alien species in phylogenetically poor communities corresponds to the increased phylogenetic dispersion of these communities and to coexistence, rather than replacement, of natives. This coexistence between native and distantly related alien species in phylogenetically poor communities could reflect patterns of trait assembly. In communities without aliens, low phylogenetic dispersion corresponds to increased dispersion of most traits. The establishment of aliens corresponds to increased trait concentration. We conclude that if quantified across the tree of life, high biodiversity correlates to decreasing receptiveness to aliens. Low phylogenetic biodiversity, in contrast, facilitates coexistence between native and alien species even if they share similar trait states.

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## HOW TO USE VEGETATION DATABASES AND MEAN PLANT TRAITS - ECOLOGICAL PREFERENCES OF ALIEN PLANT SPECIES IN NORTH-EASTERN GERMANY

**Florian Jansen[1], Christian Berg[2], Jörg Ewald[3]**

*[1] University of Greifswald, Institute of Botany and Landscape Ecology, Greifswald Germany; [2] Institute of plant science, University Graz, Austria ; [3] University of Applied Sciences, Faculty of Forestry, Freising, Germany; (corresponding author: jansen@uni-greifswald.de)*

Keywords: co-occurrence; ecological theory; Ellenberg indicator values; level of invasion; phytosociological database

Many studies of plant invasions are restricted to a few species and/or special conditions, which constrains the universal validity of the results. The comprehensive vegetation database of Mecklenburg-Vorpommern/NE Germany with 51,328 relevés allowed us to study an entire regional flora of 133 non-native plants (NNP, immigration after 1492 AD) with regard to their preferences to all kinds of habitats and along different ecological gradients. For each relevé, we computed the average Ellenberg indicator values (EIV) for temperature, light, moisture, reaction, nutrients and salt as well as plant strategy type weights. We partitioned the dataset into relevés with and without occurrences of NNP and compared them with respect to the relative frequencies of EIVs and strategy type weights.
Due to the preferential sampling of the database and the potential bias of plant indicator values we had to design a sophisticated analysis to ensure significant results. We identified deviations from random differences by testing against permuted indicator values. To account for potential bias in EIV between community types, NNP preferences were differentiated for 34 phytosociological classes and 6 formations. We tested significance and non-randomness of preferences for the group of NNP as a whole and for single NNP species within the entire dataset. We also differentiated by phytosociological classes and formations. NNP, as a group, prefer communities with high EIVs for temperature and nutrients and low EIVs for moisture. They avoid communities with low EIV for reaction and high EIV for salt. NNP prefer communities with high proportions of ruderal and low proportion of stress strategists. The differentiation by phytosociological classes reinforces the general trends for temperature, nutrients, moisture, and R and S strategy types. Nevertheless, the preferences of individual alien species reveal that NNP are not a congruent group but show individualistic ecological preferences.

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## USING STRUCTURAL EQUATION MODELLING TO TEST THE PASSENGER-DRIVER HYPOTHESIS: RESULTS FROM A NORTHERN GRASSLAND

**Shannon White[1], Steven Tannas[2], Tan Bao[1], Jonathan Bennett[1], Edward Bork[2], James Cahill[1]**

*[1] University of Alberta, Department of Biological Sciences, Edmonton, Canada; [2] University of Alberta, Department of Agriculture, Food, and Nutritional; Sciences, Edmonton, Canada; (corresponding author: shannon.white@ualberta.ca)*

Keywords: Community ecology, grasslands, invasion, biodiversity, structural equation modeling

Invasive species are one of the major agents of human-driven global change and are often cited as responsible for massive biodiversity loss. However, species rarely invade without concurrent changes in abiotic or biotic habitat, making it unclear whether invasive species are the drivers or passengers of community change. Studies have found support for both the driver and passenger models. However, the multiple causal linkages between habitat change, community properties, and invasive species make this an inherently difficult question to answer experimentally. We used Structural Equation Modeling (SEM), a technique well suited to evaluate causal networks, to examine the relationship between environmental conditions, defoliation, the plant community and the invasive plant *Poa pratensis,* in a northern temperate grassland. We applied litter removal, water addition, and nitrogen addition treatments for three years in a fully factorial randomized complete block design, in a total of 64 plots. In another 96 plots, we applied defoliation (two levels: summer or winter defoliation), water addition, and nitrogen addition treatments. Each plot treatment was $1m^2$ and each treatment combination had eight replicates. Plots were monitored for percent cover by species and environmental variables. We developed a structural equation model testing relationship between species richness, *P. pratensis*, and the litter, nitrogen, and water treatments. In a second model, we substituted the defoliation treatments for the litter treatment. With the litter treatment, species richness decreased *P. pratensis* abundance when *P. pratensis* abundance was low. In contrast, after the defoliation treatment species richness also decreased *P. pratensis* when its abundance was low. However, when the abundance *P. pratensis* was high it drove species richness. This result suggests that rather than being either passengers or drivers, invasive species can act as both, depending on abiotic and biotic conditions. Understanding this relationship is important to enable the correct management of systems to promote qualities that resist invasion and to provide insight into the dynamics of domination in plant communities.

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## DEALING WITH SPARSE DATA TO MODEL HOW NATURAL GRADIENTS AND PROPAGULE PRESSURE SHAPE FINE SCALE ALIEN PATTERNS ON SANDY SHORES

**Marta Carboni, Riccardo Santoro, Alicia T.R. Acosta**

*Università degli Studi Roma Tre, Dipartimento di Biologia Ambientale, V.le Marconi 446 – 00146 Roma, Italy (corresponding author: mcarboni@uniroma3.it)*

Keywords: coastal dune vegetation, exotic plants, natural stress and disturbance, imputation of environmental variables, zero-inflation

Questions: On sandy shores, factors related to the substrate and to wind action vary along the sea-inland ecotone, forming a marked directional disturbance and stress gradient. The input of propagules of alien plant species associated to touristic exploitation and development is intense. This has contributed to the establishment and spread of aliens in coastal systems. Nevertheless, records of alien species in vegetation databases of heterogeneous landscapes generally remained scarce, posing a potential challenge for statistical modeling. In the present study, we addressed this practical issue and attempted to shed light on the role played by environmental stress/disturbance gradients and propagule pressure on the invasibility of plant communities in these typical model systems.
Location: Sandy coasts of the Lazio (Central Italy) region
Methods: First, we proposed an innovative methodology to deal with the low prevalence of alien occurrence in the data set and high costs of field-based sampling. By taking advantage, through predictive modeling, of the strong interrelation between vegetation and abiotic features in coastal dunes we were able to predict alien occurrence. We then fitted generalized additive models to analyze 1) overall patterns of alien occurrence and spread, and 2) the specific patterns of the most common alien species recorded.
Conclusions: Our results showed that, even in the presence of strong propagule pressure, variation in local abiotic conditions can explain the differences in invasibility within a local environment. We observed that intermediate levels of natural disturbance and stress offer the best conditions for the spread of alien species. However, in our model system, propagule pressure is the main determinant of alien species occurrence and spread. Finally, we demonstrated that extending the information of environmental features measured in a subsample of vegetation plots, through predictive modeling, allows one to address complex questions in invasion biology, without requiring disproportionate funding and sampling effort.

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## ARE INVASIVE SPECIES DRIVERS OR PASSENGERS OF SUCCESSION?

**Jan Thiele[1], Maike Isermann[2]**

*[1] University of Muenster, Institute of Landscape Ecology, Muenster, Germany (corresponding author: jan.thiele@uni-muenster.de); [2] University of Bremen, Vegetation Ecology and Conservation Biology, Bremen, Germany (maike.isermann@uni-bremen.de)*

Keywords: community assembly, diversity, filter, invasive species, succession

Invasive plant species can build up dominant stands, particularly in successional plant communities such as abandoned grasslands and coastal dunes. Dominant invaders might block successional progress by excluding native colonizers or they might change successional trajectories by acting as novel filters or transformers. We studied the relationships of two invasive species, *Heracleum mantegazzianum* Somm. et Lev. and *Rosa rugosa* Thunb., with community composition and richness of different plant groups using regression models and ordination (DCA, CCA). Invaders correlated negatively with early-successional species, but not with later-successional ones. Hence, invaders do not seem to exclude native colonizers. In dominant stands of *H. mantegazzianum*, juvenile growth of native tall herbs and trees could be observed, suggesting that the invader does not block succession. But the post-invasion establishment of shrubs and trees has not been observed in dominant stands of *R. rugosa*. The major gradients of community composition resembled successional sequences from white dunes to scrub (*R. rugosa*) and from grasslands to tall-herb communities and woodlands (*H. mantegazzianum*), using a place-for-time substitution. Along these gradients, cover percentages of invaders showed bell-shaped distributions with the maxima in plant communities representing intermediate successional stages. Early-successional species continuously decreased and later-successional species increased. Absolute maxima of *R. rugosa* were not found directly on the major successional gradient, but at the upper end of a secondary gradient toward Rhamno-Prunetea communities. If the gradients corresponded to real trajectories, *R. rugosa* would modify the course of succession by transforming open dunes into shrub communities. It remains unclear whether its dominant stands are transient or stable. In contrast, *H. mantegazzianum* had an absolute maxima centered on the main successional gradient, suggesting that it declined again during succession without altering trajectories. We conclude that *H. mantegazzianum* is likely a passenger, whereas *R. rugosa* could be a driver of successional change.

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## UNDERSTANDING THE IMPACT OF BIOLOGICAL INVASION ON COMMUNITY DYNAMICS AND ECOSYSTEM FUNCTIONING USING PLANT FUNCTIONAL TRAITS

**Nicolas Gross[1], Richard Duncan[2], Philip E. Hulme[2]**

*[1] Centre d'Etudes Biologiques de Chizé, CNRS UPR 1934, Villiers-en-Bois, F-79360 Beauvoir-sur-Niort France [2] Bio-Protection Research Centre, PO Box 84, Lincoln University 7647, Canterbury, New Zealand (corresponding author: nicolas.gross@cebc.cnrs.fr)*

Keywords: biological invasion, plant functional traits, biotic interactions, community trait distribution, ecosystem functioning

Biological invasions are one of the main biodiversity threats worldwide. It is urgent to find efficient tools to predict invasive success and its consequences on native ecosystems. Although naturalization has been extensively studied (*i.e.*, which factors influence the introduction and establishment of new species), the impact of exotic species at the community and the ecosystem levels are less understood. Invasive species tend to exhibit contrasting traits from natives. Invasive species are generally characterized by exploitative trait syndrome (fast relative growth rate, high rate of resource acquisition), whereas native species tend to be more conservative (opposite trait syndrome). Here, we argue that functional differences between natives and exotics are central to understand biological invasions. We propose a four-step approach to study the effect of invasive species on community dynamic and ecosystem functioning. First step, regional trait pools: differences among natives and exotics help to identify key traits for invasion success. Functional differences highlight important dimensions by which exotics contrast with natives. Second step, community assembly: by comparing the trait distribution at the regional scale with trait distributions within communities, patterns of community assembly can be explored using null models. Contrasted trait distributions between natives and exotics can be used to detect contrasted mechanisms of community assembly along ecological gradients. Third step, biotic interactions: biotic interactions can be estimated by quantifying trait distributions at the plant neighborhood scale. At this scale, trait over-dispersion reflects facilitation while trait under-dispersion highlights competition between natives and exotics. Forth step, ecosystem functioning: because traits determine the species effect on ecosystem functioning, a change in functional diversity within communities affects the ecosystem's response to invasion. We illustrate our approach using an empirical survey performed within highly invaded grassland systems in New-Zealand that grew along contrasted gradients of elevation, rainfall and grazing intensity.

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## PHYSIOLOGICAL TRAITS TO ASSESS *HIERACIUM PILOSELLA* INVASION IN THE MAGELLANIC STEPPE OF TIERRA DEL FUEGO ISLAND (ARGENTINA)

**Mari Cruz Díaz-Barradas[1], María Zunzunegui [1], Mari Paz Esquivias [1], Leonor Alvarez [2], Marta Collantes [3], Pablo Cipriotti [4]**

[1] *Department of Plant Biology and Ecology, University of Seville, Spain ;* [2] *Smithsonian Tropical Research Institute, Panamá;* [3] *Laboratorio de Ecología de Pastizales. Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina ;* [4] *Facultad de Agronomía, Universidad de Buenos Aires, Argentina*

Keywords: patches, stable isotopes, traits, water use efficiency, wind

The invasion of natural ecosystems by alien species results in a reduction of biodiversity and modifies ecosystem function. Additionally, island ecosystems are particularly vulnerable to biological invasion because of their relative isolation from the mainland. The specific traits of an invading species, its interaction with abiotic factors and the native community determine the success of invasions. The herb *Hieracium pilosella* has invaded northern Tierra del Fuego rangelands since 1990, approximately. It forms, in some cases, large patches that replace native flora and decrease the quality of grasslands for sheep grazing. The main aim of this study was to investigate how *H. pilosella* is affecting leaf nutrient dynamics and carbon exchange characteristics of the dominant plant species in the Fuegian steppe. With this specific aim we are trying to assess how this species is a strong grassland invader in different parts of the world. Different traits have been compared between *H. pilosella*, native species (*Festuca gracillima, Poa spiciformis and Acaena pinnatifida*) and noninvasive alien species (*Trifolium repens*). Field gas exchange, photochemical efficiency, relative water content, laboratory measurements (proline and chlorophyll content), nutrient concentration and stable isotope composition have been measured in the above species with and without interaction with *H. pilosella.* Invasive species were measured between the center and border of the patches. Results showed that all native species suffered a significant increase in $\delta^{15}N$ signature when they were invaded by *H. pilosella*, probably due to its higher decomposition rate. However, a negative relationship was found between $\delta^{15}N$ and nitrogen content. Proline content was significantly higher in leaves of some non-invaded species and was negatively correlated with the C/N ratio. The $\Delta^{13}C$ exhibited the highest values in *F. gracillima* and was negatively correlated with intrinsic $A/g_S$. Therefore, it could be used as a long-term proxy of WUE. *F. gracillima,* the tallest species of this community, suffered a significant decrease in $\Delta^{13}C$ when it grew with the invasive species. *H. pilosella* exhibited a significant increase. These results enhanced the effects of inter- and intra-specific competition in the water economy in an area subjected to strong winds. Although the effects of competition within the invasive species were small compared to the differences among species, the results of MANOVA and Canonical Discriminant Analysis showed significant overall differences between natural and invaded grasslands. These data support the hypothesis that *H. pilosella* is modifying plant traits in the community.

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## UPWARD SHIFTS IN ALTITUDINAL LIMITS OF EXOTIC PLANTS IN A MONTANE GRASSLAND

**J. M. Kalwij[1,3], Mark P. Robertson[2], Berndt J. van Rensburg[2,3]**

[1] *Institute of Ecology and Earth Sciences, University of Tartu, Tartu, 51005, Estonia;* [2] *Department of Zoology and Entomology, University of Pretoria, Pretoria, 0002, South Africa;* [3] *DST-NRF Centre for Invasion Biology, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa; (corresponding author: jesse.kalwij@ut.ee)*

Keywords: alpine; exotic; montane; Sani Pass; time-series

Monitoring trends in invasive alien species is one of the Convention of Biodiversity's indicators to detect threats to biodiversity. This monitoring, however, is challenging due to a lack of country-wide and long-term data and limited availability of resources to conduct monitoring programs. In this study we analyzed trends in upper altitudinal limits of alien plants as a proxy of their geographical range between the years 2008 and 2011. This altitudinal gradient was located in South Africa and ranged from 1500–2874 m. Our results showed that the total number of alien plants did not change significantly over time. However, a repeated measures ANOVA showed a significant trend upwards for annuals (n = 19 species) but not so for perennials (n = 31). Moreover, a t-test showed that annuals had gained 165 m of altitudinal range (n = 22, $P < 0.011$) across time. This upward trend could not be attributed to short-term climatic patterns, density of passing motor vehicles or persons, or minimum residence time of introduced species. Regional climatic trends indicated increasing temperatures and a higher variation in annual precipitation patterns over the last decennia. Such trends could, at least partially, explain the upward trend of annual alien plants because annual alien plants are strong competitors for water, produce a large number of propagules, and can quickly colonize suitable habitats. We conclude that monitoring the upper altitudinal limits of alien plants is a cost-effective means to detect trends in invasive alien species in areas where suitable gradients are available. Such data can be used to answer a range of biogeographical questions.

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## *ACER NEGUNDO* INVASION ALONG A SUCCESSIONAL GRADIENT

**Patrick Saccone[1, 2], Jean-Philippe Pagès[1], Jacky Girel[2], Jean-Jacques Brun[1], Richard Michalet[3]**

*[1]Cemagref - Unité de Recherche Ecosystèmes Montagnards, St-Martin-d'Heres, France ; [2]Laboratoire d'Ecologie Alpine, Université Joseph Fourier, Grenoble, France ; [3]Université Bordeaux 1, U.M.R. INRA 1202 BIOGECO, Talence cedex, France*
*(Author for correspondence : r.michalet@ecologie.u-bordeaux1.fr)*

Keywords: Facilitation, Forest succession, Indirect facilitation, Invasion, Riparian forests

We analyzed the role of direct and indirect plant interactions in the invasion process of *Acer negundo* along a natural successional gradient in the Middle Rhone floodplain (France). We addressed two questions: 1) What are the responses of the invasive *Acer* seedlings to the native communities along the successional gradient? 2) What are the effects of the invasive *Acer* adult trees on the native communities?
In the three communities (*Salix*, *Acer* and *Fraxinus* stands), we transplanted juveniles of the invasive and juveniles of the natives in experimental gaps, with and without a herb layer, within the forest. We also quantified changes in understory functional composition, light, nitrogen and moisture among treatments.
*Acer* seedlings were directly facilitated in their survival in the *Salix* and *Acer* communities and indirectly facilitated for growth by adult *Acer,* through the reduction of the abundance of highly competitive herbaceous competitors.
We conclude that direct facilitation by the tree canopy of the native pioneer, *Salix,* is likely the main biotic process that induced *Acer* colonization in the floodplain. Indirect facilitation by adult conspecifics contributed to the population's establishment.

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## DO SIMILAR WEAPONS BETWEEN SPECIES LIMIT COLONIZATION BY BOHEMIAN KNOTWEED?

**Soraya Rouifed[1,3], Alexandra Cochinaire[1], Guillaume Meiffren[2], Laurent Simon[1], Florence Piola[1]**

*[1] LEHNA UMR 5023 University Lyon1, Villeurbanne, France; [2] Ecologie Microbienne UMR 5557, University Lyon1, Villeurbanne, France*
*(3 corresponding author: soraya.rouifed@univ-lyon1.fr)*

Keywords: *Fallopia* x *bohemica*, Bohemian knotweed, biotic resistance, limiting similarity, novel weapons

Several studies emphasized the importance of species identity in the native community to explain biotic resistance to invasion. The so-called Limiting Similarity hypothesis is based on the similarity of functional traits. It makes the assumption that the functional similarity between native and introduced species decreases the availability of suitable niches for invasive species, and thereby the invasibility of the ecosystem. However, determining the relevant traits remains a difficult challenge. In addition, very few studies experimentally examined the consequences of species interactions on invasibility. Here, we tested the Limiting Similarity hypothesis in the context of invasion by the genus *Fallopia* in France. We experimentally investigated whether the performance of propagules of *F.* x *bohemica* are limited by adult plants of species showing similar weapons to that of the invasive species. The following species were chosen: *Sambucus ebulus* (two types of similar competitive weapons: growth form and allelopathic secondary metabolites), *Rhamnus frangula* (similar allelopathic secondary metabolites), and *Rubus caesius* (no identified similar weapon). The survival, after two months of growth, and biomass allocation of either seeds or rhizomes of *Fallopia* planted in competition with the three species or without any competitor were compared. Five replicates per propagule type per treatment (either one rhizome or 30 seeds per pot) were used. Seed survival, but not rhizome survival, was reduced by the presence of the competing species. Whatever the propagule type, the growth of plantlets was affected by the competitors. The aboveground dry weight, plant height and the number of leaves were strongly reduced. Overall, we demonstrated an increasing negative effect of the competitor on *Fallopia* growth when similarity between both increased (*i.e., the* competitive effect of *S. ebulus* > *R. frangula* > *R. caesius*). This study highlights the need for examining species interactions, in addition to community composition, when testing invasibility. The benefit of taking into account the similarity of competitive weapons when measuring the resistance to biotic ecosystem is clearly outlined.

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## ETHNOBOTANY AND HABITATS OF JAPANESE KNOTWEED (*FALLOPIA JAPONICA*) IN JAPAN

**Michiko Shimoda[1], Norifumi Yamasaki [2]**

*[1] Department of Social Environment, Fuji Tokoha University, Fuji, Japan; [2] College of Environment & Disaster Research, Fuji Tokoha University, Fuji, Japan (Michiko Shimoda: shimoda@fuji-tokoha-u.ac.jp)*

Keywords: *Fallopia japonica*, invasive alien species, ethnobotanical use, Mt. Fuji, ecological limitation

*Fallopia japonica* is native to Japan, Korea, Taiwan and China. The species is now widely naturalized in Europe and North America and is regarded as one of the worst invasive alien species.
In Japan, *F. japonica* has been a common plant found close to residential and cultivated lands. A dictionary of plant names recorded 689 words for *F. japonica*, and it was the plant with the most numerous names among the compiled plants. The names describe the characteristics of *F. japonica*. In Japan, the plant has many ethnobotanical uses. Its young shoots are edible, and it is one of the popular edible wild plants in spring. Its dried rhizomes have been used in traditional medicine. It has also been used in flower arrangements. For Japanese people, *F. japonica* is not a pest but a familiar and useful plant.
Mount Fuji (3776 m altitude) is the highest mountain in Japan. *Fallopia japonica* is distributed from the mouth of Fuji River to 2500 m on the mountain. Therefore, Mt. Fuji is suitable for the ecological study of *F. japonica*. As a case study of *F. japonica*, we conducted surveys on its habitats and growth from the foot (2 m) to the alpine zone (2415 m) of Mt. Fuji. The plant was found in man-made habitats, such as verges of roads and parking lots, forest edges and disturbed ground. It was also found in natural habitats, such as a floodplain and a volcanic desert above timberline. The plant grew in a wide range of habitats, from dry soil to wet soil, but was never found in waterlogged soil. Its habitats were restricted to open and sunny sites. The height of the plant was over 2 m on the floodplain. The plant was smaller on roadsides and forest edges where the vegetation is repeatedly cut down. The plant height was up to 1 m above 2300 m in altitude.
In Japan, herbaceous vegetation is cut or mown near habitation and other infrastructure, which results in the control of overgrowth of *F. japonica* in these areas. In meadows, tall grasses dominate the vegetation. In mountainous areas, trees are dominant and open areas are limited. The friendly relationship between Japanese people and *F. japonica* suggests that these ecological limitations prevent *F. japonica* from growing very tall and occupying wide areas.

Session ‘Biological invasions’ / ORAL

## ARE SPARTIUM JUNCEUM RESTORATIONS A PROBLEM FOR CONSERVATION AREAS OF CENTRAL SPAIN?

**Rosario G. Gavilán, Mylena Gaudencio, Daniel Sánchez-Mata, Alba Gutiérrez-Girón, Beatriz Vilches de la Serna[1]**

*Departamento de Biología Vegetal II. Facultad de Farmacia. Universidad Complutense. E-28040 Madrid. Spain*

Keywords: Spartium junceum, invasions, restoration, seed bank, natural vegetation

The introduction of potential invasive species through ornamental cultivation, or for restoration purposes, is becoming a serious environmental problem. It is known that these species cause damage to biodiversity, reducing it (Lodge 1993), increasing mortality or incurring “in situ” phenomena of selection of natural flora (Callaway 2007). *Spartium junceum* is a Mediterranean shrub, and it is not natural in most of areas of Iberian Peninsula but is extensively cultivated for the restoration of roadsides. It invades nearby areas if environmental conditions are good enough for its establishment. *Spartium junceum* can affect farming systems, the economy and can produce health damage because the plant organs contain a bitter principle that has been described as a laxative and emetic. It also has glycosides like cytisine, genistine and others that are toxic to wildlife if ingested, which affect the heart’s rhythm (Font Quer 1993, Ríos & Laguna 2010) and thus are not usually consumed by herbivores.
The aim of this study was to determine how *Spartium junceum* behaves and can transform a restoration area that formerly was dominated by a *Cistus* shrub community. There is evidence that this species is highly invasive in coastal areas of the Iberian Peninsula. For this purpose, it is necessary to compare *S. junceum* stands with the surrounding natural vegetation, in this case, the chamaephytic *Cistus ladanifer* communities. To do so, we studied the herb layer of both stands to understand the impact of the dominant shrubs on it. The soil characteristics under both types of formations were checked to determine if there were changes that could affect the herbaceous and shrub layers. The importance of the seed bank to determine the composition of the vegetation in both formations was also studied. Finally, analysis of all of these effects provided enough information to evaluate the potential invasive power, under future conditions of climate change, of *Spartium junceum* in central Spain.

Session 'Biological invasions' / POSTER 19

## PLANT COMMUNITIES AND SUCCESSIONAL PROCESSES IN A SECOND-GROWTH EASTERN DECIDUOUS FOREST, BALTIMORE MD

**Stephanie M. Koontz, Vanessa B. Beauchamp**

*Towson University, Department of Biological Sciences, Towson MD USA, (corresponding author: vbeauchamp@towson.edu)*

Keywords: Succession, invasive species, community, herbivory, management

Eastern deciduous forests of the mid-Atlantic region of North America were once described as an oak-chestnut association. Today, little of this old-growth forest remains. Since the mid-19th century, there has been a continual release of former agricultural fields back to natural successional processes. However, it is unlikely reforested areas will resemble old-growth conditions. Community assembly is influenced by land use history, propagule pressure, and species performance, which are moderated by herbivory and interactions with invasive species. This study sampled the vegetation of 106 permanent plots in a secondary successional forest near Baltimore, Maryland, USA to better understand the various interactions driving community assembly. We used cluster analyses and multiple response permutation procedures to develop community classifications and nonmetric multidimensional scaling, to examine correlations between environmental variables and plant communities. Distance to paths, canopy cover, soil nitrate, and soil organic matter were most commonly associated with differences in plant community composition. Areas with open canopies near hiking and hunting paths were dominated by invasive herbaceous and shrub species. Soil nitrate levels were highest in invasive herb and fern dominated plots, and soil organic matter was highest in plots dominated by native herbs. In the tree strata, canopy openness, close proximity to paths and high nitrate levels separated communities dominated by pioneer species from those dominated by later successional species. Invasive species and their impact on successional processes are of particular concern at the study area. Two of the five herbaceous communities are invasive-dominated, but these are restricted to areas with open canopies and may decline as canopies close. More problematic is the shrub layer, where all but one community is dominated by invasive species, likely due to browse by white-tailed deer. Continued monitoring will lead to a better understanding of the role of invasive species and herbivory in succession and will aid managers in making decisions to increase wildlife use or manage target wildlife species.

Session 'Biological invasions' / POSTER 20

## ECO-PHYSIOLOGICAL PERFORMANCE OF FIVE INVADERS WITH DIFFERENT LIFE SPANS: IMPLICATION FOR MANAGEMENT

**Gyan P Sharma[1], Vartika Singh[2], Hema Singh[2]**

*[1] University of Delhi, Department of Environmental Biology, Delhi–110007, India; [2] Banaras Hindu University, Department of Botany, Varanasi-221005, India*

Keywords: Construction cost, Eco-physiology, Invasives, Traits.

Morphological and physiological traits of five invasive species with different lifespans (*Ageratum houstonianum* and *Parthenium hysterophorus* are annual*, Calatropis procera* is biennial, and *Lantana camara* and *Ricinus communis* are perennial) were studied to identify which species would potentially be the more successful invader. Leaf construction cost ($L_{CC}$) was considered as a quantifiable measure of energy demand for biomass production, is related to energy use efficiency, and results from both morphological and physiological traits. We hypothesized that a low $L_{CC}$ would give invaders a growth advantage by utilizing energy efficiently. The present study also analyzed key eco-physiological traits (WUE, Water Use Efficiency, and PNUE, photosynthetic nitrogen use efficiency) that might be related to $L_{CC}$. The $L_{CC}$ of *A. houstonianum, P. hysterophorus, C. procera, L. camara* and *R. communis* on a mass basis were 0.54, 0.41, 0.74, 0.91 and 0.94 g glucose $g^{-1}$, respectively. WUE and PNUE were 2.04, 1.89, 1.78, 1.58, 1.63 μ mol $CO_2$ $mmol^{-1}$ $H_2O$ and 235, 154, 55, 98, 48 μ mol $mol^{-1}$ $s^{-1}$ for *A. houstonianum, P. hysterophorus, C. procera, L. camara* and *R. communis,* respectively. These results revealed that *Ageratum houstonianum* and *Parthenium hysterophorus* were better performers than biennial *Calatropis procera*, perennial *Lantana camara*, and *Ricinus communis* in terms of $L_{CC}$ and key eco-physiological traits. The study showed that morphological traits are linked to physiological traits that could directly affect the invasive attributes of different invaders. This understanding is crucial to prioritizing species for ecosystem management.

Session 'Biological invasions' / POSTER 21

## THE SPREAD OF *AMORPHA FRUTICOSA* L. ALONG THE RIVERS: THE CASE STUDY OF THE BIFERNO RIVER (MOLISE, CENTRAL ITALY).

**Emanuela Carli[1], Evelina D'Alessandro[2], Piera Di Marzio[1], Carmen Giancola[1], Bruno Paura[2], Giovanni Salerno[3], Carlo Blasi[4]**

*[1] University of Molise, Department STAT, Pesche (IS) Italy; [2] University of Molise, Department SAVA, Campobasso Italy; [3] University of 'Roma Tre', Department of Environmetal Biology, Rome Italy; [4] 'Sapienza' University of Rome, Department of Environmetal Biology, Rome Italy (corresponding author: emanuela.carli@unimol.it)*

Keywords: alien species, Habitat Directive, invasion management, rivers

Rivers represent a key environment for nature conservation. They enclose habitats that have been particularly disturbed for a long time by human activities. In particular, one of the last consequences of human disturbance is the invasion of alien species, among the main causes of biodiversity loss. Since the riparian habitats are particularly prone to the invasions, the Habitat Directive asked scientists to analyze the status of alien plant species in Natura 2000 sites.
We proposed an evaluation of the current level of invasion of one of the most invasive species in riparian habitats, *Amorpha fruticosa* L. This invasive species can be found in the *ZPS IT7228230 Lago di Guardialfiera - Foce del Fiume Biferno*, in Molise region (Central Italy). The study area ranges between 0 and 300 m a.s.l. The area is also featured with high environmental heterogeneity due to human impact. In the *ZPS,* some forests of high conservation value have been recorded, such as the riparian forests coded as 92A0 "*Salix alba* and *Populus alba* galleries" according to Habitat Directive. This natural habitat type is particularly susceptible to the spread of alien plant species (e.g., *Robinia pseudoacia* L., *Ailanthus altissima* L., *Helianthus tuberosus,* L.*, Solidago gigantea* Aiton). In 2010, we collected information of the spread of *A. fruticosa* in the study area from literature, herbaria, and field surveys. We examined the presence and status in the study area by using phytosociological relevés. Using GIS (ArcGIS 9.2) as a platform of analysis and evaluation, we analyzed the surveyed populations in relation to environmental characteristics, to highlight the most invaded areas and to outline a possible future scenario.
Here we present some preliminary results on the conservation status of the Biferno river, concerning the spread of *A. fruticosa*.
Although not every alien species has harmful effects on the natural vegetation, the detection of the most invasive species allows a rapid response for control and management. We hope to produce a useful tool for nature conservation.

Session 'Biological invasions' / POSTER 22

## ORIGIN AND IMPACT OF BRAMBLE COLONIZATION ON THE BIODIVERSITY OF A XERIC STEPPE: WHICH TYPE OF ECOLOGICAL RESTORATION?

**Solène Masson [1], François Mesléard [1,2], Thierry Dutoit [1]**

*[1] Université d'Avignon, UMR CNRS IRD IMEP, 84911 Avignon, France; [2] Station biologique de la Tour du Valat, Le Sambuc, 13200 Arles, France*

Keywords: Bramble invasion, disturbance regimes, SIG.

In the last century, land-use changes, such as intensive agriculture, have caused the destruction and fragmentation of the last xeric steppe of South-Eastern France (La Crau). The creation of a landscape mosaic with different habitats and agricultural uses has modified the ecology of this dry grassland. In addition to a significant decrease of biodiversity and a standardization of animal and plant composition, brambles, *Rubus ulmifolius* L, colonize residual patches of steppe. This species is able to spread rapidly by vegetative or sexual reproduction. This species has invaded cultivated areas and/or steppe remnants that are subjected to water infiltration. This colonization leads to a decrease in the area for domestic grazing and also of the steppe birds' habitats.
The objectives of this study are the following: (1) to measure the relative importance of the main factors that cause the current invasion of bramble, (2) to determine consequences of invasion on biodiversity and (3) to test different management regimes in order to propose actions to control or not control *R. ulmifolius* extension according to different restoration objectives. Colonization determinants will be classified on the scale of grassland plots (edge effects, phase of former cultures, grazing system) using SIG analysis. Soil analyses will allow us to demonstrate the relationship between soil moisture and organic contents with an increase in bramble covering. Surveys of vegetation, entomofauna and avifauna will be conducted to determine the impact of bramble colonization on some others components of the steppe ecosystem (facilitator and/or competitor effect). A landscape analysis will allow the determination of the roles of fragmentation, connectivity and heterogeneity of brambles patches on avifauna. Field experiments, based on the application of different disturbance regimes (sheep grazing, scrub clearing) and coupled with different access to soil moisture, will be conducted to identify factors that cause the current invasion of bramble. The expected results are that only scrub-clearing and heavy sheep grazing, coupled with a limitation of the access to water resources, will significantly decreased the colonization of brambles.

Session 'Biological invasions' / POSTER 23

## DO COMMON AND ALIEN SPECIES FOLLOW ANALOGOUS TRENDS? AN APPROACH TO MINIMIZE THE ALIEN SPECIES DIFFUSION

**Sara Landi, Giovanni Bacaro, Alessandro Chiarucci**

*BIOCONNET, Biodiversity and Conservation Network, Department of Environmental Science 'G.Sarfatti', University of Siena, Via P.A. Mattioli 4, 53100 Siena, Italy (corresponding author: sara.landi@unisi.it)*

Keywords: Alien species, Common species, Nature Conservation, Natura 2000 Network

Protected areas are essential for biodiversity conservation; they represent the cornerstones on which regional strategies are built. The reserve networks are fundamental for the long-term persistence of biodiversity, especially in largely transformed landscapes in Western and Central Europe. The Natura 2000 Network is certainly one of the major tools in the European strategy for nature conservation. However, protected areas are also subjected to habitat degradation and invasion by alien species.

In the present study, we compared the patterns of species richness, composition and distribution of alien plant species with respect to the corresponding native plant species, at two different spatial scales: the plot and the whole protected area scale. The factors used to explain the richness and composition patterns of alien species at the plot scale were elevation, climate, land use type, land use heterogeneity in a buffer zone and distance from the roads. The factors used to explain the richness and composition patterns of alien species at the whole protected area scale were size, climate, size of agricultural and artificial land uses, land use heterogeneity and road density. A multiple regression approach with variable selection based on permutation was used to test the importance of the various factors in controlling the number of alien species at the two scales.

The results of this study are then discussed in order to understand which management factors are mostly responsible for the diffusion of alien species and which practices can be undertaken to minimize the diffusion of alien species.

Session 'Biological invasions' / POSTER 24

## A PHYTOMETRIC ASSESSMENT OF WETLAND VULNERABILITY TO INVASIONS

**Célia Rodriguez[1], Marika Imbert[1], Florent Arthaud [1], Soraya Rouifed [1], Florence Piola[1], Pierre Marmonier [2], Gudrun Bornette[1]**

*[1] UMR CNRS 5023, Plant ecology and wetlands, Villeurbanne, France ; [2] UMR CNRS 5023, Ecology, evolution, underground ecosystems, Villeurbanne, France ; (corresponding author: celia.rodriguezRhomeo@gmail.com)*

Keywords: Wetlands, CORINE biotopes, Phytometers, Invasibility, Fertility

The increase of trophic load has multiple effects on the functioning and biodiversity of wetland ecosystems. In aquatic and wetland ecosystems, such trophic alterations have been demonstrated to facilitate plant invasions. The aims of the present study were 1) to test the growth of invasive species used as a phytometer in a lab experiments that differ according to the nutrient level of contrasting wetland soils, and 2) to determine whether the invasive growth in the lab relates to the plant communities that grow in the wetlands, and 3) to discuss the possible use of such a methodology for assessing wetland invasibility.

For this purpose, we compared the survival and growth rate of two invasive phytometer species (*Fallopia bohemica* and *Ludwigia peploides)* on soils collected in 75 wetlands throughout the Rhône River basin that belonged to 14 CORINE Biotope habitats (5 to 6 wetlands as replicates for each habitat type). The chemical characteristics of soil samples were assessed (total contents in P, C, N, organic carbon, nitrate and ammonia nitrogen, phosphates, alkalinity).

Relationships between survival and growth rate of the phytometers and site chemical characteristics (nPCA factorial coordinates) were tested. Survival correlated positively with alkalinity and negatively with organic carbon content. Surprisingly, a negative correlation between *Ludwigia peploides* survival and nitrate and phosphate contents was observed. However, a positive correlation between its growth and $N\text{-}NH_4$, $P\text{-}PO_4$ and total P content was also observed. *Fallopia bohemica* had a high growth rate in all soils, unrelated to the nutrient content of sites.

There was no consistent relationship between the growth and survival of the phytometers and the CORINE plant community type. However, some CORINE habitat conditions seem more conducive to the development of these invasive species than others and potentially more vulnerable to invasions of *Fallopia bohemica* and/or *Ludwigia peploides.* These results outlined the usefulness of such methods for assessing the relative success of invasives according to soil characteristics but do not consider temporal variability.

Session 'Biological invasions' / POSTER 25

## THREATS AND POTENTIALS OF INVASIVE MACROPHYTE SPECIES TO INLAND FRESHWATERS IN RELATION TO CHANGING CLIMATE IN NORTHERN NIGERIA

**Sunday Paul Bako[1], Sonnie Joshua Oniye[2], Lois S.P. Bako [3]**

*[1] Ahmadu Bello University, Department of Biological Sciences, Faculty of Science, Zaria Nigeria ; [2] Ahmadu Bello University, Department of Biological Sciences, Faculty of Science, Zaria Nigeria ; [3] Federal College of Education, Department of Biology, Zaria Nigeria. (corresponding author: spbako2002@yahoo.com)*

Keywords: Macrophytes, freshwaters, climate change, Nigeria.

There are over 12 million hectares of inland freshwater bodies in Nigeria, which are mainly river systems and streams, natural and man-made lakes, naturally occurring and excavated seasonal ponds, etc. Field studies over a period of two decades in northern Nigeria identified invasive species of aquatic macrophytes that pose major concerns to the ecosystems. These were the water hyacinth (*Eichhornia crassipes*), water lettuce, (*Pistia stratiotes*), Niger grass (*Echinochloa stagnina*) and the Cattail (*Typha* sp). These were found to occur in natural and man-made lakes. These water bodies are mainly used as sources of domestic drinking water, for fishing, recreation and significantly for irrigation. Farm run-off, such as fertilizer, increases nutrient loading to the water and results in the explosive growth of aquatic vegetation.
Changing climatic patterns have been predicted to, among other impacts, alter precipitation patterns worldwide. In arid and semi-arid regions, this will result in the decrease of duration and intensity of rainfall. The increasing intensity of soil tillage for irrigated agriculture will lead to declines in available water volume in such water bodies, due to both an increase in water demand and a decreased water availability. This threatens the maintenance of the aquatic ecosystems. Presently, to safeguard ecosystem health, the management of aquatic vegetation focuses on their removal and destruction. However, there are potentials for beneficial utilization of aquatic plant resources, both at the subsistence and possibly industrial levels. These potentials have largely not been evaluated or explored. This paper reports results collected from field observations and surveys involving indigenous populations that dealt with identifying the potential of the populations and the possibilities for the exploitation and management of these aquatic resources in northern Nigeria.

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## HERBICIDES AND MECHANICAL CONTROL OF OPUNTIA DILLENII AND AGAVE AMERICANA IN THE RURAL PARK OF TENO

**José Ramón Arévalo[1], Silvia Fernández-Lugo[1], Priscila Rodríguez[1], Tamar de la Concepción[1], Tomás Mediavilla[1], Luz Marina Martín[2], Agustín Naranjo[2]**

*[1] Departamento de Ecología, Facultad de Biología, Universidad de La Laguna, La Laguna, España [2] Departamento de Geografía Física, Facultad de Geografía e Historia, Universidad de Las Palmas de Gran Canaria*

Keywords: Canary Islands, DCA, ecological, invasive species

*Opuntia dillenii* and *Agave Americana* are two American species that have been invading degraded areas of the Rural Park of Teno (Tenerife, Canary Islands). The distribution area of these species has been expanding without control in recent years, stimulated by the abandonment of agriculture and land degradation. Furthermore, in some areas, the abandonment of extensive grazing activities favors the expansion of these species. Until now, only mechanical controls have been used in many areas with very poor results. To explore other methods, we studied the potential eradication of both species by applying glyphosate (10%; Touch Down ©) in small scars made with a metallic nail and through mechanical control by uprooting individual plants and moving the rest to plastic sacks to avoid dispersion to the rest in the area. These treatments were also applied together. The treatments were replicated in 3 plots (15 x 15 m) and sampled 5 months and 4 years after treatment. We estimated the species composition (in four 2 x 2 m subplots) and the biovolume of individuals that were more than 30 cm tall. The results revealed that species composition was basically determined by the mechanical impact of removing the Agaves and Opuntias, with almost no recovery 4 years after treatment. Although the most important treatment was mechanical removal, the use of glyphosate can help prevent the return of small fragments of the invasive plants that remain in the area. However, glyphosate application alone did not have an important effect on species composition or even consistently reduce the abundance of the exotic species. These treatments (glyphosate + mechanical control) are helpful for eradicating the two invasive species in small patches and in reduced areas but are very costly for large areas.

# Conservation and restoration of plant communities

Session ‘Conservation and restoration’ / ORAL

## ESTIMATION OF SOIL QUALITY FOR NATURA-2000 AREAS: AN APPLICATION OF BIO-INDICATION

**Wieger Wamelink, Marjolein van Adrichem, Han van Dobben**

*Alterra, Wageningen UR, Wageningen The Netherlands*

Keywords: habitat types, pH, nutrients, groundwater table, quality assessment

To preserve or enhance the quality of habitat directive areas, information about the soil quality is necessary. Field measurements can provide such information, but on a regional scale, these measurements are very labor-intensive and thus costly. To estimate the soil quality for habitat directive areas in the province of Gelderland in The Netherlands, we applied the indicator system we had previously developed. In addition, the abiotic range for each habitat vegetation type and each plant species was estimated. Based on relevés made in the recent past, we estimated the soil circumstances for a range of abiotic parameters, e.g., soil pH, groundwater table, and total phosphorus content. The estimates were compared with the abiotic requirements of the present or planned habitat types to investigate whether the local soil quality met the demands of the habitat type. If the quality was outside the range of the habitat type, the difference between the estimated and required qualities was calculated as a percentage of quality deficiency. This could result from a surplus of nitrogen or another cause. Maps for the entire province were produced, indicating the deficiency shortages per parameter and for the combined parameters per habitat-type area. For almost all habitat areas, the soil quality was not sufficient for at least one soil parameter. Shortages most frequently occurred for nitrogen, phosphorous and calcium contents. To enhance the quality of some of the habitat types, it will be necessary to enlarge them or to connect them to other areas. To explore the possible extension of the habitat types, ‘search area maps’ were produced as well. For all natural areas, the abiotic deficiency shortage was estimated as if that habitat type was already present, applying the method described above. These maps indicate where the abiotic quality is sufficient for the designated habitat and thus the habitat type that could be best planned.

Session ‘Conservation and restoration’ / ORAL

## THE IMPORTANCE OF ENVIRONMENTAL FILTERS AND FOUNDER EFFECTS IN GRASSLAND RESTORATION – EVIDENCE FROM A LONG-TERM STUDY

**Norbert Hölzel**

*University of Münster, Institute of Landscape Ecology, Robert-Koch-Str. 28, D-48149 Münster, Germany*

Keywords : dispersal limitation, hay transfer, topsoil removal, Molinion, Cnidion

Restoration measures aiming at the recreation of low-productive alluvial grassland by topsoil removal and the transfer of various types of seed containing hay from target communities were monitored for 12 years between 1998 and 2009. Overall, vegetation development during the first four years was characterized by a rapid decline of ruderals, followed by a constant and ongoing spread of species transferred by hay. The origin of plant material and flooding frequency as an environmental filter were key factors in the differentiation of vegetation within the restoration site. After 12 years, the species composition strongly resembled those of the donor sites and, up until now, only a limited exchange between treatments that received hay from different origin has been observed. More than 110 species could be established from the transferred hay, and among these were numerous endangered target species. Some species, especially sedges, showed strongly delayed establishment, whereas only single species disappeared after successful recruitment. During the second half of the observation period, a massive spread of N-fixing legumes such as *Genista tinctoria* and *Ononis spinosa* occurred, reflecting the strong nutrient impoverishment by topsoil removal. Overall, the results validated topsoil removal combined with hay transfer as an extremely successful method for the long-term establishment of species-rich, nutrient-poor grassland ecosystems.

Session 'Conservation and restoration' / ORAL

## INFLUENCE OF SOIL AND MICROCLIMATE ON SPECIES COMPOSITION AND GRASS ENCROACHMENT IN COASTAL HEATH SUCCESSION

**Jasmin Mantilla-Contreras[1], Jens Schirmel[1], Stefan Zerbe [2]**

*[1] University of Koblenz-Landau, Institute for Environmental Sciences, Ecosystem Analysis, Landau, Germany; [2] Free University of Bozen, Faculty of Science and Technology, Environment and Applied Botany, Bozen, Italy (corresponding author: jasmin.mantilla@yahoo.de)*

Keywords: biodiversity, heathland conservation, N-deposition, restoration, tall grasses

Mainly due to land-use changes, European heathlands have become increasingly rare. Additionally, the increasing amount of atmospheric nitrogen deposition has resulted in the encroachment of grasses and loss of species diversity. Despite a great deal of research, there is not sufficient information about the precise environmental parameters that determine the development and maintenance of heathland vegetation. To determine the environmental factors that control heath succession and grass encroachment and to develop appropriate management schemes, we studied the influence of several soil and microclimate parameters on species composition and vegetation characteristics in five successional stages in a coastal heathlands on the island of Hiddensee, NE Germany, where the encroachment of *Carex arenaria* has become a major problem.

We recorded the highest plant species richness in grey dune and birch forest plots, although the encroachment of *C. arenaria* led to a significant decline in species richness. The most important environmental factors influencing species richness and the distribution of single species were microclimate, soil moisture, and the C/N ratio. Although many studies have reported the importance of differences in nutrient availability, we found no significant correlations between soil nutrient availability and vegetation pattern. Environmental conditions in dense *C. arenaria* stands, especially soil properties, showed great differences compared to the other successional stages. Here, we recorded the lowest pH values and the highest concentrations of Mg, Ca, and P. No correlation between the encroachment of *C. arenaria* and single environmental factors was found. Our results show not only that soil nutrients are important abiotic factors in heaths but also that microclimate and soil moisture play important roles and that many factors are involved in heath succession and in the promotion of grass encroachment. Management plans for the conservation and restoration of heathlands should therefore focus on the specific site conditions and should take several abiotic and biotic factors into account.

Session 'Conservation and restoration' / ORAL

## RELATIONSHIPS BETWEEN SOIL POROSITY, HYDROLOGY AND VEGETATION AT A LANDSCAPE-SCALE WETLAND RESTORATION SITE

**Peter Stroh[1], Francine Hughes [1], J. Owen Mountford [2], Yoseph Araya [3]**

*[1]Animal and Environment Research Group, Department of Life Sciences, Anglia Ruskin University, East Road, Cambridge CB1 1PT, UK ; [2] NERC Centre for Ecology and Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, OX10 8BB, UK ; [3] Department of Life Sciences, Open University, Walton Hall, Milton Keynes MK7 6AA, UK*

Keywords : natural regeneration, soil moisture release curve, soil stress thresholds, Sum Exceedance Value, Wicken Fen

Wetland restoration is increasingly designed to re-connect or substantially expand the boundaries of nature reserves at a landscape scale. However, land acquired for such a purpose can be highly degraded. Water regime and soil structure have considerable influence over the distribution and composition of wetland vegetation. Consequently, an understanding of the moisture-holding capacity of soils in restoration areas, as determined by soil porosity, should help explain the patterns in naturally colonizing vegetation on restored land.
Water, soil and botanical data were collected from a landscape-scale wetland restoration site and an adjacent National Nature Reserve in Cambridgeshire (UK). The water regime for each location was quantified in terms of Sum Exceedance Values (SEV). SEVs combine the extent and duration of waterlogging (SEVa) and drought (SEVd), which vegetation is subjected to as a result of fluctuating water table depths using defined soil aeration and drought stress thresholds. Botanical data were collected from each location and interpreted using corresponding SEVs. It was also possible to hindcast an estimated water regime over the previous decade for some of the sampled locations.
Soil structure was heterogeneous across the study site, ranging from well aerated to exceptionally compact. Diverse wetland vegetation was associated with well-aerated soils and minimal fluctuations of SEVa and SEVd. Low wetland species diversity was associated with either very high SEVa or with decreasing SEVa and increasing SEVd.
Hindcast water regimes allowed variations in species abundances for one vegetation type to be interpreted in terms of high rainfall in 2000/01. Where there was a strong correlation between rainfall and SEV, predicted changes in rainfall patterns associated with climate change are likely to substantially alter contemporary wetland vegetation assemblages.
This study confirmed the impracticality of restoring pre-arable vegetation on highly modified land and recommends a more flexible approach to restoration through the prioritization of hydrological management at appropriate locations and under future scenarios of reduced water availability

Session 'Conservation and restoration' / ORAL

## IMPACTS OF A MULTI-TREATMENT RESTORATION EXPERIMENT ON THE VEGETATION, SOIL AND SEED BANK OF A MEDITERRANEAN STEPPE

**Renaud Jaunatre, Elise Buisson, Thierry Dutoit**

*Université d'Avignon – UMR CNRS IRD IMEP*

Keywords: Rehabilitation of former agricultural land, Hay transfer, Soil inoculation, Nurse species seeding, Topsoil removal

Industrial cultivation phases on old plant communities, such as Mediterranean steppes, can lead to low resilience. Two main obstacles to the spontaneous recolonization of these plant communities are often the low dispersal and absence of a permanent seed bank for the target species and the high dispersal and establishment potential of unwanted species particularly due to the increase in soil fertility. What are the most efficient restoration treatments to restore these plant communities, their soil and seed bank? After the rehabilitation in 2009 of an herbaceous sheep-grazed habitat suitable for threatened steppe birds in a formerly intensively cultivated orchard in the last French Mediterranean steppe (La Crau), four experimental techniques were applied to restore the steppe plant community: i) topsoil was removed to lower ruderal species seed banks and soil trophic levels, ii) nurse species were seeded to rapidly occupy niches and then to provide safe sites for target species once sheep grazing had been reintroduced, iii) hay was transferred to provide local species seeds and iv) soil was inoculated to provide local species propagules with associated microorganisms and to lower soil trophic levels. In 2010, one year later, the above-ground vegetation, soil seed bank and soil characteristics were more or less improved, depending on the techniques used. Although the communities following nurse species seeding and topsoil removal differed most widely from the reference ecosystem (i.e., steppe), these techniques succeeded in achieving their goal by significantly lowering the abundance of unwanted dominant species in the above-ground vegetation and in the soil. While hay transfer does not have significantly higher species richness than that of the rehabilitated area for the above-ground vegetation, it shows promising results, such as some germination of target species because of their transport by this technique. Even after one year, soil transfer provides a community richness and composition very close to that of the reference ecosystem. This was remarkable, especially when considering the poor species-richness of germination during the standardized seed bank studies.

Session 'Conservation and restoration' / ORAL

## CONSEQUENCES OF RESTORATION ON THE ECOLOGICAL FUNCTIONING OF RIVERINE WETLANDS

**Safia Bechar[1], Sophie Padié[2], Djamel Mimoun[3], Gudrun Bornette[1]**

*[1] CNRS, UMR5023 Laboratoire d' Ecologie des Hydrosystèmes Naturels et Anthropisés, Villeurbanne, 69622, France; [2] École normale supérieure de Cachan ; Cachan 94235 France,; [3] Ecole Nationale supérieure des Mines de Saint Etienne, Saint Etienne, France*
*(corresponding author : becharsafia@gmail..com)*

Keywords : ecological benefit, restoration wetlands, ecosystem functioning succession, vegetation, groundwater connectivity

In the last 20 years, the huge decrease of wetlands has led managers to restore them. The questions that arise are the following: 1) what wetlands can be restored and 2) what are the benefits and durability of restorations? The aim of this work was to compare restorations conducted in four riverine wetlands of the Ain River (France). The predicted restoration responses considered the expected effect of flood disturbances, groundwater connectivity and nutrient levels. Two wetlands (A) were expected to present a low and short-term benefit of restoration because siltation processes during floods may increase eutrophication and substrate clogging. However, two others (B) were expected to present a higher benefit because they were subjected to oligotrophic groundwater supplies that limit substrate clogging and terrestrialization. These wetlands were restored by removing sediment [either fine sediment that accumulated after the cut-off (A) or gravels in incised situations (B)] to increase water depth and groundwater connectivity. One year before and four or five years after restoration, the physico-chemical water characteristics (nutrients, conductivity, temperature, and pH) and the plant communities were sampled in each wetland. The trophic level was not modified by restoration in the (A) sites. However, in the (B) sites, we observed a phosphate and ammonia nitrogen decrease and an increase in oxygen and nitrate nitrogen. In these wetlands, the increasing groundwater discharge may have modified microbial processes, favoring nitrification. For biodiversity in all wetlands, restoration led to a peak of ruderal species immediately after restoration that decreased from the third year after restoration. Only a few species remained before and after restoration in the (A) sites, whereas the conservation rate of species was higher in the (B) sites. Globally, as expected, the successional floristic trend was very pronounced in the (B) sites but not in the (A) sites, which suggested that restoration was not able to efficiently reset succession in the (A) sites. These results demonstrated that it is possible to efficiently predict the short-term (5 years) restoration benefit in terms of biodiversity and sustainability.

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## BIOMASS ACCUMULATION DURING REED ENCROACHMENT REDUCES THE EFFICIENCY OF THE RESTORATION OF BALTIC COASTAL GRASSLANDS

**Marek Sammul[1,2], Karin Kauer [1], Tiina Köster [1]**

*[1] Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Tartu, Estonia; [2] corresponding author: marek.sammul@emu.ee*

Keywords: coastal salt marsh; eutrophication; grazing; nutrients; restoration success

Boreal Baltic coastal meadow (also known as the northern European group of maritime salt marshes) is a priority habitat type (*1630) of the European Habitats Directive because of its importance for both plant and animal diversity. It is severely threatened because of its dependence on grazing. As a semi-natural habitat, it has developed under moderate human impact, which prevented the encroachment of reed or brushwood and maintained open habitats. However, the current economic situation does not favor the maintenance of coastal grasslands and leads to their abandonment and subsequent reed encroachment. Therefore, conservation agencies have begun several large-scale restoration projects to restore these habitats.

Reed encroachment, however, does not only lead to a shift in vegetation. The fast growth and high biomass accumulation of *Phragmites australis*, combined with decreases in biomass removal and a reduced mineralization rate, lead to a high increase in soil nutrients in grasslands. This natural eutrophication is not easily counterbalanced. It affects vegetation growth even in grasslands where grazing is reintroduced and, consequently, reduces the restoration success.

The comparison of 1) abandoned, 2) well-managed and 3) restored coastal meadows revealed several differences among them in both the relative and total amount of soil and vegetation nutrients. Soil properties of restored sites were mostly similar to abandoned sites, whereas vegetation characteristics returned to a "normal" level quite quickly after the restoration. The carbon stock in the soil profile doubled after abandonment. The species composition of the restored sites continued to be different from well-managed sites, but the species typical of coastal grasslands recolonized restored meadows quickly. A slow recovery of soil properties, however, made the results of the restoration frail, and the recurrent increase of tall, fast-growing species is probable if management intensity drops.

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## DRIVERS OF PLANT SPECIES DIVERSITY AT FOREST EDGES

**Olivier Chabrerie, Aurélien Jamoneau, Emilie Gallet-Moron, Guillaume Decocq**

*Université de Picardie Jules Verne – Unité "Dynamiques des Systèmes Anthropisés" (JE 2532 DSA); Plant Biodiversity Lab; 1, rue des Louvels; F-80037 Amiens Cedex; France (olivier.chabrerie@u-picardie.fr)*

Keywords: temperate deciduous forest, plant species assemblage, forest border, corridors, ancient forest

Forest edges are an important component of forest ecosystems and diversity. The objective of this study is to evaluate the influence of local, landscape and historical factors on plant species diversity at forest edges. In nine contrasting agricultural landscapes of Picardy (France), we sampled vegetation and environmental characteristics (including slope, orientation light intensity, litter thickness, surrounding landscape structures, and forest age) in 810 sampling plots nested in 54 transects randomly located at the edge of forest fragments. Each transect was composed of 15 contiguous plots and extended perpendicularly from the border to the forest interior. We investigated the relationships among local environmental conditions, landscape characteristics, forest age, spatio-temporal isolation of forest fragments, and species diversity and composition using mixed models and redundancy analyses (RDA). Mean species richness in herb, under-shrub, shrub and tree layers were, respectively, 18.1 (±0.8), 2.7 (±0.3), 2.8 (±0.2) and 3.0 (±0.2) in transects and 6.7 (±0.3), 0.4 (±0.1), 0.9 (±0.1) and 1.7 (±0.1) in plots. Mixed models showed that total, herb layer and forest herbaceous species richness decreased with distance to the forest border and forest age but increased with hedgerow density and grassland area in the landscape surrounding the transects. RDA showed that forest age and hedgerow density were the main factors driving species composition. Forest edges associated with crop lands and a high light intensity were clearly colonized by nitrophilous ruderal species (*Galium aparine, Veronica hederifolia, Urtica dioica, Heracleum sphondylium, Anthriscus sylvestris*). In ancient forests, shaded conditions, litter thickness and the dominance of *Rubus* populations act as a filter to select a small set of species able to survive under "true" forest conditions (*Hyacinthoides non-scripta*). Landscape connectivity (corridors) and suitability (type of agriculture) increase species diversity at forest edges. Finally, forest herb species richness is higher near the forest edge/border than in the forest interior, suggesting the important role of edges for forest diversity conservation.

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## SPRING WETLANDS ON A GRANITE PLATEAU IN SOUTHEASTERN AUSTRALIA: SPECIES DOMINANCE IN AN AGRICULTURAL LANDSCAPE

**Fiona Coates, Arn Tolsma**

*Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria, Australia (corresponding author: Fiona.Coates@dse.vic.gov.au)*

Keywords: spring wetlands, disturbance, species richness

Nine sedge, shrub or eucalypt-dominated floristic associations were recognized from a wetland survey on a granite plateau in southeastern Australia. All of the wetlands occurred on farmland and had been grazed for 150 years. At least half of the original wetland vegetation in the study area has been cleared, and recent conservation efforts have focused on excluding livestock from some of the remnants. An unforeseen consequence of exclusion has been an increase in the dominance of matrix species and a decline in species richness. In contrast, vegetation that has been continuously grazed is relatively species-rich and consists of ruderal annuals and interstitial perennials. However, organic soils at these sites are severely trampled. We predicted that manipulating disturbance regimes could prevent dominance by large matrix species, promote species richness and protect substrates.

The effect of excluding livestock was tested at sites that had been previously grazed. Livestock were excluded in low open sedgeland, shrubland and remnant swamp woodland, approximating a gradient of ‘canopy intactness’. The results were variable and generally unexpected. Without grazing, some ruderal and interstitial perennials increased, most likely as a result of the initial recovery after livestock removal and a greater-than-expected growth during an unusually wet and warm winter. These species were sensitive to trampling but were apparently capable of withstanding competition from aggressive introduced species, which also increased in the ungrazed plots. There was little change in clonal dominants in either grazed or ungrazed plots. The increase in native species richness and the decrease in weed cover expected in grazed plots occurred only in vegetation with an intact canopy.

In a separate trial, clonal dominants recovered rapidly after the creation of small gaps by burning or mowing ungrazed closed sedgeland, with only a minor increase in species richness after 6 months. One introduced species (*Holcus lanatus*) was disadvantaged by burning, but another (*Lotus corniculatus*) recovered rapidly after both treatments. Future results will be used to determine benchmarks for estimating the timing of management interventions.

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## VEGETATION CHANGES AND MANAGEMENT INDICATORS IN THE RESTORED FLOODED MEADOWS OF THE ALAM-PEDJA NATURE RESERVE, ESTONIA

**Jaak-Albert Metsoja [1,3], Lena Neuenkamp [2], Kai Vellak [1], Silvia Pihu [1], Jesse M. Kalwij [1], Martin Zobel [1]**

*[1] University of Tartu, Department of Ecology and Earth Sciences,Tartu Estonia; [2] University of Münster, Institute of Landscape Ecology, Münster, Germany; [3] (corresponding author: albert@ut.ee)*

Keywords: Grassland, Management, Indicator species, Species richness, Community composition

Floodplains are highly threatened throughout the world. The restoration of overgrown flooded meadows is vital for plant and bird diversity, as well as for preserving valuable landscapes.

The successful restoration of flooded meadows in central Europe strongly depends on the effective rehabilitation of the hydrological regime and the removal of excess nutrients, combined with the reintroduction of diaspores of target species. The restoration strategies in Estonia and other post-Soviet countries are less demanding because overall land-use intensity is relatively low. The hydrology and soil conditions of flooded meadows are largely unchanged, and the local species pool is intact, allowing efforts to focus on restoring meadow management after clear-cutting the bushes. Even in such places, successful restoration needs to address several questions: Are there detectable changes in the diversity and species composition of meadows abandoned for 15–20 years? Can plant species act as management indicators?

Our results show that restoration management has increased species richness. However, the extent of changes varied among meadow types and was most prominent in drier types. Additionally, the community composition of mown and unmown plots was already different after five years of restoration management. Indicator Species Analysis let us present reliable indicators for managed and unmanaged meadows, which can be used for the quick inspection of the community status; *Ranunculus auricomus* can indicate management in drier meadows, and *Calamagrostis canescens* and *Carex cespitosa* can indicate abandonment in wetter meadows. The discovered increase in richness and changes in species composition and the possibility of using simple, species-based indicators for the management status of floodplain meadows should encourage nature managers to enlarge areas under restoration.

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## SHORT-TERM CONSEQUENCES OF WETLAND RESTORATION ON THE GENETIC DIVERSITY OF A CLONAL PLANT SPECIES

**Jehanne Oudot-Canaff, Gudrun Bornette, Florence Piola, Evelyne Martel**

*UMR5023 LEHNA, Université Lyon 1, Lyon, France; 1 (corresponding author: joudotcanaff@gmail.com)*

Keywords: genetic diversity, restoration, microsatellite, metapopulation, *Berula erecta*

Genetic diversity is a key parameter to ensure the adaptation capacity and long-term viability of populations. Recent studies have shown that the evaluation of the ecological benefits of ecosystem restoration should integrate genetic considerations to assess the impact on population genetic variability and guide the restoration efforts. The present study aimed to assess the genetic diversity of populations of an aquatic plant, *Berula erecta,* collected either in restored wetlands or in unrestored wetlands. The hypotheses were that restoration may positively impact population size by increasing the available niches for the species and, consequently, may increase genetic diversity through the recruitment of new individuals that were either issued from the seed-bank or from dispersal. Before restoration, the sites were partly terrestrialized, with only small water bodies remaining. The restoration consisted of the removal of sediment in the dry part of the wetlands to restore a permanent and continuous aquatic zone. Restoration led to a considerable increase in population size. The restored areas were effectively colonized by *B. erecta*. The populations exhibited a high level of genetic diversity even though clonal propagation was the main reproduction strategy for this species. Two years after restoration, the genetic diversity ($A_R$ allelic richness, $F_{IS}$, $P_G$) did not differ between populations of restored and unrestored wetlands. For one restored wetland, individuals collected in the dug area had greater allelic richness than those collected in the unrestored area. In addition, most multilocus genotypes observed in the restored channels only occurred in a single individual, suggesting that clonal propagation was not the only method of recolonization. Recolonization by new genotypes may result from the recruitment of individuals from seeds that remained in the seed bank after restoration (cryptic genetic diversity). This study suggests that the benefits of restoration depend on the genetic diversity of relictual established and dormant populations, themselves depending on the ecological characteristics of the site (connectivity of the water-body with surrounding wetlands, successional stage, and history).

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## GENETIC CONSEQUENCES OF USING WILDFLOWER SEED MIXTURES IN ECOLOGICAL RESTORATION

**Tsipe Aavik[1,2], Rolf Holderegger [3], Peter J. Edwards [1], Regula Billeter [1]**

*[1] ETH Zürich, Institute of Integrative Biology, Zürich, Switzerland; [2] University of Tartu, Institute of Ecology and Earth Sciences, Tartu, Estonia; [3] WSL Swiss Federal Research Institute, Birmensdorf, Switzerland (corresponding author: tsipe.aavik@env.ethz.ch)*

Keywords : fitness, genetic diversity, genetic structure, inbreeding, *Lychnis flos-cuculi*

Sowing with commercial wildflower seed mixtures is a common practice for restoring species-rich communities in areas with an impoverished species pool. The potential genetic consequences of using seed mixtures, however, are poorly understood and often not considered in practical restorations. We analyzed the genetic diversity, the allelic richness, and the inbreeding coefficient and observed the heterozygosity and genetic structure of samples collected from 26 populations of the common wetland plant species *Lychnis flos-cuculi* in an intensively managed agricultural landscape in Switzerland. Some of these populations were sown several years ago as part of a habitat restoration program, while other populations were local. This enabled us to compare the genetic characteristics of populations of indigenous origin with those originating from commercially produced standard seed mixtures. We found that genetic diversity and allelic richness were similar in natural and sown populations, while inbreeding coefficients were significantly higher in sown populations. The analysis of genetic structure revealed a clear distinction between sown and natural populations. We could distinguish two homogeneous gene pools in sown populations representing most likely two source populations from which the seeds for propagation by the seed company had been collected. We conclude that the use of standard wildflower seed mixtures may have substantial genetic consequences for the gene pools of wildflower species. In some cases, altered genetic characteristics, such as the observed higher inbreeding of sown populations, could decrease population viability in the future. We suggest that some of the negative genetic and consequent fitness effects can be minimized by collecting seeds for commercial propagation from large and well-connected source populations, where there is a lower risk of inbreeding and low genetic diversity. Additionally, in case of the repeated propagation of seeds over several regeneration cycles, seed stock should be renewed after a few cycles to avoid the potential increase in inbreeding and the effect of *ex situ* propagation on adaptation.

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## EFFECTS OF GRAZING EXCLUSION ON INTERANNUAL CHANGES OF DWARF SHRUB BIOMASS IN A MOROCCAN SAGEBRUSH STEPPE

**Zakia Akasbi, Jürgen Dengler, Manfred Finckh**

*Biodiversity, Evolution and Ecology of Plants, Biocentre Klein Flottbek and Botanical Garden, University of Hamburg, Ohnhorststr. 18, 22609 Hamburg, Germany (Corresponding author: E-mail address: ak_zakia@yahoo.fr)*

Keywords : *Artemisia herba-alba*, *Artemisia mesatlantica*; permanent, regression function, standing biomass, *Teucrium mideltense.*

Intensive grazing has a primary influence on the degradation of rangelands. To quantify the effects of grazing on biomass production, grazed and ungrazed permanent plots were established in a sagebrush steppe in the central High Atlas of southern Morocco. This study focused on the three dominant dwarf shrubs, *Artemisia herba-alba*, *Artemisia mesatlantica*, and *Teucrium mideltense*. The length, width, and height of plants were measured and used to calculate plant volumes. Power-law regressions of the above-ground biomass on volume were established separately based on dried sample plants for the six species-treatment combinations. We applied these volume-biomass functions to individual-based annual volume monitoring data to calculate the standing biomass per area for each of the years from 2004 to 2009. Interannual changes in species biomass were compared between grazed and ungrazed plots. Grazing had a significant impact on interannual biomass changes for *Artemisia herba-alba* but not for *Artemisia mesatlantica*. *Teucrium mideltense* did not show a consistent effect of grazing over the years. In conclusion, grazing and precipitation both influenced plant biomass trends. During the five-year observation period, total standing biomass within the exclosure increased almost twice as much as with grazing. Thus, exclosures might accelerate the restoration of degraded rangelands in the region.

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## PLANT BIODIVERSITY MAINTAINED BY SCRUB REMOVAL IN COASTAL DUNES

**Maike Isermann [1], Paul Rooney [2]**

*[1] Bremen University, Vegetation Ecology and Conservation Biology, Leobener Strasse, 28359 Bremen, Germany; [2] Liverpool Hope University, Faculty of Science and Social Science, Geography Department, Hope Park; Liverpool L16 9JD, UK, (corresponding author: maike.isermann@uni-bremen.de)*

Keywords: *Hippophaë rhamnoides*, seedlings, soil, species richness, restoration

The Sefton Coast, North West England, is one of the largest dune systems in Britain. In these dunes, *Hippophaë rhamnoides* represents an invasive shrub that has resulted in a decrease in dune grasslands and their associated flora. Invasion of *H. rhamnoides* changes the nutrient-poor soil conditions of dunes due to nitrogen accumulation. The decline in biodiversity caused by *H. rhamnoides* indicates the need for management intervention.

To counteract the spread of this species and to restore the species-rich dune vegetation, *Hippophaë* shrubland was removed in the mid-1990s. Different restoration strategies have been used in combination in the Sefton dunes, including manual removal by cutting, mechanical uprooting by bulldozers especially to clear large stands, and in some areas grazing by domestic stock following removal.

To evaluate the restoration success, areas with *Hippophaë* scrub, restored sites and dune grassland areas known to have been without scrub for several decades were compared within a hierarchical approach considering various diversity levels. α-diversity was measured as the number of species at plot scale (4 m²). At a local scale, the turnover of species (β-diversity) was expressed as an average of the 1-Sørensen index across plots, calculated separately for plots with scrub, scrub removal, and grassland. At a landscape scale, total species richness (γ-diversity) was measured as the accumulated number of plant species.

Shrub removal regenerated the landscape heterogeneity of the coastal dune areas and increased the total species richness (γ-diversity). Species turnover at the local scale (β-diversity) was not significantly higher in areas where scrub had been removed compared to both scrub plots and dune grassland. Species richness at the plot scale (α-diversity) reached the highest values at intermediate levels of ß-diversity. Moreover, α-diversity reached the highest values in areas with scrub removal, probably due to management effects, compared to shrubland and grassland plots, respectively.

Due to nitrogen (N) fixation by *H. rhamnoides* and the release of N after scrub removal, the N content in the soils of the restored sites reached high values. However, most N indicator species occurred in the shrubland.

Although the number of plant species will be enhanced in open dunes by scrub removal, some scrub patches should be retained in the dunes to offer special habitats for many animals and to increase landscape heterogeneity.

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# THE INCREASING IMPORTANCE OF REED HARVEST IN THE WESER ESTUARY AND ITS INFLUENCE ON THE VITALITY OF THE COMMON REED (*PHRAGMITES AUSTRALIS*)

**Eva-Maria Bauer, Andreas Sundermeier**

*Federal Institute of Hydrology, Vegetation Studies & Landscape Management, KLIWAS 3.09, Koblenz, Germany, bauer@bafg.de*

Keywords: reed harvest, Weser estuary, reed beds, elevation, flood tolerance

In the Weser estuary (Northern Germany), the cutting of reed beds is still a current land use and has even become more important in recent years. Common reed is mown in the winter, between mean high water (MHW) -1 m and MHW +1.5 m, and is used as thatch material for roofs. There have been reports about problems with fungi in imported material, and thus, the commercial use of indigenous reed has become attractive again. Since 2007, the total mown area has increased considerably. We studied the influence of reed harvest on parameters such as culm density and culm diameter. The results of a pilot study indicated an effect of cutting on reed vitality depending on the stand elevation (distance to MHW). Thus, cutting above MHW can impair the vitality of common reed, whereas cutting below MHW has no negative effect on reed density and culm diameter. We will present the results of a more comprehensive ongoing experiment. Conclusions for marsh management in times of climate change will be outlined.
This study is part of the Governmental Research Programme "KLIWAS - Impacts of Climate Change on Waterways and Navigation - Development of Adaptation Options" initiated by the Federal Ministry of Transport, Building and Urban Development.

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## THE NATURAL HABITATS AND PLANT COMMUNITIES OF EUROPEAN INTEREST IN THE SANDY COASTAL AREA OF DOBRUDJA

**Marius Făgăraş**

*Ovidiusi University Constanta, Faculty of Natural and Agricultural Sciences, 124 Mamaia Blvd., 900527, Constanta, Romania, marius_fagaras@yahoo.com*

Key words: Dobrudja, Black Sea, sandy coast, natural habitats, plant communities.

Dobrudja (Dobrogea in Romanian) is a historical region of the Balkan Peninsula, which includes the Danube Delta Biosphere Reserve, the Romanian Black Sea coast and the northernmost part of the Bulgarian seacoast (until Cape Kaliakrai). The largest part of the seacoast has sandy beaches with shifting or fixed sand dunes covered by psammophile vegetation. In the investigated area, the dune habitats and the humid dune slacks are well represented in front of some littoral lakes and in the areas with low loess seawalls. The limestone cliffs are present only north of Cape Shabla, in Bulgaria.
On the broad sandy beaches of Dobrudja, a many types of habitats of community interest (according to Directive 92/43/CEE) with psammophile vegetation have been identified. Most of them are already protected within the Danube Delta or other protected areas of coastal Dobrudja. Outside of the protected areas, tourism and economic activities are the main risk factors that threaten the specific flora and vegetation of the sand dunes.
In the paper, the natural habitats of conservation interest and their most important psammophyle plant communities will be described. For each habitat type, we will provide information on the following: ecological characteristics, distribution, conservation state, plant associations, rare and threatened plants, risk factors and tendencies.

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## THREATENED INLAND SAND VEGETATION UNDER DIFFERENT TYPES OF ABIOTIC AND BIOTIC DISTURBANCES: IS THE SYSTEM RESILIENT?

**Christopher Faust, Karin Suess, Christian Storm, Angelika Schwabe**

*Technische Universität Darmstadt, Biology/Vegetation Ecology, Darmstadt, Germany*

Keywords: Rabbit grazing, Recovery, Seed production, Sheep grazing

In Central European sandy grasslands, extensive grazing is often a management tool to maintain and improve nature conservation value. As part of a long-term field experiment lasting 10 years, we investigated the beneficial effects of sheep grazing as a type of moderate disturbance. As "experiments by nature" happened in this period, we were also able to study severe biotic (rabbit grazing) and abiotic (drought) disturbances, examining the recovery and resilience of the system after these severe disturbances.
Within a six-fold replicated randomized split-plot design, 25-m² plots of threatened Armerio-Festucetum trachyphyllae vegetation were studied from 2000 to 2009 in the northern upper Rhine valley (Germany). We analyzed sheep-grazed and non-grazed plots (both with very low rabbit impact until 2005). In 2005, we established an additional plot type without rabbit and sheep grazing. Severe rabbit impact was studied in detail from 2006 to 2008 with attention to flower resources, seed production, endozoochorous seed dispersal and the consumption of phytomass by rabbits. Data were analyzed by ordination methods and mixed linear models.
Moderate disturbance by sheep grazing maintained species diversity in times of low rabbit densities. Severe drought in 2003 resulted in a marked decrease in species number, but the system had already recovered in 2004. The subsequently analyzed "high rabbit impact" resulted in decreases of species numbers, cover of bryophytes, flower and seed quantities and seed content in feces. Species numbers also declined in plots without grazing, but for different reasons. Flower phenology was not affected. After the decline of the rabbit population, species numbers slightly increased in 2009 and 2010. Non-grazed plots showed a decrease in bare ground and an increase in litter.
Despite severe disturbances by rabbits or drought, the community structure was relatively stable and showed only slight changes, especially in the case of typical Armerio-Festucetum sites (without monodominant, competitive graminoids). The system showed a high potential for recovery and resilience. In times of low rabbit impact, sheep grazing is necessary to prevent species losses.
Reference: Faust et al. Flora DOI 10.1016/j.flora.2010.09.013

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## EARLY SUCCESSION ON SUCCESSFULLY RESTORED AND RECREATED COASTAL HABITATS IN THE ŠKOCIJAN INLET (NORTHERN ADRIATIC SEA)

**Danijel Ivajnšič[1], Mitja Kaligarič[1], Nina Šajna[1], Borut Mozetič[2]**

*[1] University of Maribor, FNM, Biology Dept., Koroška 160, 2000 Maribor, Slovenia; [2] DOPPS, Birdlife Slovenia, Staničev trg 16, 6000 Koper, Slovenia; (Corresponding authors: dani.ivajnsic@uni-mb.si; mitja.kaligaric@uni-mb.si)*

Keywords: habitat restoration, halophyte vegetation, mapping, succession

The restoration or creation of habitats lost, destroyed or substantially altered has become tools for many environmental agencies, parks, regions, states or NGOs. It is currently possible to simulated many kinds of physical designs or hydrogeomorphology, but the biological components usually take a much longer time frame to respond, mostly beyond reasonable monitoring expectations. Halophyte vegetation on seacoast mudflats represents relatively simple systems based on the presence of only a few highly specialized species. Species turnover during early succession was found to be very quick after the creation of coastal mudflats in the Škocjan inlet nature reserve near Koper (Slovenia, northern Adriatic seaboards). In this site, primary succession was followed for four years after the creation of the mudflats at different micro-elevations by means of habitat mapping according to PHYSIS typology with a resolution of 2 $m^2$. The results showed that mudflats not covered by vegetation declined substantially in four years. We detected an increase (2% to 8% of the total area) in *Salicornia* and other annuals (*Salsola* and *Suaeda*) colonizing the mud and sand between the 2nd and 3rd observations, followed by a decline due to an increase in the cover of halophytic scrubs. *Suaeda maritima*, an easy-germinating pioneer annual species with seeds well represented in the seed bank, was dominant in the 1st year after the construction of the habitats but declined strongly in the subsequent two years. In the 3rd year, halophyte perennials began to establish at the sites of appropriate micro-altitude. The surface covered by lagoon seawater declined in favor of the surface covered with vegetation, thus achieving one of the targets of the habitat restoration intervention.

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## THE USES OF VEGETATION WITHIN A TACC PILOT PROJECT, MBALE, UGANDA: A PRELIMINARY REPORT

**Hilary Thomas**

*University of Glamorgan, PONT C2C Centre, Faculty of Advanced Technology, Pontypridd, Wales, UK*

Keywords : TACC UNDP Uganda conservation

The UNDP Territorial Approach to Climate Change [TACC] model provides the context for this study. The manner in which vegetation - native, introduced, existing and to be planted – will form a major element of this new, regional approach to the development of carbon-neutral and climate-change-resilient territories is presented. Impacts upon local methods of vegetation management are discussed, together with the problems and possibilities identified at the scoping and inception stages.
The Greater Mbale TACC project, located within the Mount Elgon region of SE Uganda, is one of 8 pilot schemes that partner 'national regions' from developed and less developed nations - in this case, Greater Mbale and Wales. The project aim is to build resilience to climate change in a regional rather than a national context, while operating within any relevant national and international frameworks. Considerable UNDP and other resources will be focused upon this area to produce holistic responses to local conditions and threats resulting from climate change. These include the increased frequency of landslides and flooding in this steeply sloping region forming part of the Mount Elgon massif, together with threats to species of national cultural importance. At $1^0$N latitude, a rich 'tropical high forest' vegetation diversity exists within the Mount Elgon National Park, largely replaced outside the protected area first by a zone of increasingly intensive subsistence and commercial agriculture and then by threatened relic bushlands and wetlands to the west of the study region. Three local authority districts, Mbale, Manafwa and Bududa, will participate in the TACC project, which uniquely will involve local NGOs as well as the districts both as stakeholders and in the delivery of the project. Four local NGOs have been selected as participants in the initial vegetation management schemes, through the development of tree nurseries and new management foci.
The inception of this 2-year project took place in March 2011. Because the partnership grew from existing strong links between Wales and Mbale, monitoring, evaluation and other activities will continue after the close of the pilot study. This study will identify the project elements of the TACC that are dependent upon vegetation management and determine appropriate, multivariate monitoring and evaluation criteria to include both cultural and environmental indicators. Existing vegetation management and landscape regions will be identified. These will then be used to evaluate progress toward an increased resilience and to assist in the production of a framework for future management. Desk and field data have been collected since 2010 .

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## PASTURE IMPROVEMENT BY THE FENCING TECHNIQUE OF STIPA TENACISSIMA STEPPE IN THE SOUTH-ORANIAN STEPPE OF NAAMA (ALGERIA)

**Abdelkrim Benaradj[1], Khalladi Mederbal[1], Mohamed Bouazza[2], Djillali Baghdadi[3]**

*[1] Research of Biological Sciences and Geomatics Laboratory, University of Mascara (Algeria); [2] University of Tlemcen (Algeria); [3] University Mostaganem (Algeria) (corresponding author: kbenaradj@yahoo.fr)*

Keywords: Steppe, *Stipa tenacissima*, biological recovery, fencing, desertification.

The south-Oranian steppe of Naama (Algeria) is characterized by a semi-arid climate that may shift to arid. This part of the Algerian steppe experienced several stresses that led to an increase in desertification. Among these stresses are course overuse, increasing human pressure, expansion of agricultural surfaces and silting-up by desert sand. Climate change amplifies these man-made stresses.

The intervention measures to this troubling situation are to promote the process of reverse degradation by the recovery and rehabilitation of *Stipa tenacissima*-degraded steppe by the technique of exclosure. This technique promotes natural regeneration, which best induces the biological recovery of natural steppe species.

This technique of fencing (exclosure) has a positive impact on biological recovery and favorable effects on the quantitative and qualitative increase in the rate of recovery of vegetation, plant species richness, density of plant biomass, various floristic compositions and pastoral characteristics. This technique is therefore a way to fight the degradation and desertification factors.

The technique of pasture improvement by fencing is one of the proposed solutions for the protection, rehabilitation and restoration of the degraded rangelands. This technique allowed the natural regeneration, which is the most recommended, of natural biological steppe species. Thus, the technique developed protection and involved the management of protected sites as natural reserves or national parks.

There is a need for rational management of rangeland grazing after being opened in accordance with the compliance burden. With these requirements, jobs can be offered to the local community, and keeping the steppe in a good state for future generations should be mandatory.

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## CARBON SEQUESTRATION POTENTIAL OF POST-MINING REFORESTATION ACTIVITIES ON THE KWAZULU-NATAL COAST, SOUTH AFRICA

**Margaretha van Rooyen[1], Noel van Rooyen[1], Gerrit Stoffberg[1,2]**

*[1] University of Pretoria, Department of Plant Science, Pretoria, South Africa; [2] Current address; Golder Associates Africa (Pty) Ltd, Hatfield, Pretoria, South Africa (corresponding author: gretel.vanrooyen@up.ac.za)*

Keywords : Carbon pools, coarse woody debris, litter carbon, soil carbon, succession

The mining of heavy minerals along the KwaZulu-Natal coast of South Africa destroys the existing vegetation. The rehabilitation program instituted by Richards Bay Minerals specifies that one-third of the area should be rehabilitated to coastal forest and two-thirds to commercial Casuarina equisetifolia plantations. The objectives of this study were to quantify carbon stocks in five pools on reclaimed mined land; to develop empirical relationships between stand age and carbon stocks; to compare the carbon sequestration potential of rehabilitated land under different land uses; and to recommend management practices that could maximize carbon sequestration on reclaimed land.

The carbon stocks in five pools were quantified. Estimates of the carbon contained in the aboveground and belowground tree component were obtained by applying allometric equations. Direct harvesting of litter and debris pools was performed to derive carbon stocks in these pools, and the soil samples were analyzed for soil carbon and bulk density to calculate the size of this pool.

The relationship between total, above- and belowground carbon in the C. equisetifolia plantation and stand age was sigmoidal, whereas the relationship was linear for the rehabilitating indigenous forest. Carbon accumulation in the C. equisetifolia plantations reached an asymptote after 12 years. In contrast, carbon stocks of the rehabilitating indigenous forests continued increasing and could potentially reach the level of a secondary or even primary indigenous forest. The rehabilitated indigenous forest exceeded the mean net carbon storage of C. equisetifolia plantations after 24 years. Maximum total carbon in the 27-year-old rehabilitated indigenous forest compared well to values reported for reclaimed ecosystems in the USA and Europe. Improvements in the carbon sequestration potential of the mined land can be achieved through (a) biomass burial and (b) reforestation of the harvested C. equisetifolia plantations with indigenous forest. Biomass burial could continue for a number of crop rotations, or alternatively, the plantations could be converted to rehabilitating indigenous forest after a single rotation and burial of biomass.

Session 'Conservation and restoration' / POSTER 33

## *CISTUS* SENSITIVITY TO FIRES IN THE TLEMCEN REGION (NORTHWEST ALGERIA)

**Smaïn El-Amine Henaoui[1], Mohammed Bouazza [1,2]**

*[1] Abou Bakr BELKAÏD University, Department of Biology and Environment, Tlemcen and Algeria; [2] Abou Bakr BELKAÏD University, Department of Biology and Environment, Tlemcen and Algeria*

Keywords: Cistus, flammability, combustibility, fire, Tlemcen (Northwest Algeria).

Mediterranean ecosystems are subject to numerous risks and natural disturbances such as fires caused by certain types of fire-sensitive plants such as cistus that are the subject of our study. The vegetation of Tlemcen is part of natural ecosystems. The human use of cistus matorralsi shows the fragility of these environments. Taxa that contain volatile organic compounds responsible for their ability to burn made us curious to launch a study on the flammability and combustibility of the three most dominant species (*Cistus ladaniferus subsp. africanus, Cistus monspeliensis* and *Cistus salviifolius*) in our study area to get an idea of their degrees of flammability. After the completion of our experiments, we found that the cistus species are extremely flammable (*Cistus ladaniferus subsp. africanus* and *Cistus monspeliensis*: Level 5) or combustible (*Cistus salviifolius*: grade 3). These findings confirm that these ecosystems are extremely sensitive to fire. This degree of flammability helps us locate the areas containing these species across a map of cistus sensitivity to fire in the Tlemcen region (northwest Algeria). According to our survey field, the abundance-dominance of cistus remains high or very high, which makes them very vulnerable. These plant communities are currently facing a serious threat expressed by the inevitable outbreak of wildfires due to repeated voluntary or involuntary human actions and high temperatures that led to the long dry spell currently being experienced in the region of Tlemcen. These conditions can cause the sudden ignition of the volatile organic compounds that these plant species contain. For this reason, it is very important to make decisions necessary and proper for the management, protection and conservation of these plant communities before reaching an irreversible loss of plant genetic heritage.

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## ECOLOGICAL RESTORATION OF ABANDONED RICE FIELDS TO WETLANDS: CONTRIBUTION OF THE SOIL SEED BANK

**Isabelle Muller [1], Elise Buisson [1], François Mésleard [1,2]**

*[1] UMR CNRS IRD IMEP, Université d'Avignon, 84911 Avignon Cedex, France; [2] Centre de Recherche Tour du Valat, 13200 Arles, France (corresponding author: isabellemuller@hotmail.fr)*

Keywords: degraded ecosystem, flood duration, soil seed bank, wetland restoration

In the last few decades, the development of agriculture, industry and tourism has led to a drastic reduction of Mediterranean wetlands. The Camargue (Rhône delta, south of France) has lost 40 % of its natural habitats since World War II. Recent land-use changes provide opportunities to develop a wetland rehabilitation project. The Le Cassaïre domain is mainly composed of former rice fields grazed by sheep. The aim of this project is to recreate temporary marshes, swards and dunes on the basis of local reference ecosystems using engineering work (digging and leveling). To investigate the consequences of decades of agricultural practices on the soil seed bank and its potential to reach our rehabilitation objective, the soil seed bank was sampled in February 2011 up to depths of 60 cm (the maximum depth of future temporary marshes). The results will be discussed, and future restoration treatments will be planned according to seed bank results.

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## CONSERVATION AND MANAGEMENT OF SALT MEADOW FRAGMENTS ON THE LITHUANIAN COASTLINE

**Jūratė Sendžikaitė, Romas Pakalnis, Dalia Avižienė, Leonas Jarašius**

*Laboratory of Landscape Ecology, Institute of Botany, Nature Research Centre, Vilnius, Lithuania; (corresponding author: jurate.sendzikaite@botanika.lt)*

Keywords : salt meadow, *Aster tripolium*, *Glaux maritima*, *Juncus gerardii*, conservation

Fragments of salt meadows (Ass. *Juncetum gerardii*) can be found in the western part of Lithuania on the shores of the Curonian Lagoon where only a few habitats strongly impacted by human activity have survived. The largest meadow (0.5 ha) was located on the coastline of the Curonian Lagoon in the Smelte peninsula (Klaipeda harbor). However, after the accident of the oil tanker "Globe Assimi" (in 1981), this salt meadow habitat was destroyed, and the facilities of the International Ferry Port were established (in 1986). Some plants of the red-listed species *Aster tripolium*, *Glaux maritima*, *Juncus gerardii*, *Triglochin maritimum* and *Centaurium littorale* survived only on the embankment of the eastern coast of the Smelte peninsula. To preserve the remaining salt meadows, the Smelte Botanical Nature Reserve (3.6 ha) was established in 1988. The inventory of red-listed plants was performed, and the state of rare plant populations and the threats of their extinction were investigated in 2010. The study was completed on 1014 m of shoreline. The number of *Aster tripolium* individuals and the area ($cm^2$) of *Glaux maritima* and *Juncus gerardii* thickets were estimated. Plants of these red-listed species were growing only on a narrow (about 0.5–1.5 m width) belt of the shoreline fortified with boulders and constantly washed by water; however, they did not form an entire cover. We found 4319 individuals of *Aster tripolium*, 23.3 $m^2$-thickets of *Glaux maritima* and 3.6 $m^2$-thickets of *Juncus gerardii* there, but the populations should be more abundant. In 2010, individuals of *Triglochin maritimum* and *Centaurium littorale* were not recorded. The analysis of literature references and original research data revealed that the state of red-listed plants in the Reserve does not guarantee self-regulation of the salt meadow communities. The main reason is negative anthropogenic influences because the Reserve is located in a particularly industrialized part of the Klaipėda Seaport. Therefore, the nature management plan of the Smeltė Botanical Reserve was worked out in 2010. This plan and its ecological restoration activity would enable not only the preservation of but also the increase in the population of red-listed species.

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## RESTORATION OF DIVERSITY IN BOREAL SPRUCE SWAMP FORESTS

**Liisa Maanavilja[1], Kaisu Aapala[2], Tuomas Haapalehto[3,4], Janne Kotiaho[4], Eeva-Stiina Tuittila[1]**

*[1] University of Helsinki, Department of Forest Sciences, Helsinki, Finland (corresponding author: liisa.maanavilja@helsinki.fi); [2] Finnish Environment Institute (SYKE), Natural Environment Centre / Biodiversity Unit, Helsinki, Finland; [3] Metsähallitus, Natural Heritage Services, Jyväskylä, Finland; [4] University of Jyväskylä, Department of Biological and Environmental Science, Jyväskylä, Finland*

Keywords: restoration, microhabitat, peatland, mire, *Sphagnum*

In pristine spruce swamp forests, the ground vegetation is a mosaic of *Sphagnum* on wet surfaces and feather mosses and epixylic bryophytes on hummocks, tree roots, logs and stumps. The high microhabitat diversity results in high species diversity. The area of pristine spruce swamp forests in Finland has declined by 60-80% since the 1950s, mainly due to drainage for forestry and logging. In restoration, drainage ditches are blocked to restore the original hydrology and tree stand structure and, ultimately, the characteristic plant community structure. This study aims to examine the succession process after ditch blocking and to evaluate restoration success.

We studied a time series of 18 restored spruce swamp forests, restored in the years 1995-2008. In addition, 9 drained and 9 pristine swamp forests were studied as a reference. At each study site, we placed a total of 72 sample plots, 20 cm in diameter, in a clustered design. In each plot, we estimated the coverage of mosses and vascular plants and defined the microhabitat in the growing season of 2009. Using CCA, we quantified how time since restoration and water level achieved through restoration affect the plant community and microhabitat structure. We quantified restoration success by similarity to pristine swamp forests.

We hypothesized that 1) diversity is higher in pristine swamp forests than in drained and restored sites, 2) similarity to pristine sites increases with the number of years since restoration and 3) there is an optimal water table level (WT) range for restoration success.

In contrast to our first hypothesis, microhabitat and plant community diversity were the highest in the restored sites: drainage increased microtopographical variation through peat subsidence, which created a high diversity of surfaces of different wetness when the sites were rewetted. In contrast to the second hypothesis, no clear connection existed between the time since restoration and the similarity to pristine sites. We did find a connection between the measured restoration success and WT after ditch blocking. The optimal WT for restoration success was higher than the WT observed in the pristine sites.

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## RAISED BOG CONSERVATION AND MANAGEMENT AT THE EC LIFE PROJECT SITES IN LATVIA

**Mara Pakalne[1], Aivars Slisans [2], Liene Aunina [3]**

*[1] University of Latvia, Riga, Latvia; [2] University of Latvia, Riga, Latvia; [3] Institute of Biology, Riga, Latvia (corresponding author: mara@lanet.lv)*

Keywords: Raised bogs, vegetation, monitoring, management

Raised bogs were studied within the European Commission LIFE project "Implementation of Mire Habitat Management Plan for Latvia". The study sites included the Cena Mire, Stikli Mires and Klani Mire Nature Reserves. The sites are nationally and internationally important and comprise intact raised bog vegetation with bog pools as well as fen and transition mire vegetation.
In the LIFE project sites, mire vegetation and hydrological studies were conducted. The mire margins are influenced by drainage and peat extraction. To stop the desiccation of the valuable raised bog habitats, management actions were implemented in the study sites. Before and after the raising of the water level in the study site sites, vegetation and hydrological monitoring were conducted.
Permanent vegetation plots were established next to hydrological monitoring plots, in places where vegetation changes were foreseen after raising of the water level in 2006. There are 38 monitoring plots on ditches in the raised bogs, 20 monitoring plots in raised bogs and 4 monitoring plots in transitional mire. The monitoring scheme also includes control plots. The wetness of the sites was recorded and included surface water evaluation, identification of adjacent pools and *Sphagnum*-dominated vegetation. In total, 130 vegetation monitoring plots were established.
The results show that after raising the water level in the raised bogs, the species typical of bogs started to re-appear in the drained areas, such as *Sphagnum cuspidatum.* The cover of *Calluna vulgaris* diminished. The raised water level favored the development of mire vegetation.
Since 2010, vegetation studies were started in the EC LIFE Project "Restoration of Raised Bog Habitats in the Especially Protected Nature Areas of Latvia." Field studies as well as vegetation monitoring was begun in the 4 raised bogs, Melnais Lake Mire, Aizkraukle Mire and Forests, Aklais Mire and Rozu Mire, which, in addition to mire vegetation, also include diverse forest and lake habitats.

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## VEGETATION CHANGES IN THE INITIAL 20 YEARS AFTER ESTABLISHING AN ARTIFICIAL FEN BY TRANSPLANTATION FROM A NATURAL POOR FEN

**Takashi Nishimoto[1], Yoshio Hada[2]**

*[1] Okayama Prefectural Nature Conservation Centre, Wake Japan; [2] Department of Biosphere-Geosphere System Science, Okayama University of Science, Okayama Japan (taknishi@js4.so-net.ne.jp)*

Keywords : Management, Restoration, Species composition, Succession, Wetland

To determine the succession of plant community assemblies of a poor fen on a local scale in western Japan, we performed vegetation surveys on 11 donor plots of a natural poor fen before transplantation to an artificial fen established in 1991 on reclaimed land. We used 34 fixed plots at years 3 and 5 and 36 fixed plots at years 7, 9, 12 and 20. Multivariate methods were performed on all 223 vegetation plots to differentiate the successional stages based on species composition. We identified species richness, species diversity and the relationship among plots, and we quantified the proportion of species of each life form in the original habitat for each successional stage. Active management was needed to maintain the species composition and hydrological condition of the donor fen in the artificial poor fen. Invasive species were removed every year from all areas, and *Ischaemum aristatum* var. *glaucum* was targeted for removal after the 12th year, when it was found to be the dominant species.
Using TWINSPAN analysis, 4 plot groups were identified in the second division. Two plot groups that resembled the donor plots showed higher values of species richness and species diversity than the other two plot groups, each of which was dominated by clonal perennials. In the plot group, including the donor plots of the early successional stage, species richness and species diversity increased due to the invasion of non-hydrophyte species until the 9th year and decreased thereafter due to the increase in the fixed dominant species. The dominance of clonal perennials, such as *Ischaemum aristatum* var. *glaucum*, accelerated succession.
Even though non-hydrophytes were removed, species composition similar to that of the donor fen could not be maintained in the artificial fen when *Ischaemum aristatum* var. *glaucum* dominated. The successional trend of the poor fen, which varied among plots, was characterized by the invasion by non-hydrophytes, followed by the increasing dominance of clonal perennials. Appropriate plant removal during succession may maintain the species composition of the poor fen.

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## HALOPHYTIC VEGETATION IN THE MIDDLE AND LOWER VOLGA REGION (RUSSIA): DIVERSITY, CLASSIFICATION, DISTRIBUTION AND CONSERVATION

**Tatiana Lysenko**

*Institute of Ecology of the Voga River Basin RAS, Department of phytodiversity problems, Togliatti, Russia*

Keywords : halophytic vegetation, Volga River Basin, diversity, classification, distribution, conservation

The study territory is situated in the Middle and Lower Volga River Basin and includes the territory from Ulyanovsk to Volgograd. In phytogeographical content, it is situated in forest-steppe and steppe zones. The objects of our study are halophytic vegetation. During the period from 1994 to 2010, there were approximately 2670 relevés saved in a database created on the basis of TURBOVEG (Hennekens, Schaminée, 2001) software and then processed by MEGATAB (Hennekens, 1996) software. We defined 56 lower syntaxons after comparing the received information and data from the literature. Then, searching for the location of lower syntaxons in the international system of syntaxons was performed (Mucina, 1997; Rodwell et al., 2002). Systems of syntaxons proposed by Russian scientists were also analyzed (Korotkov et al., 1991; Golub et al., 2001, 2005). The researched syntaxons belonged to classes Thero-Salicornietea Tx. in Tx. et Oberd. 1958 (order Thero-Salicornietalia Pignatti 1953, alliance Salicornion herbaceae Soó 1933), Festuco-Puccinellietea Soo 1968 (orders Cirsietalia esculenti Mirkin et Golub in Golub 1994 nom. inval.), Festuco-Limonietalia Mirkin in Golub et Solomakha 1988, Puccinellietalia Soó 1947, Artemisietalia pauciflorae Golub et Karpov in Golub et al., 2005, Glycyrrhizetalia glabrae Golub et Mirkin in Golub 1995 and Scorzonero-Juncetalia gerardii Vicherek 1973, alliances Cirsion esculenti Golub 1994 nom. inval., Festuco valesiacae-Limonion gmelinii Mirkin in Golub et Solomakha 1988, Camphorosmo-Suaedion corniculatae Freitag et al., 2000, Camphorosmo monspeliacae-Artemision pauciflorae Karpov 2001 nom. invers. propos., Glycyrrhizion korshinskyi Lysenko 2010 and Scorzonero-Juncion gerardii (Wendelberger 1943; Vicherek 1973).

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## PRIMARY PRODUCTION DURING FEN DEGRADATION AND RESTORATION: COMPARISON OF TOPSOIL REMOVAL AND REWETTING

**Łukasz Kozub[1], Arleta Pniewska[1], Wiktor Kotowski[1,2]**

*[1] University of Warsaw, Department of Plant Ecology and Environmental Conservation, Warsaw, Poland; [2] Wetland Conservation Centre, Warsaw, Poland*

Keywords : Ecological Restoration, Wetlands, Poland, Phytometry

Undisturbed rich fens are low-productive habitats with high biodiversity. Most have suffered from drainage, resulting in peat mineralization, followed by a rapid eutrophication and decline of specific species. If drainage is maintained, a subsequent shift to K-limitation may cause a drop in primary production while species richness remains at low levels. In such areas, ecological restoration by raising the groundwater level usually results in the creation of highly productive communities with low biodiversity. Another still little-applied restoration method is removing the upper, degraded peat layer. This method is expected to keep primary production low as a result of nutrient export. Our aim was to verify the influence of topsoil removal on primary production and investigate its impact on limitation patterns compared to rewetting. Our study was conducted on a fen that was severely degraded by agricultural drainage and located approximately 40 km southeast of Warsaw, Poland. Species-poor *Festuca rubra* and *Urtica dioica* communities dominate the vegetation of the fen. Relics of rich fen vegetation remain only in old peat-cuts. In the central part of the fen, a restoration project was performed in the early spring of 2009. On an area of approximately 2 ha (divided into three separate plots), the upper, degraded peat layer was removed to a depth of the mean groundwater table. We established permanent plots within the areas in which topsoil was removed and at control (degraded) and reference sites (fen vegetation in old peat-cuts). To confront the effects of topsoil removal with the technique of raising the water table, we created rewetting plots by submerging sods with degraded peat in small basins dug in the vicinity of the restoration site. Surveys were conducted on permanent plots during the two growing seasons following the restoration, including water chemistry measurements and aboveground biomass measurements. Simultaneously and in both years of the experiment, five phytometer species were planted in permanent plots in early summer and collected three months later. The phytometer biomass and N, P, and K contents were then measured. The results confirmed that the low productivity of heavily drained fens may have been caused by a strong K limitation, whereas N and P were supplied by peat mineralization. Rewetting led to K input from the groundwater, which resulted in increasing productivity. Supporting our hypothesis, the topsoil removal did not change productivity and caused a shift from a K to an N limitation.

# Anthropogenic impacts on vegetation

Session 'Anthropogenic impacts on vegetation' / ORAL

## WOODLAND PLANT RESPONSE TO URBANIZATION AND MANAGEMENT INTENSITY: OPPORTUNITIES TO MAINTAIN AND RESTORE BIODIVERSITY IN URBAN AREAS

**Hervé Daniel[1], Clémence Gault [1], Jeanne Vallet [1,2], Véronique Beaujouan [1]**

*[1] Agrocampus Ouest, UP Paysage, Angers, France; [2] Conservatoire Botanique National du Bassin Parisien, Le Mans, France; (corresponding author: herve.daniel@agrocampus-ouest.fr)*

Keywords : woodland, urban vegetation, forest plant,

The effect of urbanization on species distribution has been extensively documented, but a main challenge in urban ecology is to better understand the factors causing different distributions among species in response to urbanization. Urban woodlands are often considered to be emblematic habitats for the restoration of nature in cities and for providing ecosystem services. They are also often included in green infrastructure planning.
The objectives of this study are to evaluate the relative importance of urban context on the structure of plant assemblages in woodlands and to compare the species response to urbanization in three different cities of the same biogeographical area and in relation to the management characteristics of these semi-natural habitats.
The study was performed in the cities of Angers, Nantes and Rennes (northwestern France) where 76 isolated woodlands (with an average surface of 1.5 ha) were surveyed along an urban–rural gradient in each city. Floristic data were collected at each woodland site, and the land cover types were calculated within a 500 m buffer. Plant species were first classified as nonindigenous or indigenous, and then three groups of indigenous species were distinguished according to their affinity for the forest habitat (forest specialists, forest generalists and nonforest species).
The rural sites showed a lower plant richness than the urban ones (this was particularly true for non-native species). Our study demonstrates that, despite the establishment of non-indigenous and non-forest species in the urban part of the gradient, forest species remain the dominant group of species in woodlands so that they can contribute significantly to the conservation of biodiversity in urban areas. Our study highlighted the necessity of identifying the groups of species that drove the patterns of species richness to facilitate the relevant use of these indicators for biodiversity conservation. We discuss the implications of these results for the management of urban woodlands.

Session 'Anthropogenic impacts on vegetation' / ORAL

## WHAT ARE THE POSSIBLE EFFECTS OF GLOBAL WARMING ON SLOVENIAN FORESTS IN THE FUTURE?

**Lado Kutnar[1], Andrej Kobler[2]**

*[1] Slovenian Forestry Institute, Dept. of forest ecology, Ljubljana, Slovenia; [2] Slovenian Forestry Institute, Dept. of forest and landscape planning and monitoring, Ljubljana, Slovenia (corresponding author: lado.kutnar@gozdis.si)*

Keywords: forest site, tree species, vegetation, climate-change scenario, Slovenia

Global climate change would lead to a readjustment of the tree species composition of forests, which would affect the ecological and economic sustainability of the forests. The goal of this study was to study the potential decline of the main tree species' growing stock and dominant forest vegetation types in Slovenia as a result of the effects of climate change. Multi-target quantitative models of growing stock and vegetation have been calibrated at the spatial level of 1 × 1 km quadrants with machine-learning methods from empirical data based on previous climate data (monthly & yearly average temperatures T, precipitation R, evapotranspiration E), relief (elevation, slope, exposition) and soil data. Using the models and the existing predictions of the warming future climate, the simulations showed changes of forest site conditions and, consequently, potential tree species decline and changes in the spatial pattern of vegetation types (groups of similar forest communities) in Slovenia until the year 2100 under three climate warming scenarios: the Middle Scenario (median predicted T, median predicted R, median predicted E), the Pessimistic Scenario (max T, min R, max E), and the Optimistic Scenario (min T, max R, min E). We predict significant alterations in potential forest stand species composition and forest vegetation in Slovenia even under the Optimistic Scenario. At the end of the century, the abundance of the three structurally most important species (*Fagus sylvatica, Picea abies* and *Abies alba*) will potentially be reduced by 54% to 97%, depending on the scenario and the species. The suitable areas for these species will be reduced to the mountainous parts of Slovenia. Under the Pessimistic Scenario, an almost total decline of *Abies alba* and *Picea abies* is predicted, whereas the suitable conditions for *Fagus sylvatica* will only be available in the high mountain belt. Under different climate warming scenarios, the share of the major vegetation types (e.g., acidophilic beech forests, sub-montane beech forests, (high-)montane beech and fir-beech forest in the Dinaric region) is likely to be reduced, and the area of warmth-tolerant forests will increase significantly.

Session 'Anthropogenic impacts on vegetation' / ORAL

## GEOMORPHIC CONTROLS OF WOODY VEGETATION RESPONSES TO FLOW ALTERATION IN A MEDITERRANEAN STREAM IN CENTRAL-WESTERN SPAIN

**María Dolores Bejarano[1], Miguel Marchamalo[2], Marta González del Tánago[1], Diego García de Jalón[1], Álvaro Sordo[3]**

*[1] Technical University of Madrid, Department of Forestry Engineering, Madrid, Spain; [2] Technical University of Madrid, Department of Morphology, Madrid, Spain; [3] Technical University of Madrid, Department of Hydraulic and Civil Engineering, Madrid, Spain (corresponding author: mariadolores.bejarano@upm.es)*

Keywords : Regulation, Dam, Woody riparian vegetation, Geomorphology, Mediterranean

The expected recovery of large regulated rivers over the distance downstream from a dam is limited by relative tributary size according to the serial discontinuity concept (SDC; Ward and Stanford 1983). However, geomorphology may also influence the recovery process. We examined the woody vegetation of the riparian zone and floodplain in seven river sections distributed along the regulated reach of the Tiétar River in central-western Spain, which flows through two distinct geomorphic templates. The total annual runoff along the studied reach has decreased by an average of 30% over the past 50 years following the construction of the Rosarito Dam and the initiation of field irrigation in the region. Recovery patterns were evaluated by comparing vegetation bands established prior to and after dam erection in terms of their woody species composition, diversity and distribution. Our results did not indicate a recovery gradient of any of the analyzed vegetation attributes downstream from the dam. Instead, we found that the difference in the slope of the channel and banks (i.e., establishment surface) between the surveyed sections and the bands was the primary geomorphic factor mediating the dam and tributary effects on vegetation. Substratum and valley width also influenced the degree of vegetation recovery. Hence, the maintenance of the intensity of the flow alteration scheme by the high direct pumping pressure along the studied reach and the relatively small tributaries, coupled with differential geomorphic characteristics, overwhelmed the natural tendency of the river to recover with distance downstream. Improving water management and, particularly, an appropriate definition of the environmental flows required for restoring endangered riparian ecosystems require a detailed understanding of the existing and potential woody species behavior across the geomorphological conditions of rivers.

Session 'Anthropogenic impacts on vegetation' / ORAL

## PATTERNS AND DRIVERS OF LONG-TERM CHANGE IN SAGEBRUSH-STEPPE VEGETATION COMMUNITIES

**G. Matt Davies[1,2], Jon Bakker[1], Eva Dettweiler-Robinson[1], James Evans[3], Peter Dunwiddie[1], Janelle Downs[4], Mike Marsh[1]**

*[1] The University of Washington, School of Forest Resources, Seattle, United States of America; [2] University of Glasgow, School of Interdisciplinary Studies, Dumfries, Scotland; [3] The Nature Conservancy, Seattle, United States of America; [4] Pacific Northwest National Laboratory, Richland, United State of America. (gwilym.davies@glasgow.ac.uk)*

Keywords: *Artemisia tridentata*, *Bromus tectorum*, control charts, restoration, wildfire

The sagebrush-steppe of the inter-mountain western United States is threatened by changes to fire regimes caused by invasion of the alien, annual grass *Bromus tectorum* (cheatgrass) and by increasing anthropogenic ignition frequencies. Big sagebrush (*Artemisia tridentata*)-dominated vegetation provides a wide range of benefits to the ecosystem, including habitat for a number of rare endemic species. Despite significant research into the relationship between fire and changes in vegetation in these communities, few long-term studies exist that allow us to examine the effects of compounded disturbances. Permanent vegetation monitoring plots were established in and around the Arid Lands Ecology Reserve (south-central Washington State) in the early to mid 1990s, and they cover a wide range of abiotic conditions. Since their establishment, the plots have been variously impacted by one or more large wildfires and by post-fire restoration efforts including drill and aerial seeding of native species, herbicide application and out-planting of sagebrush seedlings. A number of the plots have, however, remained relatively undisturbed. Here we 1) describe key community groups, 2) track changes in the community composition over time and 3) evaluate the relative importance of fire, restoration, edaphic conditions and broad plant functional traits in driving vegetation change. Cluster analysis suggested that the initial composition was a function of both edaphic characteristics and historical fire frequency. Multivariate control charts provided a useful tool for visualizing changes in community composition and demonstrated that change is a function of both community-type and fire frequency. Regression trees demonstrated that fire frequency was the key driver of the degree of change but that the effects of fire interacted with elevation, soil type and initial community group. Restoration treatments appeared to have had little impact on post-fire recovery rates. Patterns of resilience can be explained by the functional traits of the dominant species and by elevational differences in site productivity.

Session 'Anthropogenic impacts on vegetation' / ORAL

## INFLUENCE OF NUTRIENT ENRICHMENT, SEDIMENTATION AND HERBICIDE RESIDUES ON SEAGRASS IN TWO CONTRASTING NEW ZEALAND HARBORS

**Virginie M. Dos Santos[1,2], Fleur E. Matheson[1], Conrad A. Pilditch[2], Georges Merlina[3,4], Arnaud Elger[4]**

*[1]National Institute of Water & Atmospheric Research, Hamilton, New Zealand; [2]University of Waikato, Department of Biological Sciences, Hamilton, New Zealand; [3]University of Toulouse, INP ENSAT, Castanet-Tolosan, France; [4]UMR 5245 CNRS/INP/UPS, EcoLab (Laboratoire d'écologie fonctionnelle), Toulouse, France (corresponding author:dossantos.vm@gmail.com)*

Keywords: herbicide, harbor development, nitrogen, light, *Zostera muelleri*

Seagrasses are declining worldwide. Eutrophication, sedimentation and herbicide contamination in estuaries are factors postulated to contribute to this decline. In this study, we surveyed two New Zealand harbors that contrast in catchment size and land use. Seagrass (*Zostera muelleri*) condition metrics and selected environmental parameters were measured to assess the potential factors regulating seagrass growth. The results showed that seagrass morphometric parameters were positively correlated to porewater ammonium ($NH_4$-N) concentrations suggesting that the growth environment in both harbors was N-limited. Sites with a higher proportion of urban and crop land use in their catchments were associated with higher concentrations of porewater nitrate ($NO_3$-N) and lower underwater light availability. This suggests that these catchments might play a role in decreasing water clarity through nutrient enrichment; however, there was no evidence of seagrass light limitation. Sediment herbicide concentrations were significantly higher in the harbor with a higher proportion of developed land use, particularly crop and urban, and were negatively correlated to seagrass photosynthetic efficiency ($F_v/F_m$). The results of this study strongly suggest that anthropogenic activities may contribute to the degradation of estuarine water and sediment quality and have detrimental effects on seagrass.

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## THE EFFECTS OF HUMAN DISTURBANCE ON PLANT POPULATIONS: A CASE STUDY OF *LIMONIUM GIRARDIANUM*, A PROTECTED ENDEMIC SPECIES IN COASTAL SALT MARSHES

**Teddy Baumberger[1,2], Laurence Affre[1], François Mesléard[1,2], Thomas Croze[1], Florent Thaler[1]**

*[1] IMEP – Institut Méditerranéen d'Ecologie et de Paléo-ecologie,Vulnérabilité des système écologique, Marseille France; [2] Tour du Valat - Centre de recherche pour la conservation des zones humides méditerranéennes, Gestion intégrée et dynamiques des écosystèmes, Le Sambuc France*

Keywords: population dynamics, conservation, indicator species, Mediterranean Basin, industrial context

Among natural coastal ecosystems, salt marshes are the source of the highest and most valuable ecological benefits. However, these areas endure profound degradation or even destruction that modifies their hydrology and substratum. In this context, salt marsh conservation represents a priority to prevent a loss of biodiversity, salt marsh functions and ecological benefits. The majority of studies highlight the necessity of considering plant species ecology and population dynamics for management and restoration success. We have focused on the protected species, *Limonium girardianum*, an endemic plant species present in the salt marshes of France and Spain. Our goal was to define the ecological characteristics of suitable habitats by i) modeling the habitat conditions in which the species is present, ii) investigating differences in population structure, and iii) investigating differences in population dynamics in relation to environmental conditions. We used a set of 198 permanent concentric plots of 1 and 50 m² and utilized a presence (91 plots) and absence (107 plots) stratified sampling strategy. Soil salinity, soil moisture during the flood and dry seasons, the proportion of three soil fractions, the maximum water level, and the mean of the water table depth were surveyed. In addition, 4,199 individuals, including seedlings, non-reproductive, and reproductive adults were surveyed within two years. Our results demonstrated that the *L. girardianum* unimodal response was highly constrained by flood and soil salinity and also by drought and plant species competition. We showed that soil texture interacts with hydrological parameters and can moderate or accentuate soil drought or anoxia. The population structure was affected by environmental conditions especially in disturbed areas where the hydrology had been intensively modified by industrial infrastructures. We also showed that the survival and fate of certain developmental stages (notably seedlings) were strongly driven by ecological conditions, especially when human disturbances had induced imbalances in the hydrology. These factors may compromise the persistence of *L. girardianum* populations, which may be considered an indicator species of certain disturbances in the biodiversity, function and benefits of salt marshes.

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## THE SENSITIVITY OF PRIMARY PRODUCTION TO PRECIPITATION

**Joanna Hsu[1], James Powell[2,3], Peter Adler[1]**

*[1] Utah State University, Department of Wildland Resources and the Ecology Center, Logan, USA; [2] Utah State University, Department of Biology, Logan USA; [3] Utah State University, Department of Mathematics and Statistics, Logan, USA (corresponding author: jhsu118@gmail.com)*

Keywords : primary production, ANPP, precipitation, climate change

In many terrestrial ecosystems, variation in aboveground net primary production (ANPP) is positively correlated with annual variation in precipitation. Global climate change will alter both the mean and the variability of precipitation, but the relative impact of these changes in precipitation on ANPP remains uncertain. At any given site, the slope of the precipitation-ANPP relationship determines the short-term sensitivity of ANPP to changes in mean precipitation, while the nonlinearity of the precipitation-ANPP relationship determines the sensitivity of ANPP to changes in precipitation variability. We used 58 existing long-term data sets to characterize precipitation-ANPP relationships in terrestrial ecosystems and to quantify the sensitivity of ANPP to the mean and variance of precipitation. We found that most study sites have a nonlinear, saturating relationship between precipitation and ANPP, but these nonlinearities were not strong. As a result of these weak nonlinearities, ANPP was 40 times more sensitive to precipitation mean than variance. A 1% increase in mean precipitation caused a -0.3% to 1.8% change in ANPP, with a 0.65% increase on average. Sensitivities to precipitation mean peaked at sites with a mean annual precipitation near 500 mm. Changes in species composition and increased intra-annual precipitation variability could lead to larger ANPP responses to altered precipitation regimes than predicted by our analysis.

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## VEGETATION PATTERNS EVOLUTION OF AN ARTIFICIALLY VEGETALIZED STORMWATER INFILTRATION BASIN

**Muriel Saulais[1], Jean-Philippe Bedell[1], Damien Lemoine[2], Delolme Cécile [1]**

*[1] LEHNA-IPE, UMR 5023, University Of Lyon, ENTPE, Vaulx-en-Velin France, (corresponding author: bedell@entpe.fr); [2] LEHNA-E3S, UMR 5023, University Of Lyon, U. Claude Bernard Lyon 1, Villeurbanne, France*

Keywords : infiltration basin, *Phragmition alliance, Phalaridion alliance,* spatial vegetation patterns, species richness

Infiltration basins are stormwater management works that can be voluntarily revegetated. The aim of our study was to determine the evolution of vegetation patterns in a functional infiltration basin after nine years. A floristic inventory in of a 4,333 $m^2$ infiltration basin revegetated in 1999 was carried out in 2008. This basin collects stormwater from a 146 ha watershed. In 1999, 30 plant species were introduced into the basin. In 2008, we counted only 7 species, which were all wetland plants. There were two main vegetation alliances represented in this basin: Phragmition and Phalaridion with *Typha latifolia*, *Typha angustifolia, Iris pseudacorus*, *Schoenoplectus tabernaemontani*, *Acorus calamus*, *Phalaris arundinacea* and *Phragmites australis*. Of these seven species, only three were species originally planted at the site. Nine years after planting, 90% of the introduced species had disappeared; this demonstrated a significant loss in biodiversity. The four species that spontaneously colonized the basin were *P. australis, S. tabernaemontani, T. angustifolia* and *T. latifolia*. Seeds of these species may have been transported by water from lakes located upstream of the basin. These species are known to colonize soils enriched in organic matter and nutrients. Of the three species originally introduced, we observed significant changes in abundance. *Phalaris arundinacea* severely declined for nine years and was only represented by a few individuals in 2008. On the contrary, *Iris pseudacorus* gradually colonized the ground; this demonstrates that there were favorable growth conditions for this species. Another favorable result was the evolution of the spatial organization of the vegetation. The landscape aspect was taken into account during revegetation and therefore, led to sophisticated geometric shapes. In 2008, the spatial organization was much simpler; the vegetation was spatially organized from upstream to downstream of the stormwater. This spatial organization led to the stratification of the landscape of the basin.

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# SEVERE CHANGES AND SUCCESSION IN THE VEGETATION COMPOSITION FOLLOWING DRAINAGE OF A LOWLAND PERCOLATION MIRE COMPLEX

**Marian Koch, Gerald Jurasinski***

*University of Rostock, Landscape Ecology and Site Evaluation, Rostock, Germany, gerald.jurasinski@uni-rostock.de*

Keywords: Long-term vegetation developments, indicator values, succession, strategy types, re-survey

Land-use and land-use change are among the major forces of biodiversity loss and extinction. One major land-use change in Central Europe during the last 100 years has been the drainage of fen and bog ecosystems. The lowering of the water table inevitably leads to changes in important environmental variables (e.g., water retention capacity, nutrient budget and availability) and, therefore, has a large impact on plant species composition. In addition, climate change may also impact vegetation composition.

Based on a partial re-survey of a vegetation analysis in an extensive percolation fen complex in Northeast Germany (Recknitz valley) from the late 1960s, the long-term development in vegetation composition has been analyzed using indirect gradient analysis (NMDS), indicator value analysis, and an evaluation of the change in strategy types. Using digitized location information and by following the original field sampling protocol we ensured sufficient relocation accuracy.

Overall, species richness in the area significantly decreased (6%). At the plot scale, the alpha diversity decreased by an average of 23%, which resulted in an increase in beta diversity. This can be explained by extinction debt: species in decline still can be found scattered throughout the investigation area. Shrubs and nitrophilous tall herbs with a lower moisture demand increased. Today, they have a much wider distribution and abundance than in the late 1960s, whereas those of oligo- and mesotrophic species with a preference for moist habitats have decreased.

This is also reflected in a shift in the average strategy type per plot. After heavy drainage in the 1970s, the subsequent succession dynamic induced a rise in competitors over stress tolerators that had previously played a more important role. There was no significant change in the indicator values for temperature, suggesting that local climate warming had a negligible effect on the vegetation composition compared to the impact of land-use change.

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## PRELIMINARY STUDY ON ANTHROPOGENIC PROCESSES THAT AFFECT FOREST VEGETATION DISTRIBUTION AND DYNAMICS IN THE GUADARRAMA MOUNTAINS IN MADRID

**Elena Castoldi[1], José Ramón Quintana[2], José Antonio Molina[1]**

*[1] Departamento de Ecología Vegetal II, Universidad Complutense de Madrid, 28040-Madrid, Spain; [2] Departamento de Edafología; (corresponding author: ecastoldi@farm.ucm.es)*

Keywords: Burnt stands, *Pinus sylvestris*, hemispherical photo, soil ions content, Neighbor joining tree.

Anthropogenic disturbances on Earth are substantial and growing**.** Human activities affect vegetation and the natural landscape in many different ways. Forests in the Guadarrama Mountains are mainly formed by deciduous *Quercus pyrenaica* and evergreen Scots pine (*Pinus sylvestris*). Both species have been exploited for wood, and *Pinus sylvestris* has been widely planted in *Quercus pyrenaica* areas. One of the most common management techniques in the region includes cutting and burning branches, in small circular stands, to control the growth of trees and shrubs. Our study aims to address the following question: How does this management technique affect the plant landscape and dynamics?
We sampled 20 burnt stands (1 $m^2$) after burning (2008-2009, November-May) and 20 non-burnt stands. We collected floristic (37 species) data, seed bank data, and soil samples. Hemispherical photos (Canon 350D, fish-eye lens) were analyzed to evaluate the canopy cover. Neighbor-joining trees were developed to examine post-fire succession (Syntax software, Podani 2000). Ordination analyses were used to identify the relationships between soil properties and plant distribution (Canoco software, Ter Braak 1990).
Floristic results show an increase in alpha-diversity in successional stages. Neighbor-joining trees showed that the nearest origin clusters correspond to recently burnt stands with a dominance of the pioneer moss species, *Funaria hygrometrica*. Results show an increase in Scots pine seedlings in burnt stands. In addition, burnt stands showed increases in ion concentrations (Na, $NH_4$, Ca, Mg, K, $NO_3$, and $NO_2$, and decreases in organic carbon. Burnt stands in shaded areas contained the highest amount of Scots pine seedlings.

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## IMPACTS OF NITROGEN DEPOSITION ON PLANT SPECIES BIODIVERSITY AND RICHNESS IN IRISH GRASSLANDS

**Jason Henry, Julian Aherne**

*Trent University, Environmental and Life Science, Peterborough, Canada (jasonhenry@trentu.ca)*

Keywords: semi-natural grassland relevé, Ellenberg index, vascular species, soil nitrogen, nitrogen deposition gradient

Nitrogen (N) input through atmospheric deposition can affect ecosystem plant species richness and biodiversity. During the last century, intensive agriculture and the combustion of fossil fuels have drastically changed global emissions and the deposition of N to semi-natural ecosystems. Accordingly, several studies have been conducted worldwide to determine the impacts of N deposition on plant species. Ireland represents one of many countries that signed (1992) and ratified (1996) the Convention of Biological Diversity, which focuses on the conservation of habitat and wildlife. Pasture represents the dominant ecosystem found in Ireland, covering > 60% of the land area. Natural grasslands have limited anthropogenic disturbances (other than rough grazing) and contain a wide diversity of plant species that are sensitive to elevated atmospheric N deposition.
The principal objective of this study was to assess the influence of N deposition on species richness and biodiversity in Irish grasslands. A secondary objective was to assess the relationship between soil N status and plant species diversity using the Ellenberg indicator index. A total of 500 relevé plots from semi-natural grasslands (Counties Cavan, Leitrim, Longford and Monaghan) were recorded along an N deposition gradient (5–25 kg N $ha^{-1}$). Soil samples were collected and analyzed for total nitrogen, texture and exchangeable cations; these soil properties along with pH were used to explore the relationship between soil chemistry and species presence. Average species richness for the counties Monaghan, Cavan, Longford and Leitrim (78.4, 81.3, 92.5 and 107.5, respectively) was highly correlated to the annual average N deposition (17.2, 14.5, 12.3 and 8.5 kg N $ha^{-1}$). County Monaghan, which received the highest N deposition, had significantly fewer species per plot compared to Leitrim and Longford. Preliminary analyses suggested a linear decrease in species richness as a function of inorganic N deposition. Similar losses to biodiversity in terrestrial ecosystems have been observed across Europe.

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## SUSTAINABLE MANAGEMENT FOR THE CULTURAL LANDSCAPE IN KOREA AND JAPAN USING AN ANALYTIC HIERARCHY PROCESS

**Jae-Eun Kim[1], Sun-Kee Hong[1], Nobukazu Nakagoshi[2],**

*[1] Institution for Marine and Island Cultures, Mokpo National University, Muan-gun, Republic of Korea; [2] IDEC, Hiroshima University, Higashi-Hiroshima, Japan (ecokimje@gmail.com)*

Keywords: AHP (Analytic Hierarchy Process), cultural landscape, decision support system, forest management

Spatial patterns of cultural landscapes reflect not only natural factors but also human influences. In the case of rural forests, cultural landscape management has been related to vegetation composition as well as species diversity. Rural forest management activities change through socio-economic environments that influence vegetation. Therefore, landscape planning and management processes of cultural landscape are complicated for decision-makers. The AHP (Analytic Hierarchy Process) is a useful tool to evaluate complex multi-criteria decision problems. By converting a problem into a hierarchical structure, the AHP helps decision-makers cope with complexity. The weights of the decision criteria and the priorities of researched alternatives are determined by comparing two elements at a time and verbally expressing the intensity of preference for one element over the other. In this regard, the AHP enables the incorporation of both qualitative and quantitative aspects of the decision problem. This study illustrates the usefulness of using AHP for the management of abandoned rural forests in Korea and Japan, which have witnessed particular decreases in *Pinus densiflora* areas. Five rural forest sites, three in Korea and two in Japan, were selected as samples. Seven criteria levels (elevation, aspect, slope, geology, land use, patch carrying capacity, and distance from inhabited area) were used to evaluate the areas. Findings show that the distance from inhabited area carried the strongest weight, while the sites in Japan had more pine forest-dominated area than the Korean study areas. In addition, the Korean sites were less suitable for *P. densiflora* management than those in Japan. The results also show that active management was important for sustaining cultural landscape planning and management. The study confirms that GIS based AHP is a useful tool for landscape planning decision-making.

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## RESPONSES OF CONIFEROUS SEEDLINGS TO A PARTIAL HARVEST ALONG A CREEK IN THE PACIFIC NORTHWEST FOREST, CANADA

**Yoshi Minami[1], Mai Oba[1], Satoru Kojima[2], John S. Richardson[3]**

*[1] Tamagawa University, Coll. of Agric., Tokyo Japan; [2] Northern Oikoscape Research Ateleir, Tokyo Japan; [3] The University of British Columbia, Faculty of Forestry, Vancouver Canada (Yoshi Minami: yoshi-min@agr.tamagawa.ac.jp)*

Keywords: inhibitory effect, coniferous seedlings, regeneration, *Gaultheria shallon*, *Rubus spectabilis*

Partial harvesting is a tool that allows for harvesting while still allowing the riparian vegetation to maintain its function. We examined the response of coniferous seedlings to a 50% partial harvest in the Pacific Northwest Forest in Canada. In this study, we focused on three coniferous species, *Tsuga heterophylla*, *Thuja plicata* and *Pseudotsuga menziesii*, which were the dominant species at the study site. Due to the harvest, light availability to the understory increased and promoted seedling establishment and growth. The number of seedlings was greatest, in order, from *T. plicata* to *T. heterophylla* to *P. menziesii*. These results reflected differences in shade tolerance, and the increased light availability was not adequate to promote their growth of the *P. menziesii* seedlings. Most seedlings grew on the leaf litter. The increase in light availability also stimulated the growth of *Rubus spectabilis*, and the dense cover from *R. spectabilis* inhibited the establishment of coniferous seedlings on the leaf litter. Although *Gaultheria shallon* also extended its cover, competition from dense *G. shallon* was not as severe as from *R. spectabilis*. *R. spectabilis* creates a seed bank, and therefore, it is able to regenerate more quickly when light conditions improve, allowing it to persist as the dominant species in the understory for long periods of time. In addition, *R. spectabilis* has the ability to shade seedlings due to its thick cover. *R. spectabilis* is common in moist sites and it formed a dense cover within 20 meters of the creek after the partial harvest. Once *R. spectabilis* was established, it continued to grow via stem recruitment and maintained a dense and stable cover. Even intense disturbance would not affect the stability of the *R. spectabilis* populations. Establishment of a 20-m reserve adjoining the partial harvest would create a shaded area under the canopy, and would prevent the establishment of *R. spectabilis*; this is important in riparian areas to allow for seedling regeneration.

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## A COMPARISON OF THE VEGETATION PATTERNS BETWEEN TWO ADJOINING COASTAL DUNES FOLLOWING 60 YEARS OF DIFFERING MANAGEMENT

**Dai Nagamatsu, Minami Takamoto, Mika Shimizu**

*Department of Regional Environment, Tottori University, Tottori JAPAN (corresponding author: daina@rstu.jp)*

Keywords: Alien plants, Coastal vegetation, Landscape management, Pine tree plantation

The Tottori Sand Dunes are typical examples of coastal dunes in Japan. They are located in the largest dunes park in the Japanese National Parks and are the most famous tourist spot on this region. The dunes are located along the coast and were originally 16 kilometers long and 2 kilometers wide. For centuries, the dunes have been regarded as a nuisance to the local population, and after World War II, the area of the dunes decreased due to pine tree plantations planted to stabilize the dunes as much as possible. Since the 1950s, two dune areas of 160 and 100 hectares, respectively, have been maintained as native sand dunes for tourists (the National Park area) and for research focusing on coastal vegetation (a reserve area in Tottori University). During the last 50 years, many alien plants have become established in the Tottori Sand Dunes and native coastal plants have increased. Citizens and the local government and have tried to preserve the dunes by removing alien plant species from the National Park area, while the coastal vegetation in the University area has been unmanaged for 60 years.
We studied the coastal vegetation structure in both the National Park area and the University area. We measured the distribution of the plant community using a GPS receiver and studied both the species composition and the abundance of the plant communities in the two dune areas. Based on vegetation surveys, the two dunes exhibited different vegetation patterns and abundance. Native *Carex kobomugi* and *Ischaemum anthephoroides* dominated the National Park area, while native *Artemisia capillaris* dominated the University area. Inland native and alien species were more abundant in the University area, while in the National Park area, alien weed communities occurred around the dunes. The coastal vegetation in these two dunes was different due to the differences in management over the last 60 years.

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## LATE HOLOCENE FOREST COMPOSITION CHANGES IN ESTONIA: THE RELATIVE IMPORTANCE OF ANTHROPOGENIC FACTORS AND CLIMATE

**Triin Reitalu[1], Mihkel Kangur[2], Tiiu Koff[2], Meelis Pärtel[3], Anneli Poska[4], Shinya Sugita[2], Siim Veski[1]**

*[1] Institute of Geology, Tallinn University of Technology, Tallinn, Estonia; [2] Institute of Ecology, Tallinn University, Tallinn, Estonia; [4] Department of Earth and Ecosystem Sciences, Lund University, Lund, Sweden; [3] Institute of Ecology and Earth Sciences, Tartu University, Tartu, Estonia (corresponding author: triin.reitalu@mail.ee)*

Keywords: Functional diversity, Landscape reconstruction algorithm, Landscape openness, Pollen data

The expansion of agriculture has resulted in a general trend of decreasing forest area throughout all of Europe over the last 4,000 years. Data regarding changes in the composition of forest species and of the functional properties of forests that have accompanied the decrease in area would provide valuable information about the mechanisms behind the decrease. In addition to the anthropogenic factors, forest composition could also be influenced by climate change.
The present study explores changes in forest composition and in forest functional diversity at a regional scale (Estonia) during the last 4,000 years. This information was used to investigate the extent to which these changes could be explained by anthropogenic and/or climatic factors.
The data on historical forest composition is derived from traditional pollen analysis accompanied by REVEALS (Regional Estimate of Vegetation Abundance from Large Sites) modeling of sedimentary pollen data from seven large (>100 ha) lakes from locations throughout Estonia. Life history and stress-tolerance traits (e.g., shade tolerance, lifespan) for each of the major tree taxa were collected from the literature and weighted average trait values were used to characterize forest functional diversity for different time-periods in each of the seven sites. REVEALS estimates of pollen taxa indicative of open area (*Poaceae*, *Cyperaceae*, *Rumex acetosella*) and arable fields (*Secale*, *Cerealia*) are used to estimate the anthropogenic factors – the proportion of open area and the proportion of arable land. The Estonian climate was characterized over the last 4,000 years using different proxy data (i.e., pollen-based reconstructions, water table depths, stable isotopes). Changes in the abundances of the major tree taxa and in the forest functional diversity were related to climate data and anthropogenic factors using Generalized Least Squares (GLS) where the spatio-temporal autocorrelation could be taken into account.
This poster shows the preliminary results from our study and we discuss the relative importance of climatic and anthropogenic mechanisms that may be related to forest decline in Estonia in the late Holocene.

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# PLANT SPECIES’ RESPONSES TO CLIMATE VARIABLES

**Wieger Wamelink, Rick Wieggers, Gert Jan Reinds, Agnieszka Malinowska, Marjolein van Adrichem, Joep Frissel**

*Alterra, Wageningen UR, Wageningen The Netherlands*

Keywords: temperature, precipitation, species distribution, relevés

Climate change will force plant species to react; they can stay and adapt, disperse at a rate that will allow them to match the climate change ‘speed’, or they will, in time, become extinct. Effects of climate change are not limited to an increase in temperature alone; precipitation is also affected. Identifying the responses and preferences of plant species to temperature and precipitation can help to better understand a species’ response to climate change and may identify species that are under threat, even if there are no signs at present that they are endangered due to climate change.
We used our previously developed method to estimate plant species’ responses to soil variables to estimate plant species’ responses to climate variables. Responses were estimated for temperature (annual mean, average highest and lowest temperature) and precipitation (yearly total and growing season total). Responses were estimated on a European scale, combining vegetation relevés, climate information from weather stations and an altitude map of Europe. We extrapolated the climate information using the altitude map to estimate the temperatures and rainfall at the sites the relevés were conducted. This method resulted in responses for many European plant species to climate variables. The responses will undergo further testing on their reliability and will be made available through the website www.abiotic.wur.nl.

# Describing biodiversity patterns at multiple scales

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## PATTERNS OF DOMINANCE BY NEEDLE-LEAF AND BROAD-LEAF EVERGREEN TREES IN NORTHERN CALIFORNIA

**Michael Barbour[1], Javier Loidi[2], Gonzalo Garcia-Baquero[2], Robert Meyer[3], Tom Cronin[4], Valerie Whitworth[5]**

*[1]University of California, Plant Sciences Dept., Davis, CA, USA (corresponding author, mgbarbour@ucdavis.edu; [2]University of the Basque Country, Dept. of Plant Biology and Ecology, 48080 Bilbao, Spain; [3]USGS, Hydrologist, Shingle Springs, CA 95682; [4]808 F Street, Davis, CA 95616; [5]108 Liwai Village Court, Winters, CA 95694*

Keywords: Coast Ranges, mixed evergreen forest, old-growth forests, Pseudotsuga, Sequoia

Mixed evergreen forest occupies about 4% of California's area (1.86 million ha), but due to logging and wildfire, <5% of this area has old-growth status. The forest is two-layered; the upper stratum is a relatively open canopy of tall conifers while the lower stratum is a more closed canopy of broad-leaved evergreen trees. Our objective was to characterize this forest along a number of environmental gradients and to identify the most important gradients. We focused this initial study in the greater San Francisco Bay region of California. Overstory conifers in this region are *Sequoia sempervirens* and/or *Pseudotsuga menziesii*. Environmental attributes included topographic and geographic location, distance from the ocean, relative site elevation, annual solar radiation, mean annual precipitation, an index of summer aridity, and annual and seasonal temperatures. Most sites were dominated by overstory conifers (13 of 17), and the degree of conifer dominance was largely explained by distance from the stand to the ocean, relative site elevation, annual solar radiation (in calories), and seasonal max/min temperatures. Other physical factors did not exhibit significant relationships with either dominance by both conifer species or dominance by either species, possibly because the presence of fog was a confounding factor. Summer fog has often been anecdotally cited as an important factor for coastal vegetation, but we lack data at an appropriately fine scale to evaluate this factor. We quantified the effect of a fog gradient indirectly from proxies such as distance to the sea, slope aspect, and relative site elevation--some of which did correlate significantly with the dominance of individual conifer tree species and between tree growth form categories.

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## DIVERSITY IN THE VEGETATION OF THE LOW MOUNTAINS IN THE BLIDA ATLAS (SUBHUMID STAGE)

**Leila Kadik Achoubi, Siham Mékidèche, Lila Brakchi**

*USTHB, Fsb, Alger, Algeria; l_kadik@yahoo.fr*

Keywords: Algeria, landscape, ecosystem

Mediterranean landscapes in low mountains are known for their floristic heterogeneity, which is the result of various ecological and human factors.
These landscapes are the most threatened and least understood natural landscapes in Algeria today. Our work contributes to the study of the anthropogenic impacts and climatic disturbances on the vegetative diversity of a landscape in the piedmont of the Blida Atlas south of Algiers.
Vegetative diversity was analyzed at two levels. The first level was that of landscape via the production of a vegetation map showing the spatial distribution of the various landscape units. The second level was that of ecosystems via systematic sampling and a floristic and ecological inventory (66 *relevés* with 210 species). These data permitted us to carry out a qualitative and quantitative evaluation of the vegetation and flora. This study also allowed us to appreciate the floristic, taxonomic, biological and phytogeographical situation of these vegetation groupings, which are threatened with disappearance by the actions of man and a changing climate.

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## PLANT DIVERSITY OF CLIMATOGENIC SILVER FIR – BEECH FOREST IN THE DINARIC KARST ACROSS SEVERAL MESOSCALE GRADIENTS

**Sven D. Jelaska[1], Mario Božić [2], Boštjan Surina [3], Oleg Antonić [4]**

*[1] Faculty of Science, University of Zagreb, Department of Botany, Zagreb, Croatia; [2] Faculty of Forestry, University of Zagreb, Zagreb, Croatia; [3] Natural History Museum Rijeka, Rijeka, Croatia; [4] Ruđer Bošković Institute, Zagreb, Croatia (corresponding author: sven@botanic.hr)*

Keywords: *Omphalodo-Fagetum*, variation partitioning, RDA, Croatia

Dinaric silver fir – beech forests, with an almost continuous area of 3,000 km$^2$, are the most widely distributed altimontane climatogenic forests in the Croatian high karst. Parts of these forests contain virgin stands, while the majority of the area is composed of selectively logged stands with naturally grown forest. Despite significant research previously conducted on these forests in the past, the relationship between plant diversity and the complex environmental gradients that occur in this landscape has not yet been examined. Here, we present the results of a unified survey of 151 plots distributed throughout the entire distribution area of these Croatian forests, including virgin and managed stands. Data on floristic composition, climate and geomorphology were gathered for all plots. After TWINSPAN and PCoA analyses of floristic data, we identified six subassociations of the *Omphalodo-Fagetum* association: *homogynetosum, galietosum, aceretosum, mercurialetosum, asaretosum* and *seslerietosum*. RDA analysis revealed that elevation, precipitations and latitude were the most important variables explaining variance in species composition. Partial RDA analysis has shown that latitude and longitude provide the greatest unique contribution, while the highest shared effects upon the species composition were the climatic and elevation data. Longitude was negatively correlated with the number of plant species, the Shannon-Wiener index and Evenness, while latitude was positively correlated with all these indices. Stands belonging to -*asaretosum* and -*mercurialetosum* subassociations had the highest plant diversity, while -*galietosum* and -*homogynetosum* contained the lowest. Differences in life form spectra across subassociations confirmed the significant influence of the latitudinal gradient on the flora of these forests. Based on their floristic assemblage, virgin stands did not aggregate together, separately from managed areas, but rather they grouped with managed stands in different subassociations across geomorphology, elevation, climatic and geographical gradients. These results suggest that environmental conditions are the driving forces influencing plant diversity in these forests and that the current management methods appear to preserve that diversity.

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## TRUE, DARK AND PSEUDODIVERSITY: RE-CONCEPTUALIZATION OF BIODIVERSITY

**Meelis Pärtel, Aveliina Helm, Robert Szava-Kovats, Martin Zobel**

*Institute of Ecology and Earth Sciences, University of Tartu, Estonia (corresponding author: meelis.partel@ut.ee)*

Keywords: conservation, habitat quality, local-regional diversity, species pool, species richness.

The total number of observed species sampled in an ecological community holds limited value for ecological theory and nature conservation because it ignores biodiversity "quality", and because absolute values might not be meaningfully comparable among studies. Therefore, we suggest a re-conceptualization of biodiversity into three components – true, dark and pseudodiversity. This entails an intersection between observed local diversity with its habitat-specific species pool – the potential set of typical species that can inhabit particular ecological conditions and that are naturally present in the region. True diversity is the portion of observed diversity that also belongs to the habitat-specific species pool. This component of local diversity can serve as a target in nature conservation. Dark diversity is the portion of the species pool absent from a site. This diversity component allows quantification of local diversity in relative terms and evaluation of the roles of local and regional processes in ecological communities. Pseudodiversity consists of species that are present in the habitat but do not belong to the typical habitat-specific species pool. Recent changes in land-use, intensification of agriculture, urbanization and the introduction of exotic species have influenced natural plant communities so that we might find some share of "wayward" species, which inflate observed local diversity but actually suggest ecosystem degradation. We encourage using ratios of true diversity to dark diversity to enable meaningful biodiversity comparisons between regions, ecosystems and taxonomic groups. Similarly, ratios of true diversity to pseudodiversity can characterize habitat quality in relative terms. True, dark and pseudodiversity requires that we define habitat-specific species pools. Recent advances in ecoinformatics have eased defining these pools, as data on species distribution, habitat requirements or co-occurrence patterns are more readily available. Our re-conceptualization of biodiversity can also be expanded to functional and phylogenetic diversity aspects. We illustrate true, dark and pseudodiversity by working examples.

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## CALCULATING GENERALIZED ENTROPY AS A MEASURE OF LANDSCAPE DIVERSITY IN AN OPEN SOURCE SPACE

**Duccio Rocchini[1,*], Luca Delucchi[1], Giovanni Bacaro[2], Paolo Cavallini[3], Hannes Feilhauer[4], Giles M. Foody[5], Kate S. He[6], Harini Nagendra[7,8], Claudio Porta[9,10], Carlo Ricotta[11], Sebastian Schmidtlein[4], Lucio Davide Spano[9,10], Martin Wegmann[12], Markus Neteler[1]**

*[1] Fondazione Edmund Mach, Research and Innovation Centre, Department of Biodiversity and Molecular Ecology, GIS and Remote Sensing Unit, Via E. Mach 1, 38010 S. Michele all'Adige (TN), Italy, [2] BIOCONNET, Biodiversity and Conservation Network, Department of Environmental Science "G. Sarfatti", University of Siena, Via P.A. Mattioli 4, 53100 Siena, Italy, [3] Faunalia, Piazza Garibaldi 5 - 56025 Pontedera (PI), Italy, [4] Department of Geography, University of Bonn, Meckenheimer Allee 166, DE-53115 Bonn, Germany, [5] School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK, [6] Department of Biological Sciences, Murray State University, Murray, Kentucky 42071, USA, [7] Ashoka Trust for Research in Ecology and the Environment, 659 5th A Main Hebbal, Bangalore 560024, India, [8] Center for the Study of Institutions, Population, and Environmental Change, Indiana University, 408 N. Indiana Avenue, Bloomington, IN 47408, USA, [9] ISTI-CNR, HIIS Lab, Via Moruzzi 1, 56124 Pisa, Italy, [10] Università degli Studi di Pisa, Dipartimento di Informatica, Largo B. Pontecorvo, 3, I-56127 Pisa Italy, [11] Department of Plant Biology, University of Rome "La Sapienza", Piazzale Aldo Moro 5, 00185 Rome, Italy, [12] University of Würzburg, Institute of Geography, Department of Remote Sensing, Remote Sensing and Biodiversity Research, Am Hubland, 97074 Würzburg, Germany (corresponding author: duccio.rocchini@iasma.it, ducciorocchini@gmail.com)*

Keywords: biodiversity, Free and Open Source Software, landscape heterogeneity, remote sensing, Rényi generalized entropy

Landscape diversity generally relates to species diversity at a range of ecological levels, such as species community diversity and genetic diversity. Species-based measures of diversity such as species richness or species turnover are the most commonly used metrics for quantifying the diversity of an area.
Nonetheless, the assessment of species diversity in relatively large areas has always been a challenging task for ecologists, mainly because of the intrinsic difficulty in judging the completeness of species' lists and in quantifying the sampling effort. Since the variability in the remotely sensed signal is expected to be related to landscape diversity, it could be used as a good proxy of diversity at the species level.
However, free and open source tools (tools that allow access to the source code) for assessing landscape heterogeneity at different spatial scales are still lacking today. In this study, we aim to achieve the following: i) provide a theoretical background of the most commonly used diversity indices stemming from information theory that are commonly applied to quantify landscape heterogeneity from remotely sensed data and ii) propose a free and robust Open Source tool (r.diversity) consisting of source code (running in GRASS GIS) for calculating diversity indices. In particular, we will focus on Rényi generalized entropy as a continuum of diversity measures. While traditional metrics supply point descriptions of diversity, in Rényi's framework, there is a continuum of potential diversity measures, which differ in their sensitivity to rare and abundant.
As far as we know, this is the first example in which Rényi entropy is provided in an open source framework. Hence, r.diversity's code is available from the GRASS GIS source code repository (http://svn.osgeo.org/grass/grass-addons/raster/r.diversity/) for further modifications and for potential re-use in the development of new indices based on new or underused mathematical theory.
We expect that the theme proposed in this study will stimulate discussions regarding the opportunities offered by free and open source Software to calculate landscape diversity.

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## ROOT SEQUENCING DOUBLES SMALL-SCALE PLANT RICHNESS MEASURES AND ALTERS DIVERSITY PATTERNS

**Inga Hiiesalu [1], Maarja Öpik [1], Madis Metsis [2], John Davison [1], Martti Vasar [1], Mari Moora [1], Martin Zobel [1], Scott D. Wilson [3], Meelis Pärtel [1]**

*[1] University of Tartu, Department of Botany, Tartu, Estonia; [2] Tallinn Technical University, Centre for Biology of Integrated Systems, Tallinn, Estonia; [3] University of Regina, Department of Biology, Regina, Canada. (corresponding author: Inga Hiiesalu, Email: Inga.Hiiesalu@ut.ee)*

Keywords: 454 sequencing, belowground, grassland, root community, species coexistence

Plant species richness data exclusively describes aboveground vegetation; roots and rhizomes have never been included in richness measurements of natural plant communities. We measured the total number of coexisting plant species as well as the aboveground richness and the number of species additionally identified belowground. We made direct comparisons between above- and belowground richness of vascular plants in identical volumes (0.1 x 0.1 x 0.1 m) above and below the soil surface, using conventional species identification to measure aboveground richness and 454 sequencing of the chloroplast *trn*L(UAA) intron to measure additional belowground richness. Taxa detected using DNA-based identification of roots increased total small-scale plant richness up to two times that of aboveground richness alone. Newly-detected belowground richness increased strongly with soil fertility, a result contrary to the negative productivity-diversity relationships that are widely reported for aboveground vegetation. Our results indicate that conventional approaches to plant diversity measurements may overlook many species coexisting at a small scale. We also show that belowground diversity becomes relatively more important in conditions where aboveground diversity decreases. Measuring plant belowground diversity will profoundly alter perceptions of biodiversity and its response to both natural and anthropogenic factors.

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## A NATIONAL SYNSYSTEM OF THE FRENCH VEGETATIONS

**Frédéric Bioret[1], Gilles Thébaud[2]**

*[1] Société Française de Phytosociologie et Institut de Géoarchitecture EA 2219, Université de Bretagne Occidentale, France; [2] Société Française de phytosociologie et Pôle de recherche et d'enseignement supérieur-Clermont-Université Herbiers universitaires (CLF) Clermont-Ferrand, France*

Keywords: classification of French vegetation, phytosociology

From 1996 to 2004, a group of French phytosociologists undertook a project to develop a national synsystem of French vegetation. Published in 2004, in collaboration with the National Museum of Natural History of Paris, this work represents the first national classification of vegetation under the sigmatist phytosociology synsystem. 712 syntaxa were identified: 76 classes, 141 orders, 7 suborders, 361 alliances and 127 sub alliances.
This work was the first step towards developing a more detailed classification, and it was used as a national reference for the phytosociological correspondence in the Natura 2000 habitat classification.
The goal of the second step of the project was to expand upon this work. The second step was initiated in 2006, in collaboration with different groups: the National Museum of Natural History, National Botanical Conservancies, the National Board of Forestry, and the ingenior school AgroParisTech Nancy.
The current work has several objectives: to prolong the declination up to the plant associations and sub associations; to facilitate the identification of syntaxa; and to identify the correspondences with the European classifications of natural and semi-natural habitats (CORINE Biotopes, EUR 27). This project is being carried out class by class. The work is coordinated by a single person for each class.
Five classes have been published since 2009 (Journal de Botanique of the French Botanical Society), nine classes are ready for publication or validation and thirty-two others are under preparation.
The *Oxycocco-Sphagnetea* class is detailed as an example. 149 Western and Medio-European syntaxa of unwooded ombrotrophic mire communities were analyzed using cluster analysis. A synsystematic model was developed for French *Oxycocco-Sphagnetea* that discriminated among two orders, three alliances and sixteen associations. These units are mainly related to moisture and nutrient gradients as well as to the longitudinal and altitudinal position of the bogs.

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## PYROSEQUENCING-BASED ASSESSMENT OF TEMPORAL DYNAMICS OF FUNGAL COMMUNITIES IN THE RHIZOSPHERE OF PLANTS

**Armen Nalian, Sikta Patnaik, James Van Kley, Alexandra Martynova-Van Kley***

*Stephen F. Austin State University, Nacogdoches, USA; (corresponding author:avankley@sfasu.edu)*

Keywords: fungal diversity, pyrosequencing, temporal dynamics

We used pyrosequencing-based analysis to detect temporal changes in the fungal communities in the rhizosphere of two common native plants in an East Texas forest. The rhizosphere of *Callicarpa americana* and *Chasmanthium sessiliflorum* were monitored for 12 months. Root samples were collected monthly from three locations on a forested hill slope. The data-set comprised 45,958 sequences of the 18S rRNA gene region that were identified to belong to Domain Fungi. Abundance, richness, evenness and distribution of fungal taxa were observed along gradients of topographic position, soil properties and plant nutrient availability. The dominant taxonomic group across all the samples was *Ascomycota* comprising more than 87% of the sequences. In total, there were 658 species, which included 21 species of phylum *Glomeromycota*. Statistical and multivariate analyses indicated significant relationships between environmental variables and the abundance and richness of fungal taxa. The relative percent abundance of fungal taxa at different taxonomic levels correlated with rainfall, position on the hill slope and host plant. In this study, a pyrosequencing-based analysis successfully described the temporal dynamics of fungal communities in the rhizosphere of two common plants and identified taxa that underwent significant changes in their abundance and richness.

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## DISTURBANCE REGIMES AND TROPHIC RESOURCES CHANGE BIOTIC INTERACTIONS IN HERBACEOUS PLANT COMMUNITIES

**Elise Buisson, Clémentine Coiffait-Gombault, Thierry Dutoit**

*Université d'Avignon et des Pays de Vaucluse, Institut Méditerranéen d'Ecologie et de Paléoécologie (UMR CNRS / IRD), IUT, site Agroparc BP 61207, 84 911 Avignon cedex 09, France (elise.buisson@univ-avignon.fr)*

Keywords: competition, assembly rules, *Brachypodium retusum*, steppe.

Analyses of the rules of assembly in plant communities are necessary to understand their organization and function. *Ex-situ* experiments allow for a better understanding of the biotic and abiotic filters that are responsible for the assembly of plant communities. We conducted an experiment on interspecific competition at a plant nursery to analyze the principal factors responsible for the assembly of a steppe plant community in the La Crau plain (Bouches-du-Rhône, France). We tested interactions between the dominant species of the community (*Brachypodium restusum*) and other characteristic steppe species (*Asphodelus ayardii, Evax pygmaea, Linum strictum, Taeniatherum caput-medusae*) according to different disturbance regimes (grazed vs. ungrazed), trophic level (steppe soil vs. arable-field soil) and the developmental stage of the dominant species (juvenile vs. adult). Plant biomass, height, diameter, SLA and interaction index calculations were measured to access the importance of each factor on *B. retusum* alone or in response to interactions with the other species. The results demonstrated that with *B. retusum*, the other steppe species are subject to competition. Nonetheless, these interactions varied and sometimes even reversed depending on 1) *B. retusum* development, 2) shoot biomass removed by grazing and 3) the trophic level of the soil. In conclusion, our results demonstrate how interaction variability can partially explain the coexistence of plant species in herbaceous plant communities.

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## DOES LATITUDINAL VARIATION IN PLANT QUALITY MATTER FOR HERBIVORES?

**Steven C. Pennings, Chuan-Kai Ho, Laurie B. Marczak, Kazimierz Wieski, Huy Vu**

*University of Houston, Department of Biology and Biochemistry, Houston, USA (spennings@uh.edu)*

Keywords: herbivory, latitude, predation, salt marsh

Salt marsh plants vary in quality across latitude. High-latitude plants are higher in nitrogen, softer, and less chemically-defended than low-latitude conspecifics or congenerics. Given a choice, herbivores and detritivores from both high and low latitudes prefer to feed on high-latitude plants. Does this variation in quality matter for herbivore performance? Laboratory growth experiments demonstrated that herbivores grew larger when fed high-latitude plants and that the differences in food quality were sufficient to explain the latitudinal variation in size observed in the field. Thus, latitudinal variation in plant quality could partially explain Bergmann's rule for herbivores. In laboratory mesocosm experiments, however, herbivore population size was strongly mediated by predators, local variation in plant quality, and herbivore ontogeny and was only slightly affected by the latitudinal variation in plant quality. We conclude that geographic variation in plant quality is of minor importance in explaining spatial variation in herbivore population density.

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# BRYOPHYTE COMMUNITY RESPONSE TO NATURAL FOREST SUCCESSION IN THE MORICSALA ISLAND RESERVE, LATVIA

**Liga Strazdina**

*University of Latvia, Faculty of Biology, Department of Botany and Ecology, Riga, Latvia (corresponding author: liga.strazdins@gmail.com)*

Keywords: bryophytes, natural forest, island, community composition

The Moricsala Island Reserve, the oldest protected natural area in Latvia and in the previous Russian Empire, was established in 1912. When the protection was initiated, a large part of the island was used as meadow and pasture. Wooded meadows and pastures are known to support a high diversity of epiphytes, therefore, it might be expected that the biological value of a traditionally managed open forest would have been lost. However, the past 100-year period should have been sufficient for the establishment of shade-tolerant bryophyte species on various substrates, including species typical of unmanaged forest. Detailed vegetation surveys were conducted on the island in the years 1909-1931 by K.R. Kupffer and 1974-1979 by M. Laivins. Therefore, the area offers an excellent opportunity to study succession in various forest habitats. Bryophytes were collected from living tree stems, coarse woody debris and from the forest floor in 59 sampling plots. All forest types on the Moricsala Island were sampled. Each sampling plot was 20 x 20 m in size, and 15 microplots were established in almost every plot (totaling 818).

In total, 124 bryophyte species were recorded from 2007-2010 (69% of all species previously recorded in Moricsala), including 19 protected and WKH indicator bryophyte species. Sixteen species were found in earlier studies, but 26 species represented new records. The highest species richness occurred on the forest floor, and the lowest level of richness occurred on living tree stems. The majority of the species were generalists, and they were found on all of the substrates studied. The highest species richness was found in mixed forest stands containing birch, Norway spruce and black alder. These forests have a high standing water level during wet summers, and they contain a high density of coarse woody debris. These factors provide appropriate conditions for bryophyte growth; particularly for liverworts. The oldest forest stands in Moricsala are more than 200 years old and are dominated by oak and lime. These forest stands had higher numbers of protected and WKH indicator bryophyte species; these species require large diameter trees and constant microclimate conditions. As expected, the lowest species richness was recorded in stands that were not forested 100 years ago. Of the species previously recorded, seven bryophyte species have disappeared; all of which were species previously found growing on meadow soil. However, ten new species, mostly shade-tolerant forest species, have been recorded in recent years.

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## IS THE LATITUDINAL DIVERSITY GRADIENT OF VASCULAR PLANTS BETTER EXPLAINED BY CLIMATE IN NORTH AMERICA?

**Leticia Dadalt, Michael W. Palmer**

*Oklahoma State University, Botany Department, Stillwater, USA (corresponding author: leticia.dadalt@okstate.edu)*

Keywords: Floristic analysis, latitudinal diversity gradient, species-area relationship, species richness.

The species-area relationship and the latitudinal diversity gradient are two of the most recognized patterns in ecology and biogeography, and they have been shown to be linked. The availability of large, spatially explicit databases for both species diversity and environmental parameters allows for more detailed investigations of the processes determining these patterns. Which should one consider as the priority when modeling biodiversity, geographical features or environmental variables? We used data from the Floras of North America Project, which consists of species richness data from 3,158 floras covering the North American continent (with the exception of Mexico) and includes all native vascular plants, as well as climatic parameters from a global climate model (WorldClim), to investigate the relative contribution of simple climatic parameters (such as the average annual precipitation and temperature) in explaining species richness patterns. We explored the overall performances of various regression models, as well as the behavior of the individual regression coefficients. As expected, the relationship between species richness and area was the strongest observed pattern. We also observed that the contribution of geographical features (such as latitude) to the model fit cannot be easily separated from that of climatic variables, such as the annual mean temperature and the temperature range. Species richness increases as the latitude and temperature range decreases and with greater annual mean precipitation values. This may indicate the importance of the geological history of the continent, especially the role of glaciation, which we will investigate in future studies. Besides these factors, the determinants of diversity are scale dependent.

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## ENVIRONMENTAL DETERMINANTS OF SPECIES RICHNESS IN CZECH THERMOPHILUS GRASSLANDS

**Kristina Merunková, Zdenka Otýpková**

*Masaryk University, Department of Botany and Zoology, Brno, Czech Republic (corresponding author: merunkova@sci.muni.cz)*

Keywords: Diversity, Productivity, Soil pH, Soil depth, White Carpathians

Semi-dry thermophilus grasslands of the White Carpathians (Czech Republic) belong to the most species-rich plant communities in Europe, with as many as 75 vascular plant species per square meter. Their richness exceeds compositionally similar communities of neighboring areas in southeastern Moravia by up to 50%. Despite their evident contrasting diversity, ecological drivers of species richness in the White Carpathians and adjacent areas of Moravia have not, thus far, been studied. Our study addresses possible explanations for the contrasting species richness of grasslands between these regions, which share the same species pool. Grasslands were studied on scales of 1 and 100 $m^2$, and various ecological factors (productivity, soil pH, conductivity, soil depth, bedrock, etc.) were recorded. Of the range of studied factors, the plots did not differ between regions in productivity or soil depth, factors that are generally regarded as influential diversity drivers. However, in southeastern Moravia, which has significantly drier climate than the White Carpathians, the soils had higher pH and conductivity levels. Further analyses revealed that species richness was driven by different sets of factors: diversity of the White Carpathian grasslands was highest in places with high biomass, low pH and on gentle slopes, while in southeastern Moravia, high diversity was associated with deep soils containing a higher organic content.

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## PATTERNS OF *ALPHA*- AND *BETA*-DIVERSITY OF VEGETATION TYPES AT THE KULA VOLCANO, TURKEY

**Deniz Işık[1], Emin Uğurlu [2], Jens Oldeland [3]**

*[1] Graduate School of Natural and Applied Sciences, Celal Bayar University, Manisa, Turkey; [2] Department of Biology, Celal Bayar University, Manisa, Turkey; [3] Biodiversity, Ecology and Evolution of Plants, University of Hamburg, Hamburg, Germany; (corresponding author: emin.ugurlu@bayar.edu.tr, ugurlu@yahoo.com)*

Keywords: Biodiversity, species richness, Simpson diversity, ANOSIM, NMDS

Kula volcano is one of the thirteen volcanoes in Turkey. With its unique Holocene volcanic geology and its Mediterranean climate, the Kula volcano is an interesting area for the study of plant life. In the past, studies on the vegetation of the Kula volcano were published that described a relationship between plant species, altitude and aspect (e.g., North-South). These studies stressed the importance of the geological material (i.e., tuff stone) that only allows specialized plants to grow. However, until now, these studies only recorded species lists; they lacked a sound sampling design that would allow for different vegetation types to be defined and compared. We present the first results of a plot-based assessment of vegetation and biodiversity characteristics carried out within a pilot-study on the vegetation of Kula volcano in the region of Manisa, southwestern Turkey. As is often stated, species biodiversity patterns and endemic richness are related to environmental factors, such as altitude, substrate, slope or aspect.
Univariate and multivariate statistical approaches allowed us to quantify the relationships between alpha- and beta diversity and the measured environmental factors that consisted of altitude, slope and aspect. Thirty-two vegetation plots were sampled for sampled species composition and species cover using the modified Braun Blanquet scale. We calculated alpha diversity measures including Species Richness (S), the Simpsons Dominance Index (D) and Margalef´s Index (M) using the free software PAST (Hammer et al. 2001). Margalef´s index is calculated by subtracting 1 from the species number (S) and dividing this number by the logarithm of the total number of individuals (N). For all measures, we found polynomial relationships with altitude. However, while the dominance index revealed a positive unimodal relationship, we found a negative unimodal relationship for (S) and (M).
In summary, we present and discuss an interesting pattern of a negative dominance-diversity relationship found for vascular plants along a short altitudinal gradient. Furthermore, we show species compositions that are clearly separated depending on the aspect and altitudinal zonation. The vegetation assessment of the Kula volcano will be continued within a PhD thesis in the near future.

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## DISTRIBUTION OF PLANT SPECIALISTS IN SEMI-NATURAL GRASSLANDS

**Zuzana Rozbrojová[1,2], Michal Hájek[1,2], David Zelený[1], Vít Syrovátka[1], Grzegorz Vončina[3]**

*[1] Masaryk University, Department of Botany and Zoology, Brno, Czech Republic (corresponding author: zuzkaroz@sci.muni.cz); [2] Academy of Sciences of the Czech Republic, Institute of Botany, Department of Vegetation Ecology, Brno, Czech Republic [3] Pieniński Park Narodow, Krościenko nad Dunajcem, Poland*

Keywords: community specialization, grasslands, habitat history, vegetation, West Carpathians

Central European semi-natural grasslands are of high importance for biodiversity, performing as refuges for threatened non-forest species. In our large-scale study, we aimed to describe diversity of West Carpathian semi-natural grassland vegetation by means of representation of habitat specialists. Based on the Czech and Slovak vegetation-plot database (48,242 plots), habitat specialization of plant species was derived from beta diversity of vegetation plots that contain the target species. Two biogeographically differentiated vegetation plot subsets were applied, representing the Outer- and Inner West Carpathians. Proportion of specialists in vegetation plots served as an index for community specialization, and mean proportions of specialists for plant communities were confronted with theoretical values, derived from all species in respective subsets. The community specialization appeared to be not casual, but some plant communities had either higher- or lower proportions of specialists. Moreover, the pattern differed for the Outer- and Inner West Carpathians. Across all vegetation plots, the proportion of specialists correlated negatively with site productivity. However, low-productive communities did not necessarily contain a high proportion of specialists, indicating that this property may relate to other environmental conditions. The differences between the Outer- and Inner West Carpathian communities corresponded well with what was expected based on the historical aspects of vegetation development. Generally, habitats that have occurred in the region since the early Postglacial were rich in species having narrow habitat requirements. This pattern was more pronounced in calcareous fens and mountain meadows in the Inner West Carpathians and in semi-dry grasslands in the Outer West Carpathians. Although the long-term habitat stability since the Holocene is clearly one of the factors underlying community specialization, the habitats developed in the Modern period can also harbor a high proportion of specialists. In summary, the assessment of community specialization can be a useful method in biodiversity conservation.

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## CLIMATIC CONTROLS OF A KEYSTONE UNDERSTORY SPECIES, *SASAMORPHA BOREALIS*, AND AN IMPACT ASSESSMENT OF CLIMATE CHANGE IN JAPAN

**Ikutaro Tsuyama[1], Katsuhiro Nakao [1],Tetsuya Matsui [2], Motoki Higa[1], Masahiro Horikawa[3], Yuji Kominami[4], Nobuyuki Tanaka[1]**

*[1] Forestry and Forest Products Research Institute, Department of Plant Ecology, Ibaraki, Japan; [2] Forestry and Forest Products Research Institute, Hokkaido Research Station, Hokkaido, Japan; [3] Toyota Motor Corporation, Toyota Biotechnology and Afforestation Laboratory, Aichi, Japan; [4] Forestry and Forest Products Research Institute, Kansai Research Center, Kyoto, Japan (Ikutaro Tsuyama: Aquarianleo@gmail.com)*

Keywords: dwarf bamboo, species distribution model, snow-cover, summer precipitation, empty habitat

The goals of this study were to identify the climatic conditions controlling the distribution of *Sasamorpha borealis* and to assess the impact of climate change on the species in Japan.
The relationship between the distribution of *Sasamorpha borealis* and five climatic variables in the Japanese Archipelago was explored using classification tree analysis. The predictive accuracy of the model was assessed using receiver operating characteristic (ROC) analysis and by comparing model predictions to an independent dataset. Potential habitat maps under the current and future climates were generated at approximately a 1-km spatial resolution.
The model was highly accurate. Although snow cover has been thought to be the most important factor controlling *S. borealis distribution*, we revealed that the species requires high precipitation during the growing season even in humid Japanese environments. Areas with more than 1522.5 mm of summer (May–September) precipitation (PRS) were classified as potential habitats, irrespective of other climatic conditions. In areas with 715.5 mm ≤ PRS < 1522.5 mm, potential habitat was limited to cooler and less snow-covered areas, and areas with less than 715.5 mm PRS were classified as non-habitat. The high fitness of the predicted to the observed distributions suggested that *S. borealis* could have survived throughout the Japanese Archipelago during the glacial period.
In future climates, 29.0–39.1% of the current potential habitat was predicted to change to non-habitat due to increasing dryness in the growing season. Areas with high precipitation remained a potential habitat for *S. borealis*.

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## SCALE OF CHANGE IN SEMI-ARID GRASSLANDS OF SOUTH-EASTERN AUSTRALIA

**Nathan Wong[1,2], John Morgan [2]**

*[1] Trust for Nature, Victoria, Australia; [2] La Trobe University, Botany Department, Bundoora, Australia (nathanw@tfn.org.au)*

Keywords: Species Area Relationship, Minimum Area, Grassland, Australia, Disturbance

Question: 1) Does scale alter the interpretation of changes following short-term disturbance impacts across semi-arid grasslands in southeastern Australia; 2) Does the use of Minimal Area calculations and Species Area Relationships strengthen the interpretation of these impacts?
Hypothesis: 1) Minimal Area for sampling should be similar across disturbed and undisturbed sites; 2) The statistical effects observed should be similar, at least at scales greater than those determined to be the Minimal Area of the assemblage studied.
Location: Three semi-arid grasslands in the Victorian Riverine Plains of south-eastern Australia, 200 km north of Melbourne.
Method: Sites were disturbed using grazing or burning and exclusion plots were also established. Grazing was applied during spring, and burning was conducted in late summer. Two spatially independent nested quadrants were sampled per treatment. Each nested quadrant consisted of a 1 $m^2$, 4 $m^2$, 16 $m^2$, 64 $m^2$, 256 $m^2$ and 1024 $m^2$ spatially dependant quadrant.
Results: Exclusion showed significant effects across the majority of scales investigated. Grazing predominantly exhibited an oversampling effect. Burning exhibited an oversampling effect on exotic species, while native species showed a near representative effect to burning.
Discussion: The effect of sample size on the interpretation of results was observed to be dependent on the scale investigated. The effects that appear at larger scales may be those that are impacting the rarer species, while those at representative scales are more evenly distributed across the entire plant assemblage. It is hypothesized that grazing is reducing the rarer plant species, while burning is having a representative effect on native species and reducing the less abundant exotic species.

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## IMPACT OF RAINFALL VARIABILITY AND GRAZING PRESSURE ON PLANT DIVERSITY IN MONGOLIAN GRASSLANDS

**Yunxiang Cheng [1], Mitsuru Tsubo [1], Takehiko Y Ito [1], Eiji Nishihara [2], Masato Shinoda [1]**

*[1] Arid Land Research Center, Tottori University, 1390 Hamasaka, Tottori 680-0001, Japan; [2] Faculty of Agriculture, Tottori University, 4-101 Koyama-Minami, Tottori 680-8550, Japan*

Keywords: Climatic variation; Dry land; Grazing gradient; Species richness; Steppe

Climate and grazing are the main drivers of plant community composition and species richness in arid environments. This study aimed to examine the vegetation response to interannual rainfall variability and grazing pressure in Mongolia. To investigate the effects of interannual rainfall variability and grazing pressure, we compared species richness for two years at two sites, in desert-steppe (the dry region) and steppe zones (the relatively wet region). Vegetation surveys were conducted during periods of peak vegetation cover (early September) in 2008 and 2009, using Braun-Blanquet's cover-abundance scale. Floristic changes were characterized by detrended correspondence analysis. Repeated-measures ANOVA was used to compare the effect of grazing pressure and year on the standing species richness and the proportion of life forms. The dominant species at the two sites were the shrub, *Caragana korshinskii*, in the desert-steppe site, and feather grass *Stipa krylovii* in the steppe site, respectively. At the desert-steppe site, the growing season rainfall (April-September) in 2008 was approximately the same as that of the 1995-2009 average, but the rainfall in 2009 was considerably lower than the average. At the steppe site, the growing season rainfall was higher in 2009 than in 2008, although rainfall in both years was higher than the average. Species composition, presented as the ratio of annual species to perennial grasses and shrubs, was significantly affected by grazing pressure and rainfall variability in both zones. In the desert-steppe zone, species richness was significantly lower in the drier year but did not vary with grazing pressure. In the steppe zone, species richness varied significantly with grazing pressure but did not vary between years. Precipitation would be more important than grazing pressure in terms of its effects on vegetation changes in dry areas with high rainfall variability. Our findings indicate that the desert steppe zone corresponds with non-equilibrium models of grazing system dynamics, whereas the steppe zone is characterized by equilibrium systems.

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## TERMITE MOUNDS IN TROPICAL WET GRASSLANDS: THEIR ROLE IN ALTERING VEGETATION STRUCTURE AND COMPOSITION

**Alessandra Fidelis,[1,3], Ana Luisa Tondin Mengardo [1], Rebeca Verônica Viana[2], Vânia Regina Pivello [1]**

*[1] Universidade de São Paulo, Department of Ecology, São Paulo, Brazil; [2] Universidade de São Paulo, Department of Botany, corresponding author: fidelis@usp.br*

Keywords: Cerrado, ecosystem engineers, termites, tropical savannas, vegetation structure

Termites are considered key ecosystem engineers because they alter the mineral and organic composition of soils, infiltration rates, and drainage. They also influence decomposition and nutrient cycling and, in fact, they can be considered the most important decomposers in tropical savannas. The Cerrado is the world's richest tropical savannah in terms of floristic composition, comprising a variety of physiognomies, from open grasslands to woodlands. Termite mounds are generally found in the more open physiognomies. In this study, we aimed to analyze the effects of small termite mounds in wet grasslands (Jalapão State Park, Tocantins, Central Brazil). We hypothesize that even small termite mounds (ca. 0.25 x 0.25 x 0.25 m) can alter local vegetation structure and composition due to the accumulation of nutrients and protection against fire. Therefore, we chose 15 termite mounds and established four plots (0.25 x 0.25) on the borders of the mounds, in the four directions; the same design was applied in neighboring areas without termite mounds. We estimated herbaceous cover, as well as bare soil area and litter. Moreover, we sampled biomass in one of the four established plots of each mound and measured vegetation height (in the four plots). We used ANOVA applied to randomization tests (Euclidean distance, 10,000 iterations) to verify statistical differences between control plots and termite mounds for the parameters measured. Additionally, we performed PCoA to confirm differences in the vegetation composition between treatments (control and mounds). The results showed a higher accumulation of biomass and lower values of bare soil cover ($P \leq 0.05$) around termite mounds. Vegetation was also taller in the mound treatment plots compared to the control plots ($P=0.02$). Vegetation composition, however, showed no difference between treatments. We concluded that small termite mounds alter vegetation structure at a small scale, and thus, they are important components of vegetation dynamics in a flammable ecosystem such as the Cerrado.

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## CHANGES IN FUNCTIONAL RESPONSE TRAITS, HABITAT PREFERENCES AND PLANT COMMUNITIES IN SECONDARY SUCCESSION OVER 220 YEARS: A STUDY FROM SE SLOVENIA

**Andrej Paušič [1], Andraž Čarni [1,2]**

*[1] Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Institute of Biology, Novi trg 2, SI-1000 Ljubljana, Slovenia, (andrej.pausic@zrc-sazu.si); [2] University of Nova Gorica, Vipavska cesta 13, SI-5000 Nova Gorica, Slovenia.*

Keywords: functional response traits, habitat preferences, land use transformations, secondary succession, Slovenia.

This study focused on the changes in functional response traits, species composition and strategies among plant communities during the afforestation process in SE Slovenia.
Relevés were collected on randomized plots in grassland areas and in forests in different stages of succession. Information regarding the succession age was extracted using old cadastral layers and digital aerial photos.
We classified the relevés into five groups and calculated the median value of the forest age for each group. DCA analysis was performed to observe the position of the relevés. The correlations (Spearman's *rho*) between the relevés and selected functional response traits were calculated.
We observed that the proportion of chamaephytes increased immediately after land abandonment. After 15-20 years, the predominant species were small phanerophytes and chamaephytes and, in the herb layer, sciophilous cryptophytes. Low-growing herb species with scleromorphic leaves and green or red flowers were the predominant plant type on grassland areas, while plant species with digitate, hydro or mesomorphic leaves and white flowers typically prevailed in forest areas. In closed forest stands, there were many more herb species with vegetative propagation (bulbils), which most often reward pollinators with pollen. In grasslands, the plant community consisted of S-CS strategists; the dominant species were those that could be classified as stress-tolerant with competitor traits. After 10 years, the community is defined as CS and after 200 years as a community with a C-CS strategy. Competitors prevail in the last stage of afforestation (closed forest stand). This study demonstrates that the changes in communities are a result of anthropogenic activity and lead to an increasing proportion of species adapted to agriculture disturbances.

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## WOODY SPECIES INFLUENCE UNDERSTORY VEGETATION THROUGH LITTER

**Kadri Koorem, Jodi N. Price, Mari Moora**

*University of Tartu, Department of Botany, Tartu, Estonia (corresponding author: Kadrl.Koorem[at]ut.ee)*

Keywords: emergence, biomass, hazel, spruce, heterogeneous habitats

It is well known that the forest overstory has significant effects on herb layer diversity. These effects occur through multiple interacting mechanisms, including the interaction of plant litter. Old growth stands of boreonemoral spruce (*Picea abies*) frequently have a shrub layer dominated by hazel (*Corylus avellana*) with a species-rich understory layer. In this study, we question if small-scale understory species richness is related to the woody species and, in particular, are there any differences in the effects of their litter? To address this, we sampled understory species composition, richness and biomass, as well as environmental variables under hazel and spruce. We conducted an experiment in which we manipulated the effect of the litter quantity and type on seedling emergence and on the biomass of understory species. Species richness and the biomass of herbaceous plants were significantly greater under hazel than under spruce. Moreover, we found 45% of the total species found under woody plants occurred exclusively under hazel. Litter layer was the only environmental variable, which differed between hazel and spruce; it was three times thicker under spruce. We found that seedling emergence and biomass were highly influenced by litter amount and litter type and, moreover, the effect of the litter quantity depended on litter type. Interestingly, seedling emergence and biomass responded differently to litter. Spruce litter suppressed seedling emergence and this negative effect increased as the amount increased, whereas the influence of hazel litter was neutral and unrelated to quantity. Seedling biomass was enhanced by litter addition and this positive effect increased as the amount increased, however, this was only the case for hazel. Increased species richness and biomass found under hazel is partly due to neutral (on emergence) and positive (on biomass) effects of its litter. Low species richness found under spruce is due to strong inhibitory effects of its litter and its high quantity. Hazel increases small-scale heterogeneity in spruce forests. We suggest that the presence of hazel is important for maintaining and enhancing biodiversity in boreal forests.

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## STUDY OF VEGETATION DYNAMICS WITHIN PROTECTED AREAS: THE CASE OF TAZA NATIONAL PARK (PNT) IN ALGERIA

**Nafissa Sfaksi[1], Dominique Laffly [1], Rachid Gharzouli [2]**

*[1] Laboratoire GEODE, UMR 5602/CNRS, Université de Toulouse II, Le Mirail, France; [2] Laboratoire de biologie végétale, Université Ferhat Abbas, Sétif, Algérie (nafissa.sfaksi@univ-tlse2.fr; dominique.laffly@univ-tlse2.fr; gharzoulir2002@yahoo.fr)*

Keywords: Algeria, biodiversity, digital analysis, protected area, vegetation dynamics

Environmental preservation and restoration depend upon knowledge of species ecology and habitats. To study the natural contexts of a protected area, we used the phytosociological method, which consists of a unique means for the collection and analysis of data.
In this study, we proposed to evaluate the dynamics of a series of vegetation within an oak forest in the National Park of Taza (Algeria), which is in a natural protected area. The vegetation presents a heterogeneous mosaic characterized by spatial and temporal discontinuities. To analyze and define the different relationships between the elements of the vegetative mosaic, a systematic sampling was applied, and the structured elements were sampled in homogeneous areas.
The data collected were submitted to conventional statistical analysis (with abundance/dominance index) and the result is the individualization of 13 groups belonging to 3 phytosociological major classes: the *Quercetea illicis*, the *Quercetea pubescentis* and the *Turerarietea-guttatea*. The different succession types were described using 57 ecological plots describing the different successional stages until equilibrium.
The second step of digital analysis consisted of the development of a software program for the study of the linear structure of the species (variables). This software was used to analyze the results of the FCA and the CA analysis. Maps produced by this software allowed us to analyze species distribution in relation to the environmental characteristics on the three main factorial axes, as well as the behavior of various taxa among themselves.
This work, coupled with a detailed cartography, will allow us to keep track of the evolution and spatiotemporal dynamics of each taxon studied as well as their communities.

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## VEGETATION CHANGE IN ESTONIA: HISTORICAL SPECIES-RICH GRASSLANDS, THEIR REMNANTS AND NEW DEVELOPING GRASSLANDS

**Merit Otsus, Silja Kana**

*Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Tartu, Estonia (corresponding author: merit.otsus@emu.ee)*

Keywords: grasslands, continuity, habitat loss, species-richness, species composition

We studied the vegetation of historical grasslands, their remnants and new grasslands in Estonia. Comparative mapping and vegetation analysis showed very low continuity of fresh species-rich grasslands over 50 yrs. The average area of habitat loss was >80%. The habitat was most frequently lost to arable land or forest. Further loss is predictable, as many remnants have been left unmanaged and are degrading. The new developing grasslands were arable fields 15-20 yrs ago, and their size (on average 2.3 hectares) is nearly the same as that of the remnants. The species richness per 2 $m^2$ was highest in the historical grasslands and lowest in their remnants. The species composition of the remnants had significantly changed compared to their original vegetation: remnant patches lacked on average 65% of their original species pool.
The vegetation of the remnants and new grasslands is related to their higher soil fertility compared to the original grasslands. The unsuitable, drier conditions of the new grasslands explain the decrease of *Carex davalliana*, *C. hostiana*, *Primula farinosa*, and *Trollius europaeus*.
The indicator species of historical grasslands were typical grassland species (e.g., *Briza media*, *Linum catharcticum*, *Rhinanthus serotinus*, *Scorzonera humilis*, and *Sesleria caerulea*), while those of the remnants were related to high fertility (e.g., *Aegopodium podagraria* and *Urtica dioica*). The indicator species of new grasslands were those of fertile and disturbed habitats (e.g., *Potentilla anserina* and *Taraxacum officinale*) or those grown as hay (e.g., *Dactylis glomerata*, *Festuca rubra*, and *Phleum pratense*).
The indicator species of remnants had lower preferences for light and higher preferences for nutrients than the indicator species of historical grasslands. The indicator species of new grasslands had lower indicator values for soil reaction.

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## WEED ASSEMBLAGE RECONSTRUCTED FROM SEEDS STORED IN COB COTTAGES: AN INSIGHT INTO 19TH CENTURY SEGETAL VEGETATION

**Igor Paušič, Sonja Škornik, Mitja Kaligarič**

*University of Maribor, FNM, Biology Dept., Koroška 160, 2000 Maribor, Slovenia (corresponding author: mitja.kaligaric@uni-mb.si)*

Key words: Archaeophytocoenosis, desiccated seeds, arable weeds, agricultural landscape

A novel source of desiccated seeds and fruits was used to qualitatively and quantitatively evaluate the weed vegetation in a traditional Central European agricultural landscape of the second half of the 19th century. In total, 7646 seeds were excavated from 100 kg of loam, chaff and straw used as building material for a cob cottage in NE Slovenia. Of those, 7290 seeds were identified as belonging to 90 species, mostly weeds and ruderals. The majority of species belong to the subclass *Violenea arvensis*. The most abundant species were characteristic of the alliance *Caucalidion lappulae* (31 taxa), followed by *Scleranthion annui* (26 taxa) and *Veronico-Euphorbion* (19 taxa). The rest of the species belong to ruderals, crops and typical grassland (or woodland) species. A strong contingent of species belonging to a termophilous segetal *Caucalidion* alliance is direct evidence for the presence and rich abundance of segetal vegetation at that time. Some of the segetal weeds, including *Anthemis cotula*, *Centaurea cyanus*, *Agrostemma githago*, *Ranunculus arvensis* and *Papaver hybridum*, are now locally extinct or very rare and declining species. On the other hand, some presently very common weeds or ruderals (such as *Erigeron annuus* and *Galinsoga ciliata*) were not present at that time. Two species that have never before been recorded from Slovenian territory, *Dulichium spathaceum* and *Paronychia cephalotes*, were found. The seeds stored in cob cottages give us insight into vegetation assemblages in arable land before dramatic changes to the Central European agricultural landscape occurred.

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## ASSESSING SPATIAL AND ENVIRONMENTAL DRIVERS OF PHYLOGENETIC ASSEMBLY IN BRAZILIAN *ARAUCARIA* FORESTS

**Leandro Duarte, Pablo Viany, Valério Pillar**

*Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Ecologia, Porto Alegre, Brazil; (Leandro Duarte: duarte.ldas@gmail.com)*

Keywords: Distance-based redundancy analysis, principal coordinates of phylogenetic structure; phylogenetic fuzzy-weighting; phylogenetic habitat filtering; variation partitioning

We analyzed the phylogenetic assembly of woody plants along the geographical range of the Brazilian *Araucaria* forest biome and assessed how it responds to environmental conditions and spatial gradients. *Araucaria* forests are found in southern and southeastern Brazil and northeastern Argentina, from 30ºS to 20ºS and at elevations ranging from 427 m to 1757 m a.s.l. We compiled floristic data (shrubs and trees) from 45 sites along the geographic range of the *Araucaria* forest biome. We applied phylogenetic fuzzy-weighting to the data and computed principal components of phylogenetic structure (PCPS). Sites were also described by environmental variables and by principal coordinates of neighborhood matrices (PCNM) as spatial filters. We used distance-based Redundancy Analysis (db-RDA) to assess the response of the phylogenetic assembly to spatial and environmental variables. Further, we analyzed the relationships between phylogenetic plant clades and environmental and spatial drivers. Variation partitioning using the first two PCPSs as response variables showed that environment (altitude and annual mean temperature) represented the major explanatory factor in the phylogenetic assembly of Brazilian *Araucaria* forests, while the effect of spatial filters was not significant. Yet, spatially structured environmental variation explained approximately one-third of the total variation in the phylogenetic assembly. Some plant phylogenetic clades, such as eurosids, were more closely related to the environmental variables than other clades, such as magnoliids. Ecological responses to the environment were not evenly structured in distinct clades occurring in Brazilian *Araucaria* forests, suggesting strong niche conservatism in some lineages and predominantly contrasting ecological responses to the environment in others. Therefore, it is very important to take into account the phylogenetic clade pool to assess processes underlying macroecological patterns. Large-scale phylogenetic habitat filtering may help us to reconcile ecology and historical biogeography by enhancing our understanding of the interplay between ecological, evolutionary and historical determinants of species assembly patterns.

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# SPATIAL HETEROGENEITIES AND FEEDBACK MECHANISMS IN FOREST-GRASSLAND MOSAICS

**Carolina C. Blanco [1], Simon Scheiter [2], Enio Sosinski [3], Alessandra Fidelis [4], Valério D. Pillar [1]**

*[1] Universidade Federal do Rio Grande do Sul, Laboratory of Quantitative Ecology, Porto Alegre, Brazil (corresponding author: carolina.blanco@ufrgs.br); [2] Biodiversity and Climate Research Centre (LOEWE BiK-F), Frankfurt, Germany; [3] Embrapa Clima Temperado, Pelotas, Brazil; [4] Universidade de São Paulo, Department of Ecology, São Paulo, Brazil*

Keywords: fire, alternative stable states, Dynamic Global Vegetation Model, topography, seed dispersal

We evaluated the effect of site heterogeneities, generated by topographic variations in incoming solar radiation, on density-dependent feedback mechanisms that arbitrate dynamics of forest-grassland mosaics in southern Brazil. For this work, we modeled vegetation dynamics using a bidimensional, spatially explicit model, which incorporates an adaptive Dynamic Global Vegetation Model (aDGVM), including topographic heterogeneities, fire spreading behavior and seed dispersal. Data from Morro Santana, Porto Alegre (30°04'32"S; 51°06'05"W; mean annual precipitation 1348 mm) were used for model parameterization and testing. The vegetation dynamics were shown to be sensitive to topography and fire frequency as well as the initial cover and spatial arrangement of forest patches. The model successfully simulated microclimatic variations and their effects on vegetation dynamics on a small scale. The coexistence of forest and grasslands was maintained over longer periods only with more frequent fires, but in all cases, simulations showed a tendency towards complete forest dominance. When considering site heterogeneities, forest expansion was faster in south-facing sites than in north-facing sites due to local density-dependent processes that were enhanced by slope incline. However, at the predominantly south-facing site, in the presence of site heterogeneities and frequent fires, forest expansion in mosaics, where the forest patches were initially highly disaggregated, was faster than in mosaics starting with highly aggregated forest patches. This finding was the case even with a lower initial proportion of landscape covered by forests and considering the same predominantly south-facing topographic map, showing that the frequency distribution of distances between forest patches is also an important factor mediating forest expansion over grasslands. Complex feedback mechanisms generated by interactions between site heterogeneities and density-dependent processes mediated by fire revealed some evidence for alternative stable states in forest-grassland mosaics of southern Brazil. This study provides an important background for future management efforts toward biodiversity conservation of natural grasslands.

# Landscape dynamics resulting from anthropogenic disturbance

Session ‘Landscape dynamics’ / ORAL

## OLD MANOR PARKS – FROM CULTURAL HERITAGE TO BIODIVERSITY CONSERVATION

**Jaan Liira, Kertu Lõhmus**

*Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia; (corresponding author: jaan.liira@ut.ee)*

Keywords: dispersal limitation; forest communities; forest species; landscape structure

The cultural and aesthetic importance of old manor parks is widely known, but their biodiversity value is still insufficiently estimated. Forest biodiversity conservation has become important because many contemporary forests comprise secondary stands or planted mono-species conifer stands. Therefore, densely wooded parks might have become the last refuges for the biodiversity of deciduous forests. Recent studies have shown that the low dispersal ability of forest species might be the major limitation for their successful establishment in newly formed habitats. In addition, the formation of optimal environmental conditions for forest specialist species can take a long time. We consider densely wooded sub-compartments of old manor parks as planted semi-natural old forest communities, as they have become a suitable substitution habitat for many forest-specific species. For this purpose, we surveyed the old, densely wooded parts (where the canopy closure of the tree layer was at least 50%) of old manor parks consisting of mature and over-mature trees. We recorded their stand structure, field layer and epiphytic cryptogams. All studied parks were established at approximately the same time during the 18-19th century.

We found that the studied park fragments do resemble old deciduous stands in their structure and species composition. These parks fragments contain a large proportion of common forest species and various indicators of old-growth forests. The habitat quality for forest biodiversity in parks was dependent on management intensity and the structure of the surrounding landscape.

We conclude that old, woody parts of parks can function as semi-natural forest habitats. We further established that over-intensive management of these parks can jeopardize their special biodiversity conservation value.

Session ‘Landscape dynamics’ / ORAL

## LANDSCAPE HETEROGENEITY AND MICROSITE CONDITIONS: WHAT DRIVES LOCAL SPECIES RICHNESS?

**Antonio Gazol, Riin Tamme, Liina Saar, Krista Takkis, Liis Kasari, Aveliina Helm, Meelis Pärtel**

*University of Tartu, Institute of Ecology and Earth Sciences, Tartu, Estonia; (corresponding author: antonio.gazol@ut.ee)*

Keywords: connectivity, multi-scale, shrub cover, soil depth, Structural Equation Models

Local communities are influenced by both regional and local processes, but separating the relative contributions of these processes is difficult because although they operate at different scales, they can create the same patterns. We used structural equation models (SEM) and spatial regression analysis to solve this problem. We examined landscape variables and microsite conditions influencing local species richness in dry calcareous grasslands (alvars) both directly and indirectly. We also separately analyzed alvar specialist and more generalist grassland species richness to discover whether they are driven by the same factors. Small-scale species richness, microsite conditions (soil factors and light variability) and shrub cover (*Juniperus communis*) were measured along small-scale transects at 33 alvar grasslands. Landscape variables (topography, human population change and habitat suitability in terms of area and connectivity) were quantified in a 5 km buffer around each sampling site. Variation partitioning using spatial variables was used to account for the spatial autocorrelation among factors.

Using SEM, we found that generalist species richness was positively influenced by both landscape (habitat suitability) and microsite conditions (shrub cover and light variability), while specialist species richness was driven mainly by soil factors. The models also indicated that topography indirectly influences generalist species richness by directly influencing habitat suitability. Variation partitioning analyses using spatial variables showed that generalist species richness was strongly influenced by a broad-scale linear trend connected to human population change, habitat suitability and shrub cover. Specialist species richness was spatially structured at small scales (relative to the sampling design), but this structure was not related to any of the variables considered, suggesting the importance of stochastic processes or other unmeasured factors. Using SEM, we determined that microsite conditions are more important than landscape factors in determining local species richness, but landscape factors were better predictors of generalist species richness than of specialist species richness.

Session 'Landscape dynamics' / ORAL

## NICHE VS. NEUTRAL PROCESSES PATTERNING SPECIES ASSEMBLAGES WITHIN FOREST METACOMMUNITIES: A CHRONOSEQUENCE APPROACH

**Aurélien Jamoneau, Déborah Closset-Kopp, Olivier Chabrerie, Emilie Gallet-Moron, Guillaume Decocq**

*University of Picardie Jules Verne, Unité de Recherche Dynamiques des Systèmes Anthropisés AMIENS, France; (corresponding author: guillaume.decocq@u-picardie.fr)*

Keywords: forest fragmentation, niche theory, neutral theory, chronosequence, forest metacommunities

Species assemblages are usually analyzed within one of the two most influential theoretical frameworks: the *niche theory*, which predicts that plant communities are mainly patterned by environmental filters and species interactions, and the *neutral theory*, which considers that assemblages are driven by species' dispersal capacities. However, recent studies have attempted to reconcile the two theories. In this study, we aimed to evaluate the respective importance of niche partitioning and neutrality in patterning species assemblages along a chronosequence of forest patches within a metacommunity framework. We recorded the presence-absence of vascular plant species in 338 forest patches, distributed among 4 age classes and 9 metacommunities of increasing fragmentation intensity. For each age class, we compared species richness, species density, species-area curves, beta diversity indices and rank-frequency curves for all species and for forest herb species separately. The results were interpreted using correlations between these diversity metrics and local, landscape, historical and spatial variables. We found that dispersal limitation was influential mainly in recent forest patches, while niche partitioning was more important in old patches. We conclude that both neutral and niche processes occurred along the chronosequence, but that the latter tended to overcome the former as forest succession proceeded. However, forest management-associated disturbances can relax niche processes and make neutral processes more important.

Session 'Landscape dynamics' / ORAL

## RESPONSES OF GRASSLAND SPECIES RICHNESS TO LOCAL AND LANDSCAPE FACTORS DEPEND ON SPATIAL SCALE AND HABITAT SPECIALIZATION

**Triin Reitalu[1,3], Oliver Purschke [1,2], Lotten J. Johansson [2], Karin Hall [2], Martin T. Sykes[2], Honor C. Prentice[1]**

*[1] Department of Biology, Lund University, Lund, Sweden, [2] Department of Earth and Ecosystem Sciences, Lund University, Lund, Sweden, [3] Institute of Geology, Tallinn University of Technology, Tallinn, Estonia*

Keywords: Connectivity, Continuity, Habitat fragmentation, History, Species diversity

We explored the relationships between grassland species richness and a series of local and landscape factors to determine to what extent do the responses of species richness depend on the degree of habitat specialization (specialists vs. generalists) and/or the scale of the study (plot vs. patch).
The richness of all herbaceous vascular plants was recorded within 50 × 50 cm plots and within 0.1-4.8 ha grassland polygons within a local agricultural landscape on the Baltic island Öland, Sweden, and the total richness was subdivided into the richness of grassland specialists and generalists. Multivariate linear models and hierarchical partitioning were used to identify local factors (habitat area and heterogeneity, grazing intensity and habitat age) and landscape factors (the proportion of surrounding grassland in 2004, 1938 and 1800 and the surrounding landscape diversity in 2004) that were significantly associated with species richness.
The responses of plant species richness to local and landscape factors depended on the degree of habitat specialization and the scale of the sampling. On the polygon scale, the richness of both specialists and generalists was positively associated with habitat area and heterogeneity, grazing intensity, habitat age and the proportion of surrounding grassland in 1800. On the plot scale, specialist species richness was positively associated with habitat heterogeneity, the proportion of surrounding grassland in 2004 and landscape diversity. Plot-scale generalist species richness, on the other hand, was negatively associated with the proportion of surrounding grassland in 1938 and positively associated with grazing intensity. On the large (polygon) scale, the levels of species richness of grassland specialists and generalists are influenced by similar processes, and both specialist and generalist plants have accumulated in old grasslands over centuries of grassland management. On the fine (plot) scale, the levels of species richness of specialists and generalists are influenced by different processes: while specialist species are sensitive to grassland isolation, generalist species may benefit from habitat isolation.

Session 'Landscape dynamics' / ORAL

## LANDSCAPE STRUCTURE AND DYNAMICS OF THE SADO ESTUARY AND COMPORTA-GALÉ NATURA 2000 SITES

**Francisco Gutierres[1], Paulo Godinho[2], Carlos Neto[1], Eusébio Reis[1], Mónica Martins[1], José Carlos Costa[3]**

*[1] Institute of Geography and Territorial Planning of the University of Lisbon (IGOT), Geography, Lisbon, Portugal; [2] National Institute of Biological Resources (INRB), Ecology, Lisbon, Portugal; [3] Superior Institute of Agronomy - Technical University of Lisbon (ISA-UTL), Botany, Lisbon, Portugal (Francisco Gutierres: franciscogutierres@campus.ul.pt)*

Keywords: Landscape, Natura 2000 Network, Structure, Dynamics

Spatial patterns observed in landscapes result from complex interactions between physical, biological and social factors. Most landscapes have been influenced by land uses, and the resulting landscape mosaic is a mixture of natural and human-managed patches that vary in size, shape and arrangement. In land use planning, at a local level, the landscape structure and dynamics must be quantified in a meaningful way to understand the landscape ecological processes. Paleoecological studies have revealed that the vegetation dynamics in the Sado Estuary, since the beginning of the Holocene, have been mainly affected by littoral transgressions, regressions and a xerification of the climate. From approximately 2000 BP to present, a very strong human impact has been felt in the vegetation of the region. In this context, the objective of this study is to understand the landscape structure and main dynamics in two sites of the Natura 2000 Network (the Sado Estuary and Comporta-Galé), with special attention to the coastal psammophilic and salt marsh communities, to associate these aspects with management practices, socio-economic factors and climate changes. The study was based on maps of land cover (1963, 1979, 1995 and 2007) from photo interpretation. Some measures of spatial patterns have been applied to analyze the landscape structure - Diversity index (Shannon and modified Simpson), Dominance, Contagion and Functional Linkage Index. A Markov model was used to study the land cover change dynamics. At the land cover level, the major consequences were the reduction of agricultural areas in favor of urban and forest areas. Concerning the estuary dynamics based on climate change scenarios, we analyzed the temporal erosion rates between sheltered and non-sheltered areas of the salt marsh communities. This study sheds light on the long-term processes in the vegetation communities and the habitat connectivity due to the loss or gain of habitat patches and/or alterations in the surrounding landscape. Finally, consideration of landscape dynamics allows us to answer questions like "What happens if ...?" assuming the constancy of the transition probabilities over time.

Session 'Landscape dynamics' / ORAL

## DIVERGENCE OF ECOSYSTEM PATHWAYS IN A LARGE FEN SYSTEM AS A RESULT OF REGIONAL DRAINAGE – THE CASE OF THE RED BOG (BIEBRZA VALLEY, POLAND)

**Wiktor Kotowski[1], Helena Bartoszuk[2], Mateusz Grygoruk[2,3], Bogdan Jaroszewicz[4], Marek Kloss[5], Hubert Piórkowski[6], Marek Rycharski[6], Monika Szewczyk[6]**

*[1] Dept. of Plant Ecology and Environmental Conservation, Faculty of Biology, Warsaw University, Al. Ujazdowskie 4, 00-478 Warszawa, Poland, w.kotowski@uw.edu.pl; [2] Biebrza National Park, Osowiec-Twierdza 8, 19-110 Goniądz, Poland, [3] Dept. of Hydrology and Water Resources, Warsaw Agricultural University, [4] Bialowieza Geobotanical Station, Faculty of Biology, Warsaw University, ul. Sportowa 19, 17-230 Białowieża, Poland, [5] Centre for Ecological Research, Polish Academy of Sciences, ul. M. Konopnickiej 1, Dziekanów Leśny, 05-092 Łomianki, Poland, [6] Department of Nature Protection in Rural Areas, Institute for Land Reclamation and Grassland Farming, Falenty, 05-090 Raszyn, Poland*

Keywords: peatland, paleobotany, ombrotrophization, drainage, ecohydrology.

We present a re-construction of the recent history of the Red Bog – a 2500-ha mire in the Biebrza Valley, attempting to explain a sudden change of vegetation reflected in the shallow peat layers. Because the area has been covered by strict protection status since the 1930s, its current vegetation can be considered to be an effect of long-term dynamic processes that were uninfluenced by direct human impact. According to paleobotanical data, the Red Bog was evolving as a groundwater-fed fen until c. 200 years ago, when an ombrotrophization process started in the middle part, leading to the development of bog-related vegetation in the center of the mire, surrounded by alder and pine-birch fen woodlands and meadow communities. We hypothesized that this change was caused by the construction of large canals in the region approximately 200-150 years ago and verified this hypothesis by dendrochronometric methods and hydrological modeling. The model confirmed that construction of the channels could have resulted in an increased outflow of groundwater from marginal parts of the mire and collection of rainwater in the central part. In addition, the relief of the bottom of the peatland gained importance after shrinkage of the mire surface, also contributing to the development of sharp vegetation zonation.

Session 'Landscape dynamics'/ POSTER 63

## SPATIAL PATTERNS OF COASTAL DUNE LANDSCAPES: AN INSIGHT INTO ATLANTIC AND MEDITERRANEAN BEACH AND FOREDUNE HABITATS

**M. Laura Carranza[1], Alicia T.R. Acosta[2], Angela Stanisci[1], Agostino Gianelli[1], Marta Carboni[2], Ana Laura Monserrat [3]**

*[1] University of Molise, Dep. STAT-EnvixLab, Pesche, Italy; [2] Università degli Studi Roma Tre, Dep di Biologia, Roma, Italy; [3] Laboratorio de Geología Marina y Dinámica Costera, FCEyN, UBA-CONICET. Buenos Aires, Argentina (corresponding author Carranza@unimol.it)*

Keywords: coastal habitats, disturbance, land-cover map, landscape metrics, spatial pattern

Coastal dune ecosystems are characterized by a strong environmental gradient that determines a coenocline, along which plant communities are distributed in a sequence (coastal zonation) from the sea to the inner sectors and where different habitats are found. In the Mediterranean basin, as in the Atlantic coasts, human impacts strongly influence coastal habitats, giving rise to several conservation problems mainly due to landscape fragmentation. The aims of this work are 1) to analyze the spatial pattern of coastal dune habitats of different coastal dunes (in the Mediterranean basin and on the South American Atlantic coasts) through a set of indicators of landscape pattern and 2) to examine them in relation to the presence of artificial areas and coastal dynamics.
Based on coastal dune land-cover maps, we calculated landscape metrics for each coastal dune cover type (related to coastal habitats), such as mean patch size, patch shape index and mean nearest neighbor. Then, the relationship between the coastal dune spatial patterns and different disturbance impacts (including artificial areas and coastline erosion) was assessed using a type of multivariate gradient analysis called Canonical Correspondence Analysis (CCA).
The mapped coastal dune cover types included different habitats (beaches, dunes and sand plain variants) related to the typical Mediterranean and Atlantic coastal dune vegetation zonations. The CCA highlighted a strong relationship between habitat spatial patterns and the disturbance factors. The surface of artificial areas is one of the variables that best explains the habitat fragmentation parameters. In natural conditions, the coastal habitats presented elongated and irregularly shaped patches, while in disturbed areas, they tended to be smaller, more regularly shaped and isolated.
The proposed landscape approach combining patch-based metrics with environmental factors through a multivariate analysis provided a comprehensive description of the coastal landscape. From an applied research perspective, this landscape approach could be useful in identifying adequate management strategies for coastal areas and for monitoring and planning natural dune environments.

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## VEGETATION DYNAMICS RESULTING FROM ANTHROPOGENIC DISTURBANCES ON THE NORTH KOLA PENINSULA

**Tatiana Chernenkova, Mihail Puzacherko, Elene Basova**

*Centre for Forest Ecology and Production RAS, Moscow, Russia email: chernenkova50@mail.ru*

Keywords: forest ecosystems dynamics, Kola Peninsula, anthropogenic disturbance

We studied temporal and spatial forest vegetation dynamics near a large copper-nickel smelter at Monchegorsk on the Kola Peninsula, Russia. The species richness and diversity in spruce forests at sites located 5 to 30 km from the smelter were quantitatively assessed and compared between 2 periods of investigation (1981-1983 and 2005-2009). Digression and recovery succession in spruce forests were characterized based on the dynamics of species composition of phytocenoses and chemical composition of atmospheric fallout, soils, and dominant plants.
On the landscape level, we assessed the typological diversity of vegetation due to natural factors and anthropogenic influences. Sintaxonomic units embody information on post-fire and post-cutting successions and reflect digression stages of plant communities due to industrial damage. Groups of associations and associations were the more precise classification units provided by the mapping of the study area. For their detection, the ecologo-physiognomic classification approach was used because its characteristics appeared most acceptable for the definition of species composition and structure of plant communities using remote sensing data.
The combination of field research's and remote sensing information (Landsat-TM, ETM+) on the basis of quantitative methods (discriminate analysis) allowed vegetation characteristics to be interpolated from sample plots on the landscape spatial level. The general pattern of ecosystem diversity assessment consisted of *i*) the preliminary processing of remote sensing imagery sets and the definition of optimal set of units for types of information for autodetection of the typological diversity of land cover; *ii*) a field survey; *iii*) the definition of classification principles and the optimal set of classification units; *iv*) cartographical modeling of forest biodiversity parameters and typological units for model area using a training sample set; *v*) estimation of the reliability of the defined units by thematic interpretation and map validation, including field data analysis. We mapped the current state of vegetation cover of the Imandra Lake basin (S=6500 km$^2$, scale 1:100 000).

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## VEGETATION CHANGES ON KOREAN COASTAL SAND DUNES FROM 1970 TO 2000

**Hyeon-Ho Myeong[1], Byung-Sun Ihm[1], Jeom-Sook Lee[2]**

*[1] Mokpo National University, Biological Science, Muan-gun, Korea; [2] Kunsan National University, Biology, Kunsan, Korea; (ecomyung@empas.com)*

Keywords: Coastal sand dunes, sand dune vegetation

Since the 1970s, Korean coastal dunes have undergone a stabilization process that has resulted in an increase in vegetation cover and a decrease in the coastal sand dunes. The objective of the study was to quantify, using aerial photography and GIS, the rate and extent of vegetation expansion and their resultant temporal changes on the Korean coastal sand dunes between the 1970s and the 2000s. The planting of coastal windbreak forests caused changes in land cover and habitat characteristics. Land cover changes in the coastal sand dune ecosystem along the temporal variations were assessed. Land cover for transportation, public facilities, paddy, coniferous forest, barren areas, and inland water having direct effects on coastal sand dunes increased by 25.72% at the Goraebul sand dunes between 1971 and 2005. At the Simok-ri sand dunes, residential, recreational, transportation, farmland, and coniferous forest areas increased by up to 26.85%. At the Shindu-ri sand dune, residential areas, paddy, deciduous forest, barren areas, and inland water increased by 26.49%; thus, the area of the coastal sand dunes decreased. Artificial forestation was almost completed before 1980 at the Goraebul sand dunes. At the Simok-ri sand dunes, coastal windbreak forests were planted before 1986 in changes between 1972 and 2008, and artificial forestation is ongoing from the coastal sand dune areas toward the shoreline. At the Shindu-ri sand dune, as at the other sites, coniferous forest increased, and coastal sand dunes decreased.

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## LANDSCAPE-ECOLOGICAL ANALYSIS AND EVALUATION OF VEGETATION STRUCTURES IN URBAN AREAS OF YOKOSUKA, JAPAN

**Keiichi Ohno[1], Akiko Yanai[1, 2]**

*[1] Institute of Environment and Information Sciences, Yokohama National University (k1ohno@ynu.ac.jp), [1, 2] Graduate School of Environment and Information Sciences, Yokohama National University*

Keywords: Geosigmataxon, Green patch, Symphytosociology, Urban area, Vegetation landscape

To collect useful information for improving the management of urban environments, we performed a landscape-ecological study of the green patches in urban areas of Yokosuka using vegetation landscape survey methods based on symphytosociology. In this study, the vegetation landscape units (sigmataxa and geosigmataxa as basic units) were classified, and their distribution patterns were analyzed. Furthermore, the ecological characteristics of each vegetation landscape unit were assessed to determine its naturalness and conservation level, and management issues were defined. After completion of the tables for classifying sigmataxa and geosigmataxa, we identified two vegetation landscape units: the Bryo-Sagino geosigmataxon in urbanized areas poor in green patches and the Rubo-Aralio=Daphno-Querco geosigmataxon in wooded and grassy areas on the hillsides rich in green patches. The Bryo-Sagino geosigmataxon was divided into four subgeosigmataxa, and the Rubo-Aralio=Daphno-Querco was divided into three subgeosigmataxa. A vegetation landscape map of the surveyed sites was made using these seven classes. This map was made using a map of 200-$m^2$ mesh, and we performed sigma and geosigma relevés in each box on the mesh map. In this way, we defined a major vegetation landscape unit, the Bryo-Sagino=Daphno-Querco hyper-geosigmataxon. This hyper-geosigmataxon was divided into three smaller units: the *Ginkgo biloba* colonnades=*Prunus mume* shrubberies hyper-subgeosigmataxon (*GbPm*-hsgs), the *P. mume* shrub=Daphno-Querco hyper-subgeosigmataxon (PmDQ-hsgs) and the *P. mume* shrub=Ardisio-Castanopsio hyper-subgeosigmataxon (*Pm*AC-hsgs). The *GbPm*-hsgs was a major vegetation landscape unit in the urbanized areas without any green patches, and it formed the matrix of an urban ecosystem in Yokosuka. Conversely, the *Pm*DQ-hsgs and the *Pm*AC-hsgs were minor vegetation landscape units with various kinds of green patches, and these hyper-subgeosigmataxa were distributed in the *GbPm*-hsgs.
Thus, most green patches in Yokosuka were divided and isolated as small islands in urbanized areas, increasing the risk of their extinction caused by both the decline of regeneration ability and the inbreeding depression of relict populations.

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## LANDFORM AND BIODIVERSITY PATTERNS

**Siegmar Thomas**

*University of Technology, Institute of Landscape Architecture, Dresden, Germany*

Keywords: terrain analysis, geomorphology, natural plant cover, site conditions, land use

The aim of this study was to underline landforms as one of the decisive characteristics for biodiversity at all scales (along with latitudinal and productivity gradients for bioregions and biomes). The important characteristics of landform diversity are (i) the altitude difference of an area, e.g., a catchment / watershed and (ii) the frequency of complementary elevations / depressions. Landforms are more important than all other site factors. The more extensive the roughness of the terrain is, the more diverse is its landscape ecology in terms of micro-, meso- (regional) and macroclimate, as well as biodiversity, species richness, plant (and animal) communities, productivity of sites for phytocoenological units and their above- and belowground biomass and height growth, clonal plants and diversity of clonal traits. Ecological gradients follow the slope curves (orthogonal trajectories of contour lines): from ridgelines at upper elevations down to deep lines in depressions / valleys, the number of plant species and / or the aboveground biomass and height growth of e.g., woody plant communities generally increases. This increase was also found in spontaneous woody species combinations in sub-mountainous hedgerows investigated in Saxony. There are also exceptions, e.g., near a lower tree line, in depressions of rugged alpine regions, in rock avalanche tracks, with scree communities (no tree growth, decrease of clonal growth forms), and often close to waterfalls and running water.
The most natural landform and biodiversity patterns are covered by human land use patterns.
We describe a bad practice example in urban free open space, the inner structure of a crop field as a “patch”, homogenized by agricultural “melioration”. For the protection of local biodiversity, it is important to not level out the landforms.

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## SPATIO-TEMPORAL CHANGES IN THE STRUCTURE OF PLANT COMMUNITIES OF THE MOUNTAIN BELTS OF LAKE BAIKAL BASIN

**Alexander Sizykh, Victor Voronin**

*Siberian Institute of Plant Physiology and Biochemistry SB RAS, Laboratory of Ecosystem Bioindication, Irkutsk, Russia*

Keywords: Pribaikalya, mountain belts, ecotonal tree-line limit, climate

We studied the vegetation of the Western and Southern Pribaikalya (the basin of Lake Baikal) and of the central part of the eastern coast of Lake Baikal (Barguzin range). For the Pribaikalya area, we analyzed the structure and dynamics of plant communities. For the mountain territories along the coasts of Lake Baikal, we collected data on the present structure of the vegetation, together with some data concerning the altitudinal tree-line dynamics. Based on aerial photos and satellite images collected in different years, we built maps of vegetation structure. We focused on the tree-line ecotonal area and made geobotanical descriptions of plant communities that were precisely geo-referenced. In this ecotonal area, we observed in the last few years the displacement of the forest belt and the reduction of the plant belt upwards, to the detriment of mountain tundra. Over the last 30 years, we observed the upward progression of the colonization front by young fir trees. These changes can be considered consequences of climate change in this region.

# Wetland biodiversity and functioning

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## EPHEMERAL DUNE WETLANDS OF THE MANAWATU COAST, NEW ZEALAND - A REVIEW OF TWO DECADES OF CHANGE

**Gillian L. Rapson[1,2], Angelina R. Smith[1], Ashley L. Murphy[1]**

*[1] Massey University, Ecology Group, Institute of Natural Resources, Palmerston North, New Zealand; [2] (corresponding author: G.Rapson@massey.ac.nz)*

Keywords: Dune, progradation, rarity, succession, climate change

The Manawatu Coast is one of the most rapidly prograding dunefields in the world. Behind the foredunes is a belt of wetlands in scattered dune slacks. The wetlands, which retain above-surface water throughout the summer, are occupied by specialist species forming carpets of <1 cm thick. Many of these species are rare, including two local endemics, *Selliera rotundifolia* and the subshrub *Pimelia actea* (occupying dying wetlands). Studies over the past two decades have involved extensive field surveys, wetland status assessments, monitoring of wetland change, development of restoration techniques, and investigations into the autecology of some wetland species, as well as extensive observations.

These wetlands appear to be classically ephemeral, in that they do not persist in either time or space. Wetlands appear to form during dry summer storms when surfaces ablate to below the normal summer water table. They exist for approximately a decade before becoming progressively infilled with restiad rushland and shrubland, ultimately succeeding to swamp forest dominated by *Dacrycarpus* and *Laurelia* sp.

The frequency of wetland formation is undetermined, though surveys indicate that it might be episodic, last happening 2-3 decades ago. However, this process does not seem to be ongoing and may not continue under future climate change scenarios, which will impact coastal progradation rates. Thus, the survival of these rare species, especially the endemics, is very problematic, as field and experimental work depicts them as having very limited habitat ranges. Intervention in the process of wetland formation is not proving productive; a manufactured wetland has not naturally acquired any specialist species over the last two years, despite the proximity of other wetlands and the effectiveness of habitat creation in restoration plantings.

Questions arise as to how these wetlands form naturally, how species move between wetlands as they become available, and the best way to conserve such dynamic ephemeral systems.

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## ASSEMBLY RULES IN WETLANDS: SHIFTING IMPORTANCE OF CANOPY, WATERLOGGING AND MANAGEMENT DURING A 3-YEAR MESOCOSM EXPERIMENT

**Wiktor Kotowski[1], Olivier Beauchard[2], Wout Opdekamp[2], Patrick Meire[2], Rudy Van Diggelen [2]**

*[1]Department of Plant Ecology and Environmental Conservation, Faculty of Biology, Warsaw University, Al. Ujazdowskie; 4, 00-478 Warszawa, Poland;*
*[2] Ecosystem Management Research Group, University of Antwerp, Universiteitsplein 1, B-2610 Wilrijk, Belgium;*

Keywords: competition, anoxia, establishment, functional diversity, functional traits.

We analyzed the relative importance of grass canopy, waterlogging and mowing on the community assembly from a pool of 34 riparian species and early succession in a 3-year mesocosm experiment. Grass canopy was the dominant factor, disabling establishment of any species in the 1st year, and this effect was only slightly lowered by mowing. When establishment took place on bare ground, waterlogging largely facilitated species richness by reducing the total biomass and lowering inter-specific competition. During the following two years, we observed a gradually increasing role of waterlogging relative to canopy, while the effects of mowing were less pronounced. We also determined germination and seedling growth traits of the same species, both outside (in response to waterlogging／no waterlogging) and in a growth chamber (in response to light／darkness), which were used to calculate functional diversity indices in mesocosm communities. Functional richness (FR) was higher in stressed (waterlogged or shaded) environments compared to non-waterlogged and non-shaded environments. However, when both stress factors occurred simultaneously, their synergic interaction lowered FR. Though stochastic factors played an increasing role in the 2nd and 3rd years, the initial pattern was largely conserved through succession, pointing out the importance of early establishment conditions on wetland vegetation patterns.

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## ARE WETLANDS AZONAL ECOSYSTEMS? - SPATIAL PATTERNS IN SEASONAL WETLAND VEGETATION IN EXTRATROPICAL AND OROTROPICAL SOUTH AMERICA

**Ulrich Deil[1], Miguel Alvarez[2]**

*[1] University of Freiburg, Institute of Biology II, Dept. of Geobotany, Freiburg, Germany; [2] University of Bonn, INRES, Dept. of Vegetation Ecology, Bonn, Germany. Corresponding author: ulrich.deil@biologie.uni-freiburg.de*

Keywords: vernal pools, Andes, vegetation survey, phytogeography, classification

Wetland ecosystems are thought to be of azonal character because environmental conditions make them, to some extent, independent from macroclimatic zonation. We wanted to see whether this holds true for seasonal wetlands and on the spatial scale of a subcontinent. The study area included austral-temperate and subantarctic climatic zones of South America and the orotropical biome of the Andean Highlands. All phytosociological relevés available to us were collected and stored in a TURBOVEG-database. In total, we found 573 vegetation samples in 28 bibliographic sources. Achieving a consistent nomenclature was a major problem. Classification and ordination were performed at the species and genus levels. The interpretation of the results is limited by the substantial floristic and ecological heterogeneity of the data (e.g., varying plot sizes and plots including an inundation gradient) and by the spatially uneven distribution of the data.
The classification revealed a higher diversity of communities than expected: 11 clusters with precise species combinations, ecology and distribution emerged from the classification. Strong spatial patterns can be observed on the continental scale, not only from vicinismus effects of the matrix vegetation surrounding the small-scale seasonal wetlands, but also in the habitat-specific flora and vegetation. The main differentiating environmental factors on large scales are macroclimatic conditions and the trophic level of the substrate. The azonal character of seasonal wetlands becomes obvious only at the supra-specific taxonomic rank by genera that speciated within this environment and evolved geographical vicarious species with similar niches (e.g., *Isoëtes*, *Limosella*, *Ranunculus*, *Hypsela*, *Oritrophium*, *Littorella*, *Lilaeopsis*, *Muhlenbeckia* and *Crassula*). At the genus level, azonality can be stated also beyond the subcontinent, as illustrated by the example of amphitropical elements between Mediterranean Chile and California.

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## WEED, GRASSLAND AND SEMI-NATURAL VEGETATION OF EAST AFRICAN SMALL WETLANDS

**Miguel Alvarez[1], Mathias Becker[2], Collins Handa[1], Neema Mogha[1], Bodo M. Möseler[1], Salome Misana[3], Helida Oyieke[4]**

*[1] University of Bonn, Vegetation Ecology – INRES, Bonn, Germany; [2] University of Bonn, Plant Nutrition – INRES, Bonn, Germany; [3] University of Dar es Salaam, Geography – DUCE, Dar es Salaam, Tanzania; [4] National Museums of Kenya, Nairobi, Kenya; (corresponding author: malvarez@uni-bonn.de)*

Keywords: Floodplain, land use, papyrus swamps, weed communities

Recently, small wetlands in East Africa have come under increasing anthropogenic pressure from agricultural use due to population growth in the surrounding areas. Compared to the upland fields, wetlands are perceived to be nutrient rich with longer water availability. Because natural wetland vegetation in East Africa fulfills many ecological and socio-economic functions, there is an urgent need to determine its characteristic species composition and the potential use of plants as bio-indicators of the conservation-degradation status of wetlands.
We carried out a survey on anthropogenic vegetation in four representative small wetlands (smaller than 10 $km^2$) in Kenya and Tanzania. Two hundred seven relevés were sampled in plots of 10 $m^2$ that were located in surfaces of homogeneous vegetation and single land uses (classified into four main types: croplands, grazing fields, fallow fields and unused fields). After classification using the modified TWINSPAN algorithm, we detected 15 vegetation units, grouped into three sets: weed communities of croplands, grassland communities and semi-natural wetland vegetation. The vegetation within fallows was assigned either to weed or to grassland communities due to their floristic similarities. The most characteristic communities of semi-natural vegetation were *Cyperus papyrus*-*Cyperus exaltatus*-comm. in oligotrophic wetlands and *Typha capensis*-comm. in mesotrophic and eutrophic wetlands, both representing fields with very low use pressure and long inundation periods. In this survey, eight weed communities were described, some of which were linked to single crops, such as *Pentodon pentandrus*-*Leersia hexandra*-comm. in rice paddies and *Eleusine indica*-*Haplosciadium abyssinicum*-comm. associated with intensive vegetable cultivation. The latter vegetation unit is characterized by many Eurasian weed species. The main factors determining the species composition in agriculturally used wetland fields are determined by the type and intensity of land use as well as by their geographical distribution. A proposed syntaxonomical classification of the studied vegetation and indicator species will be discussed.

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## FORMALIZED PHYTOSOCIOLOGICAL CLASSIFICATION OF CENTRAL ITALIAN WETLAND VEGETATION: SUITABILITY, RESULTS AND OPEN QUESTIONS

**Flavia Landucci[1], Daniela Gigante [1], Roberto Venanzoni [1], Milan Chytrý [2]**

*[1] University of Perugia, Department of Applied Biology, Perugia, Italy; [2] Masaryc University, Department of Botany and Zoology, Brno, Czech Republic.*

Keywords: Cocktail method, wetland vegetation, formalized classification, Central Italy.

During the last decade, a large set of published and unpublished data about Italian vegetation was stored in VegItaly, a web database hosted by AnArchive (http://www.anarchive.it). Supported by SISV (Società Italiana di Scienza della Vegetazione) and members of the IAVS Eco-informatics Working Group, VegItaly is a collaborative project involving several Italian Universities and coordinated by the University of Perugia; it aims at archiving, sharing and managing large data sets for statistical analyses at wide geographic scales.
A data subset including phytosociological relevés from macrophytic, wetland and wet meadow vegetation from Central Italy was extracted from VegItaly and processed by using the Cocktail method. This method, designed to simulate the Braun-Blanquet approach using a formal method, is largely based on expert knowledge, reflecting the field experience of the author and the classifications published in the literature. All analyses were performed in the program Juice 7.0. Formal definitions were created using logical operators (AND, OR and AND NOT), combining species cover values and species groups. Sociological species groups and diagnostic species of the associations were determined using the phi coefficient of association.
The plant communities recognized by this classification are representative of most of the diversity of wet ecosystems in central Italy. They included the following vegetation classes: *Lemnetea*, *Potametea*, *Charetea*, *Bidentetea tripartitae*, *Phragmito-Magnocaricetea* and *Molino-Arrhenatheretea*.
The present work represents the first application of the Cocktail method to a large data set from a wide area in Southern Europe. For most of the associations distinguished here, the number and distribution of the relevés are sufficient to develop formal definitions that are valid for Italy.

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## IMPACT OF LAND USE ON VEGETATION COMMUNITIES AND THEIR FLORISTIC COMPOSITION IN THE SMALL WETLANDS OF EAST AFRICA

**Neema Mogha, Collins Handa, Bodo Maria Moeseler, Miguel Alvarez, Matthias Langensiepen**

*University of Bonn, Institute of Crop Science and Resource Conservation (INRES), Department of Vegetation Ecology, Bonn, Germany (Corresponding author. Neema Mogha Email address : moghang@yahoo.com)*

Keywords: Community analysis, floristic inventory, Kenya, Tanzania

Population growth, degradation of upland soils and increasingly variable climatic conditions has resulted in an increased intensity of agricultural land use of small wetlands in East Africa. These practices have led to negative impacts on natural vegetation patterns and composition. Some wetlands are vulnerable to anthropogenic interventions and, hence, at risk in case of agricultural use. While small wetlands are abundant in East Africa, little work has been done on their vegetation communities, distribution and functions. Vegetation changes may provide an important tool to assess the potential and vulnerability of wetlands. We determined the relationship between habitat factors and species composition and the impact of land use changes and wetland disturbances on plant communities and their floristic composition. Vegetation sampling was carried out based on land use and land cover changes in four representative wetland systems. Rapid Rural Appraisal was used to collect information from the local people about the characteristic vegetation types as well as past and current land use activities. The stratification method was used to divide different vegetation in relation to land use and land cover. Floristic composition and species cover and abundance were assessed in 10 m×10 m plots. The vegetation was characterized and classified using statistical, syntaxonomical and ordination approaches to link species composition to environmental and land management factors. The effect of wetland use changes on species composition, the characterization of wetlands plant communities and their floristic composition will be presented.

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## SPECIES POOLS AND SMALL-SCALE SPECIES RICHNESS IN WETLANDS: A RELATIONSHIP DRIVEN BY RECRUITMENT LIMITATION?

**Sabine Güsewell, Alexandra Fraser**

*ETH Zurich, Department of Environmental Sciences, Zurich, Switzerland (corresponding author: sabine.guesewell@env.ethz.ch)*

Keywords: biodiversity, clonal growth, null model, spatial scale, species pool

Relationships between species-pool size and small-scale richness have been regarded as indicators of processes driving the species richness of plant communities. Linear relationships were thought to reflect regional processes that shape species pools, while saturating relationships were thought to reflect local processes that limit species coexistence. However, a simple simulation of random recruitments of plants from species pools shows that with increasing species pool size, an increasing number of recruitments are needed to produce linear relationships between species-pool size and small-scale richness. Accordingly, saturating relationships might result from a constant frequency of recruitment opportunities along a species-pool gradient.

We explored the implications of this idea through a field survey in Swiss wetlands. At 38 wetland sites, we determined the size of the local species pool as well as small-scale species richness per 1 $m^2$ and per 500 ramets. Small-scale richness and species pool were linearly related, but the correlation was significantly weaker than would be expected if the recruitment of species into small plots were a neutral process (null model). Comparing these data with the previous simulations showed that the number of recruitments needed to produce the observed small-scale species richness increased with species pool size. This number of recruitments was unrelated to the above-ground biomass of the vegetation but negatively related to soil moisture. The wettest plant communities had low species richness, small species pools, strong dominance of a few clonal plant species and low rates of recruitment at the community level.

These results suggest that local recruitment is an important determinant of species richness in Swiss wetlands. The relationship between soil moisture and species richness seems to be mediated by different patterns of clonal growth and their effect on opportunities for species recruitment from the species pools.

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## *EMPODISMA MINUS* ENGINEERS THE FEN-BOG TRANSITION IN NEW ZEALAND MIRES

**Tarnia A. Hodges[1], G. L. Rapson [1,2]**

*[1] Massey University, Ecology Group, Palmerston North, New Zealand; [2] (G.Rapson@massey.ac.nz)*

Keywords: Ecosystem engineering, *Empodisma minus*, de Wit replacement series, competition, capillaroid roots

We propose a framework outlining the process by which *Empodisma minus* (Restionaceae) might engineer the development of raised bogs in New Zealand, similar to the concept of *Sphagnum* as an engineer of Northern Hemisphere mires. Here, we addressed the proposal that accumulation of decay-resistant litter and increased access to scarce nutrients in poor fen conditions result in competitive exclusion of previous co-dominants by the development of habitat patches in which the environmental conditions are increasingly ombrotrophic. We tested this hypothesis by assessing the effects of *Empodisma* on the performance of *Chionochloa rubra* (Poaceae), a co-dominant, along nutrient and water table gradients in an artificial wetland. The decomposition of senesced litter of both species was also investigated along internal mire gradients in a litter bag experiment.

Overall, the Relative Efficiency Index suggested that *Empodisma* would eventually dominate the vegetation community in all the treatments. High relative yield totals indicate the species exhibit partial resource complementarity and do not fully share common limiting resources. This complementarity was greater at high water levels for each nutrient level; the higher water table apparently enabled the two species to access different nutrient resources. Capillaroid roots, thought to enable *Empodisma* to access ombrotrophic nutrient sources, were in greatest abundance in monoculture treatments regardless of nutrient levels, where intraspecific competition for nutrients was greatest.

*Empodisma* biomass was significantly more long-lived, and rhizome: foliage ratios reflected a tendency to invest more in belowground productivity in nutrient-poor environments. Our litter experiment suggested that the decomposition rates of all these tissues are significantly lower than those of *Chionochloa,* whose decomposition rates are unaffected by mire gradients. These results support the hypothesis that ecosystem engineering by *Empodisma* promotes the formation of raised mires by elaborate plant-soil feedback mechanisms involving litter production and decay and nutrient pre-emption from ombrotrophic sources and that the process of engineering may accelerate as *Empodisma* increases in density, in response to increasing intraspecific competition for nutrients.

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## DIFFERENT RESPONSES OF EARLY AND LATE COLONIZERS TO LIGHT AND WATER IN A POST-MINED PEATLAND IN NORTHERN JAPAN

**Chika Egawa, Shiro Tsuyuzaki**

*Graduate School of Environmental Science, Hokkaido University, Sapporo, Japan (Chika Egawa: cegawa@ees.hokudai.ac.jp)*

Keywords: Early succession, Facilitation, Shade, Drought, Biomass allocation

In primary succession, shade by early colonizers often facilitates seedling regeneration by ameliorating strong sunlight and soil moisture. Responses to light and water are greatly different between early and late colonizers, and therefore, the vegetation cover of early colonizers affects the regeneration of each species differently. In this study, we conducted a field experiment to examine (1) how early and late colonizers differed in their responses to changes in light and water and (2) how shade from early colonizers affected the regeneration of two species. The experiment was conducted on bare ground in a post-mined peatland in northern Japan. The seeds of *Rhynchospora alba* (an early colonizer) and *Moliniopsis japonica* (a late colonizer) were sown with three water treatments (dry, wet, control) × two irradiances (with and without 50% shading that imitates the *R. alba* cover). Seventy-five days after sowing, we excavated the seedlings and measured their shoot biomass, root biomass, seedling height and total root length. The total biomass of *R. alba* seedlings decreased with shading in all the water treatments, while that of *M. japonica* increased with shading, particularly, in the dry treatment.". The wet treatment reduced the total biomass of *R. alba*, whereas that of M. japonica increased with increasing water content. *R. alba* seedlings allocated more resources to aboveground biomass with shading and made thinner shoots, but *M. japonica* did not change the resource allocation in any of the treatments. These results show that light reduction is more determinative than drought for the growth of the early colonizer *R. alba*, and the shade by conspecies may negatively affect its own seedling growth. The late colonizer *M. japonica* is more sensitive to drought than the early colonizer without shading and thus does not become established on bare ground. However, if shaded, *M. japonica* grows faster even in the dry condition. Therefore, facilitation by an early colonizer is particularly important when the soil surface is drier for the seedling growth of the late colonizer.

Session 'Wetland biodiversity and functioning' / POSTER 70

## STATUS AND QUALITY OF VASCULAR PLANTS IN AGRICULTURALLY USED WETLANDS OF EAST AFRICA

**Collins Handa[1], Neema Mogha [1], Miguel Alvarez[1], Bodo Moseler[1], Helida Oyieke[2], Mathias Becker[1]**

*[1] University of Bonn, Plant nutrition, Bonn, Germany; [2] National Museums of Kenya, Centre for Biodiversity, Nairobi, Kenya (Collins Handa: Chanda@uni-bonn.de)*

Keywords: Indicator species analysis, Montane inland valleys, Raunkiaer's life form, Small wetlands

East African small wetlands (SWs) are currently faced with an ever-rising pressure from agricultural expansion as the demand for food increases. There is, thus, a need to establish the status of vascular plants within such wetlands to avert the possibility of biodiversity loss without documentation. We assessed the current status and quality of flora in SWs under agriculture, including the influence of land use on their diversity and distribution. Four SWs composed of two highland inland valleys and two riverine floodplains were assessed in Kenya and Tanzania. The vegetation of 224 plots (100 $m^2$) of four land use types (cultivated, grazed, fallow and unused) was sampled. Species occurrence and percentage cover were recorded. Floristic quality was determined by comparing the number of upland species against facultative wetlands species in all plots. Raunkiaer's life form classification was used to describe all species, and land uses were grouped using indicator species analysis and cluster analysis and compared using ANOVA. We recorded 439 species belonging to 242 genera in 93 families. Out of the 439 species, only 67 had a frequency >11%. Cyperaceae dominated fallow and unused sites, whereas the poaceae and asteraceae families dominated intensively cultivated sites. Cultivated and fallow plots had significantly higher species composition than unused patches ($p<0.012$). Over 60% ($n=264$) of the species recorded were mainly upland therophytes and geophytes. Indicator species included: 1) *Schkuhria pinnata*, representing drained cultivated highland floodplains*; 2) Cyperus exaltatus* for seasonally inundated lowland floodplains; 3) *Chenopodium album*, representing drained and intensively used mid-inland valleys; 4) *Avena sp*, found in medium-used sites in mid-inland valleys; 5) *Typha capensis*, representing flooded and saline patches in lowland floodplains and montane inland valleys; 6) *Ethulia conyzoides*, representing sites within seasonal and sedimented patches in lowland floodplains; and 7) *Hydrocotyle sibthorpioides*, representing highland inland valleys in perennially inundated partially used and fallow fields. Conservative species, e.g., *Cyperus papyrus* and *Cyperus exaltatus*, were restricted to unused wetlands. Generalists, e.g., *Commelina benghalensis, Cynodon dactylon, Cyperus rotundus* and *Galinsoga parviflora*, were widespread in cultivated plots. The majority (70%) of the species recorded maintained a local geographical distribution but were not representative of vegetation within SWs of East Africa. The high proportion of upland species is an indication of low floristic quality in agriculturally used wetlands.

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## PATTERNS OF EARLY SUCCESSION ON BARE PEAT IN SWISS MIRE AFTER A BOG BURST

**Elizabeth Feldmeyer-Christe, Meinrad Küchler, Otto Wildi**

*Swiss Federal Institute for Forest, Snow and Landscape Research WSL, CH-8903 Birmensdorf (corresponding author: elizabeth.feldmeyer@wsl.ch)*

Keywords: disturbance, peat slide, long-term monitoring, species diversity, Switzerland

Early successional stages in vegetation have long been studied in plant ecology. The classical issue in succession is change in species composition, the direction of change including alternative pathways towards one or several equilibrium stages. While early succession on many types of bare substrates is well documented, little is known about the patterns and pace of vegetation succession on bare peat.
Recolonization on bare peat has been studied in formerly exploited peatlands of Europe and in North America, where impact proved to be detrimental and led to a new type of vegetation. To date, few long-term studies of vegetation succession on bare peat have been carried out.
Our study reports on the colonization and early succession after a bog burst in 1987 (Feldmeyer-Christe and Mulhauser 1994) that led to the emergence of bare peat surfaces. We monitored the floristic changes for two decades through the repeated sampling of 21 permanent plots.
Species diversity and life forms were analyzed based on Shannon's equitability index and cover. We used classification and metric ordination techniques to investigate patterns of successional rates and trends. High temporal resolution of survey allowed for the analysis of the pattern of succession velocity.
Species richness increased in two distinct surges over the 21 years of succession, with the first decelerating 5 years after impact. Sedges were the life form that showed the highest cover throughout the study period. Time trajectories of the 21 plots revealed three iterative pathways towards intermediate equilibrium stages in the first years, followed by convergence in the later states. Changes in succession velocity reached a first maximum approximately six years after the slide had occurred and a second maximum twelve years later.

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## VARIABILITY OF FEN COMMUNITIES CONTAINING *BETULA HUMILIS* IN EURASIA

**Ewa Jabłońska[1], Franziska Tanneberger [2], Elena D. Lapshina [3], Liene Salmina [4], Oleg V. Sozinov [5]**

*[1] Department of Plant Ecology and Environmental Conservation, Faculty of Biology, Warsaw University, Al. Ujazdowskie 4, 00-478 Warszawa, Poland; Institute of Botany and Landscape Ecology, Ernst-Moritz-Arndt University, Grimmer Strasse 88, 17487 Greifswald, Germany, [3] Department of Environmental Dynamics and Global Climate Change, Yugra State University, ul. Chekhova 16, 628012, Khanty-Mansiysk, Russia; [4] Latvian Fund for Nature, Kronvalda boulvd. 4, Riga, 1010 Latvia; [5] Department of Botany Faculty of Biology and Ecology, Yanka Kupala State University of Grodno, Ozheshko Street 22, 230023 Grodno, Belarus*

Keywords: peatland, ordination, gradient analysis.

*Betula humilis* is a shrubby species growing on fen peatlands with a biogeographical range extending from Germany to Central Siberia. The species is declining and is the subject of conservation efforts. Because almost all stands in Central Europe have been affected by human activity, it has become very difficult to assess their ecological status and to propose conservation strategies. To learn more about the natural variability of vegetation with *B. humilis* and its relationship to human impact, we conducted a phytosociological survey of the stands of this species, covering its entire geographical range. We compiled a database, consisting of 353 of our own relevés and 379 derived from the literature. DCA revealed that the main gradient of variation is related to the general wetness of habitats, separating drained sites from hydrologically intact fens. This gradient clearly interacts with the gradients of nutrient availability and base saturation. Communities with a high contribution of fen species (and a high conservation value for *B. humilis*) occur at the lowest values of the fertility-related gradient in (moderately) drained sites, while they aggregate at high values of this gradient in natural fens. Our analysis allowed identification of the Central European stands of *B. humilis* that most closely resemble the well-preserved stand in Siberian fens.

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## PREDICTING TEMPORARY WETLAND PLANT COMMUNITY RESPONSES TO CHANGES IN HYDROPERIOD

**Juan I. García-Viñas[1], Aitor Gastón[1], Carlos Ropero[1], Carlos de Gonzalo[2], Jose C. Robredo[2], Juan A. Mintegui[2]**

*[1] Technical University of Madrid, ECOGESFOR research group, Madrid, Spain; [2] Technical University of Madrid, ETSI Montes, Madrid, Spain.*

Keywords: *Arthrocnemum macrostachyum*; habitat suitability models, global change, Doñana wetland

The expected changes in rainfall in the next decades may cause significant changes in the hydroperiod of temporary wetlands and, consequently, shifts in plant community distributions. Predicting plant community responses to changes in hydroperiod is a key issue for conservation and management of temporary wetlands. We present a predictive distribution model for *Arthrocnemum macrostachyum* communities in the Doñana wetland (Southern Spain). Logistic regression was used to fit the model using the number of days of inundation and the mean water height as predictors. The internal validation of the model yielded good performance measures. The model was applied to a set of expected scenarios of changes in the hydroperiod to anticipate the most likely shifts in the distribution of *Arthrocnemum macrostachyum* communities.

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## VEGETATION-ENVIRONMENT RELATIONSHIPS AND DIVERSITY PATTERNS IN ALPINE MIRES OF THE WESTERN CARPATHIANS AND THE ALPS

**Lucia Sekulová [1], Michal Hájek [1,2]**

*[1] Masaryk University, Department of Botany and Zoology, Brno, Czech Republic; [2] Academy of Science of the Czech Republic, 2Department of Vegetation Ecology, Brno, Czech Republic*

Keywords: vegetation, environmental gradients, species richness, species pool, water chemistry

Mire vegetation in the alpine zone of the West Carpathians and Swiss Alps was studied with a focus on the following questions:
(i) What are the main factors responsible for variation in floristic composition, and do they differ between the two regions?
(ii) Is the floristic difference between the two regions consistent along the main environmental gradient?
(iii) How do various functional groups (e.g., vascular plants and bryophytes) differ in their diversity patterns and floristic composition in two distant regions?
We sampled vegetation plots and directly measured their environmental characteristics. We used PERMANOVA to compare the similarity of vegetation composition between the regions, CCA to reveal the relationships between the species composition of the vegetation and the measured environmental factors, general regression models to identify factors determining alpha diversity, PERMDISP to compare β-diversity and rarefaction curves to compare regional species pools. The highest variation in floristic composition was explained by the acidity-alkalinity gradient in both regions. The vegetation of alkaline mires was more similar between the regions than that of acidic mires. The diversity patterns differed between vascular plants and bryophytes. The vascular plant α-diversity was explained predominantly by mineral richness in the Swiss Alps but by water pH in the West Carpathians; in general, more factors had significant effects on the species richness of vascular plants as compared to bryophytes. Bryophyte α-diversity was determined by pH and slope inclination in both regions. The highest α-diversity of vascular plants and bryophytes was found in alkaline fens in both regions. The Alps exceeded the West Carpathians in mean species richness, β-diversity of alkaline mires and total species pool, while the West Carpathians had higher α-diversity in two pH-classes. The results largely reflect the positive correlation between pH/calcium gradient and species richness in natural temperate habitats interacting with the common limestone substrate in the Alps. Bryophytes were more similar between the regions, which may reflect their good dispersal ability.

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## GENETIC AND PHYTOSOCIOLOGICAL METHODS IN A BROADER MULTI-PROXY APPROACH TOWARDS THE PHYLOGEOGRAPHY OF PEAT-BOG SPECIES IN EUROPE

**Miguel Geraldes[1,2], Estevão Portela-Pereira [1,2], João Paulo Fonseca [3], Carlos Neto [1,2]**

*[1] University of Lisbon, IGOT, Centre for Geographical Studies, Lisbon, Portugal; [2] Technical University of Lisbon, ISA, Centre of Botany Applied to Agriculture, Lisbon, Portugal; [3] Higher Institute of Applied Psychology, Eco-ethology Research Unit, Lisbon, Portugal; (mgeraldes@campus.ul.pt)*

Keywords: peat bogs, molecular biogeography, paleoclimatology, Europe

Former glacial refugia are revealed by high genetic diversity in the present and are critical in spatial planning policies and conservation strategies, as they constitute significant reservoirs of biodiversity. The Iberian peninsula has, along with the Apennine and Balkan peninsulas, the highest number of refuges identified by Médail & Diadema (2009). These areas may have acted as glacial refugia for species of present-day wide distribution in Europe, such as *Drosera intermedia* Hayne in Dreves, *Genista anglica* L., *Gentiana pneumonanthe* L., and *Cirsium palustre* L. The bogs of southern Europe, differ from the mountain bogs in that they are relict ecosystems from past colder climates. They became isolated and their communities of specialists were fragmented into a disjunctive biogeographical distribution, especially the southwest low-altitude sub-littoral bogs, decontextualized from the current climate. To understand this, a combination of different approaches is proposed: (1) morphological and phytosociological data, (2) paleobotanical and palynological data and (3) phylogeographic analyses, using genetic information from ISSRs and DNA sequences from nuclear introns and chloroplast markers. Fifteen populations of each target species will be sampled: 3 in Portugal (Estremadura-Tagus River, Alentejo-Sado River and Minho-Douro river regions), 4 in Spain (Galicia, Andalucía, Catalunya-Southeastern Pyrenees, Euskadi-Northwestern Pyrenees), 4 in Central Europe (2 in France and 2 in Germany), 2 on the Italian Peninsula and 2 on the Balkan Peninsula. This sampling will contribute to (1) thoroughly analyzing the population structure of the 4 species within the Iberian Peninsula and (2) testing the relationship between northern populations, which went extinct during glacial advances, and southern refugial populations. By combining these approaches, we will cover different rates of molecular evolution, trapping the genetic signal in a broader time scale. The within-population genetic diversity and phylogeographic patterns among populations will be evaluated, including their relationships and the level of historic gene flow among them.

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## SOUTHERN WETLAND FLORA OF THE OUED RIGH VALLEY

**Nora Bouchahm, Nora Salamkour, Abd Al Malek Derouiche, Faouizi Zahi, Ouarda Chaib, Wahiba Hamzaoui, Farah Fakraoui, Larbi Djabri**

*CRSTRA, Division of soil and water resources management in arid regions, Biskra, Algeria (Bouchahm_nora@yahoo.fr)*

Keywords: Sahara, new wetlands, Oued Righ valley, flora

The authority of the Ramsar Convention in Algeria, the Directorate General of forests, has classified 26 sites on the list of the Ramsar Convention of wetlands as being of international importance – two in 1982, ten in 2001 and 13 in 2003. If sixteen new sites receive this classification as scheduled in 2004, the number of international wetlands in Algeria would reach 42 with an area of nearly 3 million hectares, i.e., 50% of the estimated total area of wetlands in Algeria. In the past decade, the Valley of Oued Righ has experienced a water table upwelling accentuated by inputs of drainage water. This phenomenon has led to the appearance of lakes, some of which have become true wetlands with characteristic flora and fauna. This work aims to present the vegetation patterns in these wetlands located in arid regions in a new comparative context between Southern and Northern ones. The flora families were Poaceae, Zygophyllaceae, Joncaceae and Tamaricaceae. Among the widespread species, *Phragmites communis*, *Juncus maritimus*, *Frankenia pulverulenta*, *Zygophyllum album* and *Tamarix gallica* were found.

# Computational vegetation science: Structure and dynamics of plant assemblages in silico

Session ‘Computational vegetation science’ / ORAL

## LARGE-SCALE SIMULATION OF VIRTUAL PRAIRIES WITH VOLUNTEER COMPUTING

**Marc Garbey[1], Malek Smaoui [1], Waree Rinsurongkawong [1], Anne-Kristel Bittebiere[2], Bernard Clément[2], Cendrine Mony [2]**

*[1] Dept of Computer Sciences, Houston, USA; [2] UMR 6553 ECOBIO, Rennes, France (corresponding author: garbey@cs.uh.edu)*

Keywords: Clonal plant assemblages, BOINC platform, plant traits, Individual-Based Model

Modeling, especially individual-based modeling, is increasingly used as a tool to virtually test ecological theories on plant community assemblages. However, realistic models of plant communities may comprise a large parameter space. Some parameter values may be uncertain due to the scarcity of empirical data on some ecophysiological processes of plant growth.
In this case, rigorous browsing of the parameter space with as weak as possible assumptions on the parameter values is necessary but may be constrained by the available computing resources. A new alternative is to use volunteer computing for the simulations. Volunteer computing is an arrangement in which people (volunteers) provide computing resources for projects. Volunteers can be anonymous persons anywhere from the Internet, schools or businesses. We launched the virtual prairie project in 2008 on the BOINC platform (http://vcsc.cs.uh.edu/virtual-prairie/) where we simulated clonal plant dynamics.
We proposed to illustrate through the virtual prairie project how volunteer computing and the associated algorithmic machinery enabled systematic testing of the PRAIRIE model and optimizing the system for synthetic performance output. This model simulates the growth of several interacting individuals and evaluates over time characteristics at two scales: each individual and the whole population. We were able to characterize the clonal traits of individual plants that promoted the performance of the population and demonstrated that implementing a plastic response to competition may have an effect on these results. Volunteer computing enabled large-scale simulations and engages the general public in ecology and environmental sciences.

Session ‘Computational vegetation science’ / ORAL

## THE ROLE OF CLONAL PLANT SIZE AND LITTER PRODUCTION IN COMPETITIVE DYNAMICS ALONG NUTRIENT GRADIENTS

**Deborah E. Goldberg[1], William C. Currie[2]**

*[1] University of Michigan, Department of Ecology and Evolutionary Biology, Ann Arbor, MI, USA; [2] University of Michigan, School of Natural Resources and the Environment, Ann Arbor, MI, USA (degold@umich.edu)*

Keywords: wetlands, invasions, litter, maximum size, competition

Invasive plants typically increase in abundance with increasing nutrient levels. In wetlands, these invaders are often large, have high litter production, grow rapidly, and have extensive clonal growth. We used a community-ecosystem model of clonal plant growth and nutrient cycling, called Mondrian, to examine the role of plant size and litter production on invasion success and community dynamics along a gradient of nitrogen input. To isolate these two factors, the simulated natives and invaders were identical except for the maximum ramet size and then, for each size of invader, we compared the case of new ramets inhibited by litter accumulation vs. not inhibited. When litter suppression was incorporated, suppression decreased for larger size ramets. Because other studies have found that shading by live plants is much less important than shading by litter, we did not include any competition for light between living ramets. In the presence of a native community of small-medium sized plants, the minimum size of successful invaders increased as nitrogen input increased, i.e., plants had to be larger to be successful at high nitrogen input. However, in the absence of the native community, even the largest invaders could persist at the lowest nitrogen levels, implying their inability to invade the native community was due to competitive exclusion of large plants by smaller plants. Despite this variation in invasion success, natives and invaders coexisted for many intermediate combinations of nitrogen input and invader size. For the very largest invaders at the highest nitrogen levels, the invader competitively excluded almost all natives. These results cannot be explained by changes in competition for light along productivity gradients; instead we suggest that small maximum size is actually adaptive at low nutrients because such plants have the ability to produce new rhizomes and expand horizontally even at low nutrient availability because of the smaller nutrient needs per individual ramet. Allowing litter accumulation to suppress new ramet production exaggerated these trends because the litter from larger invaders further suppressed emergence of small ramets.

Session 'Computational vegetation science' / ORAL

## A BRUTE-FORCE APPROACH TO VEGETATION CLASSIFICATION

**Sebastian Schmidtlein[1], Lubomír Tichý[2] , Hannes Feilhauer[1], Ulrike Faude[1]**

*[1] Department of Geography, University of Bonn, Germany; [2] Department of Botany and Zoology, Masaryk University, Kotlarska, Czech Rep.; (schmidtlein@uni-bonn.de)*

Keywords: Cluster optimization, Indicator species, Isomap, Isometric feature mapping, Isopam

Aim: Introduction of a novel approach to the classification of vegetation data (species by plot matrices). This approach copes with a large amount of noise, groups irregularly shaped in attribute space and species turnover within groups.
Method: The proposed algorithm (Isopam) is based on the classification of ordination scores from isometric feature mapping. Ordination and classification are repeated in a search for either high overall fidelity of species to groups of sites or high quantity and quality of indicator species for groups of sites. The classification is performed either as a hierarchical, divisive method or as non-hierarchical partitioning. In divisive clustering, the resulting groups are subdivided until a stopping criterion is met. Isopam was tested on 20 real-world data sets. The resulting classifications were compared with solutions from eight widely used clustering algorithms.
Results: When examining the significance of species fidelities to groups of sites and the quantity and quality of indicator species, Isopam often achieved high ranks as compared with other algorithms.

Session 'Computational vegetation science' / ORAL

## INTERWOVEN CAUSE AND EFFECT IN NUTRIENT CYCLING, PLANT SIZE, AND INVASION SUCCESS IN A SIMULATED CLONAL WETLAND ECOSYSTEM

**William S. Currie[1], Deborah E. Goldberg[2]**

*[1] University of Michigan, School of Natural Resources and Environment, Ann Arbor, Michigan, USA; [2] University of Michigan, Department of Ecology and Evolutionary Biology, Ann Arbor, Michigan, USA (corresponding author: wcurrie@umich.edu)*

Keywords: ecosystem, feedback, wetland, nutrients, invasion

Coastal wetlands occur worldwide at the terrestrial-aquatic interface where, increasingly over the last half-century, elevated N fluxes have entered precipitation, groundwater, and stream and river runoff. Plant community dynamics, including invaders, can be expected to respond through increases in net primary production (NPP), litter production, and N cycling, which in turn could influence plant growth. Disentangling the causes and effects of elevated nutrient cycling and plant community change, including plant invasion, is far from straightforward in these coastal wetland ecosystems. We developed a new community-ecosystem model, called MONDRIAN, that is able to perform factorial sets of simulations as 'in silico' experiments to explore the complex and interwoven processes involved in triggering or determining invasion success. The model is individual based, simulating growth and competition for nutrients among individual ramets as well as clonal connections and horizontal expansion. Simulated ecosystem N cycling both drives and is driven by plant growth, litter production, and the biogeochemistry of litter and sediment organic matter. We applied the model to investigate plant size and litter production in simulated potential invaders and native marsh plants as they interacted across a range of N inflow rates to study the invasion success of large *Typha* (cattails) into historically oligotrophic marshes in the Laurentian Great Lakes, Michigan, USA. The model showed a wide range in simulated invasion success related to the interaction of invader size and N inflows. In successful invasions, wetland retention of N was higher over time, and N cycling continued to increase over time, demonstrating a positive feedback in N cycling that arose even with the highly simplified differences in plant traits in the model. This result suggests that invasions by large clonal plants into wetlands could be driven at least in part by positive feedback as the invaders create more suitable conditions for their own growth.

Session 'Computational vegetation science' / ORAL

## TESTING TRAIT CONVERGENCE/DIVERGENCE IN A GRASSLAND COMMUNITY IN SILICO

**Tomáš Herben**

*Institute of Botany, Academy of Sciences of the Czech Republic, Průhonice and Department of Botany, Faculty of Science, Charles University, Praha, Czech Republic; (corresponding author: herben@site.cas.cz)*

Keywords: virtual community, individual-based model, trait variance, trait manipulation, diversity

It has been hypothesized that the distribution of plant traits in a community of coexisting species is nonrandom. Trait divergence occurs if the traits of co-occurring species differ more than on the basis of chance. Trait convergence occurs if they differ less than on the basis of chance. While selection over a gradient is expected to generate trait convergence, trait divergence is assumed to be due to niche differentiation within the set of species.
Statistical procedures used to test these patterns critically depend on the assumptions about the trait distribution in the total species pool and size of this pool. I use an alternative approach to test these ideas by manipulating trait values in a virtual community and examining their effects on species coexistence and community richness.
I use a spatially explicit, individual-based model of clonal plants, which works with the traits of growth, resource allocation, response to competition, and plant architecture. The model was parameterized for four co-occurring species of a species-poor mountain grassland using field data. The model approximates grassland dynamics over two decades (over which empirical data are available) rather well. This virtual community was used to test hypotheses on the effects of trait structure on community dynamics. I manipulated traits (one by one) of the whole set of species to generate artificial communities with trait variance either smaller or larger than in the real community. The resulting communities were simulated for realistic time periods, and their resulting diversity was compared with simulations with trait values unchanged and with field data.
Almost all traits examined had some effect on species diversity, although the magnitude of their effects varied. Diversity generally changed monotonically, with the trait variance indicating little support for specific trait divergence. Such a modeling approach opens a possible independent avenue for testing trait structure at the community level. The quality of the results critically depends on model realism (namely, the correctness of the major structural assumptions of the model).

Session 'Computational vegetation science' / ORAL

## OPTIMAL FORAGING IN CLONAL PLANTS. THE BLIND PROSPECTOR MODEL

**Jean-Sébastien Pierre, Philippe Louâpre**

*UMR CNRS UR1 n° 6553 ECOBIO (Ecosystèmes - Biodiversité – Evolution) Campus scientifique de Beaulieu, bat 14 A 35042 Rennes Cedex*

Keywords: foraging, modeling, spatial correlation, variogram, clonal plants

Although foraging is a growing theme in clonal plant species, no precise quantitative model had yet been proposed to predict the relationship between the local amount of nutrients and the length of spacers.
Using a very simple mathematical model, we demonstrate that, as a blind prospector must stop digging in a place and walk some distance before digging again, a plant must have a prior estimation or knowledge of three types of parameters: the local mean and variance of the soil nutrient content, but also and necessarily, the variogram or correlogram at distance x from the actual position of the mother ramet. This model demonstrated that there is an optimal spacer length under some hypotheses of the spatial variogram structure. More precisely, the condition involves a limit value of the derivative of the variogram curve. It is therefore a novel marginal value theorem, built on space-related conditions rather than on time-related conditions, as in the well-known that is model commonly used for animal foraging.
We realized some simulations showing the optimal character of this strategy. Its application concentrates the offspring ramets efficiently on the richest patches of the field, the poorest patches being crossed very quickly by long spacers until a better area is found.

Session 'Computational vegetation science' / ORAL

## MONTE CARLO SIMULATION AND MATHEMATICAL ANALYSIS OF AN INDIVIDUAL-BASED MODEL FOR CLONAL PLANT DYNAMICS

**Fabien Campillo [1], Nicolas Champagnat [1,2], Cendrine Mony [3]**

*[1] INRIA, Project-Team MODEMIC, Montpellier France (corresponding author: Fabien.Campillo@inria.fr); [2] INRIA, Project-Team TOSCA, Sophia Antipolis, France; [3] Université de Rennes1, UMR 6553 Ecobio, Rennes France*

Keywords: individual-based model (IBM), clonal plant, Markov process, mathematical asymptotic analysis

We propose a stochastic individual-based model for clonal plant dynamics in continuous time and space. This model simulates the growth of clonal networks as a function of the availability of resources, which is modeled as explicit advection-diffusion dynamics for resources. After giving a partially exact simulation scheme of the model, we analyzed through numerical simulation the efficiency of plants to forage resources over the field depending on their growth form. In particular, the foraging efficiency of two differing strategies of space colonization (phalanx vs. guerrilla) was analyzed. Next, we propose a large population approximation of the model for phalanx-type populations, taking the form of an advection-diffusion PDE for population densities, where the influence of the local architecture on the clonal network takes the form of a nonlinear dependence in the gradient of resources. Finally, extensions of the model and other possible large-population scalings are discussed.

Session 'Computational vegetation science' / ORAL

## CONTEXT-DEPENDENT EFFECTS OF PLANT TRAITS ON FITNESS

**Fei-Hai Yu[1], Tomáš Herben [2,3], Radka Wildová [2,4], Deborah E. Goldberg [4]**

*[1] College of Nature Conservation, Beijing Forestry University, Beijing, China; [2] Institute of Botany, Academy of Science of the Czech Republic, Průhonice, Czech Republic; [3] Department of Botany, Faculty of Science, Charles University, Praha, Czech Republic; [4] Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI 48109, USA (corresponding author: feihaiyu@bjfu.edu.cn)*

Keywords: clonal growth model, competition, trait manipulations, virtual experiments

The potential for resource niche space division that underlies species coexistence is largely due to the traits of plants. So far, however, there is limited knowledge on how individual plant traits affect plant competitive performance in mixtures. To examine the role of individual traits in plant performance in mixtures, we used a clonal growth model highly parameterized with five rhizomatous clonal plants. We aim to examine the effect that individual traits have on the performance of the species in mixture relative to the effect they have in monoculture. We also aim to examine how the action of a trait depends on the identity of both the target species and the competitor species and hence the values of other traits of both. The results suggest a rather high degree of consistency: a change in the trait value of the target species that increased its performance in monocultures always increased its performance in mixtures and decreased that of the neighbor species. Moreover, the examined traits strongly affected the competitive ability of a plant in mixture and had 'cascading' effects on its neighbor species. On the other hand, the role that a trait played was, to some extent, species-specific and was modified by the values of the other traits that the plant species have. Thus, the contributions of individual plant traits to the competitive ability of the species are context-dependent and cannot be predicted fully without knowledge of the values of other traits.

Session ‘Computational vegetation science’ / POSTER 77

# DEVELOPMENT OF A MECHANISTIC POPULATION MODEL FOR TIDAL REEDS

**Jana Gevers [1], Boris Schröder [1,2]**

*[1] University of Potsdam, Institute of Earth and Environmental Sciences, Potsdam, Germany (corresponding author: jgevers@uni-potsdam.de);*
*[2] Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany*

Keywords: Tidal reeds, *Phragmites australis*, clonal plant, mechanistic model

The natural river bank vegetation at tidal waterways provides important ecosystem functions and services such as habitat, filtrating solid and dissolved substances from the water, and erosion control for the riverbanks. In many rivers, agriculture, hydraulic engineering and water management threaten the structure, species composition and functionality of tidal reeds (reeds that grow in the tidal zone). Global warming might entail additional risks, such as changes in water levels and a higher frequency of extreme events. Therefore, a better understanding of tidal reeds’ response to the hydrodynamic tidal-regime is essential. We use mechanistic models for analyzing the ecological processes determining distributional patterns and for assessing the impact of global warming on tidal reeds’ distribution in the Elbe River in Germany, focusing on *Phragmites australis*. As the relevant processes and the optimum level of model complexity are difficult to determine *a priori*, we use a simple-to-complex approach by gradually adding more detailed processes and mechanisms to a basic cellular automaton. Potential processes to be included into the population dynamic model are dispersal, competition, adaptive plasticity and physiological integration; whereas potentially important habitat factors represent processes related to hydrodynamics, stress factors such as salinity, competition and disturbances. The model will provide valuable insights into the relationship between habitat variability, ramet growth and reoccurring stable patterns of *Phragmites* distribution, and the model can foster an improved quantitative understanding of processes related to the dynamics and distribution of reeds.

# Clonal growth in plant communities: patterns and roles in community dynamics

Session 'Clonal growth in plant communities' / ORAL

## RELATIONSHIP BETWEEN CLONAL AND SEED DISPERSAL DISTANCES

**Riin Tamme, Meelis Pärtel**

*Institute of Ecology and Earth Sciences, Department of Botany, Tartu, Estonia; (corresponding author: riin.tamme@ut.ee)*

Keywords: clonal plant species, lateral spread, phylogeny, European glaciation history

Dispersal is defined as the unidirectional movement of individuals from their place of birth. In the case of plant species, spatial movement can occur through clonal and/or seed dispersal. Both clonality and seed dispersal are considered important in local dispersal, but seeds contribute most to long-distance dispersal. While the trade-off between clonality and seed dispersal within species has been widely studied, this relationship among species remains ambiguous.
We compiled data on mean and maximum seed dispersal distances (using reviews and case-studies) as well as information about clonal spread (using the CLO-PLA database) for 192 European plant species. Mean seed dispersal distances should represent local dispersal, while maximum distances are more related to long-distance dispersal events. Data for lateral spread were divided into two categories: 1) less than 0.25 m/yr or 2) more than 0.25 m/yr. We used generalized linear models to study the relationship between both mean and maximum seed dispersal distances and clonality. Additionally, we conducted the same analyses considering phylogenetic relationships.
We found no trade-off between clonality and seed dispersal among species. In non-phylogenetic analyses, lateral spread was positively related to both mean and maximum seed dispersal distances. However, this relationship was not significant in phylogenetic analyses, i.e., there is no evidence that these traits have coevolved.
Both ecological and evolutionary factors might explain the positive relationship between clonal and seed dispersal distances. For example, it may be ecologically beneficial to have seed dispersal for long distance and clonal spread for local population expansion. For evolutionary explanation, we suggest that European glaciation history may have promoted species with higher seed dispersal distances, regardless of clonal spread. However, to further explain the positive relationship between lateral spread and seed dispersal distances among species, more studies are needed.

Session 'Clonal growth in plant communities' / ORAL

## CARBOHYDRATE STORAGE IN MEADOW PLANTS AND ITS DEPLETION AFTER DISTURBANCE: DO THE ROLES OF SHOOT AND ROOT DERIVED ORGANS DIFFER?

**Štěpán Janeček, Jitka Klimešová, Jiří Doležal**

*Institute of Botany, Czech Academy of Sciences, Dukelská 135, CZ-379 82 Třeboň, Czech Republic Institution; (corresponding author: janecek@butbn.cas.cz )*

Keywords: carbohydrates, clonal plants, rhizomes, roots, storage

Storage of carbon as carbohydrates out of reach of disturbance is considered to be an adaptation of plants from recurrently disturbed habitats. In temperate meadows, shoot-derived organs located below-ground or near the soil surface (e.g., rhizomes, stem tubers or basal internodes of graminoids) are considered to be organs storing nonstructural carbohydrates (NC). In contrast, the function of roots as NC storage organs of these plants is less often evaluated. The aim of our study was (1) to explore the patterns of NC concentrations in roots versus shoot-derived organs for a representative number of meadow plant species and (2) to use manipulative experiments to determine whether the NC storages in roots and shoot-derived organs are differently depleted after plant disturbance.
To evaluate the patterns of NC concentrations in roots as compared with shoot-derived organs, we analyzed NC concentrations of 18 plant species growing in a dry meadow dominated by *Bromus erectus* and of 14 plant species growing in a wet meadow dominated by *Molinia caerulea* in two periods of the growing season (from June, which is the time before the meadows are traditionally mown, and October, which is the end of the growing season, when the plants should have the maximum amount of NC before winter). To study depletion from roots and shoot-derived organs, we established a pot experiment where four plant species were (i) left intact (ii) defoliated or (iii) fine roots were removed. The plants were harvested after five days, and after three weeks following disturbance, NC were analyzed in roots and shoot-derived organs.
We found that the majority of meadow perennial plants have higher NC concentrations in roots compared with shoot-derived organs, and this pattern was the same at the time of mowing (June) and at the end of the growing season (October). Our experiment demonstrated that NC storage of both roots and shoot-derived organs were similarly depleted after plant defoliation. No decrease of NC concentrations was recorded after disturbance of the root system.
We concluded that roots, but not shoot-derived organs, often represent the main NC storage organs of meadow perennial species and that NC storage within both organ types behave similarly during plant regeneration after disturbance.

Session 'Clonal growth in plant communities' / ORAL

## DISTRIBUTION OF CLONAL TRAITS AMONG WETLAND HABITATS

**Monika Sosnová, Jitka Klimešová**

*Institute of Botany ASCR, Department of Functional Ecology, Třeboň, Czech Republic (corresponding author: Monika Sosnová, sosnova@butbn.cas.cz)*

Keywords: clonal growth traits, wetland habitats, organs of clonal growth, the Netherlands

Clonality is a predominant type of reproduction in wetland plants. Compared with terrestrial habitats, wetlands host larger and easily splitting plant clones. Wetlands are, however, a heterogeneous set of habitats where the soil is saturated with moisture, and they differ in many environmental characteristics including water table dynamics, disturbance, and nutrient availability. Moreover, clonal growth is realized through the growth of various types of clonal organs that can be characterized to a great extent by specific sets of functional traits. Therefore, we asked whether clonal organs and traits are selected into particular habitat types and which traits are typical of specific habitats. First, we analyzed the distribution of clonal growth organs along the hydric gradient of wetland habitats in the Netherlands. Both analyses were performed using the data on clonality from the CLO PLA database and vegetation data from the Vegetation of the Netherlands. The data were analyzed by using two approaches: by a comparison of observed versus expected spectra of clonal organs and traits with contingency tables (presence/absence data) and by a multivariate analysis (CCA), which considered species frequencies. We found that the wettest (aquatic) habitats, i.e., habitats with open water tables, both fresh and marine, hosted species spreading by turions and plant fragments, whereas permanently waterlogged bogs were typical of rhizomatous species. By directly analyzing the distribution of clonal traits, we found that the wettest habitats are also the most specific regarding trait spectra. Those habitats hosted species characterized by the abundant production of easily spreading offspring, monocyclic shoots, and splitting clones. In contrast, species in permanently wet bogs produced polycyclic shoots and had low multiplication rates. With the exception of habitats representing both extremes of the hydric gradient, other wetland habitats were not specific in clonal organs and traits, suggesting weak environmental filtering.

Session 'Clonal growth in plant communities' / ORAL

## EFFECT OF CLONAL COLONIZATION STRATEGY ON PRODUCTIVITY IN PLANT COMMUNITIES: A WIDE-SCALE MESOCOSM EXPERIMENT

**Anne-Kristel Bittebiere, Cendrine Mony, Bernard Clément**

*U.M.R. 6553 Ecobio, Rennes, France (corresponding author: annekristel.bittebiere@orange.fr)*

Keywords: clonal growth strategy, functional group, species richness, productivity

Most species in prairie ecosystems are able to reproduce at short distances through clonality: plants grow by producing new ramets connected through horizontal stems resulting in a clonal network. Clonal plants present different strategies of spatial spreading depending on the degree of network aggregation (guerrilla, phalanx and caespitose strategies).
Our study aims to determine whether the number, nature and specific richness of clonal functional groups have an effect on the plant community productivity. We assumed that 1) the guerrilla group would be less productive than the phalanx or the caespitose groups because they allocate more biomass to connections and that 2) according to the complementarity theory, an increase in the species richness of a community would also result in an increase in its productivity.
We used an experimental approach based on 14 experimental assemblages differing by the number and the nature of the clonal growth strategy (guerrilla, phalanx, caespitose) in the mixture and the number of species per strategy (one or four species). The aboveground biomass was harvested each fall, weighed and used as a measurement of the community productivity.
After two growth seasons, we demonstrated that plots comprising guerrilla species were the least productive, whereas the most productive was a mixture of phalanx and tussock plants with eight species. The species richness has either no effect or increases the biomass production of the community, depending on the mixture of clonal forms. The clonal growth strategy may thus have an effect on some ecosystem functions and on its resulting ecological services.
A second step in our analysis would be to consider the continuum between the guerrilla and tussock forms because the preliminary results suggest that the species form influences the productivity of the community.

Session 'Clonal growth in plant communities' / ORAL

## MOLECULAR GENETIC EVIDENCE FOR CLONAL STANDS OF *QUERCUS PUBESCENS*?

**Camilla Wellstein [1], Francesco Spada [2], Giandiego Campetella[3], Roberto Canullo[3], Carl Beierkuhnlein[1], Alfons Weig[4]**

*[1] University of Bayreuth, Department of Biogeography, Bayreuth, Germany; [2] University "Sapienza", Department of Environmental Biology, Rome, Italy; [3] University of Camerino, Department of Environmental Science, Botany &w Ecology Section, Camerino, Italy; [4] University of Bayreuth, DNA Analytics & Ecoinformatics, Bayreuth, Germany; (corresponding author: francesco.spada@uniroma1.it)*

Keywords: clonal growth, woody plants, oak, persistence, microsatellites

*Quercus pubescens* Willd. is widespread at low and middle altitudes throughout S Europe. In Central Europe, the species is restricted to climatically favorable sites south of approximately 51 degrees latitude. Impressive, several-square-meter-sized, domelike clusters of up to 4 m high oak stems or clusters of dense thickets of stunted growth are scattered on shallow soils in the large seminatural dry grasslands on Monte Gargano on the Adriatic coast of S Italy. Similar clusters have been observed elsewhere in C Apennines (C Italy), in the Považský Inovec Mountains (Slovak Republic), and in Biokovo (S Croatia). For these patterns of stem emergence, it is difficult to determine merely by observation whether they represent distinct individuals or if they are generated by clonal growth. In fact, to the best of our knowledge, clonal growth has never been reported for European oaks so far. We hypothesize that the observed clusters of stems represent single clones of *Q. pubescens*. To test our hypothesis, we investigated the population genetic structure of these *Q. pubescens* stands using molecular markers. Clusters were located in two highland areas of southern and central Italy (Puglia and Marche). Individual stems were tagged and mature leaf tissue was collected for 11 clusters and for a sum of 135 stems, ensuring the inclusion of all potential clonal groupings. DNA was extracted from leaf samples and was amplified by PCR using 17 polymorphic microsatellite loci (simple sequence repeats, SSR) from *Q. petraea*. Allele frequencies were identified for each locus and were subjected to population statistical analyses. The results on genetic differentiation patterns among sampled stems within clusters on Monte Gargano show identical genetic structures, suggesting that they were generated by clonal growth. Field observations confirm the capability of clonal growth by resprouting from the base of the trunk as well as by sprouts from roots. These findings have implications for the persistence of *Q. pubescens* populations across a long time-span of climatic fluctuations (i.e., the last glacial cycle) as well as for their future development in a changing climate. Few other woody taxa have already been identified to be able to persist for more than ten thousand years in form of long-lived clones (in North America: *Quercus palmeri*, *Populus tremuloides*; and in Tasmania: *Lomatia tasmanica*).

Session 'Clonal growth in plant communities' / ORAL

## IS CLONALITY A CRITICAL DIMENSION OF CO-EXISTENCE IN TEMPORARY WETLANDS?

**Dorothy Bell, Peter Clarke**

*University of New England, Botany, Armidale, NSW, Australia (corresponding author: dbell@une.edu.au)*

Keywords: persistence versus regeneration, spatial patterns

We investigated the relative importance of the persistence niche (clonality) versus the regeneration niche (seed bank) in driving patterns of species co-existence in wetlands. First, we contrasted trait proportions (clonal versus non-clonal) in the vegetation of three types of Australian freshwater wetlands: ephemeral gilgai wetlands, semi-permanent lakes and permanent marshes. We found that clonality was overwhelmingly prominent in permanent marshes but that ephemeral wetlands exhibited a smaller proportion of clonal species and a reliance on regeneration from a persistent seed bank. We then examined temporal changes in the importance of persistence and regeneration niches in species of semi-permanent lakes dominated by the clonal emergent macrophyte *Eleocharis*. We found that both clonal growth and persistent seed banks contributed to long-term spatial patterns. Clonal growth was more important in developing the spatial framework over the whole of the wetland. However, regeneration from seed banks not only underpinned this framework in the long term but also was equally as important as clonal growth in developing spatial patterns in the more temporary parts of the wetlands where water levels fluctuated and where disturbance was prevalent.

Session 'Clonal growth in plant communities' / ORAL

## AFLP MARKERS REVEAL HIGH CLONAL DIVERSITY AND EXTREME LONGEVITY IN FOUR ARCTIC-ALPINE KEY SPECIES

**Lucienne C. de Witte[1], Georg F.J. Armbruster [1], Ludovic Gielly [2], Pierre Taberlet [2] , Jürg Stöcklin[1]**

*[1] Institute of Botany, University of Basel, Schönbeinstrasse 6, CH-4056 Basel, Switzerland. [2] Laboratoire d'Ecologie Alpine, CNRS UMR 5553, Université Joseph Fourier, BP 53, 38041 Grenoble cedex 9, (juerg.stoecklin@unibas.ch)*

Keywords: Genet size, maximum age, population persistence, climate change

We investigated the clonal diversity, genet size structure and genet longevity in populations of four arctic-alpine plants (*Carex curvula*, *Dryas octopetala*, *Salix herbacea* and *Vaccinium uliginosum*) to evaluate their persistence under past climatic oscillations and their potential resistance to future climate change. The size and number of genets was determined with molecular markers (AFLP) using a standardized sampling design in several homogenous climax populations across arctic-alpine regions in Europe. Genet age was estimated by dividing its size by the annual horizontal size increment from *in situ* growth measurements. Clonal diversity differed among species, but was generally high with a strongly left-skewed frequency distribution of genet size. The largest *C. curvula* genet had an estimated minimum age of approximately 4100 years and an estimated maximum age of approximately 5200 years, while 67.5 % of the genets in this species were less than 200 years old. The oldest genets of *D. octopetala*, *S. herbacea* and *V. uliginosum* were found to be at least 500, 450, and 1400 years old, respectively. These results indicate that the studied populations have experienced pronounced climatic oscillations in the past, including the Little Ice Age and post-industrial warming. The presence of genets in all size classes and the dominance of presumably young individuals suggest continuous recruitment over time, a precondition for adaptation to changing environmental conditions. Together, persistence and continuous genet turnover may ensure maximum ecosystem resilience. Thus, our results suggest that long-lived clonal plants in arctic-alpine ecosystems will persist despite considerable climatic change.

Session 'Clonal growth in plant communities' / ORAL

## SPACE OCCUPANCY STRATEGIES AND SPECIES DIVERSITY ON A SMALL SCALE IN A TEMPERATE MEADOW

**Jitka Klimešová[1], Tomáš Herben [2, 3], Michal Hájek [4], Martin Dančák [5], Leoš Klimeš[1]**

*[1] Institute of Botany ASCR, Department of Functional Ecology, Třeboň, Czech Republic; [2] Institute of Botany ASCR, Department of Population Ecology, Průhonice, Czech Republic; [3] Charles University, Department of Botany, Prague, Czech Republic; [4] Institute of Botany ASCR, Department of Vegetation Ecology, Brno, Czech Republic; Palacký University, Department of Botany, Olomouc, Czech Republic (corresponding author: klimesova@butbn.cas.cz)*

Keywords: biomass, clonal index, coexistence, shoot cyclicity, species richness

Plants' abilities to function are difficult to evaluate directly in the field. Therefore, a number of attempts have been made to determine easily measurable surrogates, plant functional traits that are relevant for species coexistence and hence community species richness. We believe that for the traits to be functionally relevant, their functionality must be tested. We therefore examined two traits that have been rarely used but that describe well the behavior of plants in a grassland, namely, shoot life-span (1 or 2 years, further called mono- and di-cyclic plants) and plant clonality, which is measured by an index expressing the magnitude of lateral spread and clonal multiplication. We examined whether these two traits affect key community functional indicators such as the number of coexisting species at a small scale plot (5 cm) and biomass on that plot. We expected that species with dicyclic shoots compete primarily with each other and form a matrix for species with monocyclic shoots. Monocyclic shoots are more opportunistic than dicyclic in filling the available space and thus contribute more to species richness and biomass. Moreover, species with monocyclic shoots with stronger clonal growth will contribute to a greater evenness of species abundance (due to filling available space in matrix of plants with dicyclic shoots), while the effect of plants with dicyclic shoots will be opposite. Using data on biomass and shoot number for individual species co-occurring on 225 plots 5 x 5 cm in species rich meadow in White Carpathians (Czech Republic), we supported both hypotheses. We found a positive relationship between species richness and biomass, and this relationship was tighter for plots with a high proportion of plants with monocyclic shoots relative to those with a high proportion of dicyclic shoots. Further, in plots with a low proportion of monocyclic plants, more intensive clonal growth was associated with low evenness, while no such effect was observable in plots with a high proportion of monocyclic shoots. These findings indicate that the traits that underlie space occupancy strategies play an important role in species coexistence and patterns of fine-scale species richness.

Session 'Clonal growth in plant communities' / ORAL

## SPECIES COEXISTENCE ALONG A PRODUCTIVITY GRADIENT IN WET MEADOWS: ASSESSING THE ROLE OF CLONAL AND LHS TRAITS

**Marta Carboni[1], Štepán Janeček[1], Francesco de Bello[1]*, Jirí Doležal[1], Jan Horník[1], Jan Lepš[2], Triin Reitalu[3], Jitka Klimešová[1]**

*[1] Institute of Botany, Czech Academy of Sciences, Dukelská 135, CZ-379 82 Třeboň, Czech Republic; [2] Department of Botany, Faculty of Science, University of South Bohemia, Na Zlaté stoce 1, 37005 České Budějovice, Czech Republic; [3] Institute of Geology, Tallinn University of Technology, Ehitajate tee 5, EE-19086 Tallinn, Estonia. (*corresponding author: fradebello@ctfc.es)*

Keywords: competition, clonal traits, limiting similarity, trait divergence and convergence

Ecological theory predicts that species may coexist either because they are functionally dissimilar (i.e., trait divergence due to niche differentiation), or because they are functionally similar (i.e., trait convergence because species bearing traits associated with low competitive ability will be excluded). However, how the importance of trait divergence and convergence varies across productivity gradients and depending on different vegetative and regenerative traits (including clonality) remains controversial. We sought evidence for trait convergence and divergence across a productivity gradient over 21 wet meadows in central Czech Republic, considering clonal (lateral spread, multiplication rate, persistence of connection, and cyclicity) and LHS traits (leaf, height and seed traits). In each meadow, we recorded species composition over four 1-$m^2$ plots divided into 100 quadrats, and different environmental parameters linked to productivity (standing biomass, soil water table and soil nutrient content). Species spatial aggregation within each plot (calculated by the V-score on the 100 quadrats per plot) was driven by trait dissimilarity between species in approximately 20% of the 84 plots considered, rather independently of the type of traits. The spatially aggregated species were more similar than expected by chance in only in a few plots. The results suggest stronger effects of niche differentiation between species, across multiple ecological functions, rather than a convergence of functionally similar species. Interestingly, the patterns of trait divergence and convergence were only moderately related to environmental variables, challenging the idea of easily predictable changes in assembly rules across productivity gradients.

Session 'Clonal growth in plant communities' / ORAL

## CLONAL INTEGRATION AMELIORATES PHYSIOLOGICAL EFFECTS OF DROUGHT STRESS

**Yunchun Zhang[1,2], Qiaoying Zhang[2], Marek Sammul[1]**

*[1] Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences, Kreutzwaldi 5, Tartu 51014, Estonia ; [2] Shandong Polytechnic University, Jinan, Shandong province, 250353 P. R. China*

Keywords: clonal plant, physiological integration, drought, heterogeneous environment, *Fragaria orientalis*

Abstract: Vegetative multiplication allows clonal systems to spread horizontally and to establish ramets in sites of contrasting resource status. Stolon connections between ramets permit the transportation of resources within the clone. As a result of such physiological integration, clones can act as cooperative systems; effects of drought stress on part ramet can be ameliorated under a heterogeneous environment. In this study, we examined the survival and growth of physiological integration in a clonal plant, *Fragaria orientalis*, growing in homogenous and heterogeneous environments with patches of contrasting quality (three water availability contrasts: (1) homogeneous (no contrast) group; (2) low contrast group; and (3) high contrast group). The survival and growth results demonstrated that drought stress had markedly negative effects on the survival and growth of the severed ramets of *F. orientalis*, especially in high contrast environments. When clonal fragments of *F. orientalis* experienced partial drought, clonal integration showed great benefits to the dry ramets and a small cost to the connected wet ramets. In addition, clonal integration was enhanced in high contrast environments. The results from the production of activated oxygen and the antioxidant system responses also demonstrated that clonal integration can ameliorate the physiological effects of drought stress on the clonal herb *F. orientalis* in a heterogeneous environment.

Session 'Clonal growth in plant communities' / POSTER 78

## PLANT REPRODUCTIVE STRATEGIES IN FLOODPLAINS: THE EFFECT OF AGRICULTURAL PRACTICES AND INUNDATION

**Chloé Chabert[1,4], Serge Muller[2], Bernard Clément[1], Vincent Jung[2,3], Cendrine Mony[1]**

*[1]: Université de Rennes 1, UMR CNRS ECOBIO, Rennes, France; [2]: University of Metz, UMR CNRS LIEBE, Metz, France; [3]: CEMAGREF, Grenoble, France; [4]: (chloe-chabert@hotmail.fr)*

Keywords: prairie systems, trait value, plant communities, reproductive allocation

Plant species coexistence depends on their reproductive strategies that will determine their ability to compete with each other and to colonize their environment. Most plant species in temperate systems combine sexual (fertilization of gametes) and vegetative reproduction (ensured by ramets). The relative allocation to each of these modes may depend on plant species and environmental conditions. In addition, each reproductive mode comprises a large range of possible trait values which will determine plant dispersal and space colonization.
In floodplains, inundation duration and agricultural practices filter plant traits and especially reproductive traits. It is expected that stressful conditions such as a long inundation may select clonal growth, whereas non-stressful habitats may promote sexual reproduction and tussock clonal forms. Agricultural practices should have an effect on both strategies through soil nutrient (soil enrichment) availability and may act as disturbances (e.g., mowing and grazing). The effects of such agricultural practices on selecting reproductive traits should depend on their characteristics (e.g., period, intensity, and frequency).
We used 879 floristic relevés in three different floodplains from Eastern France (Meuse, Sarre and Alzette floodplains) that we characterized by agricultural practices (e.g., type of management and intensity of management) and abiotic conditions evaluated through the indices Moisture (F) and Productivity (N) of Ellenberg. We also characterized reproductive strategies for each plant species via the Clopla and Bioflor databases. We selected traits linked with relative allocation to sexual versus asexual reproduction, characterizing sexual reproduction (e.g., flowering date and pollination vector) or asexual reproduction (e.g., CGO type and clonal growth rate). The effect of environmental conditions on plant traits was analyzed through multivariate analyses. We synthesized our results through a conceptual scheme of reproductive strategies in floodplain habitats. An independent database of a floodplain of western France (Loire River) was used to validate this scheme. We determined applications of this work in terms of management of these ecosystems in the light of global change (changes in climate and agricultural practices).

Session 'Clonal growth in plant communities' / POSTER 79

## ROLE OF CLONAL TRAITS IN THE RESPONSE OF CLONAL FRAGMENTS TO CONTRASTED PATTERNS OF DEFOLIATION: A MODELING APPROACH

**Marie-Lise Benot[1], Cendrine Mony[1], Marc Garbey[2], Malek Smaoui[2], Anne Bonis[1]**

*[1] Université de Rennes 1, UMR CNRS 6553, ECOBIO, Rennes France; [2] University of Houston, Department of Computer Science, Houston TX, USA; (corresponding author: mlbenot@gmail.com)*

Keywords: clonal integration, defoliation frequency, defoliation intensity, individual-based model (IBM), spatial heterogeneity.

Defoliation is a disturbance experienced by a wide range of plant communities, most of which are dominated by clonal plants. Defoliation can vary in spatial pattern, frequency or intensity. This study aimed to disentangle the relationships between clonal traits and defoliation parameters. Two hypotheses were tested. (1) There is at least one optimal combination of clonal traits that maximizes performance. (2) Optimal combinations of clonal traits differ according to defoliation parameters: heterogeneous defoliation promotes high lateral expansion and extensive physiological integration, while homogeneous but frequent and/or intensive defoliation favors compact architecture and resource storage. These issues were addressed using an individual-based model simulating the growth of single clonal fragments submitted to various defoliation patterns. Three indicators of performance were investigated (total biomass, number of ramets and length of the longest connection). Only biomass was affected by defoliation. The expression of clonal traits varied according to defoliation patterns. Homogeneous defoliation selected for only a few combinations. The absence of defoliation was a weaker filter, but selected for similar clonal traits. As expected, heterogeneous defoliation selected for high inter-ramet distances leading to dispersed ramet networks that may spread the risk of defoliation among ramets. In contrast, homogeneous conditions favored a potentially high number of primary connections and small inter-ramet distances, enabling a high occupation of the horizontal plane. Contrary to our expectations, resource storage was not affected by defoliation. When the performance of clonal fragments was estimated by biomass, extensive resource sharing was promoted under intermediate defoliation percentage and fine grain. However, the distance of resource sharing became irrelevant when the other indicators of performance were investigated. This modeling approach has enabled the analysis of the relationships between a large set of clonal traits and defoliation patterns. Further improvements could be implemented, especially by using a synthetic indicator of performance.

Session ‘Clonal growth in plant communities’ / POSTER 80

# THE OPTIMAL FORAGING OF CLONAL PLANTS: EMPIRICAL EVIDENCE OF SAMPLING BEHAVIOR AND INFORMATION USING

**Philippe Louâpre, Anne-Kristel Bittebiere, Jean-Sébastien Pierre, Bernard Clement, Cendrine Mony**

*University of Rennes 1 – UMR CNRS 6553 “EcoBio”, Rennes, France.*

Keywords: Clonal growth, foraging behavior, information, spacer length

Clonal plants are able to colonize space at short distances by producing connected ramets that form a network structure. They may exhibit complex foraging behavior to maximize their resource intake across the landscape. They respond to spatial heterogeneity by changing their spacer length or branching frequency. This morphological plasticity is considered an active foraging response in plants, leading to the aggregation of ramets in favorable environments. This foraging behavior suggests that ramets can evaluate the local quality of their environment and can share this information through the whole clone. Little is known, however, about how clonal plants perceive and use information about their environmental resource distribution. We studied the behavioral response of two *Potentilla* species, foraging on different artificial environments, by measuring the spacer length between each ramet along a plant stolon. Four environments were tested, either of constant (rich, medium or poor soil) or of varying quality (random series of these soils). We also tested the effect of the experience acquired by the clone on its foraging response. We have shown that the two related species do not respond similarly to the quality of the environment and to the resource distribution among ramets. *P. anserina* perceives the global quality of its environment, whereas *P. reptans* perceives changes in quality while sampling. We demonstrated in both species that the clonal individual is able to determine the local soil quality at each new rooted ramet relative to the patch richness sampled by previous ones. Our results demonstrated that, as has been shown for animal foragers, clonal plants glean information from ramet to ramet and adjust their foraging behavior accordingly. The network pattern of ramets and spacers could then mimic the Bayesian updating of patch richness estimates, without any cognitive structure.

# Describing biodiversity patterns: trait-based analyses of plant communities

Session 'Trait-based analyses of plant communities' / ORAL

## FUNCTIONAL COMPLEMENTARITY IN A WET GRASSLAND AND ITS IMPACT ON ECOSYSTEM SERVICES

**Pierre Chanteloup, Michel Thomann, Olivier Jambon, Anne Bonis**

*Université Rennes 1, UMR-CNRS 6553 ECOBIO, Rennes, France (corresponding author: pierre.chanteloup@univ-rennes1.fr)*

Keywords: functional diversity, biomass production, root traits.

Trait diversity in plant patches and communities may promote species complementarity in resource use, enabling the maximization of the resources used by plants. Spatial and temporal complementarity may also occur among species and among plant patches and thereby promote community performance. This study investigates whether complementarity effects intervene and drive ecosystem services in wet grazed grasslands i) between species, within plant patches, and ii) between patches, within plant communities. This work will thus test the importance of the functional diversity for community performance. Alternatively, the hypothesis that ecosystem services are mainly driven by community weighed mean traits rather than functional diversity will be considered.

Both agronomic and patrimonial criteria will be considered ecosystem services, taking into account various spatial scales in the grasslands as well as the temporal dynamics of the assemblages all along the vegetation season (from March until October).

*In situ* plant height and leaf traits (SLA, LDMC, C/N) were measured for most species occurring in the patches and communities, i.e., for 23 species. Root traits were measured in controlled conditions for 20 species. Those traits measurements will allow us to examine species growth and resource uptake abilities. We will investigate the relationship between i) mean trait values and functional dissimilarity among species and ii) productivity, forage quality, forage stability along the grazing season and patrimonial value of the grassland.

We will then discuss whether the heterogeneous character of the vegetation, due to the occurrence of elevation contrast and grazer-selective foraging, presents beneficial effects on the agronomic and patrimonial value of the studied grasslands.

Session 'Trait-based analyses of plant communities' / ORAL

## RAUNKIAER'S LIFE-FORMS AND INTER-SPECIFIC RELATIONS IN PATTERN FORMATION UNDER VARYING LAND USES IN SEMIARID SE SPAIN

**M.C. Cobo[1], J.A. Carreira[1], H.H. Wagner[2]**

*[1] University of Jaen, Department of Zoology, Botany and Ecology, Jaen, Spain ; [2] University of Toronto at Mississauga, Department of Biology, Mississauga, ON, Canada ; (corresponding author: mccobo@ujaen.es)*

Keywords: fertility islands, Mediterranean desertification, patchiness, reforestation, woody encroachment.

Fine spatial scale in soil and vegetation is as important as time for understanding how facilitation and competition interact for the recovery of arid zones from intensive land use. The distributional position of species on environmental gradients appears to be crucial for predicting the proportions of species involved in positive or negative interactions. Different life-forms represent different survival strategies during periods of drought, high temperatures or torrential rains characteristic of arid ecosystems. Under such harsh conditions, plant interactions may shift their sign. Our objective was to assess the relative contribution of species and life-forms to pattern formation and to positive associations, indicating facilitation, or negative associations, indicating competition processes. We selected a toposequence of five stages of secondary succession (*Stipa-,* grazing pasture-, *Artemisia-, Retama-* or *Pinus*-dominated), accounting for the effect of underlying soil properties. In each stand, the surface soil properties and cover of plant species were analyzed along a perpendicular-to-slope transect of contiguous 0.25-$m^2$ quadrats. Species richness was higher in naturally colonizing vegetation at moderate slopes in the three intermediate stages, with a stronger dominance of Therophytes. To account for spatial autocorrelation and the effect of soil on species distributions, we performed the classic and the spatial versions of the variance test. It showed salient positive inter-species relations under arrested succession in the extreme topographical conditions of (*Stipa*-), semi-natural pre-forest phases (*Retama*-) and *Pinus*-reforested vegetation. Analyses based on species richness showed a higher sensitivity for detecting positive associations. Cover data did so for detecting negative interactions, also evident by the coincident scale and strength of spatial patterns. These patterns were analyzed using variance partitioning with principal components of neighbor matrices-PCNM and multi-scale ordination-MSO. Therophytes showed the strongest spatial pattern and the highest level of positive inter-specific associations, both for richness and cover. The spatial pattern of the Therophytes was strongly related to the soil characteristics in the *Pinus*-dominated plot, and both to soil and other life-forms patches in the *Stipa*-dominated plot. A neutral relationship between Phanerophytes and Chamaephytes and a positive association at fine scales between Chamaephytes and Therophytes may be related to the driest conditions in the pasture compared with *Artemisia* and especially *Retama* plots. Our results suggest that facilitation becomes more important when abiotic stress is high in late- and mid-succession in which competition and consumer pressure is still intense.

Session 'Trait-based analyses of plant communities' / ORAL

## ASSEMBLY RULES IN THE UNDERSTORY OF A TEMPERATE FOREST

**Lars Götzenberger, Kadri Koorem, Mari Moora, Kristjan Zobel, Martin Zobel**

*University of Tartu, Department of Botany, Tartu, Estonia (corresponding author: lars.gotzenberger@ut.ee)*

Keywords: Community assembly, null models, functional diversity

Assembly rules are patterns in the structure of communities and result from biotic and abiotic filtering processes. These patterns may be used to infer the processes by which communities are assembled, specifically to determine if communities are assembled randomly or deterministically from the species pool. The principle of niche differentiation suggests that species must be functionally different to coexist, and the observed pattern should be increased dissimilarity among coexisting species. Hence, the validation of assembly rules may be performed by using traits to examine the functional composition of the observed community compared with a randomly generated community (i.e., null model analyses).
We studied community assembly patterns in the understory vegetation of a temperate forest in Estonia, at two different sites of different successional stages, one ~130 year old mature forest and one young forest 20 years since clear cutting. Data were recorded in small-scale plots (0.0625 $m^2$) and several traits were measured for individuals in the study area (plant height, vegetative mobility, root:shoot biomass ratio, and seed bank), while further traits were obtained from databases (rosette growth form and seed dispersal). We used several common tests to examine functional community assembly: guild proportionality, texture convergence, functional evenness and functional divergence. We found that species coexisting at small scales were functionally more diverse than expected at random, supporting the principle of niche differentiation. For tests of guild proportionality, functional evenness and functional divergence, results were consistent, providing strong support that biotic interactions are important in community assembly. For some of the studied traits, we found different results depending on the successional age of the community, with greater support for niche differentiation in the young forest compared with the mature forest. These findings contradict those of theoretical models that predict a greater influence of competition-driven assembly in later successional stages. We conclude that biotic interactions are an important process governing the assembly of this understory plant community but that the influence of competition can depend on the successional age of the forest.

Session 'Trait-based analyses of plant communities' / ORAL

## TRAIT-BASED ANALYSIS AND COMMUNITY ASSEMBLY OF NATIVE AND EXOTIC SPECIES ON SUBARCTIC ROADSIDES

**Jamie Leathem, Mark Vellend, Jeannette Whitton**

*University of British Columbia, Botany Department, Vancouver, Canada. (Jamie Leathem: kermit@interchange.ubc.ca)*

Keywords: functional traits, community assembly, null model, roadside, invasive plants

Forces that maintain coexistence in diverse plant communities are still much debated, but recent research using trait-based analysis suggests that coexistence is facilitated by differences in ecological strategy among species. While these findings indicate niche-based processes are vital in structuring communities, the generality of results across different ecosystems is unknown. We applied trait-based analyses to subarctic roadside communities to look for evidence of non-random assembly processes in an environment that is both exclusive to northern latitudes and representative of a ubiquitous disturbance type. We measured four functional traits and species abundance in 42 roadside plots in Yukon Territory, Canada. Using null models, we tested for signatures of habitat filtering and competitive exclusion, two important niche-based assembly processes. Our results show that the ranges of trait values across plots are smaller than expected based on random sampling from the regional species pool, a pattern suggestive of habitat filtering. We also find evidence of competitive exclusion indicated by a greater than expected local evenness of spread of trait values. In addition, we compared trait values between native and invasive species and detected a greater mean height for invasive species than for native species. The spread of invasive species is a pervasive threat to global biodiversity and identifying trait differences between groups can improve our ability to predict future invasions. Moreover, roads are common vectors for exotic species, so understanding the mechanisms of community assembly in their proximity will have important implications for the development of conservation management strategies.

Session 'Trait-based analyses of plant communities' / ORAL

## FUNCTIONAL CHANGES IN CALCAREOUS DRY GRASSLANDS IN GERMANY OVER TIME

**Ute Jandt, Helge Bruelheide**

*Institute of Biology / Geobotany and Botanical Garden, Halle/Saale, Germany (ute.jandt@botanik.uni-halle.de)*

Keywords: vegetation database, temporal trends, generalized linear models, traits

The German Vegetation Reference Database (GVRD) was used to analyze shifts in trait composition in calcareous dry grassland vegetation over time. A total of 6868 vegetation relevés from 69 different years spanning the period from 1927 to 2003 was tested for temporal shifts both in weighted mean trait values and in trait variation. Trait variation across different traits was analyzed by calculating functional diversity according to Rao's quadratic entropy. Species traits were extracted from different trait databases (e.g., BIOLFLOR and LEDA). In addition, Ellenberg indicator values and indicator values for mowing and grazing resistance were included in the analysis. We employed different evaluation strategies by either including all data without further aggregation or stratification, thus using all available single years as intervals and by accounting for different sampling intensity in different time intervals by resampling the same number of relevés per decade.
We found a clear shift in the mean trait values for traits related to increased productivity (i.e., increased Ellenberg N and F values) and in life forms (i.e., increased proportion in grasses and grass-like species). This shift corresponds to previous findings of directed temporal losses in species over time, evident in a decrease in temporal frequency of plant species with the traits mentioned. However, trait variation remained largely unchanged, pointing to a compensation for loss in species by other species with similar traits. The temporal changes will be discussed against the background of grassland management and nature conservation strategies.

Session 'Trait-based analyses of plant communities' / ORAL

## DO ABOVE-GROUND ASSEMBLY RULES APPLY BELOW-GROUND?

**Jodi Price, Inga Hiiesalu, Meelis Pärtel**

*University of Tartu, Department of Botany, Tartu, Estonia; (corresponding author: Jodi Price, Email: Jodi.Price@ut.ee)*

Keywords : DNA, guild proportionality, niche limitation, roots

Niche theory predicts that the number of species in a community is limited by the number of available niches. Some evidence has been found for niche limitation in plant communities, and much ecological theory has been developed around this concept. Importantly, this theory has been developed on the basis of studies that have sampled only above-ground species diversity. However, a major portion of vegetation resides below-ground as roots, rhizomes, and seeds. The small-scale diversity of the below-ground component of vegetation has not been measured previously because of methodological constraints in identifying roots and rhizomes among species. We used high-throughput DNA-based techniques to identify roots and rhizomes from mixed species samples, to measure small-scale below-ground diversity in temperate grasslands. Niche limitation is usually tested by examining the observed variance in species richness compared with a null model of random assembly. If niche limitation occurs, the proportion of species in each guild should also be relatively constant (i.e., guild proportionality). We used two common tests (richness variance and guild proportionality) to examine niche limitation, which have previously been applied only to above-ground data. We found some evidence for niche limitation in above-ground samples, for guild proportionality (with lower variance than was expected), but not for richness variance (which did not differ from random). However, we found significantly greater variation in species richness and guild proportionality than expected by chance for below-ground data, suggesting that environmental heterogeneity drives community assembly below-ground and not niche limitation. We found good evidence, on the basis of the agreement between the two tests, that niche limitation does not govern below-ground assembly and that species richness is largely driven by environmental heterogeneity.

Session 'Trait-based analyses of plant communities' / ORAL

## FUNCTIONAL DIVERSITY INDICES REVEAL COMMUNITY ASSEMBLY PROCESSES ALONG A SOIL CHRONOSEQUENCE

**Norman W.H. Mason[1], Sarah J. Richardson[2], Duane A. Peltzer[2] David A. Wardle[2,3], Robert B. Allen[2]**

*[1] Landcare Research, Private Bag 3127 Hamilton, New Zealand; [2]Landcare Research, P.O. Box 40, Lincoln 7640, New Zealand; [3]Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, SE901-83 Umea, Sweden*

Question: Can functional diversity reveal evidence for changes in assembly processes at multiple scales in forest communities spread along a phosphorous gradient associated with a soil chronosequence?
Study Site: A 120,000-year soil chronosequence generated by a retreating glacier in the southwest of the South Island, New Zealand.
Methods: Basal area and leaf nitrogen, phosphorous, thickness and density of all woody species was recorded in eight sites ranging in age from 60 to 120,000 years and in total soil P from 100 to 805 mg/g. Hierarchical partitioning of Rao's quadratic entropy was used to quantify functional diversity at local (quadrat), regional (site) and beta scales. Observed local and regional Rao were compared with random expectation using a null model which randomizes abundances across species within quadrats and sites respectively. Simpson's Diversity was also used to measure local, regional and beta taxonomic diversity. Relationships between functional and taxonomic diversity were examined using a Jackknifed linear regression. Analyses were performed using both quantitative abundances and presence-absence data.
Results: There was no evidence for a relationship between raw local Rao values and total Soil P. However, there was a strongly significant positive relationship between local Rao expressed relative to random expectation and total soil P. There was also evidence of a positive relationship between beta Rao and total soil P. Neither measure of regional Rao nor any of the taxonomic diversity measures were related to total soil P. When presence-absence data were used, none of the diversity measures examined was related to soil P.
Conclusions: Our results provide evidence that constraints on the traits required for dominance in local communities intensified with declining soil P. Our results also suggest that local communities became functionally more homogeneous with declining soil P. This finding demonstrates that functional diversity indices may reveal changes in community assembly processes along ecological gradients. However, this finding also shows that care is required in choosing how to quantify functional diversity. In particular, our results highlight the need to obtain an objective estimate of species abundances and also show that expressing functional diversity relative to random expectation may be the most powerful method for revealing changes in functional diversity along ecological gradients.

Session 'Trait-based analyses of plant communities' / ORAL

## DETECTING COMMUNITY ASSEMBLY PATTERNS ALONG A SOIL DEPTH GRADIENT IN A MEDITERRANEAN RANGELAND

**Maud Bernard-Verdier [1], Mark Vellend [3], Marie-Laure Navas [1,2], Eric Garnier [1]**

*[1] Centre d'Ecologie Fonctionnelle et Evolutive, Département d'Ecologie Fonctionnelle, Montpellier, France; [2] Ecole Nationale Supérieure Agronomique de Montpellier, Département des Sciences pour la Protection des Plantes et Ecologie, Montpellier, France; [3] Université de Sherbrooke, Département d'Ecologie, Québéc,Canada (corresponding author: bernard-verdier@cefe.cnrs.fr)*

Keywords: functional diversity, community assembly, rangelands, drought, null models

Overdispersion of functional attributes in a community has often been interpreted as evidence of limiting similarity due to competition, whereas trait convergence is understood as an indicator of environmental filtering. However, this paradigm, which was first established for animal communities, remains controversial in plant communities (Grime, 2006). Predictable trends in community-wide mean functional traits along productivity or stress gradients have been reported frequently (Wright et al., 2004). However, there is still no consensus on what patterns of trait distribution are to be expected along these environmental gradients.
We have investigated the distribution of 8 plant functional traits along a soil depth gradient in a dry calcareous rangeland in the south of France. The site is characterized by summer droughts and grazing, with water and nutrient stress increasing as soils became shallower. Using appropriate null models, we have tested for (i) environmental filtering on the local range and standard deviation of traits among species and (ii) trait overdispersion (indicative of limiting similarity created by competition) using mean nearest neighbor distances and the standard deviation of ordered neighbor distances. We expected functional strategies to converge in water-stressed communities and to show signs of limiting similarity due to competition for light-capture in the more fertile deep-soiled communities. However, we found quite different patterns.
We detected habitat filtering in the water-stressed communities and also in the productive ones, although different sets of traits were involved. Moreover, patterns of trait overdispersion were observed mainly in the water-stressed communities, whereas traits related to resource acquisition and competition for light tended to converge at the fertile end of the gradient. We discuss how observed patterns of trait dispersion along the gradient could lead to different interpretations of assembly mechanisms in plant communities depending on traits, abundances, and spatial scale.

Session 'Trait-based analyses of plant communities' / ORAL

## CHANGES IN PHENOLOGY AND PHYSIOGNOMY ALONG A PRECIPITATION GRADIENT IN BAJA CALIFORNIA, MEXICO

**Sula Vanderplank[1], Exequiel Ezcurra[1,2]**

*[1] University of California, Department of Botany and Plant Sciences, Riverside, USA; [2] University of California, UC-MEXUS, Riverside, USA; (corresponding author: sula.vanderplank@gmail.com)*

Keywords: Baja California, fog, phenology, precipitation gradient

In North America, the transition from Mediterranean-type ecosystems to coastal fog deserts occurs in northwestern Baja California, at the southern extent of the California Floristic Province (CFP) where it meets the northern edge of the Vizcaino Desert. The area has a predominant contingent of CFP plants, and it is a hotspot of plant endemism with approximately 30% of the native flora being locally endemic. Although temperatures north of the 30th parallel are fairly constant, rainfall decreases rapidly as one moves south along a gradient of over 300 km. The California Current upwells cold water along the coast, which causes heavy coastal fogs to hover over the land through the dry summer months, providing significant additional moisture. Several physiognomic adaptations to drought tolerance and localized climate are observed in the region, which prompts the following questions: What factors control plant phenology in this region? Can the timing of phenological events be seen to change across the precipitation gradient? Does phenological strategy vary with plant physiognomy? Long-term weather data for the broader region document large-scale climate patterns through space and time. Six weather stations were installed throughout the precipitation gradient. Plant species and their phenological stages were recorded every two months to reveal local variations. Previous studies indicated that the majority of the perennial plants in the California Floristic Province were plastic in their response to rainfall, rapidly leafing out and flowering as water becomes available. Phenological data from the southern end of the rainfall gradient shows considerable inter-annual variation in flowering events, suggesting a heavy dependence on water-availability (and not on day-length or temperature cues). Fog-harvesting species and those that exhibit true succulence appear to have more stable flowering times than drought-deciduous and sclerophyllous species. The timing and seasonality of plant phenological events in turn affect all higher trophic levels, causing pulses in resources availability.

Session 'Trait-based analyses of plant communities' / ORAL

## INTRASPECIFIC VARIABILITY IN CLONAL GROWTH IN RESPONSE TO EXTREME CLIMATIC EVENTS

**Camilla Wellstein[1], Patrizia Paci[2], Daniel Thiel[1], Juergen Kreyling[1], Anke Jentsch[3], Carl Beierkuhnlein[1]**

*[1] University of Bayreuth, Dept. of Biogeography, D-95440 Bayreuth, Germany ; [2] University of Camerino, Department of Environmental Science, Botany & Ecology Section, Camerino, Italy; [3] University of Bayreuth, Disturbance Ecology, D-95440 Bayreuth, Germany; (Corresponding author: camilla.wellstein@uni-bayreuth.de)*

Keywords: functional traits, clonal growth, grassland, drought, provenance

Current plant functional trait research aims to predict the outcome of land use and climate change at the species, community and ecosystem levels. However, there is little insight into the role of the intraspecific variability of these traits. Initial research results suggest that the functional variability of plant species may be crucial to adapt to rapidly changing environmental conditions.

Here, we investigate the impact of climate change phenomena such as drought and warming on the clonal growth of common and agriculturally important grass species (*Alopecurus pratensis, Arrhenatherum elatius, Festuca pratensis*, and *Holcus lanatus*). Furthermore, we tested for significant differences among five provenances from different climatic regions of Europe (Bulgaria, Spain, Italy, Germany, and Sweden). Clonal diversity and clonal growth were measured for 50 to 100 individuals of each species in a controlled pot experiment. The measures included the presence of clonal growth organs (CGOs) and the number of respective tillers and buds.

A mixed model analysis was applied to test each species for differences in treatment and provenance. Results indicate significant differences between provenances in the number of hypogeogenous rhizomes for *A. elatius* and *A. pratensis*. Epigeogenous rhizomes reacted significantly to treatment in *A. elatius*, mostly with a higher production under warming. Clonal diversity was not significant. The results for *H. lanatus* and *F. pratensis* were not statistically significantly different.

The clonal growth of species can differ substantially because of their provenance as demonstrated with the study species' growth by hypogeogenous rhizomes that can in turn influence their response to extreme climatic events. However, the other most common type of clonal growth organs in European plant species, the epigeogenous rhizome, turned out to be produced similarly across provenances.

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## INFORMATION FROM TREE SAPLING INDIVIDUALS REVEALS TRAIT CONVERGENCE AND TRAIT DIVERGENCE ARE RELATED TO GRADIENTS IN FOREST PATCHES

**Marcos Carlucci, Helena Streit, Leandro Duarte, Valério Pillar**

*Universidade Federal do Rio Grande do Sul, Departamento de Ecologia, Porto Alegre, Brazil (corresponding author: marcos.carlucci@gmail.com)*

Keywords: microhabitat, environmental filtering, assembly rules, limiting similarity, niche partitioning

Niche theory can be divided in two research programs: the first evaluates to what extent the members of a community tend to exhibit similarity of functional traits, whereas the second emphasizes that functional differences between organisms enable their coexistence. By exploring community trait distribution, it is generally accepted that the local action of environmental filters generates the trait-convergence assembly pattern (TCAP), whereas limiting similarity leads to the trait-divergence assembly pattern (TDAP). We evaluated the TCAP and TDAP of tree saplings in relation to ecological gradients in a microhabitat scale and inferred niche-mechanisms potentially responsible for community assembly. For this procedure, we followed a taxon-free approach using individual-based trait information from 1132 saplings occurring in 40 plots placed along gradients of canopy openness and grazing intensity in forest patches in southern Brazil. The results revealed that both TCAP and TDAP indicated niche mechanisms for the assembly of sapling communities. Specific leaf area (SLA), leaf area (LA) and frequency of toothed leaf margin (TM) maximized TCAP. SLA and TM showed a tendency to increase under closed canopies, whereas LA presented higher values in intermediate proportions of canopy openness. SLA and LA maximized TDAP and tended to vary more under closed canopies, whereas SLA and the frequency of spines that also maximized TDAP presented higher variation under lower grazing intensity. The taxon-free approach was very useful for inferring the niche mechanisms of tree sapling assembly in forest patches, although the role of phenotypic plasticity in shaping these communities is still unknown. By adopting an individual-based trait approach, we assumed that both intraspecific and intrapopulation trait variability were relevant for revealing the assembly patterns. We argue that, besides the great value for interpreting trait convergence, the use of individual-based trait data in a metacommunity framework is the best way to directly explore how trait divergence actually behaves along a gradient and to localize precisely in which part or parts of the gradient higher variation of such traits is occurring.

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## FLORISTIC AND FUNCTIONAL COMPARISON BETWEEN KARST GRASSLANDS OF THE NORTHERN ADRIATIC KARST

**Nataša Pipenbaher*, Mitja Kaligaric, Sonja Škornik**

*University of Maribor, Faculty of Natural Sciences and Mathematics, Biology Dept., Koroška 160, SI – 2000 Maribor, Slovenia;*
*E-mail: natasa.pipenbaher@uni-mb.si*

Keywords: dry grasslands, plant functional traits, SW Slovenia, DCA, CSR plant strategies

We analyzed species composition and species functional traits in the two types of extensively managed karst grasslands. Karst pastures are characterized by shallow rocky soils, high pH, and dry, warm conditions, whereas karst meadows have developed on deeper soil, with more humus and moisture and neutral to alkaline pH. The data set included a table with 100 phytosociological relevés of the studied grasslands and a matrix with 15 functional traits determined for 180 plant species. We found high species richness in these grasslands but no statistically significant differences in species richness between pastures and meadows. Differences in floristic composition were analyzed with Detrended Correspondence Analysis, which supported a clear division between the two vegetation types and indicated that species composition could be explained best in terms of soil humidity and nutrient availability. We also detected several differences in plant functional traits between meadows and pastures. Some of the traits indicate greater resource availability on karst meadows (in particular, high SLA, low LDMC). In contrast, karst pastures have more slow-growing species with a combination of traits that can be interpreted as an avoidance strategy in relation to disturbance (e.g., grazing) in low productive habitats (e.g., low SLA, high LDMC, early flowering species and plants with rosette). A lower relative proportion of competitors (C) and ruderals (R), and a higher relative proportion of stress tolerators (S) in karst pastures also suggested that these grasslands generally experience higher intensities of stress when compared with karst meadows, presumably as a result of lower resource availability on rocky shallow soil. We conclude that karst meadows and pastures differ significantly in both floristic composition and functional trait means, as a result of their distinctive land-use (disturbance) and environmental conditions.

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# PLANT BIODIVERSITY RICHNESS OF THE KARST MOUNTAINS AND THEIR SUSTAINABLE CONSERVATION (DINARIDES, W.BALKAN)

**Sulejman Redzic**

*Academy of Sciences & Art of Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina; Tel./Fax: +387 33 64 91 96; E-mail: sredzic@anubih.ba; Center of Ecology & Natural Resources of the Faculty of Science of University of Sarajevo, Bosnia and Herzegovina*

Keywords : vegetation, syntaxonomy, karst biotopes, endemic plants, refuge

There are rare places that are still characterized by rich biodiversity and, at the same time, a high rate of endemism. Such refuges are developing centers of endemic biodiversity. One such area is a complex of the karstic mountains Prenj-Čvrsnica and Čabulja in Herzegovina (W. Balkan). This has been confirmed by a study that researched the plant communities and their structure and dynamics, which took place throughout several seasons from 2005 to 2008. Vegetation cover, as a reliable indicator for specific karstic circumstances, is being differentiated in the investigated area into a great number of syntaxa (plant communities) that encompass more than 2500 vascular plants. On the surface of approximately 100,000 ha, we identified up to 236 plant communities, 116 alliances and 63 vegetation orders that belong to 34 classes. This amounts to 34% of the total number of European vegetation classes, to 100% of the currently known vegetation classes in Bosnia and Herzegovina, and to more than 80% of classes at the level of Montenegro and Croatia. Nearly 450 endemic and relict species have been identified, which is why most of the identified communities are endemic and relict ones, not only at the level of association, but also at the level of higher syntaxonomic categories, such as alliance and order. The highest diversity level characterizes those communities that make a direct contact with the calcareous geological foundation either in rock crevices belonging to the class *Asplenietea trichomanis*, or in screes on limestone that are comprised of the classes *Thlaspietea rotundifolii* and *Drypetea spinosae*, the sub-alpine and alpine pastures *Elyno-Seslerietea*, and the rocky grassland *Thero-Brachypodietea*. The high level of floristic and vegetation richness places this area among the most diverse areas both in Europe and whole Mediterranean region. Such a pattern of vegetation (syntaxonomy) and floristic diversity confirms the unique role of the dinaric-herzegovina's karst as a complex of unrepeatable ecological factors on global scale. These centers require the effective protection of biodiversity and sustainable management.

# Dispersal in space and time

Session ‘Dispersal in space and time’ / ORAL

## BETTER DISPERSAL MEANS A WIDER REALIZED SPECIES NICHE

**David Zelený**

*Masaryk University, Department of Botany and Zoology, Brno, Czech Republic (zeleny@sci.muni.cz)*

Keywords: habitat specialization, dispersal traits, spatially explicit, simulation model, spatial mass effect

Is there a link between species dispersal ability and the width of its realized ecological niche? And if so, what could be the mechanism behind this link?
To answer these questions, I used two approaches: (1) an analysis of data from a spatially explicit simulation model, in which all species have equal widths of their fundamental niches and differ in dispersal abilities and (2) an analysis of a real vegetation dataset of understory herb species in a temperate forest, combined with species trait data related to dispersal. The widths of realized species niches were in both cases calculated using the habitat specialization metric, based on the species co-occurrence pattern. Analyses of both simulated and real datasets reveal a positive relationship between a species’ dispersal abilities and the widths of their realized niches. In the understory of a temperate forest, immobile shade-tolerant herb species with relatively few heavy seeds will tend to be habitat specialists, while easily dispersed, light-demanding species with many light seeds will tend to be habitat generalists.
A possible mechanism for this relationship is a spatial mass effect. Theoretically, the species realized niche can be wider than its fundamental niche, i.e., the species may occur in an unfavorable habitat because of the existence of sink-source dynamic between populations of favorable (source) habitats and nearby unfavorable (sink) habitats. The species with a better dispersal ability will have a higher potential for spatial mass effect and, consequently, a wider realized species niche. The positive link between the dispersal ability of species and its realized niche width could therefore be interpreted as indirect evidence that the pattern of forest herb understory vegetation is influenced by the spatial mass effect.

Session ‘Dispersal in space and time’ / ORAL

## SPATIAL PATTERNS IN ARCTIC PLANT COMMUNITIES ACROSS EURASIA: THE EFFECT OF PLANT DISPERSAL ABILITIES

**Jonathan Lenoir [1], Risto Virtanen [2], Jari Oksanen [2], Lauri Oksanen [3], Miska Luoto [4], John-Arvid Grytnes [5], Jens-Christian Svenning [1]**

*[1] Aarhus University, Department of Biological Sciences, Aarhus, DK ; [2] University of Oulu, Department of Biology, Oulu, FI ; [3] University of Turku, Department of Biology, Turku, FI ; [4] University of Helsinki, Department of Geosciences and Geography, Helsinki, FI ; [5] University of Bergen, Department of Biology, Bergen, NO (corresponding author: Lenoir.john@gmail.com)*

Keywords: arctic biome, dispersal, local-to-regional richness relationship, plant communities, species turnover

The role of dispersal in controlling spatial patterns in species diversity is controversial, especially on local scales, where local environmental factors and interspecific interactions are thought to be the predominant determinants. If dispersal is an important control of plant diversity, then plant dispersal ability should affect both the geographical turnover in species composition and the local-to-regional species richness relationship. Here, we aimed to test whether the spatial patterns in arctic plant communities differ among three plant groups with contrasting dispersal ability: seed plants with relatively large diaspores, mosses and moss allies with small minute diaspores, and lichens with even smaller diaspores. A total of 1132 vegetation plots from 151 transects located in 16 different regions across the Eurasian arctic tundra were used. For each group of plants, we computed the slope of the dissimilarity-to-distance relationship (DDR) between pairs of sites as well as the slope of the local-to-regional relationship (LRR) in plant richness, both with and without accounting for environmental effects. We found that seed plants had the steepest DDR, followed by mosses and moss allies, and finally lichens, whether or not we controlled for environmental effects. Mosses and moss allies had a stronger LRR than seed plants, albeit this difference did not remain significant after controlling for environmental effects. Lichens had the strongest LRR, even when we accounted for environmental effects. We concluded that spatial patterns in arctic plant communities across Eurasia vary among the three plant groups largely as expected from their different dispersal abilities. Notably, we find clear evidence for dispersal being clearly linked to spatial turnover in species composition and also linked to the extent to which local communities are proportional to the regional species pool. Our findings thereby suggest that dispersal may play a strong role in plant community assembly across Eurasia’s large arctic tundra biome.

Session 'Dispersal in space and time' / ORAL

## ROLE OF THE SEED BANK AND SEED RAIN IN THE REGENERATION OF A TRANSITION FOREST NEAR ANDOHAHELA NATIONAL PARK, MADAGASCAR

**Elise Buisson[1], Noromiarylanto Fanambinantsoa[2], Harijaona Ramanoelina[2], Harison Rabarison[2], Fidisoa Ratovoson[3], Mélissa De Wilde[1,4], Porter P. Lowry II[5,6]**

*[1] UMR CNRS IRD - Institut Méditerranéen d'Ecologie et de Paléoécologie, IUT d'Avignon, Université d'Avignon et des Pays de Vaucluse, France ; 2 Département de Biologie et Ecologie Végétales, Faculté des Sciences, Université d'Antananarivo, Madagascar ; 3 Missouri Botanical Garden, Madagascar Research and Conservation Program, Antananarivo, Madagascar ; 4 UMR 5023 Laboratoire d'Ecologie des Hydrosystèmes Fluviaux, Université Claude Bernard Lyon 1 Villeurbanne Cedex, France ; 5 Missouri Botanical Garden, Africa and Madagascar Department, St. Louis, Missouri, USA ; 6 USM 7205 CNRS Département Systématique et Evolution, Muséum National d'Histoire Naturelle, Paris, France (corresponding author: elise.buisson@univ-avignon.fr)*

Keywords: Resilience, tropical forest, seed rain transfer, soil transfer, nucleation

This study investigates the influence of now-abandoned slash-and-burn cultivation on the resilience of a transition forest in SE Madagascar. The study sites are located midway along a precipitation/altitudinal gradient across a corridor between two large areas of the Andohahela National Park, one supporting an upland parcel of humid forest and the other supporting a lowland dry spiny thicket. The restoration of gaps in this narrow, sinuous corridor may be essential to retain connectivity as the impacts of climate change are likely to be particularly severe in this region. Vegetation surveys carried out in 2009 on 23 abandoned fields showed that these fields are not colonized by forest species but by *Mimosa delicatula*, a species indicative of succession that often leads to a dense thorny thicket. Two investigations were conducted in 2010: (1) We assessed regeneration potential by studying the seed bank and seed rain in three abandoned field sites and in adjacent forest patches, and (2) we examined the restoration potential involving nuclei of forest species on the fields by transferring seed rain and soil from the same forest patches to the abandoned fields. In the forest patches, the seed bank and seed rain were dominated by woody taxa such as *Gyrocarpus americanus* subsp. *capuronianus* and species of the genera *Commiphora, Croton and Euphorbia*. These findings indicate a potential for regeneration, despite the fact that seed dispersal must be limited because no forest species were found in the seed banks on the abandoned fields dominated by *Cynodon dactylon, Heteropogon contortus* and *Panichum maximum*, *Achyranthes aspera* and *Commelina* spp. The seed rain transfer resulted in little germination of *Grewia andramparo* and *Gyrocarpus americanus* subsp*. capuronianus,* which did not survive an unusually dry period occurring during the rainy season. The soil transfer did not lead to any germination. As none of the restoration techniques tested here were conclusive, other regeneration options are discussed.

Session 'Dispersal in space and time' / ORAL

## WHY DO SPECIES ASSEMBLAGES DIFFER BETWEEN ANCIENT AND RECENT FORESTS? AN EXPERIMENT

**Aurélien Jamoneau, Déborah Closset-Kopp, Olivier Chabrerie, Robert Saguez, Guillaume Decocq**

*University of Picardie Jules Verne, Unité de Recherche Dynamiques des Systèmes Anthropisés AMIENS, France; corresponding author: guillaume.decocq@u-picardie.fr*

Keywords: recent forest species, ancient forest species, dispersal limitation, recruitment limitation

Empirical evidence has accumulated to indicate that a subset of true forest species are lacking in recent forests, i.e., in forests that have been established recently on former arable land. Three hypotheses have been proposed to explain why these so-called 'ancient forest species' are restricted to ancient forests, i.e., forests that have continuously existed through the last few centuries. First, AFS may not yet have had time to colonize the recent forests (dispersal-limitation hypothesis). Second, low habitat quality may prevent them from being recruited (recruitment-limitation hypothesis). Third, the resident vegetation may outcompete them (establishment-limitation hypothesis). To discriminate between these three hypotheses, we designed a field experiment in which two sets of species (eight 'ancient' (AFS) and six 'recent' (RFS) forest species) were either sown or transplanted into three sites (an ancient forest, a recent forest, and a newly forested former arable land), after the removal of the resident vegetation or not. The experiment was begun in 2006 and monitored twice a year until the autumn of 2009, when seedlings were counted and the height and number of leaves, stems and flowers per plant were recorded. The results were analyzed using survival and ANOVA analyses. Our results revealed that recruitment is species-dependent, suggesting a weak effect of competition and habitat quality. In accordance with the literature, we found better performances of AFS and RFS in recent forests. Our data support the dispersal-limitation hypothesis for AFS and show that RFS are competitively excluded (shaded out) in ancient forests.

Session 'Dispersal in space and time' / ORAL

## MEDITERRANEAN GRASSLAND SEEDLING ESTABLISHMENT: THE ROLE OF SEED SIZE UNDER DIFFERENT AUTUMN MOISTURE CONDITIONS

**Gabriel Arellano[1,2], Begoña Peco [2]**

*[1] Real Jardín Botánico (CSIC), Madrid, Spain; [2] Department of Ecology, Universidad Autonoma (corresponding author: garellano@rjb.csic.es)*

Keywords: autumn drought, Mediterranean therophytes, pasture legumes, seedling survival, seed weight

Therophtyte-dominated Mediterranean grasslands have high biodiversity and high interannual fluctuations in species composition, partly due to irregular autumn rainfall. Seed size may be one of the functional characters mediating between autumn rainfall and species composition. An experiment was conducted using six grassland legume species with different seed sizes that were subjected to six different watering intensities. We monitored survival and morphological variables (shoot and root growth) for 40 days. Large seeds provide an advantage for seedling survival, but only in high relative humidity. In extreme drought conditions, seedling survival in small-seeded species equals that of seedlings from large-seeded species. Seedlings from larger seeds are larger than those of small-seeded species but have a lower root:shoot biomass ratio. This lower ratio leads to a greater relative evapotranspiration, which could explain the lower relative survival of large-seeded species during extreme droughts. Seedlings of small-seeded species are smaller and do not have this evapotranspiration expenditure. Seed size seems to be an important mediator in a non-linear dynamic between drought and the differential survival of species that determine the interannual fluctuations in the composition of Mediterranean pastures.

Session 'Dispersal in space and time' / ORAL

## SEED GERMINATION FROM DEPOSITED SEDIMENTS DURING HIGH WINTER FLOW IN RIPARIAN AREAS

**Annette Baattrup-Pedersen[1], Tenna Riis [2], Brian Kronvang[1]**

*[1] National Environmental Research Institute, Aarhus University, Denmark; [2] Department of Biological Sciences, Aarhus University, Denmark*

Keywords: riparian areas, winter flooding, seed dispersal, seed germination

Flooding has long been recognized as an important factor in structuring the vegetation in riparian areas through the mediation of different hydro-morphological processes. Flooding may also affect the vegetation by supplying seeds and vegetative fragments that may become established in these areas. In this study, we investigate seed germination from deposited sediment at different distances from a river channel along the River Odense, Denmark and examine how richness, diversity and composition vary along the gradients in sediment characteristics. We established a transect perpendicular to the stream channel that extended 101 m into the stream valley. Sediment samples were collected from a total of twenty-five 20 x 20 cm artificial grass mats positioned 2, 16, 23, 41, 70 and 101 meters from the stream. Germination from these samples was followed for 6 weeks under both moist and wet conditions in a greenhouse with a natural light regime and a mean temperature of 20 °C. Germination was most successful under moist conditions, in which the number of emerging seedlings ranged from 1050 to 3817 $m^{-2}$. Species richness (10.7 ± 1.5 species), diversity (2.13 ± 0.13) and evenness (0.90 ± 0.03) peaked in samples taken 16 m from the stream channel. Overall, the number of seedlings was positively correlated with the distance from the stream and organic matter content in the sediment and was negatively correlated with the C/N content of the sediment. Conversely, species richness and diversity were negatively correlated with the distance from the stream and organic matter content and were positively correlated with C/N. Our results clearly demonstrate that deposited sediments have large contents of viable seeds and the potential to introduce variability in compositional patterns in riparian areas where the interaction between river and riparian areas is rehabilitated through active or passive restoration.

Session 'Dispersal in space and time' / ORAL

## DISPERSAL AND MICROSITE LIMITATION IN FLOODPLAIN GRASSLAND RESTORATION

**Armin Bischoff[1], Guido Warthemann [2]**

*[1] Agrocampus Ouest, Centre d'Angers, Institute of Horticulture and Landscape Planning (INHP), UMR 1099 BiO3P, Angers, France;*
*[2] Dr. Reichhoff Landscape Planning, Dessau, Germany (armin.bischoff@agrocampus-ouest.fr)*

Keywords: Plant succession, dispersal distances, soil disturbance, seedling recruitment, river valley

Intensive management has resulted in a loss of plant diversity in European floodplain grasslands. In particular, species adapted to traditional land use have largely declined or disappeared. Restoration approaches based on the conversion to traditional management systems often fail to re-establish these characteristic floodplain species (target species).
We tested dispersal and microsite limitations in three studies on grassland restoration and succession in east German river valleys. In a long-term transect study, the migration of target species from source communities (reference grassland) into restoration grassland was analyzed over a period of ten years that began nine years after conversion to traditional management. A transplant experiment was set up to examine dispersal distances and vectors. Microsite limitation was tested by comparing seedling emergence in three soil disturbance treatments (deep tillage, shallow tillage, and control).
The transect analysis revealed a slow migration of target species into restoration sites, reaching approximately 30 to 45 m within 19 years of restoration. Similarity indices between restoration grasslands and adjacent reference communities did not significantly increase during the ten years of observation. In the transplant study, seedlings were concentrated close to the mother plants, and dispersal distances did not exceed 3 to 4 m. The strong dispersal limitation was confirmed by an analysis of seedling survival showing no differences between restoration and reference grasslands. In the undisturbed control plots, seedling emergence following seed addition by hay transfer or hand sowing was lower than 0.03%. The soil disturbance treatments significantly increased recruitment, and the highest seedling numbers were observed in the deep tillage treatment, indicating microsite limitation. The results suggest that the dense sward of floodplain grasslands represents a second strong environmental filter hampering grassland succession. In conclusion, the successful restoration of floodplain grasslands requires a combination of soil disturbance and seed transfer if source populations are not available in very close vicinity.

Session 'Dispersal in space and time' / ORAL

## QUANTIFYING THE IMPORTANCE OF SHORT-DISTANCE DISPERSAL FOR PATCH OCCUPANCY PATTERNS OF AQUATIC PLANT SPECIES IN A DITCH NETWORK

**Martin Diekmann, Tim Daake**

*Institute of Ecology, University of Bremen, Bremen, Germany; (corresponding author: mdiekman@uni-bremen.de)*

Keywords: diasporas, dispersal, incidence probability, life-history traits, variation partitioning

The main objective of our study was to analyze the contribution of short-distance dispersal to explaining the local distribution of aquatic plants (macrophytes) in a dense ditch network, based on a detailed inventory of the occupancy patterns of species in small patches in the Hollerland nature reserve near Bremen, NW Germany. More specifically, we asked (i) how much of the total variance in the local-scale species distribution of aquatic plants was exclusively attributed to dispersal, (ii) whether the short-distance dispersal ability differed between life forms, and (iii) whether the incidence patterns and dispersal abilities of species could be explained by their reproductive or other life history traits. The statistical analysis included the calculation of population connectivity values for each patch and species as well as information on important habitat factors for each patch.
The regression models explained an average of 56.2% of the total variation in patch occupancy, of which 25.5% (a proportion of 46.2%) was attributed to population connectivity. Among the species studied, pleustophytes generally had the highest patch occupancy values. The high $R^2$ for population connectivity was almost exclusively attributed to within-ditch connectivity. Across-ditch connectivity remained significant in the final models for only 14 of 25 species
Species patch occupancy and dispersal ability were positively correlated with each other. Across all species, dispersal ability decreased with increasing plant size. Generative reproductive allocation generally had no clear effect on patch occupancy or dispersal potential. In contrast, vegetative reproduction appeared to have a stronger impact on species distributions: dispersal ability and patch occupancy were negatively related to the size of the vegetative propagules, and both tended to be positively affected by the number of propagules.

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## PRE-RESTORATION SEED BANK ANALYSES IN A BACKWATER SYSTEM OF THE DANUBE FLOODPLAIN NEAR INGOLSTADT (GERMANY)

**Kathrin Kiehl, André Schwab**

*University of Applied Sciences Osnabrück, Vegetation Ecology and Botany, Oldenburger Landstr. 24, 49090 Osnabrück, Germany, e-mail: k.kiehl@hs-osnabrueck.de, a.schwab@hs-osnabrueck.de*

Keywords: Seed bank, river restoration, seed limitation, floodplain

In a large-scale restoration project, former stream channels and oxbows of the Danube river were reconnected to the stream in June 2010 by a water course that was 8 km in length and flowed through an ancient floodplain forest (2100 ha) with species-rich vegetation. In autumn 2009, 274 seed bank samples were taken to investigate the potential of the seed bank to contribute to the restoration of stream vegetation along the new watercourse in different parts of the backwater system. Before the start of the restoration, some of these parts had been completely dry, whereas other parts were temporarily flooded or deep oxbow lakes. Soil samples were taken along 18 transects across the backwater system at different locations (e.g., channel bed, slope). Seed bank samples were concentrated (according to the Ter Heerdt method, 1996), stratified and brought to the greenhouse to germinate.
Most seedlings germinated within the first six weeks, but the study was continued in total for one year. Both the number of seedlings and the number of species in the seed bank samples were higher in areas with formerly fluctuating water tables than in formerly dry or permanently flooded oxbows. The number of species of the Red-List of Bavaria and the number of habitat-specific target species were highest in those floodplain parts with highest water-table fluctuations.
In 2011, seed bank analyses will be complemented by the investigation of hydrochorous seed dispersal along the new watercourse. The effect of seed availability on the development of the actual vegetation will be analyzed.

Session ‘Dispersal in space and time’ / ORAL

## DISPERSAL AND COLONIZATION OF PLANTS IN LOWLAND STREAMS

**Tenna Riis[1], Annette Baattrup-Pedersen[2]**

*[1] Department of Biological Sciences, Aarhus University, Denmark; [2] National Environmental Research Institute, Aarhus University, Denmark*

Keywords: stream, plant dispersal, plant colonization, vegetative plant fragments, seed pool

Streams are naturally disturbed ecosystems, and the temporal and spatial dynamic of vegetation abundance and species composition is highly influenced by the dispersal and colonization of plants within the stream system. I will present results from studies on the patterns and mechanisms of the dispersal and colonization of plants in lowland streams. First, I present the rates of dispersal, retention, colonization, and survival of dispersed propagules (shoots and seeds) in a mid-sized macrophyte-rich stream. The main bottleneck for plant colonization in macrophyte-rich lowland streams is primary colonization by retained shoots and seeds, which is due in part to low retention success (1% of the dispersed shoots per 100 m reach) and to unsuccessful colonization of retained shoots (3.4% of retained shoots colonized). The number of drifting shoots and seeds per day during the growing season were 650-6,950 and 2,970-62,780, respectively, and caused no constraint on colonization. The survival rate of primary colonizations was high, with 80% surviving during the first growing season. Second, I relate the colonization processes to simple flow parameters. There was no relationship between the number of drifting shoots and flow, but the number of drifting seeds increased with flow. The number of colonizations between two consecutive sampling days was correlated with the extent of low flow in the period. The colonization loss rate was related to high flow events but was low overall. Vegetation colonized primarily in slow-flowing water, as expected, and there was no colonization preference for different water depths. Third, I describe the temporal and spatial dynamic of the seed pool in the stream by analyzing the seed pool during spring, summer and autumn in four locations down through the stream system. The influence of the seed pool in the plant colonization in spring was important even though it was only a small proportion of the total seed pool that germinated. The seed pool was dominated by terrestrial plants compared to aquatic plants.

Session 'Dispersal in space and time' / ORAL

# POSSIBILITIES OF PLANT PROPAGULE DISPERSAL VIA FISH IN EUROPEAN POND SYSTEMS

**Kateřina Šumberová[1], Richard Vachta[2], Michal Ducháček[3]**

*[1] Institute of Botany, Academy of Sciences of the Czech Republic, Department of Vegetation Ecology, Brno, Czech Republic; [2] Fish-farming and Hydrobiological Services, Vodňany, Czech Republic; [3] National Museum, Department of Botany, Prague, Czech Republic (corresponding author: katerina.sumberova@ibot.cas.cz)*

Keywords: carp ponds, Central Europe, ichthyochory, seed dispersal, wetland plant species

Fish are considered to be an important dispersal vector of plant propagules in wetland habitats. Most studies on ichthyochory (propagule dispersal via fish) are focused on tropical rain forest ecosystems. Little is known about European plant species, although a better understanding of plant-fish interactions is important for wetland biodiversity conservation. We performed feeding experiment to test possibilities of ichthyochory in 30 plant species occurring in ponds used for fish farming. Various eco-biological groups of species (e.g., wetland annuals and perennials) and types of seeds (with different sizes, shapes and surfaces) were represented. Two groups of fish, consisting of either common carp (*Cyprinus carpio*) or tench (*Tinca tinca*), were stored separately in the conditions of a fish hatchery and fed by cereal pellets containing precisely counted numbers of plant seeds. Samples of fish gut contents were analyzed under a stereoscopic microscope. The seeds were sorted according to species and damage, and undamaged seeds were allowed to germinate. We found significant differences in the proportion of damaged and undamaged seeds between the two fish species: approximately 50–60 % of seeds damaged in the carp samples, whereas the rate of damaged seeds ranged between 20 and 40 % in tench. Small rounded or oval seeds with smooth surface had the highest resistance to mechanical damage by the pharyngeal teeth of fish. Even in large-seeded species, small parts of seeds were undamaged. However, in some species (e.g., *Callitriche palustris*, *Plantago uliginosa* and *Lycopus europaeus*), seed passage through the fish gut initiated seed germination that occurred in samples that had not yet been analyzed (i.e., in liquid) stored at 5°C. The seeds of such species can be transported via fish, but they die if they do not quickly find suitable conditions for their further development. In contrast, in species such as *Juncus bufonius*, *Limosella aquatica* and *Eleocharis ovate,* additional treatment (e.g., temperature fluctuations) was necessary to achieve germination. We assume that these species are best adapted to ichthyochory because their seeds are protected against germinating too early in unsuitable conditions.

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## THE USAGE OF WOODY HABITATS BY FOREST PLANTS IN HISTORICALLY FRAGMENTED LANDSCAPES

**Kertu Lõhmus, Jaan Liira**

*Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia; (corresponding author: kertu.lohmus@ut.ee)*

Keywords: dispersal, forest communities, forest species, landscape structure

Previous experiments have shown that forest species are often dispersal-limited and, thus, need dispersal corridors to colonize new habitats. In Estonia, the land-use history of rural areas is largely known and relatively constant. Manor parks in these rural landscapes were established around agricultural manors approximately one to two centuries ago, and these parks are still surrounded by a rotational agricultural matrix. Here, we tested the hypothesis that forest plants are dispersal-limited and migrate to isolated manor parks through woody linear corridors.
We analyzed vascular forest plant species lists in 40 locations; each study location included a complex of park stand, forest stands and woody lineal habitats (corridors) in a 1-km radius around a centrally located manor park. The composition of common forest species among these three studied habitat types was contrasting. Parks had a transitional species composition between forest and corridor habitats. We found that several common forest-specific species are able to disperse over long distances and disperse over an inhospitable agricultural matrix landscape without settling in the stepping-stone or corridor habitats in between. On the landscape scale, if time is not limiting, forest plants are limited by the abundance of seed source habitats and the habitat quality in the target habitat.
Our results suggest that forest species either do not need landscape corridors to colonize forest-like manor park fragments or they do not persist in woody corridors for generations. We suggest that, contrary to common conception, the forest-specialist plant dispersal sequence should be redefined as dispersal from a forest to a fragment (park) and in some cases to corridor habitat. This implies that the dispersal ability and vectors of many forest plant species should be reconsidered or at least updated. Our results indicate that the requirements of common forest species are assured only in patch-type habitats and rarely in woody linear habitats.

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## ACHENE BUOYANCY AND GERMINABILITY OF THE TERRESTRIAL INVASIVE FALLOPIA X BOHEMICA IN AQUATIC ENVIRONMENTS: A NEW VECTOR OF DISPERSION?

**Soraya Rouifed, Sara Puijalon, Marie-Rose Viricel, Florence Piola**

*Université Lyon 1, UMR CNRS 5023 "Ecology of Natural and Man-impacted Hydrosystems", Villeurbanne, France*

Keywords: invasion, Fallopia, water dispersal, buoyancy, seedling survival

Seed dispersal along watercourses can favor the long-distance migration of invasive species, not only for aquatic or wetland species, but also for terrestrial wind-dispersed plants. It is crucial to investigate the role of watercourses in the dispersal of the knotweed hybrid complex (*Fallopia* x *bohemica*) due to its frequent occurrence on riverbanks and production of fertile achenes. For this purpose, we experimentally studied the buoyancy and germinability of *F.* x *bohemica* achenes in stirred water for 28 days. We also measured the long-term survival and growth of seedlings according to water exposure time. After nearly 2 days in water, 50% of achenes were still afloat. After 3 days, germination occurred in water, and the seedlings also floated. Moreover, the exposure of achenes to water, regardless of the length of time, significantly favored their germination rate without affecting seedling survival compared to a direct planting in soil. Furthermore, a maximum seedling dry mass was reached following exposure to water for 277 h (11.5 days), significantly surpassing the dry mass of seedlings planted directly in soil. Water exposure strongly favors achene germination and seedling survival. Our results demonstrate a high potential for the seeds and seedlings of *Fallopia* x *bohemica* to be dispersed successfully by water.

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# VARIATION IN SEED SIZE ALONG AN ALTITUDINAL GRADIENT: A COMPARATIVE APPROACH IN HUMID AND DRY SLOPES

**Seyed Mohammad Jafari[1], Shahin Zarre[1], Seyed Kazem Alavipanah[2], Morteza Atri[3]**

*[1] Department of Botany, School of Biology, College of Science, University of Tehran, Tehran, Iran; [2] Department of Cartography, Faculty of Geography, University of Tehran, Tehran, Iran; [3] Department of Biology, Faculty of Science, Bu-Ali Sina University, Hamedan, Iran*
*(corresponding author: smjafari@ut.ac.ir)*

Keywords : Functional traits, altitudinal gradients, seed size, Hyrcanian Forest

The analysis of plant functional traits along environmental gradients is of utmost importance for learning more about the patterns of ecosystem responses to environmental changes. Seed size is a key eco-functional trait that influences many properties of vegetation and plant communities, including regeneration and dynamics. In this research, intraspecific changes and variations in the seed size of selected dominant woody plants of forest and woodland communities were explored. A literature review showed a variable pattern of relationships between seed size and altitude in different habitats. Based on a comparative approach, we investigated the variation of seed size in the northern, humid and the southern, semi-dry slopes of the Alborz Mountains, along four altitudinal transects. To omit life form and plant height effects and to study phylogenetic and niche conservatism effects, an intraspecific and within-life form survey of changes in seed size was employed. Selected species included *Fagus orientalis*, *Quercus castaneifolia*, *Crataegus* sp., *Carpinus orientalis*, *Lonicera floribunda*, *Carpinus betulus*, *Quercus macranthera, Juniperus sabina* and *Celtis australis*. We considered seed weight/length, excluding appendages and fleshy parts, as a seed mass/size parameter. Seed weight has been measured to the nearest 0.1 mg; however, because of the small size of seeds in some species, the weight of 100 individuals was used in analysis. Statistical analysis of seed size values showed completely different patterns in northern and southern slopes. The results of this study showed that, in northern slopes, which have been covered by dense deciduous forest, seed size decreases with altitude. This result is in accordance with previously observed data and can be attributed to shadiness, dispersal mechanisms and forest disturbance effects. However, in southern slopes, the reverse pattern was observed, which indicates that larger seeds are favored in high altitudes, principally because of severe environmental conditions. Generally, plants with heavier seeds are at an advantage at higher elevations because their seedlings have more reserves available to cope with environmental stresses.

# Plant communities in aquatic ecosystems

Session 'Plant communities in aquatic ecosystems' / ORAL

## A RETROSPECTIVE SERIES OF SATELLITE IMAGES FOR STUDYING MACROPHYTIC VEGETATION DYNAMICS IN THE COASTAL ZONES OF LARGE LAKES

**Urmas Peterson[1,2], Jaan Liira[3]**

*[1] Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Estonia (E-mail address: urpe@aai.ee); [2] Tartu Observatory, Tõravere, Tartumaa, Estonia; [3] Institute of Ecology and Earth Sciences, University of Tartu, Tartu, Estonia*

Keywords: Lakeshore vegetation, retrospective satellite images

A retrospective data set of moderate-resolution Landsat TM and ETM+ satellite images was used to estimate the changes in cover of emergent macrophytes in the coastal zones of large lakes in northeastern Europe. The images date back to the mid-1980s and cover the period until 2010. We demonstrate that medium-resolution satellite images can be used successfully for the retrospective monitoring of macrophyte vegetation in the littoral zone of large water bodies by applying a very simple image classification methodology. In addition to image interpretation, the large-scale retrospective approach allows us to analyze the roles of various factors on vegetation dynamics.
The coastal areas of the studied lakes show a tendency to become overgrown with reed and other macrophytes in the conditions of the generally reduced agricultural intensity in the catchment areas. We applied a multi-factorial general linear mixed model to examine the effect of potential drivers on the horizontal extension of coastal macrophytes in one of the lakes, Lake Võrtsjärv. The factors included were the following: the coastal region of the lake, the potential occurrence of anthropogenic disturbance, the presence of small inflows, the impact region of large inflows and year of observation. All factors tended to have an effect, but their influences need to be further investigated.

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## MACROPHYTES IN AZOREAN LAKES

**Andreia Cunha, Ana Mafalda Cruz, João Ramos, Pedro Raposeiro, Ian Dodkins, Ana C. Costa, Vitor Gonçalves**

*CIBIO – Centro de Investigação em Biodiversidade e Recursos Genéticos – Pólo Açores, Departamento de Biologia, Universidade dos Açores, 9501-855 Ponta Delgada, Azores, Portugal (cunhandreia@gmail.com)*

Keywords: Azores, Lakes, Macrophytes, Limiting factors

The Azores archipelago is located in the North East Atlantic, between 36º 45' and 39º 43' N and 24º 45' and 31º 17' W, in the biogeographic region of Macaronesia. It is composed of nine volcanic islands, distributed in three groups: Oriental (São Miguel and Santa Maria), Central (Pico, Faial, Terceira, Graciosa and São Jorge) and Occidental (Flores and Corvo). Its volcanic geomorphology led to the formation of lakes in endorheic craters that occur on five of the nine islands.
The aquatic flora includes a wide range of microscopic and macroscopic organisms that belong to very different taxonomic groups. Macrophytic algae and phanerogams play an important role in regulating processes in the aquatic ecosystem and are sensitive to changes in water chemistry and quality. Several factors contribute to the establishment and development of macrophytes in and around lakes, such as lake transparency, lake depth and watershed land use. These are the major features of an environmental status evaluation.
The aim of this work is to evaluate the differences in the macrophytic communities of lakes from different watersheds on several Azorean islands: São Miguel, Pico, Corvo and Flores. The sampling campaign occurred in the summer of 2010. The margins of each lake were surveyed, and a list of species was obtained. Abundance was established using the DAFOR scale separately for the margins and in the water. Each sampling location was characterized according to its geomorphological and physical characteristics, such as the altitude, depth, land use, transparency and substrate.
The macrophyte species composition of the lakes was found to differ among islands, reflecting the influence of environmental factors. The main influences were altitude, margin incline, location in urbanized/forest/natural vegetation areas, and land use. *Scirpus fluitans* and *Juncus effusus* were found in the lakes of the four islands. *Juncus bulbosus* was found in São Miguel, Pico and Flores and *Osmunda regalis, Littorella niflora* and *Hydrocotyle vulgaris* were found mainly in São Miguel and Flores. The presence and/or absence of endemic and native species contributed as a distinguishing factor to the lakes under study.

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## VERNAL POOL ECOSYSTEMS ON BOTH SIDES OF THE STRAIT OF GIBRALTAR: HABITAT AND FLORISTIC VARIATION

**José Antonio Molina, Ana Lumbreras, Cristina Pardo**

*Universidad Complutense de Madrid, Departamento de Biología Vegetal II, 28040-Madrid, Spain*
*(corresponding author: J.A. Molina, jmabril@farm.ucm.es)*

Keywords: Biogeography, coastal temporary ponds, community ecology, Western Mediterranean Basin

Vernal pool (VPs) ecosystems were studied along a latitudinal gradient across the Strait of Gibraltar (SG) separating Europe and Africa. We analyzed floristic composition, vegetation zonation, physico-chemical water parameters, and the molecular characters of target VPs species of two vernal pool areas on both sides (Iberian and Moroccan) of the Strait. Despite the small distance between the regions, the pools clearly differ in species composition and ecology. However, they show a similar zonation, comprising isoetid, batrachiid and helophytic vegetation. The distribution of the plants is related to nutrient load. Water nitrate concentration is higher in Morocco, where VPs are characterized by the *Isoetes velata* subsp. *adspersa* and *Ranunculus saniculifolius* communities. Iberian VPs have lower water nitrate content and are characterized by the *Isoetes velata* subsp. *velata* and *Ranunculus peltatus* communities. Molecular results showed the role of the SG in the diversification among populations on both sides. We explain this difference as most likely being caused by different management regimes on respective sides of the Strait, with greater human pressure presumed in Morocco. Long-term (historical) and present-day (ecological) processes have been proposed to account for the habitat variation in vernal pool ecosystems on both sides of the Strait of Gibraltar.

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## PATTERNS OF PLANT DIVERSITY IN FARMLAND PONDS: DRIVERS AND FUNCTIONS

**Margherita Gioria [1,2], Giovanni Bacaro [3], John Feehan [1]**

*[1] University College Dublin, School of Agriculture, Food Science and Veterinary Medicine, Dublin, Ireland; [2] University of Konstanz, Ecology, Department of Biology, Konstanz, Germany; [3] University of Siena, Department of Environmental Science, Siena, Italy*

Keywords: biodiversity, biotic-abiotic relationships, conservation planning, cross-taxon congruence, surrogate taxon

Ponds represent one of the most diverse ecosystems in the agricultural matrix. Promoting pond conservation efforts and mitigating the ecological impacts of human-related activities requires a solid understanding of the main drivers and functions of freshwater biodiversity patterns in space and time. Here, we used a dataset from 54 farmland ponds in Ireland to 1) describe the structure (diversity and composition) of the marginal and aquatic vegetation; 2) model the response of plant community data to a set of environmental variables and management practices; and 3) evaluate the potential for plant community data to explain and/or predict community patterns for water beetles (Coleoptera), a taxonomic group that has been recommended for use in the evaluation of pond biodiversity. To achieve these goals, we used a range of analytical univariate and multivariate approaches, and the advantages and pitfalls associated with the use of each modeling approach in freshwater ecosystems were evaluated. In total, 67 wetland plant species were recorded from the emergent, submerged, and floating vegetation of the study ponds. The variables that most determined plant community patterns were the duration of the hydroperiod, pond depth, and type of dominant substratum. Grazing intensity also substantially affected the characteristics of the farmland pond vegetation. Plant community data were consistently correlated with water beetle species richness and composition and showed a positive predictive power. These findings have important implications in conservation planning. First, wetland plants can be effectively used as surrogate taxa in the identification of conservation-priority ponds. Second, conservation strategies aimed at maintaining and enhancing pond biodiversity should be based primarily on considerations on plant species composition. The importance of identifying an analytical protocol suitable for modeling plant diversity, plant-insect interactions, and plant-abiotic data is discussed.

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## SPECIES RICHNESS AND FUNCTIONAL GROUPS IN RESPONSE TO ANTHROPOGENIC STRESS AND DISTURBANCES IN SHALLOW LAKES

**Florent Arthaud[1], Dominique Vallod [1,2], Joël Robin [1,2], Gudrun Bornette [1]**

*[1] University Lyon1, ENTPE, CNRS, UMR5023 LEHNA, Lyon France; [2] ISARA-Lyon, Ecosystems and Aquatic Resources, Lyon France*

Keywords : submerged aquatic vegetation, eutrophication, drought, competition, light

In shallow lakes, the way anthropogenic activities are influencing biodiversity and the consequences for ecosystem functioning are key issues for maintaining the services and goods associated with such wetlands. Submerged aquatic vegetation is a major driver of ecosystem functioning, and their maintenance is absolutely necessary for the maintenance of these services. The aim of this study was to measure the responses of aquatic plant communities to anthropogenic disturbances and eutrophication instigated by the management of these lakes for fish production. We studied, in 60 shallow lakes, the impact of 3 factors partly ruled by human practices (nutrient level, drought and connectivity between lakes) on aquatic plant species richness and functional diversity.

Nutrient level and the drying frequency resulted in a decline of species richness and a modification in the relative abundance of the different plant strategies. However, functional diversity only decreased for the highest nutrient levels. Surprisingly, connectivity was negatively correlated with species richness, suggesting that the positive effect of dispersal on species richness may be offset by other constraints, such as the increasing accumulation of phytosanitary products in lakes from upstream to downstream in the chain of connected lakes.

Nutrient level is the major driving force of plant biodiversity in shallow lakes. However, frequent disturbances due to drying events induce a cyclic succession that helps maintain high biodiversity by inducing a reduction in nutrient levels immediately after drying.

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## RESPONSES OF FRESHWATER PLANTS TO DEWATERING: BIOMECHANICAL PROPERTIES AND MORPHO-ANATOMICAL DETERMINISM

**Elena Hamann, Sara Puijalon**

*Université de Lyon, Lyon, France – UMR CNRS 5023 Ecologie des hydrosystèmes naturels et anthropisés, Université Lyon 1, F-69622 Villeurbanne, France (corresponding author: sara.puijalon@univ-lyon1.fr)*

Keywords: Wetlands, submerged aquatic vegetation, drought, biomechanics, phenotypic plasticity

Wetlands are highly impacted by global change, particularly by hydrological alterations that can induce dewatering. Dewatering represents a drastic change in the mechanical constraints encountered by submerged aquatic plants. Under aquatic conditions, submerged aquatic vegetation encounters low gravitational forces and bears hydrodynamic forces mostly in tension. This situation is contrary to that found under terrestrial conditions, in which gravitational forces are high and bending forces predominate. The objective was to study the capacity of aquatic plants to produce self-supporting growth-forms following dewatering and to test their resistance to terrestrial mechanical constraints. Plant stems and leaves were hypothesized to have a higher tissue density under emerged conditions, leading to increased stiffness and mechanical strength in bending.

Plastic responses to drawdowns were assessed by sampling eight aquatic plant species (*Berula erecta*, *Hippuris vulgaris*, *Juncus articulatus*, *Lythrum salicaria*, *Mentha aquatica*, *Myosotis scorpioides*, *Nuphar lutea*, and *Sparganium emersum*) under submerged and emerged conditions in the same wetland. For the two sets of plants, dry matter content (DMC) and volumic mass was measured in stems and leaves, and their biomechanical properties were assessed for tension and bending.

Under emerged conditions, several species (*J. articulatus*, *L. salicaria*, *M. aquatica*, and *M. scorpioides*) displayed the expected response for the tissue density (higher DMC and volumic mass) and biomechanical traits (higher stiffness and mechanical strength) of stems and leaves, particularly in bending. These results demonstrate that some species display plastic responses that lead to the production of self-supporting growth-forms. These responses should allow them to cope with terrestrial mechanical conditions, which is crucially important for survival and flowering.

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## THE ROLE OF SPECIES FUNCTIONAL TRAITS FOR DISTRIBUTIONAL PATTERNS IN LOWLAND STREAM VEGETATION

**Giulia Cavalli[1], Annette Baatrup-Pedersen [2], Tenna Riis [1]**

*[1] Aarhus University, Department of Biological Sciences, Aarhus; [2] National Environmental Research Institute, Department of Freshwater Ecology, Silkeborg, Denmark*

Keywords: freshwater functional traits abundance invasive

Freshwater ecosystems provide goods and services to human society, and invasion is a major threat to them. Plant invasion affects community dynamics, threatens biodiversity and promotes biological homogenization. In this study, we explore functional traits in three groups of species: invasive species, disturbance-tolerant species and rare species in lowland streams. To investigate the role of functional traits in species distributional patterns, we investigated the relationships between a range of species features and species abundance in approximately 1,200 stream sites in Denmark covering a gradient in size and water alkalinity. We applied a co-inertia analysis including functional traits (e.g., life form, vegetative propagation and pollen vector), bioindicator values and Grime CSR scores to investigate their significance for species distributional pattern. We found a clear correlation between species abundance and traits related to dispersal such as vegetative propagation and diaspore type. We discuss the obtained results in relation to species invasion in lowland streams being highly influenced by anthropogenic disturbances.

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## BRYOPHYTES AND WATER: SPECIES ASSEMBLAGES DRIVE HYDROLOGICAL PROCESSES AT CUSHION AND CATCHMENT SCALE

**Pascale Michel[1], William G Lee[2]**

*[1] Biodiversity and Conservation Team, Manaaki Whenua-Landcare Research, P.O. Box 10 345, The Terrace, Wellington 6143, New Zealand; [2] Biodiversity and Conservation Team, Manaaki Whenua-Landcare Research, Private Bag 1930, Dunedin 9054, New Zealand (michelp@landcareresearch.co.nz)*

Keywords: bryophytes, water storage, ecosystem services, species composition, morphological traits

Terrestrial bryophytes contribute substantially to the water dynamics of many ecosystems by intercepting rainfall, dew and fog and by absorbing 8-14 times their dry mass in water. Consequently, they provide enhanced water storage and may influence a wide range of ecological processes. The importance of bryophyte assemblages to local water dynamics was tested by 1) quantifying the loss of water storage as a result of changes in species composition, and 2) determining the effect of species mixture and cushion architecture on water retention. The terrestrial bryoflora in New Zealand native tussock grassland, nine years following a burning experiment, showed major changes in bryophyte composition and accumulation, with significant consequences for catchment hydrological processes. Predominantly dominated by the pleurocarpous moss *Hypnum cupressiforme*, the inter-tussock bryophyte carpet in unburned areas contributed to a mean additional water storage capacity of 0.2 mm. In burnt plots, *Polytrichum juniperinum* became dominant, and the reduced bryophyte biomass, cover and water content resulted in a mean loss of 75% of the potential water storage. A greenhouse experiment was used to investigate the influence of bryophyte traits and species mixtures on water storage. Species mixtures in bryophyte cushions had both additive and non-additive effects on the water economy (compared with monocultures), and these interactions depended on the composition of species assemblages and on morphological characteristics (plant shoot architecture and cushion density). Non-additive effects occurred when bryophyte species in mixtures converged morphologically. Our results indicate that changes in assemblages of bryophyte species at the ecosystem and cushion level may cause major changes in the provision of ecosystem services, such as water, independent of other vegetation responses to disturbances and precipitation.

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## THE IMPACT OF AQUATIC VEGETATION ON THE DIVERSITY OF A RIVER ECOSYSTEM

**Krzysztof Szoszkiewicz[1], Jan Blachuta[2], Daniel Gebler[1]**

*[1] Poznan University of Life Sciences, Department of Ecology and Environmental Protection, Poznan, Poland; [2] Institute of Meteorology and Water Management, Ecology Department, Wroclaw, Poland*

Keywords: macrophytes, river ecosystem, macroinvertebrates, ecological interactions

A comprehensive hydrobiological survey involving experts of various biological groups in running waters was conducted in 2009 within the PNRF-founded international project (acronym "deWELopment"). The survey was conducted in the Wel river catchment situated in the northern part of lowland Poland. The purpose of this study was to evaluate the influence of macrophyte vegetation on invertebrate organisms. The botanical survey was undertaken according to the Polish macrophyte monitoring approach, in which the abundance of all vascular plants, bryophytes and filamentous algae is recorded on 100-meter-long river sections. In addition, the bank vegetation was described with the River Habitat Survey system. The study of benthic organisms was conducted twice in the year (spring and autumn sampling) using the BMWP-PL method based on the UK Biological Monitoring Working Party score (BMWP). The biological survey was supplemented by hydrochemical analyses and hydromorphological evaluation. The analysis of collected data revealed the existence of numerous links between elements of the ecosystem. A significant correlation between the botanical Macrophyte Index for Rivers (MIR) and BMWP-PL index was revealed. The spring benthic communities were more strongly related in vegetation than the invertebrates revealed during the autumn sampling. The number of EPT taxa (Ephemeroptera, Plecoptera and Trichoptera) was inversely correlated with the macrophyte diversity metrics (number of species, Shannon-Wiener index and evenness). The abundance of submerged plants was positively related to the high quality water, indicated by the benthic GOLD index (Gastropoda, Oligochaeta and Diptera), whereas helophyte abundance was negatively correlated to this index. It was also demonstrated that the occurrence of benthic species was positively correlated with bank vegetation, which was mostly trees. The identified relationships showed the importance of vegetation on the diversity of other elements of the river ecosystem. The revealed interactions must be considered in the biological monitoring of freshwaters, which are implemented in the EU under the requirements of the Water Framework Directive.

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## HOW DO HYDRO-MORPHOLOGICAL AND PHYSICO-CHEMICAL FEATURES GOVERN MACROPHYTE COMPLEXITY IN A HYPEREUTROPHIC AND IMPACTED RIVER?

**Rossano Bolpagni[1], Alex Laini[1,2], Erica Racchetti[1], Marco Bartoli[1], Pierluigi Viaroli[1]**

*[1] University of Parma, Department of Environmental Sciences, Parma, Italy; (corresponding author: rossano@dsa.unipr.it) [2] "Sacro Cuore" Catholic University, Institute of Agricultural and Environmental Chemistry, Piacenza, Italy*

Keywords: macrophyte assemblages, habitat complexity, hydro-morphological features, water trophic status, conservation strategies

Since the end of the 19th century, riverscapes have been intensely exploited by human activities in order to obtain energy and drinking- and irrigation-water and to guarantee hydraulic security. Hydro-morphological alterations due to water diversion, dams and channelization have highly impacted river ecological integrity, affecting both nutrient and hydrological cycles. Furthermore, altered riverscapes experience high pollution loads from urban and agricultural activities, especially in potamal river stretches, resulting in nutrient-rich and turbid waters. As a consequence, macrophyte communities are subjected to multiple stressors that affect structure and diversity, leading to the dominance of nitrophilous species and to the hyper-simplification of the life-growth-form spectrum. Despite this effect, few monitoring projects have been funded for ecological data collection in order to define specific restoration strategies, to improve river habitat health status, and to identify the processes that govern the evolution and self-maintenance of aquatic plant communities.
In August 2009, the macrophyte assemblages of 30 different river reaches in the lower Oglio River stretch (Northern Italy) were described in terms of structural diversity and species composition. The lower Oglio River is characterized by the presence of 6 hydroelectric power plants and 16 water diversions for irrigation purposes. Nitrogen mass balance in the studied area has highlighted a surplus due to intense animal farming and agricultural activities, resulting in elevated concentrations of nitrate in river water (up to 8 mg $N\text{-}NO_3^-$ $l^{-1}$), which is typical of eutrophic ecosystems. The aim of this research was to explore the relationships among aquatic plant communities and to characterize both i) hydro-morphological features (i.e., water velocity and fluctuation, mean discharge and sediment characteristics) and ii) physico-chemical status (i.e., nutrients and conductibility) of each river reach. The collected data allowed us to compare the patterns of variation in species composition with patterns of habitat complexity decline and river flow, riverbank and channel morphology alteration in a heavily impacted watershed.

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## THE ROLE OF DISTURBANCE IN THE MAINTENANCE OF MACROPHYTE DIVERSITY IN LARGE RIVER FLOODPLAINS

**Antoine Keruzoré, Nigel Willby, Dave Gilvear**

*School of Natural Sciences, Institute of Biological and Environmental Sciences, University of Stirling, Scotland, UK (corresponding author: antoine.keruzore@stir.ac.uk)*

Keywords: Intermediate Disturbance Hypothesis, connectivity, backwater, flood, biomass

Research in river ecology conducted in floodplains mostly focuses on river corridors. However, in low gradient rivers, a strong hydrological dynamic is responsible for the formation of lateral aquatic habitats. Whereas the main channel remains under constant water flow pressure, lateral aquatic habitats present various degrees of connectivity to the main channel. For instance, under base flow conditions, backwaters maintain a downstream connection to the main channel and then experience standing water conditions that favor macrophyte growth. During flood flows, backwaters temporarily but fully connect to the main channel dynamic and then experience potentially disturbing high water velocities, as well as an exchange of propagules.
Synoptic surveys indicate that plant diversity in riverine backwaters in Scotland tends to be greatest at intermediate connectivity and productivity. However, our experimental studies also suggest that the effects of flood disturbance on biomass are generally too small or localized to account for such high levels of diversity through the regulation of competitive exclusion. Instead, diversity seems to depend on the interplay between connectivity, retention and recruitment. These processes have a strong temporal dimension. This result suggests that diversity at a floodplain level will be greatest where the fluvial dynamic is sufficient to maintain the coexistence of backwaters with a range of ages from the newly created and frequently connected to the mature and permanently disconnected.

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## CAN WE PREDICT THE COMMUNITY-WIDE EFFECTS OF HERBICIDES FROM TOXICITY TESTS ON PLANT SPECIES? A CASE STUDY ON FRESHWATER MACROPHYTES

**Claire Coutris [1,2,4], Georges Merlina [1,3], Jérôme Silvestre [1,3], Eric Pinelli [1,3], Arnaud Elger [1,2]**

*[1] Laboratoire Ecologie Fonctionnelle et Environnement, UMR 5245 CNRS/INP/UPS, Castanet-Tolosan, France; [2] Université Paul Sabatier, Toulouse, France; [3] INP ENSAT, Castanet-Tolosan, France; [4] Present address: Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, Ås, Norway (corresponding author: arnaud.elger@cict.fr)*

Keywords: pesticide mixture, chemical stress, community ecotoxicology, water plant assemblages

There is an increasing need to include the community response to contaminants in ecotoxicological risk assessments. Because most ecotoxicological tests are conducted on single species, it would be of considerable practical value to be able to use the outcome of such tests to predict the effects of contaminants at a community level. The aim of the present study was to examine whether the effects of an herbicide mixture (50 % atrazine, 35 % isoproturon and 15 % alachlor) on single macrophyte species can be used to predict its community-wide impacts. First, we tested the sensitivity of six species (*Azolla filiculoides*, *Ceratophyllum demersum*, *Elodea canadensis*, *Lemna minor*, *Myriophyllum spicatum* and *Vallisneria spiralis*) grown separately and exposed to 0.6 to 600 µg $L^{-1}$ of the herbicide mixture. In our second experiment, conducted in microcosms, we tested the effects of herbicides on macrophyte assemblages composed of the same six species exposed to 0, 6 or 60 µg $L^{-1}$ of the herbicide mixture. Species grown separately exhibited contrasting sensitivities to the herbicide mixture. *Vallisneria spiralis* was the most resistant species. *C. demersum*, *M. spicatum* and *E. canadensis* exhibited intermediate sensitivities. *A. filiculoides* and *L. minor* were the most sensitive species. In microcosms, community biomass and Shannon evenness index were reduced after 8 weeks at 60 µg $L^{-1}$. Communities also exhibited changes in their composition: the relative and absolute abundances of *C. demersum* increased at 6 µg $L^{-1}$, whereas the relative abundance of *V. spiralis* increased at 60 µg $L^{-1}$. These results were predictable from the individual dose-response models built for the different species. We therefore concluded that the short-term effects of herbicides on simple macrophyte communities could be inferred from the sensitivity of individual species. However, further investigations are required to examine whether longer-term effects can be predicted as well, especially in more complex communities.

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## ENDEMIC VASCULAR PLANTS RELATED TO WET HABITATS IN EUROPE

**Carsten Hobohm, Ines Bruchmann**

*University of Flensburg, Biology, Auf dem Campus 1, D 24943 Flensburg (corresponding author: hobohm@uni-flensburg.de)*

We extracted a list of vascular plant taxa associated with damp, wet and inundated environments from the database EvaplantE. At least 339 taxa, which are endemic to Europe, occur regularly in wet habitats. Only a few of the 339 taxa are hydrophytes, which live in lakes or rivers. Far more taxa occur in habitats such as river banks or slopes in the surroundings of springs or waterfalls. One hundred three are closely associated and 236 are less closely associated with such habitats. Eighty taxa (of the 236 less closely related taxa) are mainly associated with other habitat types but have a minority of their populations also occurring under wet conditions.
The distribution patterns of endemics associated with wet habitats show a relatively high diversity in the Central and Western Mediterranean regions, the Alps and Atlantic regions. The highest numbers were in France, and there was a small number of endemics to the east of Europe. We did not find a clear north–south gradient with high numbers of endemics in the Canaries, Madeira Archipelago and Mediterranean and low numbers in Scandinavia and northern Russia.
Compared to rocks and screes, grassland, scrubs and heaths, or forests, the number of endemics associated with wet habitats in Europe is low. We assume that this result is due to the separation of water bodies in combination with the young age of wetlands and low ecological continuity across wetland localities.
Absolute numbers of endemics in a region can be used as a measure for responsibility in the framework of international nature conservation policies. In this sense, France has the highest responsibility for European endemic vascular plants associated with wet habitats.

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## HETEROGENEITY AND SPATIAL DISTRIBUTION OF VEGETATION IN ITALIAN VOLCANIC LAKES: WITHIN-LAKE AND BETWEEN-LAKE DIVERSITY

**Mattia M. Azzella[1], Luca Luiselli [2], Carlo Blasi [1]**

*[1] La Sapienza University, Department of Environmental Biology, Rome, Italy; [2] ENI S.p.A, Environmental Department, Rome, Italy*

Keywords: macrophytes pattern, riparian zone, WFD

The relationship between macrophytes and freshwater environments in the Mediterranean area has received little attention, particularly with respect to Italian volcanic lakes (VL). The aim of this study was to investigate the relationships between species composition, distribution of the communities and the physical-chemical parameters in VL to assess the structural heterogeneity and spatial distribution of these plant communities. We collected data on the presence and coverage of macrophyte species in 9 central Italy VL and measured the physical-chemical parameters of the water in each basin. We performed 175 transects in VL, using a non-aligned random sampling with the number of transects being proportional to the lake surface. Transects were laid from the shore to the center of the lake, down to the maximum depth of macrophyte growth (3.5 m to 26 m, depending on the lakes). Macrophyte abundances were evaluated as % coverage at the sampling spot. Data were analyzed by PCA, using the transects as independent variables, and with a var-covar cross-product matrix based on macrophytes abundances. There was a distinct splitting of transects by lake (with 68% of variance explained by the first three axes), with a clear classification of centroids based on the gradients of species richness from poor to high load of nutrients in the water. As for water depth, the macrophyte communities still maintained a clear classification by lake (variance 66%). Consequently, the riparian communities also varied among lakes in terms of depth distribution. The median percentage of riparian species varied between 35 and 44%, depending on the individual lakes, with a tendency for lakes with better water conditions to house higher percentages of riparian species ($\chi^2 = 65.50$, $P < 0.00001$). This finding was confirmed by comparisons of current data with historical data (collected in 1908, in two VL), showing a clear reduction in the number of riparian species with water alteration. In conclusion, our data suggest that riparian vegetation diversity can be used as one of the metrics for assessing water quality condition. The general implications are discussed.

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## RIPARIAN GALLERIES OF INSULAR STREAMS IN THE AZORES ARCHIPELAGO

**Ana Mafalda Cruz, Andreia Cunha, João Ramos, Pedro Raposeiro, Ian Dodkins, Ana C. Costa, Vitor Gonçalves**

*CIBIO – Centro de Investigação em Biodiversidade e Recursos Genéticos – Pólo Açores, Departamento de Biologia, Universidade dos Açores, 9501-855 Ponta Delgada, Azores, Portugal (anamvcruz@gmail.com)*

Keywords: Insular Stream, Azores, Riparian Galleries, Macrophytes

The macrophyte communities in the Azores have low species richness compared to continental systems, due to the isolated nature of the Archipelago. The ocean barrier prevents the dispersal of viable seeds or plant fragments. Factors such as unstable substrates and the torrential regime of the streams also limit the development of macrophyte communities. The poor diversity reduces competition, allowing the existing species to be maintained in larger niches and to reach higher abundances than the same species in European watercourses. There are publications on the specifics of the Azorean vegetation, but the biology and ecology of aquatic vegetation are not well studied.
The aim of this work is to assess differences in stream aquatic plant communities from different watersheds in several Azorean islands.
The sampling campaign was conducted in spring 2010, in São Miguel, Santa Maria, Faial and Flores islands. Each sampling site was surveyed along a 100-m-long section. Species occurrence and abundance was assessed along the margins and in the channel. The INAG protocol for sampling macrophytes was used; this protocol also records information on the physico-chemical characteristics of the channel and margins.
The key macrophyte species and their abundances (determined as percentage covers) differed from upstream to downstream in the sampled sites, reflecting the influence of several factors. Downstream sampled sites were located in urban areas and were characterized by high flow and nutrient levels; midstream sampled sites were located in areas used for forestry and presented higher dissolved oxygen and basic pH; and upstream locations corresponded to native vegetation areas at higher altitudes.
There are also floristic differences between islands. Although *Hedychium gardneranum* and mosses are abundant in São Miguel and Flores, there are other species, mainly endemic to the Azores, that differentiate these islands. The low diversity and broad ecological range of species may be due to insularity.

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## STATUS AND DISTRIBUTION OF AQUATIC PLANTS IN NORTHERN AFRICA

**Laila Rhazi[1], Patrick Grillas[2], Mouhssine Rhazi[3], Nieves Garcia[4], Melanie Bilz[4], Annabelle Cuttelod[4]**

*[1] Hassan II Aïn Chock University, Faculty of Sciences, Laboratory of Aquatic Ecology and Environment, BP 5366 Maarif Casablanca, Morocco; [2] Tour du Valat: Research Centre for Mediterranean Wetlands, Le Sambuc, 13200 Arles, France; [3] Moulay Ismail University, Faculty of Sciences and Techniques, Department of Biology, BP 509, Boutalamine, Errachidia, Morocco; [4] Species Programme, IUCN (International Union for Conservation of Nature), 219c Huntingdon Road, Cambridge, CB3 0DL, United Kingdom. (corresponding author:grillas@tourduvalat.org)*

Keywords : aquatic flora, conservation, IUCN red list criteria, regional level assessment

North Africa exhibits a rich flora, including a high proportion of endemics resulting from its location at the crossroads of the Eurosiberian and tropical regions and from its geological history. It makes an important contribution to the Mediterranean biodiversity hotspot. The anthropogenic pressures on biodiversity and natural habitats are high in this region as a result of demographic growth and the needs for economic development. The aquatic habitats are very rich and diversified but are among the most vulnerable to the destruction or degradation of plant diversity. This assessment of the present situation of the aquatic plants in the region and of the main pressures that threaten them is a key step for long-term conservation through the identification of the highest priorities.
In the framework of the « North African Freshwater Biodiversity Assessment », the conservation status of 521 aquatic plants species have been assessed at the species level using IUCN criteria. Most of the assessed species are perennials (72%) that are strictly dependent on wetland habitats. Approximately 24% of the assessed species are threatened in the region. Almost half (44%) of the endemic species (33) are threatened at the regional level and thus globally. The data were insufficient for 10% of the species, among which 12% are endemic in the region. This result highlights the need for more field research to improve our knowledge of the conservation status of the species (distribution, status of populations and threats) and to identify the most threatened ones.
The loss and degradation of habitat quality is the main threat for 95% of the aquatic plant species in the region. However, the present extinction level is low (0.2%), and only one species (*Laurembergia tetrandra*) is considered to be extinct in the region. Morocco, Algeria, and the northwestern tip of Tunisia are hotspots for the biodiversity of aquatic plants in North Africa. The situation of the aquatic flora, and that of other groups of species found in freshwater habitats (especially fish and dragonflies), highlights the need for joint actions of the local and regional decision makers and the international organizations dedicated to the long-term conservation of regional aquatic biodiversity.

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## VEGETATION OF SPECIAL TYPES OF PONDS USED FOR FISH FARMING IN THE CZECH REPUBLIC

**Kateřina Šumberová**

*Institute of Botany, Academy of Sciences of the Czech Republic, Department of Vegetation Ecology, Brno, Czech Republic*

Keywords: artificial water bodies, fishpond management, rare plant communities, wetland vegetation

In the Czech Republic, most water bodies are artificial. The most frequent are fishponds, which are used for fish production and especially the breeding of common carp (*Cyprinus carpio*). The vegetation of fishponds has been studied since the first half of the 20th century. However, there are also other types of ponds, usually of small area, which are used for other purposes. Due to limited access to the public and their "more artificial" appearance, data on the vegetation of this habitat type were nearly lacking for a long time. Since 1999, I have intensively studied the vegetation of such fish-farming ponds. Three pond types were studied: (1) fish storage ponds, which are used for the short-term storage of consumable fish; (2) trout ponds serving for trout (*Salmo trutta*) breeding; and (3) other ponds, which are usually used for rare or ornamental fish breeding. Fish storage ponds are usually not in service during summer and are drained at that time. The two latter types of ponds are flooded mainly during the whole year. Vegetation elimination on these habitats is performed by various methods, e.g., mechanically (mowing and eradicating) or by herbicides or grazing. Therefore, these ponds are colonized by stands of plants that survive well under relatively intensive disturbances. Using the dataset of 565 relevés and field observations, more than 60 plant communities were identified in special fish-farming ponds. Many of these communities are rare in other types of wetlands, and they are considered to be threatened. For instance, in the fish storage ponds with long-term bottom exposure and mowing of vegetation, *Leersietum oryzoidis* is very common. *Cyperetum micheliani* is typical of shortly exposed fish storage ponds. In ponds used for rare and ornamental fish breeding (type 3), the highest number of rare communities occurred, e.g., *Potametum trichoidis, Potametum graminei* and *Batrachio circinati-Alismatetum graminei.* Trout ponds were characterized by common plant communities, e.g., *Glycerietum fluitantis* and neophytic *Elodeetum canadensis*.

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## PHYTOCOENOTIC AND FLORISTIC DIVERSITY OF OXBOWS IN THE RIVERINE LANDSCAPE OF CENTRAL-EUROPEAN LOWLANDS (POLAND)

**Wojciech Stachnowicz**

*Adam Mickiewicz University, Faculty of Biology, Department of Plant Ecology and Environmental Protection, Umultowska 89, 61-614 Poznań, Poland (corresponding author: wsta@op.pl)*

Keywords: riparian flora and vegetation, species and community richness, surface water bodies, large river valley, Natura 2000

Biodiversity in riverine landscapes should be investigated with a consideration of its hierarchical structure (Ward et al. 1999; 2002). This approach seems to be applicable not only on a physio-geograghic level of observation (e.g., within a river valley and its tributaries) but also taking into account both the origin and variability of geomorphic landforms, including surface water bodies. It is also appropriate for oxbows, which are highly differentiated according to their shape, depth and (sometimes ephemeral) connectivity with the river channel. Riparian water bodies belong to the most variable natural structures originated from fluvial processes. Having investigated both vascular plant flora and vegetation in more than a hundred oxbows situated within an extensive section of the large, lowland Warta River (Wielkpolska, Poland), I am going to focus on the potential ecological patterns of this biodiversity dataset. In relation to both (1) the species richness and (2) the diversity of plant communities, I considered the following characteristics of reservoirs: (3) their length, (4) width, (5) perimeter, (6) surface area, (7) distance from (and connectivity with) the river channel, and (8) approximate variability of surface water table, *i.e.,* its (partial or entire) drying (assessed through a comparison of contemporary maps and aerial photographs with recent, in-field, GPS-positioned observations). Geobotanical documentation of the investigated oxbows comprises more than 2000 floristical registers (including some full phytosociological relevés) and over 100 syn-phytosociological relevés. Using the second, recently neglected syn-phytosociological (or sigma-taxonomical) method of Tuexen (1979) and Schwabe (1997), I am going to demonstrate its usefulness for comprehensively documenting (and future monitoring) vegetation diversity within oxbows. Additionally, it may also be considered as a tool for further attempts of classification of riparian water bodies on their phytocoenological backgrounds. I hope that eventually these results will be a reference for assessments of the 'favorable protection state' of Natura 2000 habitats (3150 in the Annex 1. of the 92/43/EEC directive).

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## PLASTIC RESPONSES OF TWO AQUATIC ANGIOSPERMS TO DEWATERING

**Mélissa De Wilde, Sara Puijalon, Gudrun Bornette**

*Laboratoire d'Ecologie des Hydrosystèmes Naturels et Anthropisés UMR CNRS 5023, Université Lyon1, Lyon, France (corresponding author: melissa.de-wilde@univ-lyon1.fr)*

Keywords : wetlands, global change, dewatering, aquatic angiosperms, phenotypic plasticity

Wetlands and their associated biodiversity are particularly sensitive to changes in hydrological conditions induced by global change. This study (founded by the program ANR WETCHANGE CEPS and the FRB) examined the plastic responses of two aquatic plant species (*Berula erecta* and *Baldellia ranunculoides*) to a sudden dewatering. These two species grow in shallow aquatic habitats. Therefore, the hypothesis that a rapid phenotypic adjustment would allow them to survive and grow in drained conditions was investigated. The experiment was conducted in a greenhouse under controlled conditions (temperature, light and sediment) for 10 weeks. Survival, biomass and dry mass allocations to plant organs, leaf dry matter content, and three traits related to plant performance (specific leaf area, SLA; leaf lifespan, LLS; and relative growth rate, RGR) were measured before, during and after the establishment of the constraint. The sudden dewatering induced a decrease of *Berula erecta* SLA linked to a greater leaf dry mass. Under drained conditions, this species produced leaves with higher construction cost (higher leaf dry matter content) and longer lifespan (LLS). For this species, the increase in RGR suggested a better performance under drained conditions than under submerged ones, potentially linked to higher $CO_2$ availability. For *Baldellia ranunculoides,* dewatering led to a decrease in SLA, LLS and RGR, suggesting a decrease in short-term performance under dewatered condition. The consequences for the ecology and species distribution are discussed.

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## PLANT RESISTANCE TO MECHANICAL STRESS: EVIDENCE OF AN AVOIDANCE-TOLERANCE TRADE-OFF

**Sara Puijalon[1], Tjeerd J. Bouma[2], Christophe J. Douady[1,3], Jan van Groenendael[4], Niels P.R. Anten[5], Evelyne Martel[1], Gudrun Bornette[1]**

*[1] Université de Lyon, Lyon, France – UMR CNRS 5023 Ecologie des hydrosystèmes naturels et anthropisés, Université Lyon 1, F-69622 Villeurbanne, France; [2] Netherlands Institute of Ecology (NIOO-KNAW) – Centre for Estuarine and Marine Ecology; P.O. Box 140; 4400 AC Yerseke; The Netherlands; [3] Institut Universitaire de France, Paris, F-75005, France; [4] Institute of Water and Wetland Research - Radboud University Nijmegen; Toernooiveld; 6525 ED Nijmegen; The Netherlands; [5] Section of Plant Ecology & Biodiversity - Institute of Environmental Biology; Utrecht University; P.O.Box 800.84; 3508 TB Utrecht; The Netherlands*

Keywords: biomechanics, hydrodynamics, trade-off, strategies, evolution, submerged aquatic vegetation, mechanical stress

External mechanical forces resulting from the pressure exerted by wind or water movement are a major stress factor for plants and may cause regular disturbances in many ecosystems. A plant's ability to resist these forces relies either on minimizing the forces encountered by the plant (avoidance strategy) or on maximizing its resistance to breakage (tolerance strategy). We investigated plant resistance strategies using aquatic vegetation as a model and examined whether avoidance and tolerance are negatively correlated.

We tested the avoidance-tolerance correlation across 28 species using a phylogenetically corrected analysis, after construction of a molecular phylogeny for the species considered.

Different species demonstrated contrasting avoidance and tolerance, and we demonstrated a significant negative relationship between the two strategies, which suggests an avoidance/tolerance trade-off.

The existence of a such trade-off has important ecological and evolutionary consequences because i) it would lead to constraints on the evolution and variation of both strategies, limiting their evolution towards extreme values; ii) it may constrain many morphological, anatomical and architectural traits that underlie avoidance and tolerance, including growth form, canopy size and shape; and iii) it could lead to the evolution of alternate strategies in the different species.

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## INTEGRATED LABORATORY AND FIELD APPROACHES TO EXAMINE THE ROLE OF HERBICIDE RESIDUES IN THE DECLINE OF EELGRASS (ZOSTERA SP.) MEADOWS

**Marion Fidenci [1,2], Jean Kallerhoff [1,3], Jérôme Silvestre [1,3], Georges Merlina [1,3], Evelyne Buffan-Dubau [1,2], Angel Belles [4], Isabelle Auby [5], Hélène Budzinski [4], Arnaud Elger [1,2]**

*[1] Laboratoire Ecologie Fonctionnelle et Environnement, UMR 5245 CNRS/INP/UPS, Castanet-Tolosan, France; [2] Université Paul Sabatier, Toulouse, France; [3] INP ENSAT, Castanet-Tolosan, France; [4] Laboratoire Environnements et Paléoenvironnements Océaniques et Continentaux, UMR 5805 CNRS/Univ. Bordeaux/EPHE, Talence, France; [5] IFREMER, Arcachon, France.(corresponding author: Marion.Fidenci@etu.ensat.fr)*

Keywords: anthropogenic stressor, diffuse contamination, seagrass, Zostera noltii

Eelgrass is a keystone aquatic macrophyte of coastal temperate ecosystems that are rapidly declining worldwide. Various factors (*e.g.,* eutrophication, 'wasting disease' and xenobiotic contamination) are potentially involved in this decline, but the exact role of these factors, and their possible interactions, are often not clearly identified. We present here some approaches currently developed in Atlantic and Mediterranean French lagoons to assess the impact of diffuse herbicide contamination on dwarf eelgrass *(Zostera noltii* Hornem*).* The first approach consisted of relating seagrass conditions across field sites to herbicide contamination (determined using POCIS integrative sampling on the water column and ASE extraction on sediments). Other physicochemical parameters (*e.g.,* NHx water and sediment contents, redox potential and water turbidity) were also measured to account for their possible influence on eelgrass. To further investigate these initial correlative results, a second approach was developed under controlled laboratory condition and consisted of exposing eelgrass to some of the contaminants found in the natural environment to build dose-response models. The direct effects of herbicides are addressed through measures of growth rate, photosynthetic efficiency, pigment composition, RNA / DNA ratio and the activities of oxidative stress enzymes. A last approach will consist of transplanting some eelgrass along contamination gradients to monitor plant dynamics and stress biomarkers. This approach will account for both the direct and indirect effects of herbicide residues on eelgrass. These different laboratory and field approaches will provide some tools to determine whether there is a causal relationship between herbicide contamination and eelgrass decline and help identify some possible impacts of herbicides in interaction with other stressors.

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## THE EFFECT OF A XENOBIOTIC (CD) ON ANTIOXIDANT SYSTEMS IN THE AQUATIC MACROPHYTE ELODEA *CANADENSIS*

**Hana Sbartai[1], I. Ibtissem Sbartai[2], Sabrina Zouainia[1], Djebar Mohammed Reda[1]**

*[1]. Badji Mokhtar University of Annaba. Department of Biology. Laboratory of Cell Toxicology. Algeria. [2]. University Center of El-Tarf. Department of Biology. Laboratory of Cell Toxicology. Algeria*

Keywords: Cadmium, chlorophyll a and b, Biomarkers, oxidative stress, Elodea canadensis

Pollution, whatever its nature and its origin, remains the most important factor that changes the nature and composition of ecosystems. Today, the marine environment is affected by different types of wastes, from industrial, agricultural or urban areas, and at all spatial scales, from national to global scales. Cadmium is one of the most toxic pollutants; its phytotoxicity occurs through the disruption of the mineral nutrition of plants. As a consequence a slower growth rate, there is an inhibition of photosynthesis and the induction of certain biomarkers involved in the defense system, such as proline, GSH, GST, and CAT. However, the use of certain aquatic plants (bioindicators of pollution) could be an effective technique for reducing the impact of pollutants. Therefore, the efficiency of a plant species in phytoremediation will depend in part on its tolerance and/or the pollutants. In this context, a preliminary study was conducted to measure the possibility of using *Elodea canadensis* in the purification of contaminated water, and its ability to concentrate Cadmium in its different organs. For this purpose, plants of *Elodea Canadensis* were planted in nutrient solutions with increasing concentrations of cadmium chloride (10, 20, 40 or 80 µM) for 7 or 14 days. The results showed that the plant weight increase was negatively related to increasing cadmium concentrations and to time. We also measured an increasing concentration of proline and a decreasing concentration of chlorophyll a and b. The GST activity increased after 7 and 14 days of treatment, with an inhibition at high cadmium concentrations (40 and 80 µM), whereas the GSH activity increased for the low cadmium concentration after 7 days but was inhibited completely after 14 days of treatment. Finally, the measurement of catalase activity showed its induction at low cadmium concentrations and its inhibition at higher concentrations after 7 days of treatment, whereas it was completely inhibited at all concentrations after 14 days of treatment.

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# EVIDENCE OF COPPER IMPACT ON FRESHWATER ENVIRONMENTS USING *MYRIOPHYLLUM ALTERNIFLORUM*: RESTORATION, BIOMONITORING AND MANAGEMENT

**David Delmail, Pascal Labrousse, Philippe Hourdin, Michel Botineau**

*G.R.E.S.E. E.A 4330, Laboratoire de Botanique et Cryptogamie, Faculté de Pharmacie, 2, rue du Dr Marcland, 87025 LIMOGES Cedex France (corresponding author: david.delmail@wanadoo.fr)*

Keywords : *Myriophyllum alterniflorum*, heavy metal, copper, restoration, biomonitoring.

*Myriophyllum alterniflorum* D.C., an aquatic macrophyte native to north-European stream freshwaters, was found even in polluted environments from the Vienne River and its tributaries, which are often loaded with anthropogenic copper in the Limousin region of France. Vitroplants of this species were reintroduced in degraded locations, and the restoration was successful as insect larvae, crawfish, leeches and moderlieschen alevins were found in reintroduced macrophyte beds. Furthermore, the positive *in situ* acclimation of the *M. alterniflorum* patches predicted potential biomonitoring applications. Indeed, this species is known to be heavy-metal tolerant, and it appears to be a strong candidate for the development of new plant biomarker models specific to pollution in stream environments, as none were developed until now. Among ten physiological parameters studied during 35 days after *in situ* reintroduction, the photosynthetic pigments (chlorophylls a and b and carotenoids) presented an excellent sensitivity to copper contamination. A strong correlation was shown between the pigment contents of *M. alterniflorum* and the copper water concentration. This correlation allowed the establishment of models to estimate (i) the phytotoxicity of the heavy metal and (ii) the heavy-metal concentration from the pigment data. The accuracy of the models is limited to copper concentrations ranging from 0.07 µg $l^{-1}$ to 12.60 µg $l^{-1}$, offering many opportunities to apply this new method in many European polluted stream waters without using expensive and complex analytical methodologies (e.g., ICP-MS). The biological and chemical information gained from this rapid and cost-effective approach will allows the development of environmental health programs to manage the heavy-metal load in stream ecosystems. Moreover, this study is a breakthrough in the biomonitoring of freshwaters because it leads to an enhanced environmental management program with the development of new biomarkers of freshwater macrophytes.

# Vegetation responses to disturbances

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## VARIATION OF PLANT PHENOLOGY AMONG FIRE REGIMES ON IBITY MOUNTAIN (MADAGASCAR)

**Swanni T. Alvarado[1,2], Elise Buisson [1], Harison Rabarison[2], Charlotte Rajeriarison[2], Chris Birkinshaw [3], Porter P. Lowry II [4,5]**

*[1] Institut Méditerranéen d'Ecologie et de Paléoécologie (UMR CNRS / IRD), Université d'Avignon et des Pays du Vaucluse, Avignon, France; [2] Département de Biologie et Ecologie Végétales, Faculté des Sciences, Université d'Antananarivo, Madagascar; [3] Missouri Botanical Garden, Madagascar Research and Conservation Program, Antananarivo, Madagascar; [4] Missouri Botanical Garden, Africa and Madagascar Department, St Louis, Missouri, USA; [5] Département Systématique et Evolution, Muséum d'Histoire Naturelle (USM 7205), Paris, France (corresponding author: swanni_ta@yahoo.es; swanni.alvarado@etd.univ-avignon.fr)*

Keywords: *Uapaca bojeri*, herbaceous savanna, management, Tapia Woodland

Understanding phenology is critical for explaining the coexistence of species in a given ecosystem. The study of the abiotic and biotic variables that influence phenological cycles is fundamental for determining plant strategies involved in the processes of colonization and regeneration. Fire is one of the main factors that can alter these cycles. We report results from research conducted on Ibity Mountain, a new protected area in Madagascar where fire is the most highest threat to biodiversity and the principal factor causing degradation of native savanna and Tapia (*Uapaca bojeri*) woodlands, which have been transformed into anthropogenic grasslands and remnant fragments. These formations are burned annually by the local population to renew pasture for livestock, to clean fields and to control rats. The effects of fire on the plant communities of Ibity are still poorly understood, a fact that constitutes a major hindrance for developing effective management plans. The current fire regime involves more frequent burning at lower temperatures than would naturally occur, which favors dominance by adult trees of *U. bojeri* and leads to monospecific savannas in which native elements are eliminated. A 1-year phenology study was performed starting in February 2010 on a set of 16 1-m² quadrats in 8 savanna sites and on 3-15 individuals of all woody species in 6 Tapia woodland sites. In savannas, the herbaceous vegetation is largely reduced to members of the Poaceae and Cyperaceae families, which exhibit vegetative post-fire regeneration using rhizomes, although some annual species occur in the wet season at low density. Succulent species such as *Pachypodium brevicaule*, *P. densiflorum* and *Aloe* spp. are fire resistant, and their phenological cycle is similar in the two environments. In Tapia woodland, many species display vegetative regeneration by resprouting, and flower and fruit production is reduced, especially for Sarcolaenaceae. Results will be discussed with regard to their implications for the vegetation management plan.

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## VARIATION IN POPULATION DEMOGRAPHY AND LIFE HISTORY TRAITS OF TECATE CYPRESS SUGGESTS A PRE-HISTORICAL FIRE REGIME DIFFERENCE ACROSS THE USA-MEXICO BORDER

**Roland de Gouvenain[1], Jose Delgadillo [2]**

*[1] Rhode Island College, Biology Department, Providence, RI, USA; [2] Universidad Autónoma de Baja California, Facultad de Ciencias, Ensenada, BC, México; (corresponding author: rdegouvenain@ric.edu)*

Keywords: California, closed-cone cypress, demography, evolutionary ecology, life history trait evolution

Fire is the most important environmental disturbance in the Mediterranean-type chaparral ecosystems of southern California and northern Baja California, Mexico. We evaluated the origin of a putative difference in fire regime across the USA-Mexico border by using replicated field demographic sampling, dendrochronology, and population matrix models to compare the demographic structure, life history traits, and population dynamics of Tecate cypress (*Hesperocyparis forbesii* Adams) in southern California and northern Baja, Mexico. Demographic structure, incidence of cone serotiny, and age at onset of reproduction were different, but the intrinsic rate of population increase (λ) response norms to simulated changes in the fire-return interval were similar between the two sets of populations. The presence of ecological and demographic differences suggests that a difference in fire regime between southern California and northern Baja has existed long enough (> 8000 yrs) to drive evolutionary divergence between the two sets of populations. These differences cannot have been triggered during the last century solely by different fire management policies across the international border, although this recent human influence may have added complexity to the difference in the natural fire regime. The transitional area between the two different fire regimes appears to be situated south of Ensenada in a zone of ecological transition already recognized by others and not at the international border itself.

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## EFFECTS OF AN EXPERIMENTAL STORM SURGE AND SEDIMENT DEPOSITION ALONG AN ESTUARINE GRADIENT IN NORTHWESTERN FLORIDA, USA

**Loretta Battaglia, Matthew Abbott, Jesse Fruchter, Adam Chupp**

*Southern Illinois University, Department of Plant Biology and Center for Ecology, Carbondale, Illinois, USA (lbattaglia@plant.siu.edu)*

Keywords: climate change, coastal, hurricane, sediment

Coastal ecosystems along the northern Gulf of Mexico are some of the first ecosystems directly impacted by hurricane disturbances and rising sea levels. We hypothesized that hurricane-generated storm surges disassemble landward communities dominated by species intolerant of high salinity pulses and burial by sediment inputs, thereby enabling species from seaward positions to establish further inland. In 2009, five transects were established at points along East River, a tidal river ecosystem in northwestern Florida. Each transect was surveyed for elevation and extended perpendicular to the river into upland habitat to include 1 m, 2 m, and 3 m changes in relative elevation from the river's edge. In September 2010, five 0.68-$m^2$ plots were established in each of the zones along the five transects (n = 75). Following an initial plant composition survey in which species cover was estimated, four of the five plots in each zone received a saline storm surge (28 ppt) and sediment application. The sediment treatment resulted in a 5 cm deep layer that consisted of a 2:1 mixture of marine sand and river silt. Sediment was collected adjacent to transect stations 1 and 3 in the East River. In October 2010, plots were revisited and the overall % mortality attributable to the treatment was estimated. Although the surge/sediment experiment was initiated only very recently, short-term mortality data indicate large impacts of the experimental treatments on the vegetation. Many of the plants that were buried appeared to be dead at the time of the second visit to the plots. With the exception of several plots that are inundated periodically by the East River, the majority of plots remain covered by a 5 cm sediment layer of sand and silt. The combination of saline water and sediment burial drove patterns of high mortality across the estuarine gradient. We will continue to monitor these plots and evaluate any compositional shifts that may occur, particularly changes consistent with landward migration of species into plots where mortality was high.

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## FACTORS CONTROLLING THE DIVERSITY OF GROUND-LAYER LICHENS ON ALVARS OF WESTERN ESTONIAN ISLANDS

**Inga Jüriado, Ede Leppik, Jaan Liira, Ave Suija**

*Institute of Ecology and Earth Sciences, Department of Botany, University of Tartu, Lai 40, 51005, Tartu, Estonia (corresponding author: inga.juriado@ut.ee)*

Keywords: calcareous grasslands, disturbances, management, species richness

Lichens are abundant in the ground-layer vegetation of alvars, where vascular plant cover is sparse. Due to the extraordinary combinations of environmental conditions (e.g., droughts and flooding) lichen assemblages in alvar grasslands consist of taxa unusual for the boreal region as they contain species belonging to sub-Mediterranean, alpine, sub-pontic, and sub-oceanic geographical elements. In our study, we targeted quantification of the effect of the environmental conditions and habitat disturbances on the species richness, cover and composition of the lichen communities, by observing 60 alvar grassland fragments on islands of western Estonia. Our survey revealed that most of the alvar grasslands in Estonia have vascular plant cover too dense to support a high cover of epigeic lichens. Lichens were found mainly in habitats that suffered from past intensive disturbance regimes, including former military areas and limestone quarries. Major factors influencing the lichen species richness and composition in alvar grasslands were the bush cover and soil properties, such as soil depth, Ca, Mg and organic matter content. The composition of assemblages of epigeic lichen species in alvar grasslands was also influenced by cover of stones, plants, and the presence of bryophytes. The proper management of alvars is important for epigeic lichen biota, because overgrown alvars reduced plant diversity result in the loss of epigeic lichen communities.

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# LANDSCAPE AGE, CLIMATE STABILITY AND FIRE REGIME PREDICTABILITY: DEVELOPING AN UNDERSTANDING OF BIODIVERSITY IN OLD STABLE LANDSCAPES

**Grant Wardell-Johnson, Ladislav Mucina**

*Curtin Institute for Biodiversity and Climate, School of Science, Curtin University, Perth, Australia (corresponding author: g.wardell-johnson@curtin.edu.au)*

Keywords: Landscape age, climate stability, fire regime predictability, soil fertility, refugium

Steve Hopper (2009) introduced landscape age, climate buffering and soil nutrient status as descriptors for a continuum between old, climatically buffered landscapes characterized by low soil fertility (OCBIL) and young, often disturbed landscapes characterized by fertile soils (YODFEL). We recognize climate stability, landscape age and fire regime predictability as large-scale, long-term evolutionarily important dimensions driving biodiversity patterns and processes in Old Stable Landscapes (OSLs). We therefore construct a globally relevant, qualitative template to enable the testing of evolutionary-ecological hypotheses concerning biodiversity. Our template is characterized by having operationally defined dimensions, which can be used to design surveys and experiments to address the issues of biodiversity conservation, recovery, and restoration under variations in landscape age, climatic stability and fire regime. We recognize short-term, mid-term and long-term rejuvenation processes leading to operational definitions of recent, young, old and ancient landscapes. The last two of these are characterized by taxa that are the result of selective pressures associated with long-lasting and slow soil impoverishment. We also distinguish three types of climatically stable landscapes based upon climatic stability with respect to the Plio-Pleistocene boundary and the Mid-Miocene transition. Finally, recognizing that climate is the primary driver of fire regime, with topographic and other factors becoming important at more local scales, we recognize various types of highly predictable pyro-landscapes. These three dimensions define a conceptual model suggesting that the positions of OSLs are found at the intersection of the environmental templates defined by these dimensions. Our template has worldwide relevance, with OSLs being widespread on the planet. The most likely places to find OSLs are where there is the long-term persistence of the following: 1) a highly predictable, strongly seasonal climate coinciding with predicable fires during the dry season; 2) predictable nearly year-round high precipitation patterns where fires are rare; or 3) very dry environments where fires are rare.

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## EFFECTS OF FIRE MANAGEMENT ON THE FLORA OF A GRAVEL RIVER IN CENTRAL JAPAN

**Masato Yoshikawa, Dan Izumi**

*Tokyo University of Agriculture and Technology, Institution of Agriculture, Tokyo Japan*

Keywords: Field burning, Houki-gawa River, *Miscanthus sacchariflorus, Miscanthus sinensis*, spring ephemerals

There are many gravel-bed rivers in Japan, which have a special flora on their dry and sandy floodplain. However, the natural vegetation of these rivers has declined because of highly controlled water flow and limited sediment transportation. The sandy surfaces of the floodplains have not been regenerated even by large flush events and have been covered with fine sediments. Consequently, the habitat of typical plants of gravel-bed rivers disappeared, and the riparian vegetation became dominated exclusively by *Miscanthus sacchariflorus* and *M. sinensis*.
The floodplain of the Houki-gawa River, in the northwestern part of the Tochigi prefecture, has been managed by controlled field burning for more than 20 years. Field burning is practiced in the end of February by local farmers. The main purpose of this management is to prevent the incidence of harmful insects and diseases in adjacent rice fields. However, this activity positively affects riparian vegetation.
We set up 36 and 14 plots (20 m × 20 m) in burned and unburned areas, respectively, including *M. sacchariflorus*-dominated sites and *M. sinensis*-dominated sites. Plant species in these plots were recorded in April and June of 2008 or 2009. There were 276 species present in the burned plots and 210 species present in the unburned plots. The Jaccard similarity coefficient between burned and unburned plots was 0.47 in the *M. sacchariflorus*-dominated plots and 0.44 in the *M. sinensis*-dominated plots. The burned plots dominated by *M. sacchariflorus* contained many spring ephemerals such as *Adoxa moschatellina*, *Allium monanthum*, *Anemone flaccid*, and *Corydalis lineariloba*. In addition, tall herbs such as *Scrophularia kakudensis* and *Ranunculus grandis* were increased in the burned plots dominated by *M. sinensis*. On the other hand, the species that appeared only in the unburned plots were mainly alien species, such as *Eragrostis curvula* and *Anthoxanthum odoratum*. From these results, it was clear that field burning changed the riparian flora by creating seasonal and spatial habitats for many native species. The coexistence of *Miscanthus* species and small spring ephemerals was a unique phenomenon. The improvement of conditions by litter burning and supplying diaspores from mountains upstream led to this combination.

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## INFLUENCE OF TEMPERATURE AND SMOKE ON THE GERMINATION OF FORBS OF THE BRAZILIAN CERRADO

**Julia Dombroski, Bêtania Santos Fichino, Alessandra Fidelis, Maurício Perine, Vânia Regina Pivello**

*Universidade de São Paulo, Department of Ecology, São Paulo, Brazil (jurgdombroski@gmail.com)*

Keywords: fire ecology, heath shock, Cerrado forb species, smoke, germination

Fire is an ecological determinant of the Brazilian Cerrado, being one of the most common land management techniques applied by rural communities. Major consequences of fire are the increase of temperature above the soil and the production of smoke. To investigate the influence of temperature and smoke on the germination of six forb species common in Brazilian open cerrados, seeds from different populations were collected and exposed to temperature and smoke treatments. Five replicate treatments were performed with 20 seeds of each species. Temperature treatments consisted of exposing seeds to heat shocks at 60°C, 100°C, 150°C and 200°C for 1, 3 and 5 minutes, and there was a control group with no heat. Smoke treatments consisted of imbibing the seeds in two different dilutions of smoke solutions (1:1 and 1:10) for 24 h, using distilled water as the control. Seeds remained for 40 days in a germination chamber (12/12 h, 28ºC). Germination rates obtained from temperature and smoke treatments were compared using two-way and one-way ANOVA, respectively. The results showed different temperature effects on the species: some species maintained their natural high germination rates at 150°C, and other species were able to germinate only at 100°C or less. No species had germination rates that were influenced by exposure time or that showed an interaction between temperature and exposure time. Smoke treatments showed no influence on germination rates. According to our results, temperature was the most important fire factor that could influence the germination rates of the six Cerrado species tested. Therefore, the temperature reached by fires is an important factor that must be considered in population dynamics studies in Cerrado environments, despite other fire factors that were not considered in this study.

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## SPATIO-TEMPORAL ANALYSIS OF BUSH FIRES ON IBITY MOUNTAIN (MADAGASCAR): IMPLICATIONS FOR DEVELOPING A MANAGEMENT PLAN

**Swanni T. Alvarado[1,2], Narindra Ramahefamanana[2], Elise Buisson[1], Harison Rabarison[2], Chris Birkinshaw [3], Porter P. Lowry II [4,5]**

*[1] Institut Méditerranéen d'Ecologie et de Paléoécologie (UMR CNRS / IRD), Université d'Avignon et des Pays du Vaucluse, Avignon, France; [2] Département de Biologie et Ecologie Végétales, Faculté des Sciences, Université d'Antananarivo, Madagascar; [3] Missouri Botanical Garden, Madagascar Research and Conservation Program, Antananarivo, Madagascar; [4] Missouri Botanical Garden, Africa and Madagascar Department, St Louis, Missouri, USA; [5] Département Systématique et Evolution, Muséum d'Histoire Naturelle (USM 7205), Paris, France (corresponding author: swanni_ta@yahoo.es; swanni.alvarado@etd.univ-avignon.fr)*

Keywords: fire ecology, Uapaca bojeri, savanna, teledetection, MODIS, vegetation management plan

For centuries, bush fires have been a widely used management tool in savanna ecosystems throughout the world. In Madagascar, people control and use fire for diverse purposes. Human-set fires mainly burn the herbaceous stratum, although in certain conditions they can affect the viability of woody species. The research reported here took place on Ibity Mountain, situated in the Malagasy Highlands, which is dominated by savannas and remnant fragments of Tapia (*Uapaca bojeri*) woodland. The objective was to determine the spatial and temporal distribution of dry-season fires using satellite data from 2000-2010 in an effort to improve the vegetation management plan for this new protected area. A uni-temporal and a multi-temporal approach were used to analyze bush fires. Satellite images from MODIS products (MOD09Q1 and MCD45A1) available since April 2000 enabled us to: 1) define the fire season precisely; and 2) analyze the frequencies of fire over a 10 year period. We are now attempting to identify the possible seasonality of bush fires on Ibity according to topography, geomorphology and vegetation type. A map of fire frequency and the position of the most vulnerable plant formations will help inform the development an integrated fire and vegetation management plan.

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## EFFECTS OF FIRE AND STORM SURGE ON SPECIES HETEROGENEITY AND RICHNESS IN THE PINE ROCKLAND COMMUNITY OF BIG PINE KEY, FL, USA

**Danielle E. Ogurcak [1,3], Jay P. Sah [2], Michael S. Ross [1,2]**

*[1] Florida International University, Department of Earth and Environment, Miami, USA; [2] Florida International University, Southeast Environmental Research Center, Miami, USA; [3] corresponding author: dogur001@fiu.edu*

Keywords: herbaceous flora, fire, storm surge, ANOSIM, NDVI

The loss of pine rockland community in the Lower Florida Keys is being driven by a combination of rising sea levels, episodic storm surge events, and reduced fire frequency. Since 2006, lower elevation locations in the pine rockland community have seen a massive mortality of pines and a change in the highly diverse herbaceous flora. We hypothesize that compositional changes in herbaceous flora will vary depending on the level of storm surge inundation received from Hurricane Wilma, which passed over the Florida Keys on October 24th, 2005. In an effort to determine how the storm surge affected community change in the pine rockland habitat on Big Pine Key, we investigated how herbaceous composition has changed in areas of contrasting fire history and storm surge impact along an elevation gradient. The storm surge impact was determined from changes in the normalized differenced vegetation ratio from Landsat TM imagery acquired before and after Hurricane Wilma. The percent cover and density of herbaceous plants and shrub species less than 1 meter in height were sampled in permanent plots over 4 sampling years. The first sampling events occurred in 1999-2001 as part of a fire-effects study, with one sampling event before and two after a prescribed fire in burn treatment plots and control plots. In the post-storm surge sampling (summer 2008), ten groups of four 1-$m^2$ circular subplots were randomly selected for resampling in four of the permanent plots. Data were analyzed using Non-Metric Multidimensional Scaling (NMDS), ANOSIM, and SIMPER in Primer 6.0 to assess changes among plots across the four sampling events. ANOSIM indicated a significant difference ($p < 0.04$) in composition for all 3 pre-Wilma sampling events versus 2008 for all but the highest elevation plot. Heterogeneity increased substantially in low elevation plots compared to higher elevation plots. Overall, the storm surge had a greater effect on species composition than fire treatments. These results demonstrate the varying effects that different disturbances have on species heterogeneity and provide clues to how community assemblages will shift as sea level rises and glycophytes are replaced by more salt tolerant species.

Session 'Vegetation responses to disturbances' / POSTER 102

## ASSESSING THE EFFECTS OF NATURAL DISTURBANCE ON DOMINANT MANGROVE COMMUNITIES IN THE AYEYARWADY DELTA, MYANMAR

**Toe Toe Aung[1], Mochida Yukira [2], Maung Maung Than[3]**

*[1] Yokohama National University, Graduate School of Environment and Information Science,Yokohama Japan; [2] Yokohama National University, Faculty of Human and Education Science,Yokohama Japan; [3] Mangrove Project Coordinator, British Embassy, Yangon, Myanmar (corresponding author: toeaung02@gmail.com)*

Keywords: Mangroves, Cyclone Nargis, Rhizophora apiculata, Avicennia officinalis, Heritiera fomes

This study aimed to assess the effects of a natural disturbance, Cyclone Nargis, on mangrove communities in the Ayeyarwady delta of Myanmar. Three dominant mangrove communities were selected and five permanent plots (each 10 m x 10 m) for each community were monitored after the impact of Cyclone Nagis at the beginning of May, 2008. These mangrove communities were dominated by Rhizophora *apiculata, Avicennia officinalis, or Heritiera fomes,* each growing at different distances from the nearest river and at different elevations. The seedlings, saplings, and adult trees of each mangrove species found in each plot were recorded, including their positions, survival and mortality, seedling recruitment and also necessary environmental variables. After Cyclone Nargis, it was observed that the mortality of *A. officinalis* and *H. fomes* trees (growing on islands at high elevation) was less than 10 %, whereas that of *R. apiculata* (growing on riverbanks at low elevation) was more than 90 %. Almost all surviving trees of *A. officinalis* and *H. fomes* regrew efficiently through vegetative sprouts from damaged stems, and abundant mangrove seedlings were also recorded in these two communities. In contrast, only a few surviving trees of *R. apiculata* were recorded as they had no vegetative sprouts, and a limited number of mangrove seedlings occurred in this community. Due to the high mortality of *R. apiculata*, riverbank erosion occurred in this community. Therefore, the effects of natural disturbance, specifically Cyclone Nargis, differed significantly according to the mangrove vegetation type. The *R. apiculata* community was demonstrated to be highly vulnerable to disturbances and should be prioritized for conservation.

Session 'Vegetation responses to disturbances' / POSTER 103

## THE HETEROGENEOUS DISTURBANCE HYPOTHESIS: EFFECTS OF DISTURBANCE ON BIODIVERSITY IN CULTURAL LANDSCAPES VERSUS MILITARY AREAS

**Anke Jentsch[1], Martin Alt[2], Constanze Buhk[2], Steven Warren[3]**

*[1] University of Bayreuth, Disturbance Ecology, D-95440 Bayreuth, Germany, email address: anke.jentsch@uni-bayreuth.de; [2] University of Koblenz-Landau, Geoecology / Physical Geography, D-76829 Landau, Germany; [3] Colorado State University, CEMML, Fort Collins, Colorado, USA*

Keywords: phytodiversity, landscape dynamics, threatened and endangered species

The Heterogeneous Disturbance Hypothesis (HDH; Warren et al. 2007) suggests that numerous natural and human disturbances varying in type, spatial and temporal scale and their interactions enhance biodiversity. To investigate this hypothesis, the effects of land use dynamics as well as military disturbances on plant diversity in two landscapes in central Europe were surveyed. These two landscapes are characterized by similar climate, bedrock and soil. However, they vary in disturbance regime: one is an agricultural landscape (Fichtelgebirge), the other one is a huge military training area (Grafenwöhr). Within each landscape, 100 plots, each 1 ha in size, were placed within a systematic grid. In addition to disturbance type, information regarding temporal and spatial characteristics and the selectivity of disturbance was collected. Furthermore, plant species richness and identity were sampled within each spatial unit, including patch, plot and landscape. Analyses were conducted using partial least squares regression and boosted regression trees, two methods that detect interactions between species richness and the disturbance regime.

The results show a higher level of heterogeneity in the investigated military training area than in the agricultural landscape. A total of 32 different disturbance types were detected and allocated to 595 identified patches. The results indicate that multiple disturbances lead to enhanced plant species richness. Of the 647 different species found, 18% are threatened and endangered species. Disturbances related to forestry were best correlated with high plant species richness. Temporal parameters of disturbance regime such as frequency and seasonality of events had the highest explanatory value for species richness. Spatial parameters such as the area and distribution of disturbances and the selectivity such as logging for age classes had lesser influence on species richness.

In conclusion, the heterogeneity of the environment and disturbance regime, and the interactions between natural and human disturbances lead to maximized plant species richness. The heterogeneous disturbance regime appears to be the major driver of species richness.

# Warm-temperate deciduous forests in Southern Europe, East Asia and elsewhere around the Northern hemisphere

Session 'Warm-temperate deciduous forests' / ORAL

## CHARACTER OF WARM-TEMPERATE FORESTS IN ASIA

**Kazue Fujiwara[1], Qian Tang[2], Atsuko Harada[1]**

*[1] Yokohama City University, Graduate School of Nanobioscience, Yokohama, Japan; [2] Henan University, Research Institute of Yellow River Culture and Sustainable Development, Kaifeng, China (Kazue Fujiwara: email kazue@ynu.ac.jp)*

Keywords: cool-temperate forest, evergreen broad-leaved forest, intermediate forest, forest hardiness, Warmth Index, Coldness Index, laurifoliation

The term warm-temperate (W-T) forest was proposed by Kira (1949), based on climatological data and Warmth and Coldness Indices that were calculated by summing monthly mean temperatures. With these indices, Kira recognized that there were three types of forest in the temperate zone. Generally, the forest zone in East Asia is divided into temperate and subtropical forest, with evergreen or deciduous *Quercus* forests in the mid-latitudes of the Northern Hemisphere. The northern border of evergreen broad-leaved (EGB) forests can support deciduous *Quercus* as a secondary forest after clear-cutting. These deciduous *Quercus* forests were called W-T forests in drier areas with Warmth Index (WI) values of 85-180. The Warmth Index is 85-180 for W-T EGB forests and 45-85 for cool-temperate (C-T) forests. The main species of warm-temperate deciduous *Quercus* forests in Asia are *Quercus serrata*, *Q. aliena*, *Q. acutissima* and *Q. variabilis*, which are common in China, Korea and Japan. On the other hand, C-T species are *Q. mongolica* in China and Korea, *Q. liaotungensis* (= *Q. wutanshanica*) in China and *Q. crispula* (*Q. mongolica* var. *grosseserrata*) in Japan. Nakashizuka (2003) proposed that W-T *Quercus* forests developed after natural fire or human disturbance such as fire or cultivation. It is the physical character of W-T deciduous *Quercus*. Sakai examined the frost-hardiness of the main evergreen (subtropical and W-T) and deciduous species (W-T and C-T). *Q. Serrata, Q. acutissima*, and *Q. aliena*, in particular, have low frost-hardiness but are higher than the frost hardiness of *Fagus crenata* and *Q. crispula*. In Asia, we thus have a W-T deciduous *Quercus* forests zone. These forests cover lowland S-Korea and between the Yangtse (Changjiang) and Yellow (Huang He) rivers in China. In Japan, they occur in the Nagano and Yamagata basins. These areas, under a humid climate, have invasive planted EGB tree species from hedges, gardens and Shinto shrine forests. Areas next to lakes and ponds especially have many invaders, which grow to three to six meters. These phenomena were reported by Walther et al. (2003), but not for Korea and China, which may be too dry. These forests correspond to others occurring in the Northern Hemisphere.

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## THE TEMPERATE FORESTS OF THE IBERIAN PENINSULA

**Javier Loidi**

*University of the Basque Country, Department of Plant Biology and Ecology, Ap. 644. 48080 Bilbao, Spain (javier.loidi@ehu.es)*

Keywords: deciduous forests, sub-Mediterranean, Querco-Fagetea, lauroid elements, marcescent oaks

Temperate forests are those that are adapted to a temperate climate, i.e., mid-latitude summer-moist. In Europe, areas with this climatic type are occupied mostly by deciduous oak (*Quercus sp. pl.*) and beech (*Fagus sylvatica*) forests. In the Iberian Peninsula, deciduous forests show a typical distribution pattern in which they live under summer-moist conditions. The Mediterranean summer-dry area is clearly occupied by sclerophyllous Mediterranean-type formations. In spite of the classification into the broad-temperate European class *Querco-Fagetea*, with dominance by deciduous woody elements, there are a couple of remnant evergreen elements surviving today in the southern part of the continent. These elements are linked to a Mediterranean influence (sub-Mediterranean), but among them are also genuine ombrophyllous species, such as *Ilex aquifolium* or *Hedera helix*, which can be considered true lauroid species adapted to a moist, mild temperate climate, which similar to that of central southeastern China or the southeastern USA. Concerning their climatic envelope, those forests live under oceanic and sub-Mediterranean conditions inside the temperate climatic type. Their distribution is general in the north and northwestern fringes of the Iberian Peninsula. In the central regions, they are found in the mid-elevations of the mountains, and in the south, there are some small areas in upper-montane moist locations. Under sub-Mediterranean conditions, these forests are dominated by marcescent *Quercus* species, such as *Q. pubescens, Q. faginea, Q. broteroi, Q. canariensis* and *Q. pyrenaica*. An important number of endemics adapted to forest habitat live in these forests live, and they support the hypothesis of the southern European glacial refuges.

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## WARM-TEMPERATE FORESTS OF CENTRAL PORTUGAL: A MOSAIC OF SYNTAXA

**Pedro Bingre[1,2], José Carlos Costa[2], Dalila Espírito-Santo[2]**

*[1] Instituto Politécnico de Coimbra, Coimbra, Portugal, [2] Instituto Superior de Agronomia, Centro de Botânica Aplicada à Agricultura, Lisbon, Portugal (dalilaesanto@isa.utl.pt),*

Keywords: temperate forests, Mediterranean forests, lauroid, semi-deciduous, central Portugal

In spite of extensive afforestations with allochthonous tree species, the Atlantic facade of the mountain chain that extends through central Portugal still presents several examples of autochthonous forests that show significant floristic and ecophysiological diversity. Along an N-S transect of no more than 100 km across the range, zonal forest types may vary from deciduous *Quercus robur* or *Q. pyrenaica* formations with an evergreen understory (*Viburnum tinus* or *Arbutus unedo*, respectively) to semi-deciduous *Qu. broteroi* woodland, in which some malacophyllous shrubs may also be found in the undergrowth. Sclerophyllous forests of *Qu. suber* are also present in certain locations. Adding further diversity to the vegetated landscape are extra-zonal groves of non-sclerophyllous evergreens like *Prunus lusitanica, Rhododendron ponticum*, *Laurus nobilis* and *Myrica faya*, relics of a Tertiary laurisilva.
Whereas data suggest that a macroclimatic gradient (from meso-temperate to meso-Mediterranean) may be responsible for such a variety of habits in forest formations, a convoluted set of orographic, edaphic, hydrologic, microclimatic and paleohistorical variables also contributes to explanation of the variation in this peculiar region.
This study compares these plant communities of central Portugal, using Braun-Blanquet methodology, and attempts to ascertain which syntaxa may be considered properly to be warm-temperate forests.

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## DOWNY OAK WOODS OF ITALY: PHYTOGEOGRAPHICAL REMARKS ON A CONTROVERSIAL TAXONOMIC AND ECOLOGICAL ISSUE

**Riccardo Guarino[1], Giuseppe Bazan[1], Bruno Paura[2]**

*[1] University of Palermo, Dept. of Environmental Biology and Biodiversity, via Archirafi, 38 – 90123 Palermo (Italy); [2] University of Molise, Dept. S.A.V.A., via De Sanctis, 1 – 86100 Campobasso (Italy) - (corresponding author: riccardo.guarino@unipa.it)*

Keywords: Downy oak, syntaxonomy, phytogeography, variability, distribution patterns.

The importance of downy oak as an integral component of the "sub-mediterranean" woods has been underscored by many studies. Nevertheless, terms like "submediterranean" and "downy oak" are some of the most faintly understood concepts in European phytogeographical and taxonomical research. Downy oak is well known to be a problematic taxon. The name "*Quercus pubescens*" (= *Q. humilis*) piles together populations characterized by increasing phenotypic and genomic polymorphisms along north-south gradients, which is commonly explained as the result of a "founder effect" given by a relatively fast post-glacial re-colonization of the northern stands through rare long-distance dispersal events.
On the other hand, the southern polymorphisms of the downy oak provides evidence for geographic/environmental selection driven by different edaphic conditions along clinal gradients of cold and drought stress, even if the distinction of different species is blurred by systematic hybridization and introgression that have been enhanced by the recent deforestation.
Because downy oak occurs widely throughout the Italian Peninsula, we tried to detect some ecological and geographical borders which might be useful to identify climate-vegetation feedback mechanisms as well as to sharpen the syntaxonomical and systematic investigation of such a critical species complex. Our work is based on a well-distributed geo-referenced set of vegetation data, combined with layers of environmental variables (elevation, climate and soil chemistry). The statistical significance of the correlation between vegetation and environmental data has been evaluated through the Mantel's test.
Our results suggest that there are some borders in the distribution/prevalence of morphologic traits of *"Q. pubescens"* (regarded here as a species complex). These borders are not limited by sharp ecological or geographical gaps but instead reflect patterns of selection and phenotypic variability in key traits of the geographical range.

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## DISTRIBUTION OF THERMOPHILOUS DECIDUOUS FORESTS IN THE CENTRAL AND WESTERN BALKAN PENINSULA AND THEIR STRUCTURAL FEATURES

**Andraž Čarni [1,2], Nina Juvan [1], Mitko Kostadinovski [3], Petra Košir [1,4], Aleksander Marinšek [1,5], Vlado Matevski [3], Andrej Paušič [1], Urban Šilc [1]**

*[1] Institute of Biology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia, [2] University of Nova Gorica, Nova Gorica, Slovenia, [3] Institute of Biology, Faculty of Natural Sciences and Mathematics, University of Ss. Cyril and Methodius, Skopje, Macedonia, [4] University of Primorska, Koper Slovenia, 5 The Higher Vocational College for Forestry and Hunting, Postojna, Slovenia (corresponding author: carni@zrc-sazu.si)*

Keywords: Balkan, distribution, thermophilous forest, plant trait, *Quercetalia pubescentis*

This work presents the geographical distribution and ecological differentiation of thermophilous deciduous forests (*Quercetalia pubescentis)* of the central and western part of the Balkan Peninsula. These forests can be divided into two main groups. The first group is dominated by various deciduous species of the genus *Quercus* (calciphilic *Quercus pubescens* does not belong to this group). These forests appear mainly on deeper soils over non-carbonate bedrock and are distributed above all in the eastern, drier part of the Balkan Peninsula. The other group of communities is dominated by *Carpinus orientalis, Ostrya carpinifolia* and *Quercus pubescens*. These forests can be found along the Dinaric Alps, in other areas under the influence of the Mediterranean Sea, and as extra-zonal vegetation in the continental parts of the Balkan.

We also tried to analyze the gradient from thermophilous to mesophilous deciduous forests. The testing was done in the central part of the Balkan Peninsula, in the southern part of the Republic of Macedonia. In the lowland, we can find a variety of thermophilous forests dominated by *Quercus frainetto, Q. cerris, Q. petraea, Q. trojana, Q. pubescens, Ostrya carpinifolia* and *Carpinus orientalis*. However, sites at higher altitudes are dominated by beech forests (*Fagus sylvatica*). Because detailed climatic data are not available, altitude is treated as a proxy variable that reflects the climatic gradient. We calculated various plant traits along the gradient (including bio-indicator values, life forms, life spans, chorotypes and diversity indices). The results bring information about significant changes in some species along this gradient. We conclude that thermophilous deciduous and mesophilous deciduous forests differ by species composition and structural features.

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## NUMERICAL CLASSIFICATION AND ECOLOGICAL CHARACTERIZATION OF WARM-TEMPERATE OAK FORESTS OF TURKEY

**Emin Uğurlu[1], Jens Oldeland[2], Erwin Bergmeier [3]**

*[1]Department of Biology, Celal Bayar University, Manisa, Turkey; [2] Biodiversity, Ecology and Evolution of Plants, University of Hamburg, Hamburg, Germany; [3]Georg-August-Universität Göttingen, Albrecht-von-Haller-Institut für Pflanzenwissenschaften, Untere Karspüle Göttingen, Germany; (corresponding author: emin.ugurlu@bayar.edu.tr, ugurlu@yahoo.com )*

Keywords: Plant Ecology, Phytosociology, Numerical Classification, Warm-Temperate Oak, Turkey

Turkey covers a wide range of forests and other woods that were broadly divided by Atalay (2000) into four major types: 1) temperate broadleaved and mixed forests; 2) temperate coniferous forests; 3) temperate grasslands, savannas and shrublands; and 4) Mediterranean forests, woodlands and shrublands. Further subdivision within the temperate broadleaved and mixed forests identifies: a) Central Anatolian deciduous forests, b) East-Anatolian deciduous forests, and c) Euxinic-Colchic deciduous forests. Although these classifications are useful at a broad scale, little work has been done to phytosociologically classify vegetation at the regional scale in Turkey. Likewise, characterizations of ecological profiles from such vegetation units are missing.

We present the first numerical classification of Turkish warm-temperate deciduous and mixed oak forest types based on an extensive literature review of phytosociological data from regional-scale relevés. More than 1100 published and unpublished records were gathered into a vegetation database. In total, ten main clusters were identified. These include the following: a) two large clusters of temperate deciduous mesic to xeromesic oak forests; b) five clusters of Mediterranean evergreen to deciduous herb-rich oak forests; and c) three clusters of Mediterranean evergreen shrub-rich oak forests. A large set of environmental descriptors was gathered, e.g., climate, topography, geology and human impact. These descriptors and ecoregional classifications were used to characterize the newly identified clusters. Finally, indirect and direct gradient analyses were done to identify the relevant factors that best differentiate the clusters.

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## PERSISTENCE OF THE TERTIARY RELICT DECIDUOUS TREE *TETRACENTRON SINENSE* IN SUBTROPICAL SW CHINA

**Cindy Q. Tang**

*Institute of Ecology and Geobotany, Yunnan University, Kunming 650091, China*

Keywords: Tertiary relict deciduous tree, Distributional pattern, Habitat; Population status, Reproductive strategy

China is one of the important global refuges of Tertiary relict tree flora. *Tetracentron sinense* Oliv. is only found in China, the Himalayas and northern Myanmar. It is a member of the monotypic family *Tetracentronaceae*, reflecting the ancient nature of the temperate flora of East Asia. The habitat and population dynamics of this species are little known. We analyzed the habitat characteristics, population status, age structure, and productive modes of the Tertiary relict deciduous broad-leaved forests of the eastern Ailao Mountains, Yunnan, SW China. *T. sinense* populations occur in unstable habitats marked by gap-formation or landslides. These populations show a sporadic regeneration pattern, colonizing and establishing on unstable sites by means of abundant wind-dispersed seeds. After colonization, *T. sinense* persists for a long time and dominates in the canopy layer, even reaching the emergent layer in places, aided by its long life span and vegetative reproduction capability. Our study of the distribution patterns and ecology of *Tetracentron sinense* should yield a scientific basis for recommendations for the conservation of its natural populations.

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## SPECIES COMPOSITION OF SEMI-NATURAL OAK FORESTS IN THE WARM-TEMPERATE DECIDUOUS FOREST ZONE IN JAPAN

**Yoshinobu Hoshino[1], Seiji Tsuji[2], Junichiro Kajinami[1]**

*[1] Tokyo University of Agriculture and Technology, Department of Agriculture, Tokyo, Japan [2] Japan Women's University, Homei Elementary School, Tokyo, Japan; (Yoshinobu Hoshino: email Hoshino@cc.tuat.ac.jp)*

Keywords: Quercus serrata forest, Quercus crispula forest, cool-temperate forest, Warmth Index, Coldness Index

The warm-temperate deciduous forest (WTDF) zone, where major evergreen broad-leaved trees are rarely found, was defined by climatological range using both the Warmth Index (WI) and Coldness Index (CI) proposed by Kira (1945). According to Kira (1949), the climatological range of the WTDF zone is WI above 85°C and CI below -10°C. Natural WTDF types in Japan have been reported by various authors, including Nozaki & Okutomi (1990). According to the literature, the main tree species of the natural forests are *Quercus serrata*, *Castanea crenata*, *Fagus japonica* and *Carpinus laxiflora* as deciduous trees and some conifers (*Abies firma* and *Tsuga sieboldii*). These natural forests show very restricted distributions because of heavy human activities in the area. Deciduous Quercus forest in the WTDF zone mainly exists as semi-natural Q. serrata-dominated forests maintained by long-term human utilization for fuel. We focus on the characteristics of species composition of *Q. serrata* semi-natural forest in the WTDF zone through comparison to the *Quercus crispula* semi-natural forest, which is found in the cool-temperate zone, because these forests are found abundantly elsewhere. The character of *Q. serrata* semi-natural forests in the WTDF zone is that they are rich in deciduous shrub species such as *Acer crataegifolium*, *Viburnum phlebotrichum*, *Fraxinus sieboldiana*, *Meliosma myriantha* and *Callicarpa japonica*. The *Quercus crispula* semi-natural forest found in the cool-temperate zone has clearly separated into lower and upper cool-temperate forest types. The species composition of the lower type is very similar to that of *Q. serrata* forest in the WTDF zone. Common species of both forests are *C. crenate*, *Rhododendron kaempferi*, *Viburnum wrightii*, *Euonymus oxyphyllus* and *Pinus grayana*. As for *Quercus*-dominated semi-natural forests, there are no clear differences in species composition between the forests in the WTDF zone and in the lower cool temperate zone.

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## DECIDUOUS WOODLANDS IN MEDITERRANEAN CALIFORNIA AND THE NEAR EAST

**Mark A. Blumler**

*SUNY-Binghamton, Binghamton, NY, USA (email mablum@binghamton.edu)*

Keywords: Mediterranean ecosystems, evergreen sclerophylls, subtropical dry ecosystems, deciduousness as Mediterranean adaptation

Despite the widespread perception of the dominance of evergreen sclerophylls, some Mediterranean-climate regions have significant representation of winter-deciduous species. In particular, California and the Near East both feature extensive areas dominated by deciduous rather than evergreen species, especially oaks. In central California, the blue oak, *Quercus douglasii*, dominates interior foothills that have wet winters and long dry summers. Valley oak (*Q. lobata)* and garry oak (*Q. garryana)* also are found in interior, hot-summer locations. In southern California, the englemann oak (*Q. englemannii)* is also found in interior, hot-summer regions, whereas the evergreen *Q. agrifolia* dominates nearer the coast, where summers are less severe. In the Near East, the Mediterranean climate occurs along the Zagros foothills, a region with an almost complete absence of sclerophylls but which is instead dominated by several deciduous species in genera such as *Pistacia* and *Zizyphus* as well as oaks. In the Levant, deciduous and evergreen species co-occur, with the deciduous species predominating noticeably on the soils that are most fertile and most droughty in summer. Distribution patterns suggest evergreen sclerophylls are not strictly Mediterranean but rather subtropical semi-arid in their adaptation, whereas deciduous species out-compete them under the most purely Mediterranean conditions.

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## BROAD-LEAVED OAK FOREST IN NORTHEASTERN SPAIN: A CASE STUDY OF *QUERCUS PYRENAICA* COMMUNITIES USING MULTIPATT APPLICATION

**Beatriz Vilches de la Serna[1], Rosario G. Gavilán[1], Daniel Sánchez-Mata[1], Miquel de Cáceres[2]**

*[1] Complutense University, Department of Vegetal Biology II, Madrid, Spain; [2] Centre Tecnológic Forestal de Catalunya, Catalonia, Spain; bvilches@farm.ucm.es*

Keywords: multipatt, IndVal, Quercus pyrenaica, ecological niches

*Quercus pyrenaica* forest grows on the siliceous soils of the Iberian Peninsula in mountainous areas. They often appear as degraded stages due to the intense exploitation by humans, which includes charcoal production and forest fairs; they can also grow as relic forest in limited areas. In Northeastern Spain, in addition to this complexity, a mixture of substrata is found and siliceous rocks appear in calcareous ranges.

The aim of this work is to explore the floristic relationships between *Q. pyrenaica* forest spread in different mountains, some mainly calcareous, some typical siliceous, using an extension of the Indicator Value method recently proposed by De Cáceres, Legendre and Moretti (2010). We applied this methodology to 69 phytosociological relevés representing oak forests in six mountain ranges and obtained indicator species for each community and for combinations of communities. The relevés showed niches in common between them, including degrading stages. Differences among site groups in terms of bioclimatic or biogeographic patterns can be observed from ranges closer to the coast to those inland or from northern to southern situations.

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## TREE MORTALITY, RECRUITMENT AND POPULATION STRUCTURE DYNAMICS IN MIXED OAK-DOMINATED FORESTS IN WESTERN MEXICO

**Miguel Olvera Vargas, Blanca L. Figueroa Rangel**

*Departamento de Ecología y Recursos Naturales; Centro Universitario de la Costa Sur. Universidad de Guadalajara. Apartado Postal # 108. C.P 48900 Autlán de Navarro, Jalisco. México (corresponding author: molvera@cucsur.udg.mx)*

Keywords: Tree mortality, recruitment, population dynamics, oak forests, Mexico

We investigated the variation in tree mortality and recruitment rates between two contrasting floristic zones in mixed-oak forests in western Mexico for an eight-year interval. For our research, we considered all trees ≥ 5 cm diameter at breast height. Population structural changes were evaluated in relation to annualized tree mortality and recruitment rate variation. Our main goal was to provide quantitative bases for assessing spatio-temporal dimensions in tree mortality and recruitment. The long-term data considered for the analysis consisted of 60 circular permanent sample plots. Absolute tree mortality counts were converted into annual rates, and a logarithmic model was used to extrapolate the absolute tree recruitment counts to annual rates. Finally, a plot with the annualized rate of mortality against the annualized rate of recruitment, by species and by floristic zone, was developed to discern a possible balance between these two demographic processes. In addition, we used inequality and asymmetry measurements to evaluate similarities in diameter tree-size distribution for those species shared between floristic zones over time. Our results suggest that the patterns of tree mortality seem to take place deterministically, concentrated at the lower diameter-size class but unrelated to environmental or floristic zonation. We also found that there is an unbalanced demographic process between tree mortality and recruitment. This does not, however, significantly affect population structure or species diversity.

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## WARM-TEMPERATE DECIDUOUS FORESTS OF EASTERN NORTH AMERICA, IN GLOBAL PERSPECTIVE

**Elgene O. Box**

*University of Georgia, Geography Department, Athens, Georgia, USA (boxeo@uga.edu)*

Keywords: Global zonation, evergreen versus deciduous, eastern North America, bioclimatic comparison

Humid temperate regions can be divided into a warm-temperate (WT) zone, with warmer summers, milder winters and a longer growing season (thermally equivalent to some Mediterranean areas); and a cool-temperate zone, with cooler summers, more severe frost and often a lasting snow cover. The warm-temperate zonal vegetation is evergreen broad-leaved (i.e., "laurel") forest, but Kira recognized that deciduous forests may also occur as stable forests in WT areas and coined the term 'warm-temperate deciduous forest' for some deciduous forests in interior southern Japan where winters were too cold for evergreens. In this sense, WT deciduous forests occur not only in East Asia but also in the Middle East, perhaps N Africa, southern Europe and the southeastern USA. These last include the "oak-hickory" forests of the Southern Piedmont and Ozark Plateau and the "Southern Mixed Hardwoods" (with *Fagus* and evergreen *Magnolia*). Obvious questions concern the distinguishing characteristics of these WT deciduous forests, the relative advantages of evergreen and deciduous trees in such winter-mild climates, and why deciduous forests persist and evergreens do not dominate if the climate is warm enough for evergreens. These questions are addressed through ecophysiological and geohistorical evidence as well as biogeographic and bioclimatic evidence. Factors favoring deciduous trees in winter-mild climates may include winter dryness (e.g., China), inhibition of water uptake and conductivity at low but above-freezing temperatures, and low temperature extremes. Finally, an attempt is made to define the warm-temperate climate quantitatively, using climatic variables, and to clarify terms such as 'submediterranean' and 'thermophilous' [deciduous] by bioclimatic comparisons.

Session 'Warm-temperate deciduous forests' / POSTER 104

## COMPARATIVE STUDY OF EVERGREEN BROAD-LEAVED FORESTS IN THE WARM-TEMPERATE ZONE BETWEEN SOUTHERN KOREA AND NORTHERN KYUSHU, JAPAN

**Sung-Je Lee[1], Keiichi Ohno[2], Jong-Suk Song[3]**

*[1] Yokohama National University, Graduate School of Environment and Information Sciences, Yokohama, Japan; [2] Yokohama National University, Research Institute of Environment and Information Sciences, Yokohama, Japan; [3] Andong National University, Department of Biological Sciences, Andong, Korea (phytoeco@gmail.com)*

Keywords: phytosociology, Korea, Japan, vegetation, evergreen broad-leaved forest

We compared the vegetation structure of Evergreen Broad-Leaved Forests (EBLF) in the warm-temperate zone of southern Korea and northern Kyushu, Japan. Particular comparative analyses involved the following: vegetation structure by a phytosociological method and a $\chi^2$ independence test; correlation between distributions in 7 regions in Korea and Japan based on community units and environments by DCA; and correlation and similarity (or migration-route inference of EBLF) among 7 regions by a Quantitative Common Coefficient (QCC). The 7 regions are Inland Korea (IK), Southern Island (SIK), Southwestern Island (SWIK) and Jeju-Do island (JJK) in Korea and Northwestern Kyushu (NWJ), Northeastern Kyushu (NEJ), and Tsushima island (TSJ) in Japan. The vegetation structure of the EBLF shows a total of 10 units. The distribution of the 7 regions on axis 2 of the DCA correlates highly with mean temperature (Temp), mean Coldness Index, mean Warmth Index (WI), mean precipitation, and $R^{2*}$ and $Y^{**}$ values of Temp and WI changes over 37 years. A *Dendropanax morbiferus-Quercus acuta* community appears as highly independent in IK and JJK. A *Skimmia japonica* var. *intermedia* f. *repens-Q. acuta* community (IK) and a *Cyrtomium fortunei* var. *fortunei-Quercus glauca* community (JJK) appear to be highly independent in each region. A *Polystichum polyblepharon-Machilus thunbergii* association appears as highly independent in SIK and SWIK. The regions therefore have high correlation and significance with the communities and associations. No community units correspond to the independence and significance between Korea and Japan. These results mean that the vegetation structure of EBLF in Korea is quite different from that in Japan, even if some canopy structures are similar between Korea and Japan. The occurrence of EBLF in Korea increases into SIK and SWIK through JJK; into SIK through TSJ from northern Kyushu; and into IK from SIK, according to the QCC analysis and geographical position (distances among the 7 regions).
$^{*}R^2$: the difference extent of mean temperature change in each year
$^{**}Y$: the growth extent of mean temperature over 37 years.

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## UPWARD SHIFT OF THE ESTABLISHMENT AREA OF CANOPY TREE SPECIES: THE INFLUENCE OF CLIMATE CHANGE IN CENTRAL JAPAN

**Dai Koide, Yukira Mochida**

*Yokohama National University, Graduate School of Environment & Information Sciences, Yokohama, Japan (daikoide@hotmail.com)*

Keywords: Climate Change, Distribution Shift, Altitude, Canopy Tree Species, Japan

Canopy tree species are the basic producers in terrestrial ecosystems, and their distribution has been predicted to change due to climate change. Such a prediction is necessary to evaluate the ecological risks for the sustainable use of ecosystem services. There were many limitations in previous studies, however, such as lack of consideration of ecological processes and a lack of long-term research. On the other hand, the present altitudinal difference between young trees and adults provides a useful index for climate-induced distributional change, because young trees are influenced by present climate and adults were influenced by past climate. This research aims to clarify the altitudinal difference between young trees and adults to assess the influence of climate change on canopy tree species.
Research plots were set on a ridge in Shizuoka prefecture, central Japan. There were 50 research plots of 0.05 ha ranging from 130 m to 2700 m in altitude. Species name, diameter at breast height (DBH) and tree height were recorded for every tree taller than 1.3 m. As seed production was most likely to start only after the tree had reached the canopy layer, a tree was defined as an individual whose DBH was smaller than the average DBH of sub-canopy trees. Species for which more than 20 individuals were found were selected for analysis. At the research site, the annual mean temperature has increased approximately 1.4°C during the past 60 years. In contrast, the annual precipitation has not shown a remarkable change.
A total of 23 species was selected for analysis. For 17 species of these 23, the mean altitude of young trees was higher than that of adults. The mean altitudinal difference between young trees and adults for all 23 species was 41 m, which was significantly greater than zero. This means that the young trees of canopy tree species, as a whole, were appearing at higher altitudes.
This upward shift of young trees may be caused by climate change. The influence of climate change is that, compared with the period when the present adult trees had been established, the rising temperature has pushed the establishment area for each species to higher altitude.

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# VEGETATION STRUCTURE OF "EOBURIM," A FISH-SHELTER FOREST IN ISLAND-COASTAL AREAS IN SOUTHERN KOREA

**Sun-Kee Hong, Jae-Eun Kim**

*Institution for Marine and Island Cultures, Mokpo National University, Korea*

Keywords: Eoburim, Fish-breeding forest, Island-coastal vegetation, Ordination

*'Eoburim'* (fish-shelter forest) has been designated in coastal and riparian areas in Korea, representing one pattern of traditional Maeul forest in Korea. Such forests have value for vegetation research and serve as a cultural resource for preserving biocultural diversity. Fish-shelter forests on southern islands and southern coastal areas are in the warm-temperate zone, so evergreen broad-leaved forest and pine forest appear in the same general area. Patterns and processes in the fish-shelter forests in island and coastal landscapes have been influenced by human activities and natural disturbances (grazing, fires, tourists and land-use). Black pine (*Pinus thunbergii*) and evergreen broad-leaved forests are developed in the island and coastal areas, and there are several types of vegetation community according to forest use. Coastal villages have developed near these vegetation types, and people have used these forests in several ways (*e.g.*, getting fuel and wild vegetables and sacred places) according to indigenous knowledge. The biodiversity of flora and fauna that adapted to the management intensity is an important emerging issue in conservation strategies for secondary nature. In this paper, we briefly present the vegetation patterns and landscape structure of fish-shelter forests in island and coastal areas. To clarify the characteristics of the vegetation communities, we surveyed several types of fish-shelter forest. Phytosociological surveys and tree censuses were performed in the various forest types in island and coastal areas. Ordination, cluster analysis and other statistical analyses were applied to clarify the similarity of vegetation communities in each forest type. Compared with natural forests, the floristic composition and community structure of managed forests was simple, but there are some differences in the flora of the managed forests. This means that human management and other activities are influencing the forests, leading to differences in floristics and vegetation patterns.

# Biodiversity and functioning of riparian habitats: indicators of change

Session 'Riparian habitats' / ORAL

## A PROJECTION OF TEMPORARY STREAMS UNDER SEMI-ARID CLIMATE SCENARIOS. EVIDENCE FROM AN EPHEMERAL MEDITERRANEAN STREAM

**Raquel Fernández-Lo Faso, Francisco García-Novo**

*University of Seville, Plant Biology and Ecology Department, Seville, Spain (corresponding author: lofaso@us.es).*

Keywords: riparian, plant communities, hydrogeomorphology, structure and function, anthropic impacts.

Temporary rivers are among the most common freshwater ecosystems. Nevertheless, they have been far less studied than permanent ones, even in European Mediterranean areas where forests are protected as Priority Habitats. The number of temporary rivers is expected to increase under contemporary climatic change, highlighting the importance of extended research. Because plants are indicators of conditions, processes and uses, their distributional patterns along temporary streams could provide insight into the regulation and functioning of these systems. The predicted decrease in total precipitation (and runoff) for many semi-arid areas (e.g., the Mediterranean basin) will affect the channel structure and habitat characteristics for plant species adapted to previous conditions.
We studied the vegetation patterns of an ephemeral Mediterranean stream, Cañada del Pinar, (Doñana Natural Park, SW Spain). The stream was subject to water flow diversion for 25 years before the hydraulic connectivity with its former tributary and floodplain was partially restored in 2006. In addition to the artificial reduction in the number and magnitude of flows, the hydraulic regime was also modified by a gradual descent of water table depth of the local aquifer due to human exploitation. Both hydraulic outcomes (reduced flow and aquifer depletion) are expected to occur naturally under the predicted climate scenario for many semi-arid areas. Therefore, the structure and functioning of the Cañada del Pinar stream could help illustrate future processes governing riparian communities at ephemeral streams. Cluster and boundary detection (SMW) analyses were used to detect the structure of the riparian forest along the stream (3,8 km). Annual plant communities (412 1-$m^2$ plots) were studied across the main channel with ordination (NMDS), similarity (ANOSIM), and correlation (Pearson) techniques. Potential controlling factors (hydrology, geomorphology, radiation and land uses) were also quantified. As expected, results showed that water is the main factor controlling the structure and functioning of the Cañada del Pinar stream, both directly (physical disturbance and limiting factor) or indirectly (geomorphology).

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## TAKING THE SPATIAL STRUCTURE OF THE HEDGE NETWORKS INTO ACCOUNT FOR RIPARIAN ECOLOGICAL RESTORATION

**Clélia Carreau, Guillaume Forget, Ivan Bernez**

*INRA- Agrocampus Ouest, UMR 985 ESE "Ecology & Ecosystem Health". 65 rue de Saint-Brieuc-CS 84215-35042 Rennes cedex France (corresponding author: Clelia.Carreau@rennes.inra.fr)*

Keywords: Headwaters, passive river restoration, GIS, landscape ecology, exemplar restoration practices

Safeguarding riparian ecosystems is a key issue in maintaining the ecological health of rivers. Riparian vegetation plays a key role in riparian ecosystems by stabilizing riverbanks, limiting concentrations of water pollutants, and regulating stream temperatures and stream flow. The aim of our study was to better understand the influence of the landscape structure and in particular the importance of hedge networks in the re-colonization of riverbanks by trees after passive restoration.
We studied headwaters in Normandy (France) on the catchment of the Oir River. Two streams were passively restored six and four years ago. Passive restoration consisted of the deletion of stresses caused by cattle on river banks (heavy trampling and grazing), which allowed the natural recolonization by plant communities. We compared the patterns of vegetation in these streams with the ones of another stream located in the same catchment, and evaluated ecological health from an expert point of view.
Passive restoration led to an increase in tree cover along the river banks and contributed to an improvement in the integrity of the physical banks. The presence of trees influenced the herbaceous diversity along the river banks after restoration. We analyzed their role as seed-bearers and examined how their spatial distribution contributes to seed retention by measuring the spatial autocorrelation between seedlings and trees. The spatial repartition for each tree species was also mapped to determine whether the distribution patterns of species reflect differences in dispersal abilities.
This study highlights that the usefulness of GIS in the mapping and analysis of landscape structural changes for understanding relationships between landscape structure and ecological processes. Such results could help managers by proposing low-cost restoration methods that promote natural spontaneous re-colonization.

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## USING MULTI-SOURCE DATA FOR ASSESSING RIPARIAN VEGETATION STATUS AT A LARGE SCALE

**Simon Dufour[1], Barbara Belletti[2], Elise Buisson[3], Laurence Hubert-Moy[1], Jean Nabucet[1], Hervé Piégay[2], Roberto Quinones[1], Sébastien Rapinel[1], Vincent Tamisier[3], Elise Wiederkehr[2]**

*[1] COSTEL UMRCNRS 6554 LETG - Université Rennes 2, Géographie, Rennes, France; [2] CNRS EVS UMR 5600 ENS, Lyon, France; [3] IMEP, Avignon, France (corresponding author: simon.dufour@univ-rennes2.fr)*

Keywords: remote sensing, riparian corridor, fluvial landscape, LiDAR, Water Framework Directive

Scientific and applied issues require the development of an appropriate set of tools to assess riparian vegetation status at a large scale. Indeed, indicators are needed to itemize habitats, to locate patrimonial reaches, to monitor changes and pressures, to order priorities among conservation projects set up at the watershed scale and to assess restoration actions. As various ecological parameters must be studied, different approaches are needed. The objective of this presentation is to illustrate how to use different sources of data, including remotely sensed images, to provide an appropriate set of indicators for riparian vegetation at a large scale. Thus, three questions are addressed through the following case studies: (i) automatic mapping of riparian areas, (ii) characterization of distribution, diversity and architecture of species and habitats and, (iii) temporal evolution of riparian landscapes. First, we propose a semi-automated and object-oriented approach to delineate riparian vegetation accurately and continuously along the hydrographic network. Such an approach can be used to map habitat connectivity and other ecological attributes such as the ecotone density. We also compared the respective advantages of top-down and bottom-up approaches for large scale mapping (i.e., is it better to map from regional to local levels by demixing processes or from local to regional levels by aggregation processes?). Second, we show how riparian species and habitats can be assessed from LiDAR data for 3D parameters (height and density) and field data for the distribution of biodiversity and species. These indicators can provide useful information for modeling the distribution of riparian species and habitat structures at a regional scale. Third, the temporal dimension is integrated to compare the diversity in landscape trajectories between reaches at a regional scale. This question is illustrated by the diachronic analysis of 53 braided reaches located within the Rhône watershed over the last five decades. Dynamic indicators are used, such as the turn-over rate of vegetated patches. This provides information that we can use to understand channel changes and their biological and anthropogenic drivers.

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## REMOTELY SENSED RIPARIAN CORRIDOR INDICATORS IN RELATION TO THE ECOLOGICAL STATUS OF RIVERS

**Thierry Tormos[1], Pascal Kosuth[2], Bertrand Villeneuve[1], Kris Van Looy[1], Yves Souchon[1]**

*[1] Cemagref, UR MALY, Pole ONEMA/Cemagref hydro-écologie des cours d'eau, Lyon, France; [2] Cemagref, UMR TETIS, Territoires Environnement Télédétection et Information Spatiale, Montpellier, France.*

Keywords: Riparian Corridor, Ecological Status, VHSR Images, Spatial Indicators, Pressure/Impact Models

The definition of restoration strategies on riparian corridors requires an improved understanding, at a regional scale, of the relative influence on river ecological status of both human surrounding pressures (from the upstream watershed to the local riparian corridor) and riparian vegetation. This work presents new operational routine methodologies for (i) accurate and fine-scale land cover mapping within riparian corridors over large extents, by combining information from very high spatial resolution remotely sensed images and ancillary data; (ii) building spatial indicators reflecting human pressures and riparian vegetation impact mechanisms on river ecological status; and (iii) building spatialized pressure/impact models at regional scale. These methodologies were developed and implemented over the Herault watershed (1150 km, 2650 km², 3 ecoregions, southern France) and over the Normandy Region (6000 km, 25000 km², northwest France). Detailed fine-scale riparian corridor land cover maps were produced on the two studied areas with high accuracy (89%) through an object-oriented classification procedure combining information from orthophotos (0.5 m pixels), Spot 5 XS satellite images (10 m pixels), and complementary spatial thematic data. Then, several spatial indicators were defined and built. For example, six types of indicators specific to the role of riparian forest have been defined: (1) length and (2) area indicating the presence and intensity of this vegetation along the river; (3) connectivity (number of gaps/km of river) and (4) length of gaps reflecting the role of thermal regulation related to the shadow cast by the vegetation; and (5) the average width and (6) uniformity (varying width) reflecting, with the connectivity indicators, the ability of this vegetation to act as a buffer. Finally, the introduction of these indicators in Pressure/Impact models highlights the influence of herbaceous and tree riparian vegetation on a 20 m buffer width on the macroinvertebrate community. Remotely sensed riparian corridor indicators are a key issue in the monitoring and managing of riverine landscapes.

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## PAN-EUROPEAN MODELING OF RIPARIAN ZONES BASED ON REMOTE SENSING AND GIS

**Nicola Clerici, Christof Weissteiner**

*European Commission – JRC, Institute for Environment and Sustainability, Ispra (Italy); correspondence address:nicola.clerici@jrc.ec.europa.eu*

Keywords: riparian areas, riparian zones, river, remote sensing

A new riparian zonation model based on satellite remote sensing data is proposed. The model makes use of spectral, land-use and topographic information to derive riparian zones at a 25 m resolution for continental Europe based on a fuzzy approach. The zonation model is not designed to be a high-precision mapping tool for local scale analysis but to provide the first picture of riparian zone distribution patterns for Europe at a continental scale. Based on model results, approximately 2% of continental Europe is detected as riparian. A high density of riparian zones is found in mountainous areas, where the dense river network and extended natural habitats create conditions for riparian abundance. In plain areas, the presence of agricultural areas is the main cause of riparian zone low density and high fragmentation. A first characterization based on CLC2000 data shows that a major fraction of European riparian zones (around 69%) is associated with forested habitat, and to a minor extent to other vegetation lifeforms. This result is important, as it provides the location and a quantitative indication of forested habitats in Europe, which have also ecological significance as riparian zones. The three strategies used to achieve reliability measures of the model (input data accuracy, qualitative observation using VHR imagery, and independent ecological datasets) produced satisfactory results. The different accuracy levels derived vary approximately between 70% and 90%, although being highly variable at regional level. The main sources of error are produced by CCM-river-path misplacement and by the generalization process used to build the CLC2000 dataset. Lower accuracy levels of input datasets in northern European countries have increased the inaccuracy of riparian detection in these regions. This study allowed the identification of some main gaps and weaknesses present in the European spatial datasets of continental extent, hindering the achievement of higher accuracy values in riparian zones modeling. We stress the importance of developing, in the near future, a European 2D river network dataset at high resolution for the investigation of riparian zones and freshwater ecosystems.

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## IMAGE-BASED METHODS TO CHARACTERIZE DEGRADATION PATTERNS OF MEDITERRANEAN RIPARIAN FORESTS

**M. Rosário Fernandes, Francisca Aguiar, M.Teresa Ferreira, J.M. Pereira**

*Forest Research Centre,; Instituto Superior de Agronomia, Technical University of Lisbon, Portugal (corresponding author: mrfernandes@isa.utl.pt)*

Keywords: landscape metrics, field spectrometer measurements, ecological status, *Arundo donax* L., land-use

Riparian ecosystems are among the most altered in the world. For millennia, Iberian ecosystems have been severely impacted by direct human disturbances in riparian zones. River restoration programs indicate the urgent need for developing expeditious methodologies to evaluate the ecological quality of rivers and related riparian zones. Image-based methods such as satellite or airborne multispectral images are more cost-effective than field assessments, with the advantage of gathering information for unreachable areas. However, high spatial resolution (HSR) imagery (< 5 x 5 m pixels) is necessary for mapping riparian vegetation due to the inherent high spatial variability and the small width of riparian zones.

To characterize the degradation patterns of riparian forests, we propose the linkage of two image-based methods using HSR images: 1) the assessment of spatial structure through the calculation of landscape metrics and 2) the use of the spectral signature of the vegetation.

This study was performed in tributaries of the Tagus River, Central Portugal using data from 3900 vegetation patches mapped along approximately 80 km of riparian areas, and in selected river stretches highly degraded due to alien plant invasions.

Degraded riparian forests were identified by a low number of small tree patches with less complex shapes and a low interspersion of patch distribution. Areas that were highly degraded due to the invasion of giant reed (*Arundo donax*) were characterized by simple, elongated and highly connected patches.

However, these results should be complemented with information on species composition, because large riparian patches may correspond to well-preserved riparian areas. Canopy and leaf spectral measurements were performed on the giant reed and on the co-existing species to assess the spectral separability of the native and non-native species. Preliminary results pointed to differentiation in the visible and near-infrared regions. Validation will be performed in a HSR image. The combination of the spectral and spatial data improves the awareness of riparian structural-compositional patterns and contributes to the development of efficient GIS tools.

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## RIPARIAN AND COASTAL HABITATS ARE THE MOST IMPORTANT DONORS OF INVASIVE PLANTS OF EUROPEAN ORIGIN

**Veronika Kalusová[1], Milan Chytrý [1], John T. Kartesz [2], Misako Nishino [2], Petr Pyšek [3,4]**

*[1] Masaryk University, Department of Botany and Zoology, Brno, Czech Republic; [2] Biota of North America Program, Chapel Hill, USA; [3] Academy of Sciences, Institute of Botany, Průhonice, Czech Republic; [4] Charles University, Department of Ecology, Praha, Czech Republic (corresponding author Veronika Kalusová: kalveron@tiscali.cz)*

Keywords: alien species, habitat invasibility, level of invasion, primary and secondary range

Many habitats worldwide are subjected to an increasing input of invasive plants, but several studies have shown that habitats differ in the resulting levels of invasion. Although unveiling the determinants of invasion success among habitats has become an important research agenda, there is still limited knowledge of the effects of invaders' habitats in their primary range on their performance in the secondary range.
To find the main donors of invasive plants originating from Europe, 37 broadly delimited European habitat types were derived from the Map of the Natural Vegetation of Europe (Bohn et al. 2004). Lists of native species for these habitats were extracted from the description of mapping units. European species naturalized outside their primary ranges were identified using two sources: (1) Floristic Synthesis of North America (Kartesz 2010) and U. S. Federal and State Weed Lists (USDA, NCRS 2010) for North America and (2) the catalog of global invasive plants (Weber 2003) for the world. Species habitat affiliation in the invaded range was examined using 11 terrestrial WWF ecoregions available in the Synthesis and invaded habitats' description in Weber's catalog.
Similar patterns of invaders' donor habitats were revealed for both North America and the world. The most important sources of naturalized or invasive plants were alluvial forests together with alder cars, coastal sand-dunes and the heaths of Western Europe. The highest numbers of species from these habitats were found to invade shoreline ecoregions of North America and riparian habitats, freshwater wetlands, pastures and coastal habitats such as scrub, dunes and beaches of the world. Moreover, European habitats donating the highest proportion of invasive species to other continents were also most invaded by extra-European aliens. This suggests an important role of riparian and coastal habitats in invasion. Similar processes involving disturbances and fluctuations of available resources shape the biota of these habitats. Therefore, they are both prone to invasion and serve as a source of alien species for other continents.

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## LOCAL *VS.* REGIONAL PROCESSES EXPLAINING PLANT COMMUNITY ASSEMBLY ALONG FOREST STREAMS

**Emmanuelle Araujo Calçada[1], Kathleen Vanderheyden[2], Laura Broeckx[2], Martin Hermy[2], Déborah Closset-Kopp[1], Guillaume Decocq[1*]**

*[1] University of Picardie Jules Verne, Unité de Recherche Dynamiques des Systèmes Anthropisés, Amiens, France; [2] K.U. Leuven, Division of Forest, Nature and Landscape, Leuven, Belgium; *corresponding author: guillaume.decocq@u-picardie.fr*

Keywords: forest community assembly, forest stream, hydrochory

The determination of processes governing the maintenance of biological diversity and the assessment of their relative importance are a major research challenge in ecology. The processes explaining plant composition and distribution are ordered hierarchically: (1) regional processes (can a plant reach a certain site?); (2) local habitat conditions (can a plant germinate, grow and reproduce at this particular site?); and (3) assembly rules (due to interactions among species: competition, facilitation, mutualism and all other biotic interactions). As diaspore dispersal along rivers is mainly constrained by the unidirectional movement of water flow, these systems offer a unique opportunity to study the relative importance of deterministic processes in community assembly. In this study, we quantify the relative effects of longitudinal connectivity and local habitat conditions on species richness and composition. Vegetation, seed bank and flooding-associated seed rain were assessed along transversal transects of 4 plots found in the riparian zone, which was replicated 23 times along two forest streams. Abiotic variables such as elevation, light intensity, stoniness and chemical soil characteristics were recorded for each plot. We used multiple regression and non-linear regression to examine the effects of regional factors (e.g., seed rain and site location inside the forest) and local factors on species richness and beta-diversity. Redundancy analyses with variation partitioning were also used to study community composition. Forest and non-forest herb species were separated for the analyses, and some species traits such as buoyancy were included. We show that site elevation is the main factor influencing vegetation species richness. Vegetation composition is mainly explained by regional factors, e.g., seed rain composition and the proportion of forest habitat upstream (67% of explained variance).

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## SPECIES COMPOSITIONAL AND FUNCTIONAL VARIATION OF RIPARIAN FORESTS: DISPERSION INDICATORS

**Francisca C. Aguiar[1], Jorge Orestes Cerdeira[1,2], M. João Martins[1,2], M. Teresa Ferreira[1,3]**

*[1] Forest Research Centre, Technical University of Lisbon, Agronomy Institute, Lisboa, Portugal; [2] Dept. of Sciences and Biosystems, Agronomy Institute, Lisboa, Portugal, Dept. of Natural Resources, Environment and Territory, Agronomy Institute, Lisboa, Portugal (corresponding author: fraguiar@isa.utl.pt)*

Keywords: functional traits, environmental variables, spatial scale, trees, Mediterranean region

The spatial variation of plant species assemblages and its relationship with environment is a central theme in plant ecology, which can provide frameworks for the conservation, restoration and management of threatened types of vegetation, such as riparian forests. Whereas most studies have used species-centered approaches, functional ecology is widely accepted as a mean of providing a mechanistic understanding of the spatial variation of communities.
Riparian woody species abundances and environmental features from 175 near-natural sites throughout mainland Portugal were collected. Sites were grouped according to the relative abundance of species and were termed Compositional Groups (CG). Sites were also grouped in Functional Groups (FG), which were derived from the abundances of groups of species with similar traits. The most relevant environmental variables, at diverse spatial scales (regional and local), were identified using a variable selection procedure. We devised four complementary Dispersion Indicators to assess the extent to which a given group of sites (CG or FG) is circumscribed in the space defined by the following environmental variables: 1) diameter, 2) the volume of the convex hull, 3) the sum of the distances from each site to the centroid of the group, and 4) the minimum total distance of a spanning tree of a group.
Clustering revealed four CG: alder woods, ash woods, tree-heath shrublands, and semi-arid shrublands; and four FG: waterlogging-tolerants, competitors with fleshy-type fruits, evergreen acidophyllous, and stress-tolerants. Most of the CG diverged in their spatial occurrence from the FG. The most dispersed groups in the environmental space presented broad trait composition (waterlogging-tolerants and competitors with fleshy-type fruits) and were floristically diverse (alder woods). No evidence was found to support the hypothesis that FG were more (or less) linked to the environment than the CG. Riparian woody assemblages were mainly governed by broad-scale environmental variables related to climate, topography, and river hierarchy. Groups of sites with very narrow trait spectra were largely confined to the most extreme environmental conditions in the study area.

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## VEGETATION OF RIPARIAN WOODED MEADOWS (SLOVENIA) IN RELATION TO LIGHT CONDITIONS AND ABANDONMENT

**Sonja Škornik[1], Nina Šajna [1], Simona Kaligarič[2], Mitja Kaligarič[1]**

*University of Maribor, FNM, Biology Dept., Koroška 160, 2000 Maribor, Slovenia; 2 Institute of the Republic of Slovenia for Nature Conservation, PObreska cesta 20a, 2000 Maribor, Slovenia (corresponding author: sonja.skornik@uni-mb.si)*

Keywords: Abandonment, Agricultural management, Multivariate analysis, Photosynthetic Active Radiation (PAR), *Solidago gigantea*

The remains of riparian forests, stretching along the flood plains of Central and Eastern Europe, are considered to be one of the most natural ecosystems in the prevailing agricultural landscapes. We studied the plant species richness and composition in remnants of riparian wooded meadows (RWM) along the middle stream of the Drava River. In addition to vegetation relevés, light intensity (PAR) was also measured in the plots. We registered and sampled 41 plots of still-active (mowed twice per year), and at different time period (< 5 yr, 5-15 yr, > 15 yr) abandoned RWM. Within the still-mowed RWM, two floristically distinct types were recognized, which matched with light availability. Species richness was significantly highest for mowed RWM with lower light intensity. The number of species per plot on active RWMs was negatively correlated with light. This could be explained with the influence of species-rich riparian hornbeam forests that contribute many understory species. CCA of only active RWM showed that species composition was significantly related to light availability. The CCA with all 41 plots of RWM demonstrated that abandonment caused significant changes in plant species composition and that light was a strong predictor. We found no correlations between light and time since abandonment. In our study, we found two neophyte species, *Solidago gigantea* and *Rudbeckia laciniata,* to be widespread in RWM. Their expansion after abandonment is very rapid, especially for *S. gigantean*. We showed that the aboveground biomass of *S. gigantea* is significantly related to time since abandonment. The proportion of *S. gigantea* in the above-ground biomass of the RWM herb layer could reach 94% per plot. The clear positive correlation between the cover-abundance values and the light intensity of *S. gigantea* suggested that abandoned RWMs are very susceptible to colonization until there is enough light and that their cover-abundance declines with the establishment of a shrub layer.

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## HYDROLOGY, SUBSTRATE TYPE AND DENSITY EFFECTS ON SPECIES GROWTH AND SURVIVAL IN EVERGLADES TREE ISLANDS

**Susana L. Stoffella, Michael S. Ross, Jay P. Sah, Pablo Ruiz**

*Southeast Environmental Research Center, Florida International University, Miami, FL 33199, USA. Corresponding author E-mail:stoffell@fiu.edu*

Keywords: Tree islands, Substrate type, Plant-soil interaction, Soil-water interaction, Wetland restoration

Tree islands are among the most distinctive features of the Florida Everglades. As based on area, they cover a small proportion of the Everglades, but they perform disproportionately important ecosystem and cultural functions, especially nutrient cycling and the provision of habitat for both wildlife and humans. The recent declines in the tree island density and area have mainly been attributed to prolonged periods of high water, however, depressed water tables can also lead to tree island loss when associated with very intense fires.
The Loxahatchee Impoundment Landscape Assessment (LILA) site is a 32-hectare model of the Everglades ecosystem located at the Arthur R. Marshall Loxahatchee National Wildlife Refuge in Boynton Beach, Florida. This "living laboratory" allows experts to test and apply restoration techniques on a small, controlled scale before taking them into the vast Everglades ecosystem. LILA, with its controlled hydrological framework, provides an excellent opportunity to investigate the responses of species to flooding during tree island development. An experiment was, therefore, designed to test the hydrologic effects on seedling growth and survivorship and the effects of tree spacing on the growth of individual trees and stands.
A peat-core and a limestone-core island, representing two major types found in the Everglades, were constructed in four macrocosms. A mixture of nine tree species was planted on each island in March of 2006 and 2007. The survival and height growth of the seedlings were assessed periodically through the fall of 2010. The relative elevation was used as a hydrological variable, indicating the ground elevation above or below the mean surface water adjacent to the island over the period from May 1st, 2007, to April 30th, 2009. The survival and growth improved with increasing relative elevation on both of the tree island substrate types. The effect of the substrate on seedling performance showed a higher survival of most species on the limestone tree islands and faster growth on their peat-based counterparts, whereas density effects on growth and survival were negligible. These results could have profound implications for the restoration of forests on existing landforms and the artificial creation of tree islands.

Session 'Riparian habitats' / ORAL

## VULNERABILITY OF ALLUVIAL VEGETATION OF THE LOIRE RIVER (FRANCE) IN RELATION TO CLIMATE CHANGE

**Sabine Greulich[1], Marc Villar[2], Jean-Louis Yengué[1], Isabelle La Jeunesse[1], Gildas Lemonnier[1], Clélia Carreau[1]**

*[1]University François Rabelais UMR CNRS 6173 CITERES, Tours, France; [2]INRA Orléans, France; (corresponding author: greulich@univ-tours.fr')*

Keywords: Habitats, plant categories, flooding regime, temperature, vegetation dynamics

Within the context of climate change, wildlife managers expect scientists to predict vegetation changes. However, the evaluation of the future dynamics of species and habitats within a given geographical context is not an easy task. For an example of this problem, the present study focused on the Loire River floodplain (France). As a starting point, the study quantified the major habitat types present in the floodplain and their dynamics during the last 30 years and addressed a list of target species for each habitat type, including the dominant species, rare species considered in different protection schemes and exotic and invasive species expected to increase further under increasing temperatures. After a data and literature review for each category of species and habitats, the results were analyzed with regard to two parameters that are impacted by climate change: the temperature and duration of flooding.
The study showed that the quantitative data needed to build distribution models for plant species under future conditions are only available for a minority of the target species, in particular, for those species most frequently investigated. Specifically, knowledge gaps exist concerning the link between the temperature and species abundance in the field and for the established life cycle phase. Another knowledge gap that limits the possibility for predictions of vegetation change concerns future flooding patterns on a habitat scale.
Thus, the study highlights the disparity between the expectations of nature managers for precise answers concerning the consequences of climate change and the limited possibilities for scientists to respond in the short term. As a conclusion, the study suggests a sample strategy for vegetation and climate data on a floodplain scale.

Session 'Riparian habitats' / ORAL

## USING TREE GROWTH AS A PROXY FOR RECENT HYDROLOGICAL CHANGES IN SOUTHERN EUROPEAN FORESTED WETLANDS

**Patricia María Rodríguez-González[1], Filipe Campelo[2], António Albuquerque[1], Rui Rivaes[1], Teresa Ferreira[1], João Santos Pereira[1]**

*[1]Forest Research Centre, School of Agriculture, Technical University of Lisbon, Tapada da Ajuda 1349-017, Lisboa, Portugal; [2]Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, P.O. Box 3046, 3001-401 Coimbra, Portugal. (Corresponding author patri@isa.utl.pt)*

Keywords: dendrochronology, environmental change, hydrological regime, riparian functioning, riparian vegetation.

The predictable relationship between water availability and radial growth in many tree species has made it possible to use relative changes in tree-ring widths as an excellent proxy for climate/hydrological variation, particularly in moisture-limited areas of the globe where wetland tree sensitivity to hydric changes is not well understood. In the present study, we investigated the effects of different hydrological regime and water-availability changes in tree growth and form in Southern European forested wetlands. The field sampling was carried out between 2003 and 2009 in freshwater, forested wetlands located along the Atlantic coastal belt of the Iberian Peninsula. The study was focused on *Alnus glutinosa* (L.) Gaertn and included wetland trees, dependent on stagnant water (a lentic hydrologic regime) and riparian trees dependent on running water (a lotic hydrologic regime). Trees differing in their distance to the channel and height from the water table level were geo-referenced and sampled, and the tree dimensions (height and diameter), form (trunk inclination and stems per tree), and wood cores/trunks were recorded. A total of 250 wood samples were taken (150 trees), processed with dendrochronological techniques and analyzed, together with field data and hydrologic/climatic data. The responses of young trees and recent radial growth derived from the hydrological regime (lentic *vs.* lotic) and water availability changes were examined. Tree form-functional and growth responses were also related to the hydrological regime and tree position within the riparian/wetland area. We found significant differences between young growth trends for trees growing in sites with different hydrological regimes and levels of water availability. For the period studied, the differences in the growth rate decreased with the age of the tree but were still apparent at age 20, particularly for wetland (lentic-dependent) trees. Recent radial growth was significantly affected by the relative position to water, but the response was modulated by the tree form (shrubbiness). The observed responses can provide important clues to predict how wetland and riparian trees would react or adapt to environmental or anthropogenic alterations resulting in hydrological regime changes.

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## REGENERATION OF FLOODPLAIN TREE SPECIES MAY NOT BE SUFFICIENT TO PREVENT SPECIES LOSS DUE TO HYDROLOGICAL ALTERATION

**Jacqueline White[1], Robert Peet[1,2]**

*[1]University of North Carolina at Chapel Hill, Curriculum for the Environment and Ecology, Chapel Hill USA; [2]University of North Carolina at Chapel Hill, Biology, Chapel Hill USA (Jackie.white@unc.edu)*

Keywords: regulated rivers, floodplain forests, regeneration, range shifts

Floodplain forests provide valuable resources and ecological services, yet rivers and their associated floodplains have been extensively modified because most of the large rivers of the world have been dammed. Many studies have attempted to elucidate the changes in forest composition due to altered hydrology, usually through the comparison with a reference condition. An alternative method for assessing the effects of river regulation on forest dynamics is through an evaluation of the relationship between the hydroperiod and forest structure and process across the hydrogeomorphic gradient. One hypothesis for the effects of river regulation is that species are lost due to a homogenization of the flooding gradient, which facilitates the range expansion of competitive and flood-tolerant species at either end of the gradient at the expense of intermediate species. In order to examine the potential for range shifts and species loss from the floodplain of a brownwater coastal plain river, we monitored seedling survivorship in 118 vegetation plots over four seasons and characterized the surrounding forest composition using the Carolina Vegetation Survey protocol. Pre- and post-dam flood frequency and duration were quantified across the floodplain. We then assessed the relationship of flooding with tree species regeneration dynamics. Using the abundance-weighted position along the flood gradient as a metric of "the hydrologic niche" of a species, we compared intraspecific differences between mature trees and other strata. Although this provided little evidence for range shifts, a comparison of seedlings to mature stems revealed that, on average, species are recruited into plots with different hydrology, but it appears that they are unable to establish in these sites. Additionally, within a plot, the seedling hydrologic niche was consistently different for mature trees versus seedlings. In general, canopy species tended to occur in wetter areas compared to the general seedling species pool, indicating that seedling establishment alone is not sufficient. The low recruitment into smaller stem size classes provided further evidence that, over time, some species may be lost from the floodplain.

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## DENDROECOLOGY AS AN INDICATOR OF RIPARIAN FUNCTION AND A DRIVER OF MESO-SCALE ECOSYSTEM IMPACTS

**John C. Stella[1], Jess Riddle[1], Hervé Piégay[2]**

*[1]Forest and Natural Resources Management, State University of New York College of Environmental Science and Forestry, Syracuse, NY (corresponding author: stella@esf.edu); [2]University of Lyon, UMR 5600 – CNRS, Site ENS-Lyon, ISIG Platform*

Keywords: riparian ecosystems, tree-ring, Populus, global change, ecogeomorphology

In Mediterranean-climate river ecosystems throughout the world, human competition for water resources has stressed biotic communities, and population growth, land use and climate change threaten to further impair them. In riparian zones, there is a need to develop tools to measure these impacts on the key biological and physical processes that sustain the health and potential recovery of the ecosystem. We used the dendroecology of *Populus nigra*, a riparian tree that is vulnerable to changes in local hydrology, to analyze ecosystem responses following gravel mining along the Drôme River, a Mediterranean-climate stream in Southern France. We cored trees at seven floodplain sites, measured ring widths, and calculated site-based indices of growth to compare the severity and timing of local growth decline along the river. The results indicated that tree growth has declined at some sites coincident with documented in-channel mining sites and associated channel incision and groundwater drop and that patterns of low growth and crown dieback were consistent with stress due to reduced water supply. Recent radial growth varied 5-fold between sites, yet this variation was not due to the age of the tree, individual size at an early age, or stand density. The normalized growth index was negatively correlated with the proportion of dead crowns, though the relationship was non-linear, with low growth for the three sites that experienced the greatest crown dieback. Regime Shift Detection analysis of site chronologies showed significant sustained growth decline at four sites after 1980, following the period of intensive in-stream mining downstream. Site growth declines were initiated in years of meteorological droughts that occurred after (but never prior to) the mining period and were spatially distributed to suggest local bedrock controls on soil depth. The results indicate that these semi-arid systems were vulnerable to multiple physical drivers, but that the severity of impacts was conditioned by interactions between drivers at different scales, including regional climate variability, reach-based hydrogeomorphic alteration, and local lithological controls.

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## TYPICAL, DIAGNOSTIC OR CHARACTERISTIC SPECIES: WHAT IS WRONG WITH IT? A METHODOLOGICAL FRAMEWORK TO DEFINE "TYPICAL" SPECIES FOR ASSESSING THE CONSERVATION STATUS IN RIPARIAN FORESTS

**Damien Marage [1,2]**

*[1]AgroParisTech – ENGREF, UMR 1092 Laboratoire d'étude des ressources Forêt-Bois, F-54000 Nancy, France [2]INRA, UMR 1092 Laboratoire d'étude des ressources Forêt-Bois, F-54000 Nancy, France (Corresponding author: D, MARAGE, damien.marage@agroparistech.fr)*

Keywords: ecological indicator, natura 2000, relative abundance distribution, riparian forests, species trait, typical species

Most of the riparian forests in the European Union (EU) are considered to be natural habitat types of interest, and they are included in the NATURA 2000 network, one of the key tools of biodiversity conservation in Europe. The main goal of this pan-European ecological network is to maintain a 'favorable' conservation status of selected species, called 'typical'. The conservation status of a habitat type is considered favorable when its natural range and area of occupancy are stable and the conservation status of its typical species are favorable, meaning that their natural ranges are not reduced nor likely to be reduced in the foreseeable future. However, how do we define the list of these typical species per natural habitat type? An official reporting at the level of the EU is required every six years to assess the management of such sites to fulfill the requirements of the Habitats Directive. In order to address this crucial issue, a methodological framework was developed and applied at a national scale in France. This framework was based on the modelling of the relative abundance distribution of each community using large phytosociological databases in France, that is, SOPHY and Ecoplant. The following three riparian forest habitat types of European interest were tested according to the Interpretation Manual of European Union Habitats: 92A0 (*Populion albae*), 91E0 (*Alnion incanae*) and 91F0. Using a matrix of species traits to avoid ecological redundancy, a list of typical herbaceous species was obtained for each habitat. Each list was compared with 'diagnostic' species sensu Chitry and the classical 'characteristic' species sensu Braun-Blanquet.
This framework should rapidly become a key component of conservation management, as it offers a consistent, repeatable, affordable and ecologically explicit method to define typical species and assess the conservation status in riparian forests.

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## ASSESSING THE EFFECTS OF RIPARIAN VEGETATION MANAGEMENT ON VEGETATION CONDITION IN NORTHERN VICTORIA, AUSTRALIA

**Christopher Jones[1], Peter Vesk[1], David Duncan[2]**

*[1]University of Melbourne, Melbourne, Victoria, Australia; [2]Department of Sustainability and Environment (Arthur Rylah Institute for Environmental Research), Melbourne, Victoria, Australia (corresponding author: jonescs@student.unimelb.edu.au)*

Keywords: vegetation change, monitoring, riparian, management

Understanding the trajectory of native vegetation change in response to past and present management actions is crucial to maximizing future management success. Land clearing and development for agriculture is the major cause of vegetation change in Victoria. Remnant native riparian vegetation exists along some streams within this highly modified landscape. Two commonly used management tools for protecting and restoring these areas are fencing and licensing to control/exclude livestock. Millions of dollars are spent each year in Victoria on vegetation management and assessments. To keep time and resource costs down, sensitive monitoring programs are avoided, whereas vegetation condition survey protocols that use a subjective and categorical estimation of variables are very common. Such assessments have limited application for vegetation monitoring. Categorical variables can be insensitive to change detection, and there is often large observer-driven variation. However, the utility of categorical assessments may be increased by evaluating change using data calibration. Benefits of this approach include increasing the value of the previous investment and expanding the monitoring time-period captured. We examined this process by resurveying sites of remnant riparian vegetation in Northern Victoria, which had been surveyed 15 years earlier by Robinson and Mann (1996). For the resurveys, we used the same subjective categories used in the original surveys and an additional set of more objective and continuous measures. By calibrating both methods used in the resurveys, we approximated the continuous estimates and associated uncertainties for the original surveys. The results showed that this method was able to measure change between the two different data sets. The primary drivers of change in this system were found to be the grazing level, distance upstream, tree cover and fencing. An assessment of management showed that the removal of grazing from a site resulted in a range of vegetation responses across a selection of vegetation condition attributes.

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## RELATIONSHIPS BETWEEN ENVIRONMENTAL VARIABLES AND VEGETATION IN THE EPHEMERAL STREAMS OF THE TWIQUI WATERSHED, SAUDI ARABIA

**A. M. Assaeed, S. L. Al-Rowaily, M. I. El-Bana, F.A. Al-Dujain**

*Dept. of Plant Production, College of Food & Agric. Sciences, King Saud University. P.O. Box 2460, Riyadh 11451, Saudi Arabia*

Ephemeral streams are common features in arid regions and support transition habitats for mesophytic flora, including rare and endemic species. The vegetation, watershed morphometrics, and soil characteristics were characterized from 54 randomly selected reaches of the Altwiqui watershed. The watershed was characterized by a sixth-order drainage basin with dentritic to sub-dentritic patterns at higher elevations and parallel to sub-parallel patterns in the lower elevation. The total number of streams was 959, with the majority of the investigated streams as first- or second-order streams. A total of 75 species belonging to 29 families and 69 genera were recorded. The richest families were Asteraceae, Poaceae, Fabaceae and Brassicaeae. Classification of vegetation stands using cluster analysis displayed six clear vegetation groups, each with specific indicator species. Detrended Correspondence Analysis (DCA) and the length of the first two axes of the DCA, indicating a complete turnover in species composition, confirmed the six vegetation groups. The cumulative variance recovered in the Canonical Correspondence Analysis (CCA) variance-regression ordination was substantial (72.8%). The structure of plant communities may be influenced primarily by a combination of morphometric and edaphic variables of the watershed and anthropogenic pressure, which in turn, may determine the distribution and abundance of moisture and nutrients and perhaps promote habitat specialization and/or competitive exclusion. The findings of the study have implications for the design of rehabilitation programs of watersheds disturbed by human activities.

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## DISTRIBUTION OF TREE SPECIES IN RELATION TO THE MICRO-TOPOGRAPHY IN THE RIPARIAN AREAS OF THE SUB-ALPINE ZONE, CENTRAL JAPAN

**Hirofumi Kondo[1], Akiko Sakai[2]**

*[1]Graduate school of Environment and Information Sciences, Yokohama National University, Yokohama, JAPAN; [2]Research Institute of Environment and Information Sciences, Yokohama National University, Yokohama, JAPAN (hs.kondo@gmail.com)*

Keywords: riparian forest, sub-alpine zone, micro-topography, disturbance, precipitous mountain

Few studies deal with riparian forests in sub-alpine zones, as compared to cool- and warm-temperate mountainous zones. Our field study was carried out in riparian forests distributed in the Southern Alps of Central Japan. This study aimed to (1) describe the micro-topographical condition of the riparian forests, (2) determine the spatial pattern of the tree distribution in relation to the micro-topography in this subalpine zone, and (3) compare the characteristics of these riparian forests with previous studies in the temperate mountainous zones. The results showed that seven micro-topographical units, with three main distinctive disturbance regimes, were classified. These three regimes were stable surface, surface susceptible to debris flow disturbance, and surface susceptible to landslide. *Albies veitchii*, *Albies mariesii* and *Tsuga diversifolia* (climax species) were distributed on the stable surface area, *Salix cardiophylla* was distributed on the surface susceptible to debris flow disturbance area, and *Alnus matsumurae* was distributed on the surface susceptible to landslide in this riparian forest. When compared to previous studies in the cool and warm temperate mountainous zones, the micro-topographical units in the riparian forests of the subalpine zone were basically similar, whereas the floristic composition was found to be different. Moreover, in this study, mountainside conifers were distributed near the bottom of valley, and the number of tree species was also fewer.

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## RIPARIAN WILLOW COMMUNITIES IN SLOVENIA: INVASION BY ALIEN SPECIES

**Urban Šilc**

*Institute of Biology, Scientific Research centre of the Slovenian Academy of Sciences and Arts,Ljubljana, Slovenia; (corresponding author: urban@zrc-sazu.si)*

Keywords: willow, invasive species, Salix

The work presents the distribution, invasion by alien species and preservation status of willow-dominated communities. We collected all of the existing relevés of riparian communities classified within the *Salicetea purpureae* class from Slovenia and compiled them in a Turboveg database.

These communities in Slovenia are found in the alpine region, where they are still in a relatively natural state, and in lowlands, where this is less preserved. Changes in the hydrological regime, building of dams and narrowing of riparian zones have a major influence on the changes of willow riparian communities. As these communities are classified into several FFH habitat types of the European Habitats Directive, their status in nature conservation and planning is of great importance.

The floristic composition and the particular proportion of alien species were taken into consideration as indicators of the preservation status of riparian habitats. The results of the research showed that communities of lowlands were greatly affected by alien species, whereas communities in higher altitudes still existed in their primary form. Differences also appeared along rivers where gravel was still transported with the water flow and between large and smaller rivers.

Changes of the riparian vegetation indicated higher anthropogenic pressure in lowlands but also more suitable ecological conditions for the spread of alien species along rivers.

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# THE CONTRIBUTION TO A RIPARIAN-FOREST TYPOLOGY OF THE TAGUS BASIN (PORTUGAL)

**Estevão Portela-Pereira[1,2], Miguel Geraldes[1,2], Carlos Neto[1,2], José Carlos Costa[2], Jorge Capelo[2,3]**

*[1]University of Lisbon, IGOT, Centre for Geographical Studies, Lisbon, Portugal; [2]Technical University of Lisbon, ISA, Centre of Botany Applied to Agriculture, Lisbon, Portugal ; [3]INRB - Portuguese National Institute of Biological Resources, Oeiras, Portugal (estevao@campus.ul.pt)*

Keywords: Riparian Forests, Tagus Basin, Typology, Environmental Factors

The Portuguese Tagus Basin (PTB) represents approximately 28% of inland Portugal. Climatically, it presents an asymmetry between northern and southern areas, the former being more humid and influenced by Cordillera Central (1993 m), whereas the latter are clearly Mediterranean with a long dry season (Alentejo peneplain). Geologically, there are 3 major areas: the largest, Hesperic Massif (HM) in the east, dominated by granites and a schist-greywacke complex; the downstream lowlands of Tagus Cenozoic Basin (TCB), which is of sandy-clay and carbonate formations; and the mainly limestone Lusitanian Meso-Cenozoic Basin (LMB) in the west-northwest. In general, the PTB climate and geomorphological diversity promote perennial rivers in the N and temporary ones in the S. The LMB has its fluvial regime controlled by karst. Human impacts are ancient, yet the rural exodus over recent decades has promoted a natural reinstatement of riparian forests in some rivers, whereas the invasion of exotic plants has occurred in others. The aim of this work was to establish a typology of riparian forests present in the PTB.

Concerning this, natural forests of riparian corridors can be typified, as follows: 1) Perennial rivers: channel banks that have alder forests of *Alnus glutinosa* at slow waters and willow galleries of *Salix salvifolia* in rapid ones. Forests of *Salix atrocinerea* also appear in mountain streams, and willow-poplar forests of *Salix neotricha*/*Populus nigra* occur in lowland rivers. 2) Temporary rivers present different types of galleries according to the dryness period of the riverbed. Forests of *S. neotricha*/*P. nigra*, predominate on the LMB, and willow forests of *S. atrocinerea* are mainly found on lowland sandy areas and *S. salvifolia* at torrential streams. At the driest areas, namely E-SE, ash forests of *Fraxinus angustifolia* and *Tamarix africana* and *Fluggea tinctoria* thickets dominate. Elm forests of *Ulmus minor* are occasionally present in small streams on the LMB. The most-spreading floodplain forests are dominated by *F. angustifolia* on rather inundated zones and by *S. atrocinerea* on regularly inundated zones. However, the PTB riparian forests were invaded by exotic woody plants: the major invaders were *Arundo donax* in agricultural and urban areas, mostly the LMB and Lisbon Region and *Acacia* sp. in forestry areas affected by fires. In addition, exotic *Salicaceae* were another problem.

# Alpine vegetation: threats in a changing world

Session 'Alpine vegetation' / ORAL

## ALPINE BIOGEOGRAPHIC CONTEXTS FOR CLIMATE IMPACTS

**George P. Malanson[1], Daniel B. Fagre[2], Lindsey Bengston[2]**

*[1]University of Iowa, Department of Geography, Iowa City, IA USA; [2]USGS, Glacier Field Station, West Glacier, MT USA, (corresponding author: george-malanson@uiowa.edu)*

Keywords: alpine, North America, ordination, tundra

The alpine tundra response to climate change should be interpreted in the context of its biogeographic pattern across a region. The species abundance on plots was taken from numerous studies across the western region of North America. Additionally, the extensive surveys of alpine tundra by Komarkova (1979) and Damm (2001) from the Indian Peaks Area, CO, USA and Glacier National Park, MT, USA were analyzed, and we derived or measured UTM coordinates for them. These data are taken at face value, that is, as representing the variation of the tundra of their surroundings when those were more extensive or of their own limited extent.
The species-plot data were ordinated using non-metric multidimensional scaling, and detrended correspondence analysis and the data of Komarkova and Damm were used in a Mantel test to determine the relative importance of environmental variables and geographic distance in differentiating the tundra plant communities. Alpine plant communities were differentiated at local geographic scales, as well as regionally, but exhibited a continuum of variation. Local differentiation was often related to the water conditions, as indicated by species affinities, but geographic distance and climatic differences were confounded at a regional scale. The interpretation of change due to climate should recognize that local microclimates may replicate broader regional climatic differences.

Session 'Alpine vegetation' / ORAL

## HOMOGENIZATION OF EUROPEAN SUMMIT FLORAS UNDER GLOBAL WARMING

**Gerald Jurasinski[1], Jutta Kapfer [2], Kari Klanderud[2], Gian-Reto Walther[3], John-Arvid Grytnes[2]**

*[1]University of Rostock, Landscape Ecology and Site Evaluation, Rostock, Germany. gerald.jurasinski@uni-rostock.de; [2]University of Bergen, Ecological and Environmental Change Research Group, Bergen, Norway; [3]University of Bayreuth, Plant Ecology, Bayreuth, Germany*

Keywords: climate change, range shift, beta diversity, re-survey, large scale study, Alpine

Since the beginning of this century, a significant amount of evidence has accumulated that global warming is indeed provoking a large-scale reaction of the world's biota. In essence, plants can show two possible reaction patterns: they may shift their phenology or their range. Range boundaries are very distinct in mountain regions because, with altitude, several important environmental controls change rapidly (e.g., temperature, radiation, moisture). In several studies, by re-surveying mountain tops once or several times, it has been shown that species shifted their ranges to higher elevations, together with an increase in average temperatures during the same period. In 2009, we published a small study based on previously published data from 7 Alpine summits in the Bernina range/Switzerland region (Jurasinski & Kreyling 2007) and showed that the upward shift led to a homogenization of the summit floras.
In the present survey, we compiled a pan-European data set to evaluate whether homogenization is also effective on much larger scales and is, therefore, a continentally coherent phenomenon. We present data from 111 Alpine and Arctic summits across Europe that have been re-surveyed at least two times. The time between the re-surveys understandably varied, and the shortest time span was 47 years, whereas the longest was 106 years. The data set covered only 15° longitude but had a huge latitudinal extent of approximately 40° from Southern Switzerland to Svalbard. We evaluated homogenization by calculating the multiple plot similarity between each summit and neighboring summits (those that fell into a specified radius). This was performed for several neighborhood sizes for each summit.
The relative normalized increase in richness was much more pronounced in the northern region. In contrast, the homogenization effect varied with latitude, and in the northern region, neighboring summits became increasingly dissimilar. This may have been caused by different initial species pool saturation levels.

Session 'Alpine vegetation' / ORAL

## RESISTANCE OF A SUBALPINE MEADOW AFTER TWO YEARS OF SEASONAL CLIMATE CHANGE AND AN EXTREME EVENT

**Marie-Lise Benot, Patrick Saccone, Karl Grigulis, Emmanuelle Reydet, Rachel Vicente, Jean-Christophe Clément, Sandra Lavorel**

*Laboratoire d'ECologie Alpine, CNRS -Université Joseph Fourier UMR 5553, Grenoble, France (corresponding author: mlbenot@gmail.com)*

Keywords: drought, heat-wave, plant traits, community structure, litter decomposition

Understanding and predicting the responses of ecosystems to climate change have become key issues in ecology. Only a handful of studies have investigated the effects of climate change on mountain grasslands and have focused on the responses to progressive changes in climatic conditions. Yet, most climatic scenarios also predict an increase in the frequency of extreme events, with larger impacts than those predicted using mean changes alone. We manipulated the climate and the mowing regime for two summers (2009-2010) in a sub-alpine grassland in the Central French Alps. Two climatic conditions were simulated: the current climate (no change in temperature and precipitation adjusted to the past 30-year average) and a climate change, which corresponded to a change in mean conditions during the growing season (+1°C and a 30% decrease in precipitation) and a 3-week extreme event in 2009 (+6°C with no precipitation). The responses of six species structuring the community and with contrasted life histories, the community structure and ecosystem functioning were assessed. The plant responses to climate change were variable across species and traits. However, climate change, especially extreme drought and heat-wave, significantly increased leaf senescence in four species (two rosette and two Poaceae species). Although not significant, a similar trend was observed for the rhizomatous graminoids, whereas the only shrub species (*Vaccinium myrtillus*) was not affected by the climate manipulation. Consistent with observations in managed grasslands, mowing significantly decreased the above-ground biomass production and increased the species diversity, although neither parameter was significantly affected by the climate manipulation. The increased temperature and reduced precipitation during the 2010 season decreased the litter decomposition rates but only for species with higher litter decomposition rates under controlled climate conditions. The studied grassland appeared resistant to two years of climate manipulation. However, these initial results suggest that moderate changes in temperature and rainfall, combined with extreme climatic events, could impact the structure and functioning of sub-alpine grasslands over the long term.

Session 'Alpine vegetation' / ORAL

## FLOWERING IN THE MONGOLIAN STEPPE: EFFECTS OF THE TOPOGRAPHY, YEAR, AND CLIMATE MANIPULATION

**Brenda Casper[1], Pierre Liancourt[1], Peter Petraitis[1], Lkhagva Ariuntsetseg[2], Bazartseren Boldgiv[3], Brent Helliker[1], Alain Plante[4]**

*[1]University of Pennsylvania, Department of Biology, Philadelphia, PA, USA; [2]University of Wyoming, Department of Botany, Laramie, USA; [3]National University of Mongolia, Department of Ecology, Ulaanbaatar, Mongolia; [4]University of Pennsylvania, Department of Earth and Environmental Studies, Philadelphia, PA, USA (Brenda Casper: bcasper@sas.upenn.edu)*

Keywords: climate change, flowering, grazing, phenology, steppe

Rising temperatures and increased variation in precipitation due to global climate change are expected to affect plant development and, thus, the timing of flowering, which can have important implications for reproduction. In this study, we examined flower production during the first two years of a four-year climate change experiment in the semi-arid steppe of Northern Mongolia. The experiment employed two different passive warming devices: open-top chambers (OTCs), which warm during the day, and open-sided chambers (OSCs), which warm primarily at night. The warming treatments were applied in conjunction with grazing and water addition. The experiment was conducted at two elevations on a south-facing slope, where the upper slope was drier. We used survival analysis to examine the contributions of the chambers, grazing, watering, slope location and year to the onset of flowering. The best model included only the slope location and year, indicating the greater importance of these factors in comparison to the experimental treatments. Flowering was observed earlier on the upper slope in 2009, a wetter year than 2010. A direct comparison between the OTCs and control plots showed that flowering also occurred earlier in the OTCs than in controls and that this difference was greater in 2009. There was no effect of experimental treatment on the number of species flowering during either year, but more species flowered in 2010. How the number of flowering species differed between the slope locations changed with the year. The number of flowers for individual species was also examined for treatment effects; when significant, the OTCs reduced flower number and watering increased it. As OTCs reduce the volumetric soil water content, in addition to elevating the temperature, the effect of the OTCs on soil water was more pronounced in wetter years. We suggest, therefore, that flowering phenology and total flower production may have primarily responded to the lower soil moisture in the OTCs rather than elevated temperatures. Thus, in the Mongolian steppe, we predict that the increasing variation in precipitation will have greater repercussions for plant reproduction than rising temperatures.

Session 'Alpine vegetation' / ORAL

## THE RESPONSES OF ALPINE PLANT AND SOIL COMPOSITION TO CHANGES IN SNOW COVER IN THE OLD MAN RANGE, NEW ZEALAND

**Diego Urrutia Guevara[1], Dr. Katharine Dickinson[1], Dr. Adrian Monks[2]**

*[1]University of Otago, Botany Department, Dunedin, New Zealand ; [2]Landcare Research, Dunedin, New Zealand; (corresponding author: Diego@urrutia.es)*

Keywords: Alpine, snow, distribution, vegetation, soils.

Alpine Zones are characterized by short, cold, and unpredictable growing seasons. One of the locations where alpine environments are found is the Old Man Range, on the South Island of New Zealand. The topography of these mountains creates sheltered areas where snow accumulates and exposed areas, in which the strong winds remove the snow from the slopes and ridges. The presence of snow determines the length of the growing season, and its insulation effect creates milder and more stable temperatures, higher soil moisture, and offers protection from the impact of wind and ice. As a result of these conditions, the distribution of soils and vegetation is largely determined and limited by snow cover.
One of the world's oldest experimental snow fences was built in 1959 on the windward side of a summit plateau in the Old Man Range. The snow fence, built perpendicular to the prevailing westerly winds, reduces wind speed and causes the accumulation of larger amounts of snow on its leeward side, which persists for a longer time. Consequently, changes had occurred in the plant species composition since the reporting by Smith et al. (1995), from their survey in 1991, and a second survey carried out by the Department of Botany in 2003. A third vegetation survey was performed in 2011. These results will be analyzed together to determine the responses of the soil and plant composition to the induced environmental conditions of the snow fence over the past 20 years.
Additionally, soil samples were taken from areas with different exposure around the snow fence to study the effects of different levels of snow accumulation in soil composition. Two nearby natural snowbanks acted as the control in this experiment. The same methodology as above will be used to study the soils and plant composition. These two snowbanks will provide us with the natural plant and soil composition of this area.
The main hypothesis of this study is that a plant and soil composition that is similar to a natural snowbank is being caused behind the snow fence. The results of this research may be officially presented for first time in the 54th International Symposium of the International Association for Vegetation Science.

Session 'Alpine vegetation' / ORAL

## ENVIRONMENTAL VARIABLES AND FUNCTIONAL TRAIT RELATIONSHIPS IN MEDITERRANEAN HIGH MOUNTAIN GRASSLANDS IN CENTRAL SPAIN: A DIRECT APPROACH

**Alba Gutiérrez-Girón[1], Susana Elvira[2], Victoria Bermejo[2], Rosario G. Gavilán[1]**

*[1]Complutense University (UCM), Plant Biology II, Madrid, Spain; [2]CIEMAT, Ecotoxicity and Air Pollution, Madrid, Spain; (corresponding author: albaggiron@farm.ucm.es)*

Keywords: Fourth-corner analysis, functional strategies, habitat constraints, soil temperatures

During the last decade, trait-based approaches have become increasingly frequent in plant ecology. Species traits are considered the result of climatic, biotic and disturbance-conditions filtering and determine the potential of species to persist or establish under a given set of environmental conditions. However, alpine plant communities are considered to be sensitive to global warming, and climate predictions expect more drastic variations in Mediterranean areas. The detection of the relationships among functional traits and environmental variables is a useful approach to evaluate the main habitat constraints in Mediterranean high mountain ecosystems and predict future changes on plant biodiversity in face of global change. In this study, we investigated the relationship of plant functional traits and environmental variables in the high mountain grasslands of Central Spain by considering leaf, reproductive and morphological traits. The environmental variables analyzed were climatic, soil and disturbance parameters. Plant traits and environmental variables were directly correlated using a floristic data set as a link matrix and carrying out fourth-corner analysis.
The main habitat constraints identified were low temperatures and water shortage during the growing season. We observed different resource acquisition and establishment strategies in the species set studied, despite the harsh environmental conditions that were expected to reduce the number of successful trait combinations severely. Due to their functional strategies, cushion and other small-leaved woody plants represented the most vulnerable group of species facing global change in the study area.

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## DO PLANT FUNCTIONAL TRAITS SHIFT ALONG SNOWMELT GRADIENTS? – A MECHANISTIC APPROACH TO DESCRIBE THE TRANS-TRASMAN ALPINE RELATIONSHIP

**Annika Korsten[1], Adrian Monks[2], Katharine J.M. Dickinson[1]**

*[1]Alpine Ecosystems Research Group, Ecology Programme & Department of Botany, University of Otago, Dunedin, New Zealand; [2]Landcare Research, Dunedin, New Zealand (corresponding author: ackorsten@gmail.com)*

Keywords: alpine, snowbank, plant traits, gradient analysis, snowmelt date, Southern Hemisphere

Abiotic stress is the major factor that structures plant communities in the alpine zone. Predicting the plant responses to this environment is critical to understanding the likely impacts of land use and climate change on these communities. In this study, we modeled the location of selected traits of alpine plant species along a localized snowmelt gradient in New Zealand and Australia to determine the key characteristics affecting species distribution in the alpine zone. Although snow cover can protect plants from environmental extremes, persistent snow cover can considerably shorten the length of the growing season. We observed that plant species in early exposed sites had heavier seeds, were taller, produced leaves with a small specific leaf area and, in New Zealand, had a high dry matter content. In Australia, however, the trait patterns were not as pronounced. These results suggest that quite different strategies are successful at the extremes of the snow melt gradient and in between countries. In New Zealand, early exposed species tolerate the extremes of wind and temperature by investing heavily in leaf biomass and large seeds. The short growing season at late exposed sites selects for a strategy of rapid establishment and fast resource acquisition at the expense of structural robustness. In Australia, a longer growing season and more predictable summer temperatures may result in less distinct habitats and more uniform vegetation structure. We suggest that the narrow environmental tolerances (at least for the New Zealand plant species) of the late exposed species will make this group particularly vulnerable to the effects of changing environmental conditions, such as earlier predicted snowmelt. Further examination of the underlying processes (e.g., nutrient distribution and biotic interactions) is required to complement these findings in both countries.

Session 'Alpine vegetation' / ORAL

## FACILITATION IN THE ALPINE ZONE : IS FACILITATION BY AN ALPINE CUSHION DEPENDENT ON STRESS OR GENDER?

**Brittany Cranston[1], Katharine Dickinson[1], Adrian Monks[2], Ragan Callaway[3]**

*[1]University of Otago, Botany Department, Dunedin, New Zealand; [2]Landcare Research, Dunedin, New Zealand; [3]University of Montana, Biology, Missoula, USA (britt.cranston@gmail.com)*

Keywords: alpine, facilitation, cost, gynodioecy, gender, elevation, *Silene acaulis*

Facilitation allows beneficiary plants to exploit environments previously uninhabitable, perhaps leading to range expansion, shifts in realized niches, and increased invasibility. Interest in the role of facilitation in structuring plant communities has been increasing in recent years, however, the costs incurred by the beneficiary plants are often excluded from such studies and have never been investigated with respect to gynodioecy. Females in gynodioecious populations are often described as more tolerant of environmental stress than hermaphrodites. Whether this stress-tolerance extends to competitive stress (i.e., competition with beneficiaries) is still unclear. We investigated the role of gender and environmental stress (elevation) on the facilitation and associated costs (competitive stress) to the gynodioecious alpine plant, *Silene acaulis,* at Swiftcurrent Pass, Glacier National Park, Montana, USA. Increases in beneficiary species richness and abundance, as compared to the control (no cushion), in cushion plots were greater at the higher elevation site, suggesting an increase in the intensity of facilitation with environmental stress. The percent cover of beneficiaries was positively associated with environmental stress in female plants and negatively in hermaphrodites. This indicates that the intensity of facilitation by females, but not hermaphrodites, increased with environmental stress. The leaf morphology and flower phenology showed signs of stress at the increased elevation and with increased percent cover of beneficiaries and included smaller leaves and fewer flowers per plant. *S. acaulis,* therefore, incurred a significant cost for facilitating other alpine species, though the cost was greater for females. Despite this, the seed size increased with environmental stress for females only, suggesting an increased fitness for female *S. acaulis* in stressful habitats.

This study is the first to identify females in a gynodioecious population as stronger facilitators. The intense facilitation by female *S. acaulis*, coupled with their high susceptibility to the costs, suggests that females may be easily displaced by beneficiaries, allowing for the range expansion and encroachment of lowland plants.

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# NO FACILITATIVE EFFECT OF CUSHION PLANTS: A SURPRISE FROM THE ROOF OF THE WORLD?

**Jiří Doležal*, Miroslav Dvorský, Zuzana Chlumská, Kateřina Janatková, Václav Kryštůfek, Martin Kopecký, Francesco de Bello, Klára Řeháková**

*Institute of Botany, Czech Academy of Sciences, Dukelská 135, CZ-379 82 Třeboň, Czech Republic (*corresponding author: dolezal @butbn.cas.cz)*

Keywords: cushion plants, stress gradient hypothesis, facilitation, nurse effect, biological soil crusts

The ongoing rapid retreat of glaciers in the Himalayas provides new habitats for living organisms, and cushion plants might play a crucial role in colonizing such newly deglaciated areas and in facilitating the establishment of other species. The growth form of cushion plants represents a suitable adaptation for severe conditions of alpine zones all over the world. Many cushion species are known for their beneficial effect on other species through the improvement of microhabitat conditions. These positive interactions seem to increase with the harshness of the environment, thus, supporting the stress-gradient hypothesis. We tested this hypothesis in the extreme conditions of the arid Transhimalaya. We collected data on the association of species with a cushion plant, *Thylacospermum caespitosum* (Caryophyllaceae), along a 4620-5830 m elevational gradient. In addition to the effects of *Thylacospermum* on vascular plants, we also explored its effects on microbial communities and the physico-chemical properties of the soils. We did not find evidence that other plant species grew more often inside cushions. The number and abundance of species were greater outside cushions than both within and on the edge of cushions. None of the 69 species detected was positively associated with cushions, whereas approximately 30% of them were negatively associated. Both a lower pH and less nutrients (i.e., P and $NH_4$) were found below cushions. In addition, the contents of Ca, Mg and $NO_3$ were reduced below cushions. The quantity of heterotrophic bacteria was higher below cushions at the lowest elevation, whereas the opposite was found for less water-limited sites at the higher altitudes. The phototrophic portion of the microbial community showed a higher biovolume outside cushions, where it was not light-limited. Contrary to the expectations, we found that, under extreme conditions, the facilitative interactions between plants diminished. This can be (at least partly) attributed to the intensive competition for soil resources, which are depleted inside *Thylacospermum* cushions. These results challenge the idea of cushions as nurse species under extreme combinations of high altitude and dryness and call for the testing of alternative mechanisms governing the maintenance of diversity in these habitats.

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# NEW KNOWLEDGE ON THE ECOLOGY AND DISTRIBUTION OF TWO RARE ARCTIC-ALPINE SPECIES, *CAREX RUPESTRIS* AND *ELYNA MYOSUROIDES*, IN THE WESTERN CARPATHIANS

**Ivana Šibíková[1], Anton Petrík[2], Dušan Senko[1], Jozef Šibík[1]**

*[1]Botanický ústav SAV, Department of Geobotany, Dúbravská cesta 14, 845 23 Bratislava 4; (ivana.sibikova@savba.sk);*
*[2] Botanická záhrada UK, Botanická [3]SK-841 04 Bratislava*

Keywords: DTM (Digital Terrain Model)-based predictions, relic vegetation, Tatra Mountains.

*Carex rupestris* All. and *Elyna myosuroides* (Vill.) Fritsch are arctic-alpine species, which, in distributional optima, form co-dominant or dominant vegetation stands. In the Alps, Pyrenees, Carpathians and the Balkans, these species are distributed as islands. In the Western Carpathians, both taxa belong to extremely protected and critically endangered rare species and are included in the Slovak Red List of vascular plants. In the present study, we aimed to contribute to the general knowledge of the ecology and distribution of both species. To this end, we summarized all of the known, published or unpublished, localities of their occurrence, and we present new, only recently discovered localities, including (probably) the most numerous and the most viable newly found populations of *Carex rupestris* in the Western Carpathians. The ecological preferences of the species, such as soil characteristics, geology and environmental variables, were studied and analyzed, as well. The phytocoenological classification of the stands is addressed, and the protection status and potential threats are discussed. On the basis of recently known localities, their parameters and characteristics, a distributional prediction of the possible occurrences of both rare species in the area of the Tatra Mountains was simulated.

# Climate change experiments in temperate grasslands

Session 'Climate change experiments in temperate grasslands' / ORAL

## CLIMATE CHANGE EXPERIMENTS IN TEMPERATE GRASSLANDS: SESSION INTRODUCTION

**Cameron N. Carlyle[1,2], Shannon R. White[3], Lauchlan H. Fraser[2], James F. Cahill[3]**

*[1]University of British Columbia, Department of Botany and Biodiversity Research Centre, Vancouver, Canada; [2]Thompson Rivers University, Natural Resource Sciences, Kamloops, Canada; [3]University of Alberta, Department of Biological Sciences, Edmonton, Canada (corresponding author: cameron.carlyle@gmail.com)*

Temperate grasslands cover 9% of the terrestrial land mass, are important biodiversity hotspots, and are extensively used for agriculture. Their global distribution, which includes all of the continents except Antarctica, is governed by precipitation patterns, fire regimes and management practices. Changes to temperature and precipitation patterns in association with climate change have already occurred in these regions, and models have predicted greater change in the future. Whereas the temperate grasslands are generally not predicted to experience severe increases in mean annual temperatures relative to other regions, their sensitivity to changes in water, coupled with their global significance, warrants concern and future study. Experiments are the best approach to understand how temperate grasslands will respond to complex and potentially interacting factors, and the research community has responded. By experimentally manipulating temperature, rainfall, $CO_2$ and other factors, those researching these systems have addressed a range of questions that encompass many components of temperate grassland ecosystems, including nutrient cycling, soil microorganisms, trophic dynamics, ecosystem stability, and below- and aboveground vegetation responses in terms of productivity, composition and diversity. We summarized the current state of climate change experiments in temperate grasslands as an introduction for this session.

Session 'Climate change experiments in temperate grasslands' / ORAL

## INTERACTING EFFECTS OF CLIMATE CHANGE AND GRAZING ON GRASSLAND PLANT COMMUNITIES ALONG A NATURAL PRODUCTIVITY GRADIENT

**Lauchlan H Fraser[1], Cameron N Carlyle[1,2], Roy Turkington[2]**

*[1]Thompson Rivers University, Biology, Kamloops, Canada; [2]University of British Columbia, Botany, Vancouver, Canada. (corresponding author: lfraser@tru.ca)*

Keywords: Global climate change, semi-arid grassland, productivity-diversity relationship, plant species richness

Considering that half of the terrestrial land mass is grazed and that climate change has the potential to impact the composition and function of this grassland, it is important to understand the interactions between grazing and climate-induced changes in grassland ecosystems. We expected that community resistance to climate-induced stress and disturbance would decrease with increasing productivity in temperate grasslands in the southern interior of British Columbia, Canada. We conducted a four-year factorial experiment testing the interacting effects of warming (ambient or increased), water availability (ambient, reduced, increased), and clipping (clipped or unclipped) and repeated the experiment at three points along a natural productivity gradient. Clipping had the largest effect on community composition and function and affected plant communities across the gradient. The effect of temperature was minimal, whereas the response to water manipulations varied unexpectedly across the gradient. As expected, median-productivity, high-diversity grasslands were less resistant to stress and disturbance than low-productivity ones. However, high-productivity grasslands had a relatively high resistance. Our results suggest that climate warming and disturbance can alter community function and composition in relatively short time periods, the response varies across a productivity gradient and species richness does not always confer community stability.

Session 'Climate change experiments in temperate grasslands' / ORAL

## COMPLEX RESPONSES TO ALTERED WARMING, WATER, AND DEFOLIATION: RESULTS FROM A FIELD EXPERIMENT IN THREE NORTHERN GRASSLANDS

**James Cahill[1,5], Shannon White[1], Edward Bork[2], Behnaz Attaien[3], Scott Chang[3], Scott Wilson[4], Samson Nyanumba[1], Jeffrey Newton[1], Heather Proctor[1]**

*[1]University of Alberta, Department of Biological Sciences, Edmonton, Canada; [2]University of Alberta, Department of Agriculture, Food, and Nutritional Sciences, Edmonton, Canada; [3]University of Alberta, Department of Renewable Resources, Edmonton, Canada; [4]University of Regina, Department of Biology, Regina, Canada; [5](corresponding author: jc.cahill@ualberta.ca)*

Keywords: Community ecology, climate change, plant-soil dynamics, grasslands, biodiversity

Temperate grasslands are landscapes of change. Variable levels of water, temperature, and defoliation all have the potential to alter plant and soil processes over short and long time-scales. Furthermore, these systems are of significant economic, cultural, and biological value, and thus, how they respond to changes in climate and management requires enhanced understanding. In 2007, we established a multi-factorial experiment in three locations in the Canadian prairies, in which we manipulated, at the plot level, the water supply (rainout shelters and water addition), warming (open-top chambers), and defoliation (hand clipping). These treatments were effective at altering the air temperature by approximately 3 degrees and water reaching the plots by 60%. Our study locations were at the northern edge of the Great Plains, a region particularly understudied with respect to abiotic influences on grassland dynamics and soil processes. Due to the diverse skill-sets of the multi-investigator team, we were able to measure a large number of responses, including the following: plant diversity, above- and belowground productivity, root turnover, nutrient cycling, soil respiration, soil microbial and arthropod diversity and abundance, root and shoot decomposition rates, forage quality, and abiotic conditions.
When examined individually, few generalities emerged from isolated response variables among sites. For example, productivity was reduced by warming in two sites and water in a different combination of two sites. There was little indication that the warming effects increased over the course of the study; instead, we conclude that these systems responded rapidly to the changing conditions. More integrative 'system-level' interactions indicated complex interactions among the different biotic and abiotic components of these systems, and these relationships themselves varied among the sites. Due to this variability, we suggest that substantial global collaboration will be required to elucidate general patterns.

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## RAINFALL VARIABILITY AND COMMUNITY DYNAMICS IN CHIHUAHUAN DESERT VEGETATION

**Scott L. Collins[1], Michell L. Thomey[1], Yang Xia[1], William T. Pockman[1], Selene Báez[2]**

*[1]Department of Biology, University of New Mexico, Albuquerque, NM, USA; [2]CONDESAN, Iniciativa de Estudios Ambientales Andinos, Quito, Ecuador*

Keywords: Desert grassland, precipitation variability, community structure, net primary production

Climate models predict a decrease in annual precipitation and an increase in climate variability over the next century in the Southwestern US. Aridland ecosystems are predicted to be highly responsive to climate variability and climate change. To better understand how climate variability will affect species composition and dynamics in the Northern Chihuahuan Desert, New Mexico, we initiated a series of experiments to determine how changes in winter, summer and annual precipitation will affect the dominant species and net primary production (NPP). Long-term measurements of the aboveground NPP in grass- and shrub-dominated vegetation showed that some functional groups in grasslands and shrublands are highly responsive to interannual changes in seasonal soil moisture but less sensitive to seasonal precipitation. This likely occurs because not all of the moisture from precipitation infiltrates into the rooting zone, and, thus, changes in the size of rainfall events may have a greater impact on soil moisture than changes in total precipitation. Despite this interannual variability, the abundance of the Chihuahuan Desert grass, black grama (*Bouteloua eriopoda*), was found to be increasing at a greater rate than Great Plains-dominant blue grama (*B. gracilis)*. Through several manipulative experiments, we showed that the aboveground NPP and species functional responses differed between the treatment plots that received either one large or several small precipitation events each month. We also showed that black grama and blue grama differed in their physiological responses to precipitation size and frequency. Furthermore, in a long-term rainfall manipulation experiment, we found that black grama was highly susceptible to prolonged drought, unlike the co-occurring native shrub, creosotebush (*Larrea tridentata*). Blue and black grama also differed in response to warming, grazing, fire and nitrogen addition. Together, these results demonstrate that the ability of the Chihuahuan Desert species, black grama, to increase in abundance at the expense of the Great Plains species, blue grama, will depend on the interaction among key abiotic drivers, including precipitation variability and extreme events, atmospheric nitrogen deposition and fire.

Session 'Climate change experiments in temperate grasslands' / ORAL

## GRASSLAND ECOSYSTEM RESPONSES TO EXPERIMENTAL MANIPULATIONS OF THE PRECIPITATION REGIME

**Alan Knapp[1], Melinda Smith[2], Scott Collins[3], John Blair[4]**

*[1]Colorado State University, Department of Biology and Graduate Degree Program in Ecology, Ft. Collins, CO, USA; [2]Yale University, Department of Ecology and Evolutionary Biology, New Haven, CT, USA; [3]University of New Mexico, Department of Biology, Albuquerque, NM, USA; [4]Kansas State University, Division of Biology, Manhattan, KS, USA; (corresponding author:aknapp@colostate.edu)*

Keywords: aboveground net primary production, climate change, rainfall regimes, soil moisture

Precipitation patterns and amounts are critical environmental drivers for grasslands. In the Central Plains grasslands of the U.S., mean temperatures are expected to increase, and rainfall patterns are predicted to become more variable, with increased frequency of large rainfall events and extended inter-rainfall droughts. Changes in the timing of rainfall events will alter soil moisture dynamics, and increased temperatures may intensify or moderate the impacts of altered rainfall timing by increasing evapotranspiration. Since 1998, we have been assessing the ecosystem consequences of these climate changes using field-scale rainfall manipulation plots to alter the timing of growing season rainfall events in intact grassland plots. Complimentary manipulations of precipitation regimes were conducted in other, more arid grasslands as well. The results indicated that there were significant reductions in the aboveground net primary productivity (ANPP) with altered rainfall patterns, which included fewer, but larger, rain events and extended periods between rain events. However, this response was variable among years. Across all of the years, the ANPP was positively correlated to the mean soil water content and negatively correlated to within-season soil moisture variability. Because the altered rainfall treatment resulted in a reduction in the mean soil moisture, rainfall regimes characterized by more extreme rainfall patterns can increase the sensitivity of the ANPP to interannual variation in precipitation amounts in these more mesic grasslands of the Central United States. However, when short-term experimental manipulations of the precipitation regime were conducted in more arid grasslands, the responses in the ANPP were opposite to those in the mesic grassland. The size of individual rain events had a disproportionate effect on the ANPP in these drier grasslands, with the positive effects of a few large events potentially offsetting the negative effects of reductions in the precipitation amount. Collectively, these results suggest that grassland responses to alterations in precipitation inputs may vary dramatically, depending on the long-term hydrologic regime.

Session 'Climate change experiments in temperate grasslands' / ORAL

## IMPACTS OF CLIMATE EXTREMES ON A MESIC GRASSLAND

**Melinda Smith[1], David Hoover[2,3], Alan Knapp[2,3]**

*[1]Yale University, Department of Ecology and Evolutionary Biology, New Haven, CT, USA; [2]Colorado State University, Department of Biology, Ft. Collins, CO, USA; [3]Colorado State University, Graduate Degree Program in Ecology, Ft. Collins, CO, USA*

Keywords: aboveground productivity, drought, climate change, heat wave, tallgrass prairie

Increased frequency and intensity of climate extremes, such as heat waves and severe drought, are expected too accompany the forecasted climate change. To assess the impacts of this understudied aspect of climate change on mesic grasslands, we examined the responses of the tallgrass prairie ecosystem in North America to a simulated two-week heat wave of differing intensity within the context of ambient vs. drought conditions. The drought was imposed from May to October 2010 using rainfall manipulation shelters located in an intact prairie at the Konza Prairie Biological Station (KS, USA), with the drought treatment receiving ~30% of ambient rainfall. Nested within the rainfall treatments, a two-week heat wave at four levels of intensity (+0, +2, +4, or +8 ºC above ambient) was imposed in late July. We measured a range of responses, including ecophysiological, plant community and ecosystem function. We focused primarily on the responses of the co-dominant $C_4$ grasses, *Andropogon gerardii* and *Sorgastrum nutans*, as previous studies have suggested that these species may differ in their responses to alterations in temperature and precipitation. We expected that *S. nutans* would be more sensitive and respond negatively to drought, whereas *A. gerardii* would respond more strongly as the intensity of the heat waves increased. Greater sensitivity to drought was evident for *S. nutans* with larger reductions in leaf water potential, net photosynthesis, and aboveground biomass relative to *A. gerardii*, which was less sensitive to heat and drought. The effect of the heat wave on net photosynthesis was strongly contingent on the soil moisture for both dominant grasses. At ambient soil moisture levels, *A. gerardii* displayed a negative linear physiological response as the heat wave intensity increased, whereas a non-linear response was evident for *S. nutans,* with reductions only occurring at the highest heat wave intensity. There was no effect of the heat wave treatments on net photosynthesis for either species when the soil moisture levels were low. Overall, total aboveground net primary production (ANPP) was reduced by the drought treatment. However, because the biomass of *S. nutans* was reduced by drought and it was not for *A. gerardii*, the dominance by *A. gerardii* increased. Because the heat wave lasted only two weeks, perhaps there was no effect of any of the heat wave treatments on the ANPP or the plant community. These results suggest that more extreme climates have the potential to alter the patterns of productivity and dominance in this mesic grassland due to differential responses of the dominant $C_4$ grasses.

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## THE BASIS OF COMMUNITY RESISTANCE TO CLIMATE CHANGE IN A LIMESTONE GRASSLAND, AND WHY IT MAY NOT LAST

**Jason Fridley[1], J. Philip Grime[2], Andrew Askew[1,2], Barbara Moser[3], Catherine Ravenscroft[1]**

*[1]Syracuse University, Department of Biology, Syracuse, NY, USA; [2]University of Sheffield, Department of Animal & Plant Sciences, Sheffield, UK; [3]Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland; (corresponding author: fridley@syr.edu)*

Keywords: climate change, plant invasions, adaptation, soil heterogeneity, competition

In this study, we reviewed the vegetation responses to nearly two decades of the annual manipulation of winter temperature and summer precipitation in a species-rich calcareous grassland of Northern England (Buxton, Derbyshire, UK). The demonstration of a surprising level of community resistance to climate forcing in this ecosystem after the first decade of manipulations prompted a more detailed look at the potential resistance mechanisms, including 1) finer-scale measurements of the community composition and substrate variation in the context of potential ‘micro-refugia’, 2) population-level measurements of genetic and functional shifts in response to climate treatments for several key species, and 3) an examination of whether dispersal limitations by potential dominants further to the south was preventing a larger-scale community turnover. We found that many species had the capacity to shift spatially along fine-scale soil-depth gradients in response to changing soil moisture regimes and that some species also showed considerable population-level differences along both soil-depth and climate gradients. However, the simulated invasion of two dominant grasses from warmer and drier calcareous grassland from Southeast England revealed no inherent biotic resistance of this ecosystem to new phenotypes, regardless of whether communities or populations had adjusted locally. We suggest that, over the time scale of a few decades, ecosystems that are generally nutrient-poor with slow population dynamics and are further typified by high substrate variation, such as the Buxton ecosystem, react slowly to the onset of new climate regimes and have the capacity to adapt by shifting along fine-scale microclimate gradients. Over longer time scales, where the probability of the establishment of new migrants from the south is high, we expect a large degree of community turnover and the potential for shifts in ecosystem processes, while the region would still be subject to the constraints imposed by local resource conditions (e.g., low fertility). Our work highlights the necessity of considering a range of spatial and temporal scales when predicting the future of ecosystems under new climate regimes.

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## COMMUNITY TRAIT COMPOSITION AND ECOSYSTEM FEEDBACKS TO GLOBAL CHANGE: INTER- VS. INTRA-SPECIFIC VARIABILITY AND TEMPORAL SCALE

**Elsa Cleland**

*University of California San Diego, Ecology Behavior & Evolution Section, La Jolla, California, U.S.A.*

Keywords: community composition, ecosystem function, functional traits, global change

Species responses to climate change and the resulting potential biotic feedbacks represent one of the greatest uncertainties in the predictions of ecosystem responses to climate change. Species can respond plastically to environmental change in the short term and shift in abundance in the near term, and species composition can shift due to the loss or gain of species over longer timescales. The influence of community structure in ecosystem responses to climate change will depend on how the trait composition of the plant community shifts, due to this combination of shifts within species and shifting abundances of species that vary in their trait means. The balance of inter- vs. intra-specific trait shifts is likely to vary depending on the trait of interest and time scale. For instance, phenology is a particularly plastic trait, for which species are highly responsive to environmental cues. In a system with a constrained growing season, the schedule of ecosystem primary production is likely to be mostly influenced by plastic phenological responses, and shifting species composition is less likely to influence ecosystem phenology. However, for traits, such as tissue nutrient content, that are related to decomposition and nutrient cycling, when variation within a species is low relative to the differences among species, longer-term shifts in community composition are likely to have a greater impact on ecosystem nutrient cycling than short-term plastic responses within the initial community. In this study, recently developed techniques for partitioning within vs. among species trait variation were used to estimate the relative contributions of plastic responses vs. shifting community composition in determining community aggregated phenological and decomposition responses in the context of grassland global-change experiments.

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## BIODIVERSITY IS NOT AT EQUILIBRIUM BUT REFLECTS THE GHOST OF ECOLOGICAL PROCESSES PAST

**Johannes (Jean) M. H. Knops, Chad E. Brassil, Erin K. Miles**

*University of Nebraska, School of Biological Sciences, Lincoln, NE, USA (jknops2@unl.edu)*

Keywords: succession, species diversity, old fields, equilibrium diversity, island biogeography

Understanding the factors that determine and maintain species diversity is a central topic in community ecology. It is often assumed that, ultimately, in succession, plant communities reach a stable equilibrium diversity level. However, even within later successional stages, plant species diversity may fluctuate over time due to changes in resource availability, disturbance regime, and the regional species pool. We examined species diversity in an “old-field” grassland community in Cedar Creek, Minnesota, USA. The data were collected from 1900 permanently marked 0.5 $m^2$ plots located in 19 fields abandoned between 1927 and 1982. The plots were sampled 6 times over a 23-year period. Based on the species diversity at the previous time period and the rates of immigration and extinction, we utilized island biogeography theory to predict species equilibrium at the plot level. The immigration and extinction rates both varied over time and showed a curvilinear relationship with the diversity present. The extinction rates varied four times more, in relation to diversity, than the immigration rates. The actual diversity fluctuated between 6.1 and 7.3 species per 0.5 $m^2$. In contrast, the predicted equilibrium species diversity fluctuated between 4.1 and 7.9 species. However, the direction of change for both actual and predicted diversity was the same over each time period. The predicted equilibrium species diversity varied by as much as 50% of the diversity from the previous sampling period, whereas the actual diversity changed by only 20%. The actual diversity only partly reflected recent processes that drive species diversity and, in large part, reflected past ecological processes. This was likely to have been caused by the longevity of individual plants even in this relatively dynamic grassland plant community. Secondly, the community was oversaturated at some time points and undersaturated at others. The times when the plant community was undersaturated created windows of opportunity for the establishment of new species. Thus, the key aspect determining ecosystem invasibility may be the species turnover and the variability of immigration and extinction rates over time, not simply the overall community diversity.

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## PLANT AND SOIL RESPONSES TO FOUR YEARS OF WARMING AND NITROGEN ADDITION IN A GRASS-DOMINATED, NORTHERN TEMPERATE OLD FIELD

**Hugh Henry, Jennifer Hutchison, Min Ku Kim, Eric Moise, Michelle Turner**

*University of Western Ontario, Department of Biology, London, ON, Canada*

Keywords: atmospheric nitrogen deposition, climate warming, grasses, herbivory, winter

In many northern temperate ecosystems, it is useful to examine the plant and soil responses to climate warming in the context of predicted increases in atmospheric nitrogen deposition and changes in soil-freezing dynamics over the next century. In particular, despite the potential for increased plant growth in response to a longer growing season, reductions in snow cover can increase the frequency and intensity of soil freeze-thaw cycles, damaging over-wintering plants and decreasing ecosystem nitrogen retention. Starting in 2006, we examined the plant and soil responses to warming and nitrogen addition in a grass-dominated, northern temperate old field. We administered warming using overhead infrared heaters, with one heating treatment conducted year-round to simulate climate warming, and the other warming treatment conducted only over the winter to explore the contribution of winter warming to the year-round warming effect. Although warming, indeed, increased the frequency of soil freeze-thaw cycles, the increased intensity of soil freezing was not sufficient to decrease the ecosystem nitrogen retention, and changes in the soil nitrogen dynamics in response to nitrogen addition overwhelmed the relatively subtle effects of warming on the soil nitrogen. Both the year-round and winter-only warming increased plant biomass in the second year, the only year when the warming initiated substantially earlier plant growth in spring, whereas warming had no effect on plant biomass in the other years. In most years, nitrogen addition was the most influential factor in increasing plant biomass, but the effects of nitrogen addition and warming on plant biomass were biased substantially by the activities of small herbivores, who fed preferentially in the treated plots. Surprisingly, increases in plant biomass in response to warming and nitrogen addition did not coincide with changes in the net ecosystem carbon dioxide exchange, and in general, there was a decoupling of plant and soil responses to the treatments. Overall, despite the wide range of effects of warming and nitrogen addition on plant, soil and ecosystem processes, there were very few interactions between these two factors.

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## ASSESSING THE IMPACTS OF CLIMATE CHANGE, ELEVATED CO2 AND EXTREME EVENTS ON MESIC AND ALPINE GRASSLANDS

**Jean-François Soussana[1], Catherine Picon-Cochard[1], Juliette Bloor[1], Amélie Cantarel[1], Giorgio Alessio[1], Jacques Roy[2], Sandra Lavorel[3]**

*[1]INRA, UR0874, UREP, Grassland Ecosystem Research, 234, Av. Du Brézet, F-63100 Clermont-Ferrand, France; [2]UE Ecotron, CNRS, Campus de Baillarguet, France; [3]LECA, Université Joseph Fourier, Grenoble, France; E-mail: jfsoussana@clermont.inra.fr*

Keywords: Grasslands, climate change, CO2, primary productivity, plant functional traits, photosynthesis.

We investigated the changes in grassland ecosystem function and structure under the influence of projected climate scenarios by combining the following three types of ecosystem manipulation experiments: i) a multiple driver monolith transplant experiment combining warming (+3.5°C), summer rain exclusion (-20%) and elevated $CO_2$ (+200 ppm); ii) a rain exclusion (automated rain shelters) and warming (passive and active infrared warming) experiment replicated at two sites (alpine and mesic grasslands) to test the impacts from heat and drought extremes projected by climate scenarios (2040-2060) in comparison with those of past extremes (i.e., summer of 2003 heat and drought); and iii) a controlled-environment experiment (4 $m^2$ macrocosms, Ecotron, Montpellier) testing the interaction between the elevated $CO_2$ and heat and drought extremes that have started in 2010. Results from the first experiment showed the following: i) the effects of both warming and the simultaneous application of warming, summer drought and elevated $CO_2$ on annual aboveground biomass were positive at the start of the study but became progressively negative over the course of the experiment; ii) warming and combined climate drivers reduced the abundance of graminoids and increased the abundance of legumes after three years; and iii) community-level aggregated leaf traits responded more strongly to combined climate change than to individual climate change drivers throughout the study. Results from the second experiment showed that heat and drought events projected for the 2050's led to a large leaf and canopy mortality in mesic grasslands, whereas alpine grasslands dominated by *Festuca paniculata* appeared to be resilient to projected climate extremes.

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## SENSITIVITY OF PLANT SPECIES TO CLIMATIC EXTREMES DURING GRASSLAND SUCCESSION

**Carl Beierkuhnlein[1], Camilla Wellstein [1], Juergen Kreyling[1], Tina Astor [3], Anke Jentsch [2]**

*[1]Dept. of Biogeography, University of Bayreuth, D-95440 Bayreuth, Germany; [2]Department of Ecology, Swedish University of Agricultural Sciences, Box 7044, 750 07 Uppsala, Sweden; [3]Disturbance Ecology, University of Bayreuth, D-95440 Bayreuth, Germany*

Keywords: drought, heat wave, plant functional types, EVENT-experiment, BIODEPTH-experiment,

Trajectories of succession are often perceived to be deterministic, depending on the environmental conditions and a given starting point. However, biotic interactions may influence the sequence of plant assemblages and dominance patterns, depending on the species traits at a certain stage of succession.
In this study, we investigated the development of grassland communities after the end of the BIODEPTH experiment (1996-1999). On the same substrate, 64 plots with defined species diversity and composition were established and maintained for the period of this experiment. The plots were organized into two blocks with a random distribution within them.
After 1999, weeding was ceased, and the grasslands were allowed to develop starting from various levels of diversity. In general, the plots developed towards increasing similarity of species composition, indicating convergent succession. However, in 2003, an extreme summer drought and heat wave affected the communities. This extreme event affected the vegetation dynamics by altering successional pathways. Individual trajectories were persistent even after five years. Thus, stochastic developments after heavy impacts can be expected. Consequently, the predictability of succession seems to be reduced in the face of an increasing probability of climatic extremes.
In parallel, the responses to drought and heat wave were found to be species-specific. In particular, the recovery of the vegetation after this impact was strongly dependent on species traits and functional diversity at the community level. In this study, we analyzed the contribution of specific functional traits to the resilience of grasslands.
Since 2009, winter rain was increased artificially in 50% of the plots, representing all of the former levels of biodiversity equally. The experiment became part of the EVENT-experiments, where we manipulated climatic changes and, especially, the precipitation regime under controlled conditions. An increase of winter precipitation was projected in various regional climate models for Central Europe. As we cannot expect direct effects (during winter time) but rather delayed responses, we are testing now the influence of a modified seasonality and amount of rainfall.

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## EFFECTS OF RECURRENT SEVERE DROUGHT ON MULTIPLE ECOSYSTEM FUNCTIONS IN TEMPERATE GRASSLANDS

**Anke Jentsch[1], Juergen Kreyling, Michael Elmer, Ellen Gellesch, Bruno Glaser, Kerstin Grant, Roman Hein, Marco Lara, Heydar Mirzae, Stefanie E. Nadler, Laura Nagy, Denis Otieno, Karin Pritsch, Uwe Rascher, Martin Schädler, Michael Schloter, Brajesh K. Singh, Jutta Stadler, Julia Walter, Camilla Wellstein, Jens Wöllecke, Carl Beierkuhnlein**

*[1]University of Bayreuth Disturbance Ecology, D-95440 Bayreuth, Germany, email address: anke.jentsch@uni-bayreuth.de*

Keywords: invasion, phenology, plant–climate interactions, precipitation change, productivity

Studying the effects of extreme weather events, such as drought, on biodiversity and ecosystem functions is one of the most important facets of climate change research. Rarely, however, are multiple ecosystem functions measured in a single study in order to address the general patterns across the different categories of responses.
We conducted a long-term field experiment, where we applied recurrent severe drought events annually for five consecutive years to constructed grassland communities in Central Europe. The 32 response parameters studied were closely related to ecosystem functions, and included primary production, nutrient cycling, carbon fixation, water regulation and community stability. Surprisingly, in the face of severe drought, the above- and below-ground primary production of plants remained stable across all of the years of the drought manipulation. Yet, severe drought significantly reduced the below-ground performance of microbes, as indicated by reduced soil respiration, microbial biomass, cellulose decomposition rates and mycorrhization rates. Drought reduced the leaf water potential, leaf gas exchange and leaf protein content, whereas it increase the maximum uptake capacity, leaf carbon isotope signature and leaf carbohydrate content. With regard to community stability, drought induced complementary plant–plant interactions and shifts in flower phenology and decreased the invasibility of plant communities and primary consumer abundance.
Our results provide the first field-based experimental evidence that climate extremes initiate plant physiological processes, which may serve to regulate ecosystem productivity. A potential reason for the different dynamics in various ecosystem services facing extreme climatic events may lie in the temporal hierarchy of patterns of fast versus slow responses. Such data on multiple response parameters within climate change experiments foster the understanding of the mechanisms of resilience, of synergisms or decoupling of biogeochemical processes at the ecosystem level. Future work is needed to elucidate the role of biodiversity and of biotic interactions in modulating ecosystem responses to extreme climatic events.

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## ADAPTING ECOSYSTEM CONSERVATION MANAGEMENT TO CLIMATE CHANGE: THE CASE OF CALCAREOUS GRASSLANDS SUBJECT TO SIMULATED DROUGHT

**Jean-Paul Maalouf, Yoann Le Bagousse-Pinguet, Lilian Marchand, Emilie Bâchelier, Blaise Touzard, Richard Michalet**

*UMR 1202 BIOGECO, INRA-Bordeaux 1 University, Talence, France*

Keywords: Calcareous Grasslands, Climate Change, Management, Diversity, Ecosystem Functioning

The effects of climate change and its interactions with human-induced disturbances should be considered in conservation management strategies. For example, conservation management such as regular mowing and drought events have the same inhibitory effects on the growth and diversity of competitive species, which tend to dominate abandoned European calcareous grasslands. However, the interaction between conservation management and drought events may decrease the positive interactions between plants, which would ultimately lead to a collapse of species diversity and ecosystem processes. We addressed the following questions: 1) Do drought events play a positive role in calcareous grassland conservation by limiting the dominance of competitive species; and 2) does the coupling of drought and mowing events severely affect the ecosystem? The combinatorial effects of repeated mowing events, an experimentally induced drought and biotic interactions on the survival of two transplanted competitive grasses were evaluated in calcareous grasslands in a southwestern region of France. Species richness, aboveground productivity and the litter decay rate were measured. Transplant survival decreased with drought but was not affected by mowing or biotic interactions. Species richness did not change in response to the treatments. Drought was the only factor that decreased aboveground productivity and the litter decay rate. Drought events limited the dominance of competitive species without affecting diversity. However, changes in ecosystem processes may have repercussions on diversity in the following seasons. In terms of conservation management, mowing calcareous grasslands can be avoided in dry years, which has economic implications, and can be maintained without perturbing species diversity.

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## SUBORDINATE PLANT SPECIES PROMOTE RESISTANCE OF PLANT COMMUNITY DURING SUMMER DROUGHT

**Pierre Mariotte[1,2], Charlotte Vandenberghe[2], Alexandre Buttler[1,2,3]**

*[1] Ecole Polytechnique Fédérale de Lausanne EPFL, School of Architecture, Civil and Environmental Engineering (ENAC), Laboratory of Ecological Systems (ECOS), Station 2, 1015 Lausanne, Switzerland; [2] Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Site Lausanne, Station 2, 1015 Lausanne, Switzerland; [3] Laboratoire de Chrono-Environnement, UMR CNRS 6249, UFR des Sciences et Techniques, 16 route de Gray, Université de Franche-Comté, F-25030 Besançon, France. (corresponding author: pierre.mariotte@epfl.ch)*

Keywords: Subordinate species, drought, insurance hypothesis, plant community, rainout shelter

Grassland communities are composed of dominant and subordinate species, both of which contribute to diversity. The role of dominant species in ecosystem functioning has received a lot of attention. However, less abundant species may have a larger influence on ecosystem processes and function than their relative abundance suggests. The "filtering" hypothesis (Grime 1998) suggests that the important role of subordinate species facilitates the recruitment of certain dominant species during recolonization after a disturbance event. In our current study, we examined the role of subordinate species in plant communities during summer drought (insurance hypothesis).
The field experiment was situated in a species-rich pasture of the Swiss Jura Mountains. Within a cattle-excluded area, we defined 30 plots of 1.20 x 1.20 m with homogenous vegetation. A removal treatment was randomly applied to the plots in 2009 and 2010 as follows: (C) control without removal, (S) removal of subordinate species, and (D) random removal of dominant biomass in proportion to removed subordinates. During the summer of 2010, a drought treatment (2 months) was combined with the removal treatments. All plots were covered with rainout shelters to intercept rainfall. Fifteen plots that served as "control drought" plots were watered using the collected precipitation. In each plot, the total aboveground biomass, which was sorted by plant species, was harvested before and after the summer drought. Measurements of the litter decomposition were performed between November 2009 and April 2010 and between May and October 2010 using minicontainers.
The results of the interaction between the removal and drought treatments show that plant communities without subordinate species have a lower resistance to drought and decreases in the aboveground biomass and the litter decomposition rate. In other drought plots (C, D), the subordinate species are more resistant to water limitations and comprise a higher proportion of total biomass compared to dominant species. Therefore, we conclude that subordinate species may promote the resistance of the plant community against summer drought and play an important role in ecosystem function, especially in the context of climate change.

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## DISCRIMINATING CLIMATE CHANGES FROM LAND-USE CHANGES TO EXPLAIN THE ABSENCE OF SHRUB COLONIZATION IN A MEDITERRANEAN STEPPE

**Thierry Dutoit, Frédéric Henry**

*Université d'Avignon, UMR CNRS IRD IMEP, IUT d'Avignon, Site Agroparc BP 61207, 84911 Avignon, Cedex 9, France (thierry.dutoit@univ-avignon.fr)*

Keywords: Competition, grazing, rainfall, La Crau, France

Since the end of the 20$^{th}$ century, climate changes and land-use changes are considered to be the main drivers of global changes in the world. Nevertheless, in semi-natural ecosystems, few data are available to evaluate the actions of each factor due to the lack of long-term and small-scale surveys on vegetation dynamics, biodiversity and/or changes in human land-uses. Currently, *in situ* experiments are used to follow the long-term effects of climate changes and/or land-use changes on ecosystem function and biodiversity. In a Mediterranean steppe of southern France (La Crau) where the natural colonization by shrub and trees has not been observed, even after 23 years of grazing abandonment, 3 potential tree colonizers (*Quercus ilex, Pinus halepensis, Cistus monspeliensis*) were transplanted in the autumn of 2006. The objectives of the current study were to distinguish between land-use changes (sheep grazing/exclosures) and climate changes (watered/not watered) on the growth of 1920 transplanted saplings. After two years, our results show a significant negative effect of sheep grazing and drought on the 3 species. *Q. ilex* was more resistant to sheep grazing than *P. halepensis* and *C. monspeliensis*. However, *Q. ilex* showed drastic drought-induced mortality during the first year after the transplantation. The accumulation of the two tested constraints that were present in the plain may explain why *P. halepensis* and *C. monspeliensis* were unable to colonize the steppe. If the traditional agricultural practice of sheep grazing is not abandoned, the significant increase in the mean annual temperature (1°C), which has been measured in this area for the last 20 years, and the changes in the distribution of the annual rainfall will compound the effects of sheep grazing on the natural shrub colonization by decreasing the herbaceous plant biomass.

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## A COMPARATIVE ANALYSIS OF WATER ECONOMY-RELATED TRAITS IN SPECIES-RICH SEMINATURAL MEADOWS OF CENTRAL EUROPE

**Jiří Doležal, Štěpán Janeček, Vojta Lanta, Francesco de Bello, Jan Lepš, Jitka Klimešová**

*Institute of Botany, Czech Academy of Sciences, Dukelská 135, CZ-379 82 Třeboň, Czech Republic (corresponding author: dolezal @butbn.cas.cz )*

Keywords: plant traits, water deficit, phylogenetically independent contrasts, leaf dry matter content

Understanding the life-history strategies of plants that coexist in temperate grasslands is important to maintain plant biodiversity. Water economy-related traits, in particular, are becoming increasingly important in the context of rising temperatures and the potential effects of exceptional heat waves such as those that have recently occurred in Central Europe during the last several years. After a dry spring in 2007, we explored whether 44 meadow species differed in the leaf water content (LWC) and the water deficit (WD = $LWC_{rehydrated\ plant} - LWC_{field\ plant}$). Furthermore, we used several indicators of water stress ($\delta^{13}C$, nonstructural carbohydrates, root/rhizome water content, leaf nutrient content) as predictors of LWC and WD. The study was performed in two grasslands that differed in nutrient and water availability (i.e., dry vs. wet sites) to test whether the plant trait responses were related to different environmental conditions, vegetation composition or plant phylogeny. There were large interspecific differences in LWC (mean 76%, range 51-90%) in both grassland sites. Tall forbs displayed the highest LWC values, and graminoides exhibited the lowest LWC values. These differences were retained after full rehydration. The LWC was positively correlated to SLA, root/rhizome water content and carbohydrate concentration and negatively correlated to foliar C, C:N ratio and $\delta^{13}C$. Most bivariate trait relationships remained significant after phylogenetic correction. LWC and species abundance within a meadow community were negatively correlated. Dominant grasses of both grassland sites displayed a lower LWC and tolerated a higher WD. These species may be better equipped to cope with environmental stresses that are connected with severe drought. Dominant species (*Molinia* spp., *Carex montana, Bromus erectus, Deschampsia cespitosa*) are strongly associated with resource-retentive life histories (smaller leaf water and N content, higher LDMC, leaf C content and C:N ratio, less negative $\delta^{13}C$ values). In addition, dominant species are capable of rapid biomass production after a disturbance because they contain high carbohydrate concentrations in belowground organs.

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## INFLUENCE OF CLIMATE AND LAND USE CHANGES ON LOW LYING BALTIC COASTAL HABITATS

**Jasmin Mantilla-Contreras[1], Iris Möller[2], Tom Spencer[2], Stefan Zerbe[3]**

*[1] University of Koblenz-Landau, Institute for Environmental Sciences, Ecosystem Analysis, Landau, Germany; [2] University of Cambridge, Department of Geography, Cambridge, U.K.; [3] Free University of Bozen, Faculty of Science and Technology, Environment and Applied Botany, Bozen, Italy (corresponding author: jasmin.mantilla@yahoo.de)*

Keywords: climate change, ecosystem functions, land use change, salt grassland

Global environmental change (climate change, agricultural and land-use changes) poses a growing challenge to the management and maintenance of the varied habitats and ecosystems that characterize the shores of the Baltic Sea. To guarantee the current and future protection of these ecosystems, it is important to understand the following: (i) the ecosystem functions in the context of the coastal system as a whole and (ii) how these ecosystem functions are maintained, enhanced, or restored in the context of changing environmental conditions.
Within the interdisciplinary project 'Biodiversity, Ecology, and Management of Baltic Coastal Habitats', we studied the influence of environmental changes on the Baltic Sea coast in the region of Mecklenburg-Vorpommern in northeastern Germany. Salt grasslands have developed in this area due to continuous agricultural land use (grazing) and are now a characteristic component of the landscape. Salt grasslands offer an important habitat for many animal and plant species, act as a sediment sink and fulfill a wave dissipating function as a natural defense against the sea. However, the traditional use of polders and the continuous polder construction over recent years has led to the decline of these types of habitats. Future climate change may pose an additional threat. Currently, we cannot predict whether the salt grasslands will sustain themselves in the context of such climatic change. In the current study, we present our results on the function of salt grasslands and explore how the salt grassland ecosystem may react to the predicted environmental changes in the next decades.

# LIST OF PARTICIPANTS

| | | | |
|---|---|---|---|
| **AAN Anne**<br>University of Tartu | TARTU | Estonia | anneaan@ut.ee |
| **AAVIK Tsipe**<br>ETH Zürich | DüBENDORF | Switzerland | tsipe.aavik@env.ethz.ch |
| **ABDELKRIM Benaradj**<br>University of Mascara | BECHAR | Algeria | kbenaradj@yahoo.fr |
| **ACOSTA Alicia**<br>University of Rome | ROMA | Italy | acosta@uniroma3.it |
| **AGRILLO Emiliano**<br>University of Roma | ROMA | Italy | emiliano.agrillo@uniroma1.it |
| **AGUIAR Francisca**<br>University of Lisbon | LISBOA | Portugal | fraguiar@isa.utl.pt |
| **AKASBI Zakia**<br>University of Hamburg | HAMBURG | Germany | ak_zakia@yahoo.fr |
| **ALEXSIS John de britto**<br>St.Xavier's College | PALAYAMKOTTAI | India | bjohnde@yahoo.co.in |
| **ALVARADO Swanni t.**<br>Université d'Avignon et des pays du Vaucluse | TOULOUSE | France | swanni_ta@yahoo.es |
| **ALVAREZ Miguel**<br>University of Bonn | BONN | Germany | malvarez@uni-bonn.de |
| **AMARA Mohamed**<br>Université de Tlemcen | ALGER | Algeria | amara_alg@yahoo.fr |
| **ARAUJO CALCADA Emmanuelle**<br>Université de Picardie | COYE LA FORET | France | emmanuelle.araujo-calcada@u-picardie.fr |
| **ARTHAUD Florent**<br>University Lyon 1 | VILLEURBANNE | France | florent.arthaud@univ-lyon1.fr |
| **ASKEW Andrew**<br>Syracuse University | MATLOCK | United States | a.p.askew@sheffield.ac.uk |
| **ASSAEED Abdulaziz**<br>King Saud University | RIYADH | Saudi Arabia | assaeed@ksu.edu.sa |
| **ATTAR Hesham**<br>INRA | MONTPELLIER | France | hamzahesham@hotmail.com |
| **AUNG Toe**<br>Yokohama National University | KAWASAKI CITY | Japan | toeaung02@gmail.com |
| **AZZELLA Mattia martin**<br>La Sapienza | ROMA | Italy | mattia_azzella@yahoo.it |
| **BAATTRUP-PEDERSEN Annette**<br>National Environmental Research Institute | SILKEBORG | Denmark | abp@dmu.dk |
| **BADIBANGA Georges**<br>British American Tobacco | KINSHASA | Democratic Republic of the Congo | georgesbadibanga@yahoo.fr |
| **BAGHDADI Djilali**<br>University of Mstaganem | RELIZANE | Algeria | baghdadidjilali@hotmail.com |
| **BAKO Sunday paul**<br>Ahmadu Bello University | ZARIA | Nigeria | spbako2002@yahoo.com |
| **BALSEVICIUS Arunas**<br>Station of nature Research and Environmental Education | MARIJAMPOLE | Lithuania | gtess@mari.omnitel.net |
| **BARBOUR Michael**<br>University of California | WINTERS | United States | mgbarbour@ucdavis.edu |
| **BARTHA Sandor**<br>MTA | VACRATOT | Hungary | sanyi@botanika.hu |
| **BáTORI Zoltán**<br>University of Szeged | SZEGED | Hungary | zbatory@gmail.com |
| **BATTAGLIA Loretta**<br>Southern Illinois University | CARBONDALE | United States | lbattaglia@plant.siu.edu |
| **BAUER Eva-maria**<br>Federal Institute of Hydrology | KOBLENZ | Germany | bauer@bafg.de |
| **BAUMBERGER Teddy**<br>IMEP | MARSEILLE | France | teddy.baumberger@univ-cezanne.fr |
| **BEAUCHAMP Vanessa**<br>Towson University | TOWSON | United States | vbeauchamp@towson.edu |
| **BECHAR Safia**<br>CNRS | VILLEURBANNE | France | becharsafia@gmail.com |

| | | | |
|---|---|---|---|
| **BEDELL Jean-philippe**<br>ENTPE | VAULX EN VELIN | France | bedell@entpe.fr |
| **BEIERKUHNLEIN Carl**<br>University of Bayreuth | BAYREUTH | Germany | carl.beierkuhnlein@uni-bayreuth.de |
| **BEJARANO Maria dolores**<br>Technical University of Madrid | MADRID | Spain | lolesbejarano@yahoo.es |
| **BELL Dorothy**<br>University of New England | ARMIDALE | Australia | dbell@une.edu.au |
| **BENOT Marie-lise**<br>LECA | CESSON-SEVIGNE | France | mlbenot@gmail.com |
| **BERNARD-VERDIER Maud**<br>Centre d'Ecologie Fonctionnelle et Evolutive | MONTPELLIER | France | bernard-verdier@cefe.cnrs.fr |
| **BERNEZ Ivan**<br>INRA | RENNES | France | ivan.bernez@agrocampus-ouest.fr |
| **BIEDERMAN Lori**<br>Iowa State University | AMES, IOWA | United States | lbied@iastate.edu |
| **BIORET Frédéric**<br>Société Française de Phytosociologie | BREST | France | frederic.bioret@univ-brest.fr |
| **BISCHOFF Armin**<br>Insitute of Horticulture and Landscape Planning | ANGERS | France | armin.bischoff@agrocampus-ouest.fr |
| **BITTEBIERE Anne-kristel**<br>Campus de Beaulieu | RENNES CEDEX | France | annekristel.bittebiere@orange.fr |
| **BIURRUN Idoia**<br>University of the Basque Country | BILBAO | Spain | idoia.biurrun@ehu.es |
| **BLANCO Carolina**<br>Universidade Federal do Rio Grande do Sul | PORTO ALEGRE | Brazil | carolina.blanco@ufrgs.br |
| **BLUMLER Mark**<br>Binghamton University | BINGHAMTON | United States | mablum@binghamton.edu |
| **BOLPAGNI Rossano**<br>University of Parma | PARMA | Italy | rossano@dsa.unipr.it |
| **BONIS Anne**<br>CNRS | RENNES | France | anne.bonis@univ-rennes1.fr |
| **BORNETTE Gudrun**<br>CNRS | VILLEURBANNE | France | gbornett@univ-lyon1.fr |
| **BOUCHAHM Nora**<br>CRSTRA | BISKRA | Algeria | bouchahm_nora@yahoo.fr |
| **BOUZILLE Jan-bernard** | RENNES | France | jan-bernard.bouzille@univ-rennes1.fr |
| **BOX Elgene**<br>University of Georgia | ATHENS | United States | boxeo@uga.edu |
| **BRUUN Hans henrik**<br>University og Copenhagen | KøBENHAVN | Denmark | hhbruun@bio.ku.dk |
| **BUISSON Elise**<br>Université d'Avignon | AVIGNON | France | elise.buisson@univ-avignon.fr |
| **CAHILL James**<br>University of Alberta | EDMONTON | Canada | jc.cahill@ualberta.ca |
| **CAMPETELLA Giandiego**<br>University of Camerino | CAMERINO | Italy | diego.campetella@unicam.it |
| **CAMPILLO Fabien**<br>INRIA | MONTPELLIER | France | Fabien.Campillo@inria.fr |
| **CARBONI Marta**<br>Università Roma Tre | ROME | Italy | mcarboni@uniroma3.it |
| **CARLI Emanuela**<br>University of Molise | PESCHE | Italy | emanuela.carli@unimol.it |
| **CARLUCCI Marcos**<br>Universidade Federal do Rio Grande do Sul | PORTO ALEGRE | Brazil | marcos.carlucci@gmail.com |
| **CARLYLE Cameron**<br>University of British Columbia | KAMLOOPS | Canada | cameron.carlyle@gmail.com |
| **CARNI Andraz**<br>Institut of Biology of Slovenia | BREZOVICA | Slovenia | carni@zrc-sazu.si |
| **CARRANZA Maria laura**<br>Unimol | ROME | Italy | laura.carranza@virgilio.it |

| | | | |
|---|---|---|---|
| **CARREAU Clélia**<br>INRA | RENNES | France | Clelia.Carreau@rennes.inra.fr |
| **CASPER Brenda**<br>University of Pennsylvania | MERION STATION | United States | bcasper@sas.upenn.edu |
| **CASTOLDI Elena**<br>Universidad Complutense de Madrid | MADRID | Spain | elena.castoldi@gmail.com |
| **CAVALLI Giulia**<br>Arhus University | BRABRAND | Denmark | giuliac@biology.au.dk |
| **CHABERT Chloé** | RENNES | France | chloe-chabert@hotmail.fr |
| **CHABRERIE Olivier**<br>Université de Picardie Jules Verne | AMIENS | France | olivier.chabrerie@u-picardie.fr |
| **CHANTELOUP Pierre**<br>Université de Rennes | RENNES | France | chanteloup.pierre@laposte.net |
| **CHAZIT Charles-françois**<br>Company | CHAZAY D'AZERGUES | France | c-f.chazit@ecobiotex.fr |
| **CHELLI Stefano**<br>University of Camerino | CAMERINO | Italy | stefano.chelli@gmail.com |
| **CHENG Yunxiang**<br>Tottori University | TOTTORI | Japan | yx-cheng@alrc.tottori-u.ac.jp |
| **CHERNENKOVA Tatjana**<br>Centre for Problems of Ecology and Productivity of Forests RAS | MOSCOW | Russia | chernenkova50@mail.ru |
| **CHIARUCCI Alessandro**<br>University of Siena | SIENA | Italy | chiarucci@unisi.it |
| **CHYTR_ Milan**<br>Masaryk University | BRNO | Czech Republic | chytry@sci.muni.cz |
| **CLELAND Elsa**<br>University of California | LA JOLLA | United States | ecleland@ucsd.edu |
| **CLERICI Nicola**<br>EC JRC | ISPRA | Italy | nicola.clerici@jrc.ec.europa.eu |
| **CLOSSET-KOPP Déborah**<br>Unité de recherche Dynamiques des systemes anthropisés | AMIENS | France | deborah.closset-kopp@u-picardie.fr |
| **COATES Fiona**<br>Department of Sustainabiltiy and Environment | FITZROY NORTH | Australia | Fiona.Coates@dse.vic.gov.au |
| **COBO Mary carmen**<br>University of Jaen | JAEN | Spain | mccobo@ujaen.es |
| **COLLINS Scott**<br>University of New Mexico | ALBUQUERQUE | United States | scollins@sevilleta.unm.edu |
| **COTTON Catherine**<br>Springer | DELFT | Netherlands | catherine.cotton@springer.com |
| **CRANSTON Brittany**<br>University of Otago | DUNEDIN | New Zealand | britt.cranston@gmail.com |
| **CRUZ Ana**<br>Universidade dos Açores | PONTA DELGADA | Portugal | anamvcruz@gmail.com |
| **CUNHA Andreia**<br>Azores and Biology Department of the Azores University | PONTA DELGADA | Portugal | cunhandreia@gmail.com |
| **CURRIE William**<br>University of Michigan | ANN ARBOR | United States | wcurrie@umich.edu |
| **DA SILVA HAESER Iporã**<br>Universidade Federal do Rio Grande do Sul | PORTO ALEGRE | Brazil | iporash@gmail.com |
| **DADALT Leticia**<br>Oklahoma State University | STILLWATER | United States | leticia.dadalt@okstate.edu |
| **DAMGAARD Christian**<br>Aarhus University | SILKEBORG | Denmark | cfd@dmu.dk |
| **DANIEL Hervé**<br>Agrocampus Ouest, Centre d'Angers INHP | ANGERS | France | herve.daniel@agrocampus-ouest.fr |
| **DARINOT Fabrice**<br>Réserve Naturelle du Marais de Lavours | CHINDRIEUX | France | contact@reserve-lavours.com |
| **DAVIES Matt**<br>University of Glasgow | DUMFRIES | United Kingdom | gwilym.davies@glasgow.ac.uk |
| **DE BELLO Francesco**<br>Institute of Botany | TREBON | Czech Republic | fradebello@ctfc.es |

| | | | |
|---|---|---|---|
| **DE CáCERES Miquel**<br>Centre Tecnològic Forestal de Catalunya | SOLSONA | Spain | miquelcaceres@gmail.com |
| **DE GOUVENAIN Roland**<br>Rhode Island College | NORTH PROVIDENCE | United States | rdegouvenain@ric.edu |
| **DE WILDE Mélissa**<br>Laboratoire d'Ecologie des Hydrosystèmes Naturels et Anthropisés | VILLEURBANNE | France | melissa.de-wilde@univ-lyon1.fr |
| **DECOCQ Guillaume**<br>Jules Verne University of Picardie | AMIENS | France | guillaume.decocq@u-picardie.fr |
| **DEIL Ulrich** | FREIBURG | Germany | ulrich.deil@biologie.uni-freiburg.de |
| **DEL MORAL Roger**<br>University of Washington | SEATTLE | United States | moral@uw.edu |
| **DELMAIL David** | LIMOGES | France | pascal.labrousse@gmail.com |
| **DíAZ-BARRADAS Mari cruz**<br>University of Seville | SEVILLE | Spain | diaz@us.es |
| **DICKINSON Katharine**<br>University of Otago | DUNEDIN | New Zealand | kath.dickinson@otago.ac.nz |
| **DIEKMANN Martin**<br>University of Bremen | BREMEN | Germany | mdiekman@uni-bremen.de |
| **DOLEZAL Jiri**<br>Institute of Botany | TREBON | Czech Republic | dolezal@butbn.cas.cz |
| **DOS SANTOS Virginie**<br>University of Waikato | HAMILTON | New Zealand | dossantos.vm@gmail.com |
| **DRAKOU Evangelia**<br>Aristotle University of Thessaloniki | THESSALONIKI | Greece | edrakou@bio.auth.gr |
| **DUARTE Leandro**<br>Ecology | PORTO ALEGRE | Brazil | duarte.ldas@gmail.com |
| **DUFOUR Simon**<br>Université Rennes | RENNES | France | simon.dufour@univ-rennes2.fr |
| **DUNCAN David**<br>Department of Sustainability and Environment | HEIDELBERG | Australia | david.duncan@dse.vic.gov.au |
| **DURANEL Arnaud**<br>University College London | WOKING | United Kingdom | arnaud.duranel.09@ucl.ac.uk |
| **DUTOIT Thierry**<br>Université d'Avignon | AVIGNON CEDEX 09 | France | thierry.dutoit@univ-avignon.fr |
| **EGAWA Chika**<br>Hokkaido University | SAPPORO | Japan | cegawa@ees.hokudai.ac.jp |
| **ELGER Arnaud** | | France | arnaud.elger@cict.fr |
| **ENRIGHT Neal**<br>Murdoch University | PERTH | Australia | N.Enright@murdoch.edu.au |
| **ESPíRITO SANTO Maria dalila**<br>Centro de BoTânica Aplicada à Agricultura | LISBOA | Portugal | dalilaesanto@isa.utl.pt |
| **FEILHAUER Hannes**<br>University of Bonn | BONN | Germany | hannes@giub.uni-bonn.de |
| **FELDMEYER-CHRISTE Elizabeth**<br>Swiss Federal Institute | BIRMENSDORF | Switzerland | elizabeth.feldmeyer@wsl.ch |
| **FERNANDES Maria rosário**<br>Forest Research Centre | LISBOA | Portugal | mrfernandes@isa.utl.pt |
| **FERNáNDEZ LO FASO Raquel**<br>Univerity of Seville | SEVILLE | Spain | lofaso@us.es |
| **FIDELIS Alessandra**<br>Universidade de São Paulo | SãO PAULO | Brazil | fidelis@usp.br |
| **FIDENCI Marion**<br>Laboratoire d'Ecologie Fonctionnelle (Ecolab) | CASTANET-TOLOSANE | France | Marion.Fidenci@etu.ensat.fr |
| **FOMBANG Nzetang victor**<br>CRTI Cameroon | BUEA | Cameroon | crticam@yahoo.com |
| **FONT Xavier**<br>University Barcelona | BARCELONA | Spain | xfont@ub.edu |
| **FORGET Guillaume**<br>INRA | RENNES | France | guillaume.forget@rennes.inra.fr |

| | | | |
|---|---|---|---|
| **FOSTER Bryan**<br>University of Kansas | LAWRENCE | United States | bfoster@ku.edu |
| **FRANK Christine** | HALLE | Germany | christinefrank.halle@online.de |
| **FRANK Dieter**<br>State Agency for Environmental Protection | HALLE | Germany | Dieter.Frank@lau.mlu.sachsen-anhalt.de |
| **FRASER Lauch**<br>Thompson Rivers University | KAMLOOPS | Canada | lfraser@tru.ca |
| **FRIDLEY Jason** | FAYETTEVILLE | United States | fridley@syr.edu |
| **FROEND Ray**<br>Edith Cowan University | JOONDALUP | Australia | r.froend@ecu.edu.au |
| **FUJIWARA Kazue**<br>Yokohama City University | CHIGASAKI CITY | Japan | kazue@ynu.ac.jp |
| **FUKAMACHI Atsuko**<br>Tokyo University | OHTAKU | Japan | atq.shio@gmail.com |
| **GALLET Sébastien**<br>Université de Bretagne Occidentale | BREST CEDEX 3 | France | sebastien.gallet@univ-brest.fr |
| **GARCíA-BAQUERO Gonzalo**<br>University of Basque Country | BILBAO | Spain | gonzalo.garcia-baquero@ehu.es |
| **GARCíA-MIJANGOS Itziar**<br>University of Basque Country | BILBAO | Spain | itziar.garcia@ehu.es |
| **GARCíA-VIñAS Juan i.**<br>University of Madrid | MADRID | Spain | juanignacio.garcia@upm.es |
| **GARNIER Eric**<br>CEFE, UMR CNRS 5175 | MONTPELLIER | France | eric.garnier@cefe.cnrs.fr |
| **GASTON Aitor**<br>University of Madrid | MADRID | Spain | aitor.gaston@upm.es |
| **GAVILáN Rosario g.**<br>Universidad Complutense | MADRID | Spain | rgavilan@farm.ucm.es |
| **GAZOL Antonio**<br>University of Tartu | TARTU | Estonia | antonio.gazol@ut.ee |
| **GEBLER Daniel**<br>Poznan University of Life Sciences | POZNAN | Poland | dgebler@up.poznan.pl |
| **GERALDES Miguel**<br>University of Lisbon | LISBOA | Portugal | mgeraldes@campus.ul.pt |
| **GERDOL Renato**<br>Ferrara University | FERRARA | Italy | grn@unife.it |
| **GERHOLD Pille**<br>University of Tartu | TARTU | Estonia | pille.gerhold@ut.ee |
| **GEVERS Jana**<br>University of Potsdam | BERLIN | Germany | jgevers@uni-potsdam.de |
| **GIGANTE Daniela**<br>University of Perugia | PERUGIA | Italy | daniela.gigante@unipg.it |
| **GILLET François**<br>Université de Franche-Comté | BESANCON | France | francois.gillet@univ-fcomte.fr |
| **GIORIA Margherita**<br>University of Konstanz | KONSTANZ | Germany | margheritagioria@yahoo.com |
| **GOLDBERG Deborah**<br>University of Michigan | ANN ARBOR | United States | degold@umich.edu |
| **GOODALL David**<br>Edth Cowan University | JOONDALUP | Australia | D.GOODALL@ECU.EDU.AU |
| **GREULICH Sabine**<br>University of Tours | VENDôME | France | greulich@univ-tours.fr |
| **GRILLAS Patrick**<br>Fondation Tour du Valat | ARLES | France | grillas@tourduvalat.org |
| **GRIME Philip**<br>University of Sheffield | SHEFFIELD | United Kingdom | j.p.grime@sheffield.ac.uk |
| **GROSS Nicolas**<br>INRA | BEAUVOIR-SUR-NIORT | France | nicolas.gross@cebc.cnrs.fr |
| **GUARINO Riccardo**<br>Unit of Botanical Sciences | PALERMO | Italy | guarinotro@hotmail.com |

| | | | |
|---|---|---|---|
| **GUTIERRES Francisco**<br>IGOT-University of Lisbon | LISBON | Portugal | franciscogutierres@campus.ul.pt |
| **GUTIÉRREZ-GIRÓN Alba**<br>Complutense University | MADRID | Spain | albaggiron@farm.ucm.es |
| **GüSEWELL Sabine**<br>ETH Zurich | MüNCHENBUCHSEE | Switzerland | sabine.guesewell@env.ethz.ch |
| **GöTZENBERGER Lars**<br>University of Tartu | TARTU | Estonia | lars@ut.ee |
| **HAMANN Elena**<br>Lyon 1 | LYON | France | elena.hamann@yahoo.fr |
| **HANA Sbartai**<br>Université de Badji Mokhtar | ANNABA | Algeria | hanasbartai@yahoo.fr |
| **HANDA Collins**<br>University of Bonn | BONN | Germany | Chanda@uni-bonn.de |
| **HARADA Atsuko**<br>Yokahama City University | YOKOHAMA-CITY | Japan | usatsukosd08@hotmail.co.jp |
| **HENAOUI Smaïn el-amine**<br>Université Abou bakr Belkaïd | TLEMCEN | Algeria | amine_33_ecoenv@yahoo.fr |
| **HENRY Hugh**<br>University of Western Ontario | LONDON | Canada | hhenry4@uwo.ca |
| **HENRY Jason**<br>Trent University | PETERBOROUGH | Canada | jasonhenry@trentu.ca |
| **HERBEN Tomas**<br>Institute of Botany | PRUHONICE | Czech Republic | herben@site.cas.cz |
| **HERMY Martin**<br>Leuven University (K.U.Leuven) | LEUVEN | Belgium | martin.hermy@ees.kuleuven.be |
| **HIIESALU Inga**<br>University of Tartu | TARTU | Estonia | salix@ut.ee |
| **HIKUSIMA Tukasa**<br>Tokyo University | TOKYO | Japan | fuktsu@cc.tuat.ac.jp |
| **HOBOHM Carsten**<br>IAVS | LUENEBURG | Germany | hobohm@uni-flenburg.de |
| **HODGES Tarnia**<br>Massey University | PALMERSTON NORTH | New Zealand | tarnia.hodges@gmail.com |
| **HONG Sun-kee**<br>Mokpo National University | MUAN | South Korea | landskhong@gmail.com |
| **HOSHINO Yoshinobu**<br>Tokyo University | TOKYO | Japan | hoshino@cc.tuat.ac.jp |
| **HSU Joanna**<br>Utah State University | NEW YORK | United States | jhsu118@gmail.com |
| **HöLZEL Norbert**<br>University Münster | MüNSTER | Germany | nhoelzel@uni-muenster.de |
| **ILOMETS Mati**<br>Tallinn University | TALLINN | Estonia | ilomets@tlu.ee |
| **ISEKI Tomohiro**<br>Tokyo Vagetation Research Society | TOKYO | Japan | RXC10122@nifty.ne.jp |
| **ISERMANN Maike**<br>Bremen University | BREMEN | Germany | maike.isermann@uni-bremen.de |
| **IVAJNSIC Danijel**<br>Faculty of natural sciences and mathematic | MARIBOR | Slovenia | dani.ivajnsic@uni-mb.si |
| **JABLONSKA Ewa**<br>University of Warsaw | WARSAW | Poland | e.jablonska@uw.edu.pl |
| **JAFARI Seyed mohammad**<br>University of Tehran | TEHRAN | Iran | se.mo.jafari@gmail.com |
| **JAMONEAU Aurélien**<br>Université de Picardie Jules Verne | AMIENS | France | aurelien.jamoneau@u-picardie.fr |
| **JANDT Ute** | HALLE/SAALE | Germany | ute.jandt@botanik.uni-halle.de |
| **JANE?EK _t?pán**<br>Institute of Botany | T?EBO? | Czech Republic | janecek@butbn.cas.cz |
| **JANSEN Florian**<br>University Greifswald | GREIFSWALD | Germany | jansen@uni-greifswald.de |

| | | | |
|---|---|---|---|
| **JAUNATRE Renaud**<br>Université d'Avignon | AVIGNON | France | renaud.jaunatre@yahoo.fr |
| **JELASKA Sven**<br>University of Zagreb | ZAGREB | Croatia | sven@botanic.hr |
| **JENTSCH Anke**<br>University of Bayreuth | BAYREUTH | Germany | jentsch@uni-landau.de |
| **JOLY Pierre**<br>CNRS Lyon1 | VILLEURBANNE | France | pierre.joly@univ-lyon1.fr |
| **JONES Christopher**<br>University of Melbourne | ST KILDA WEST | Australia | c.jones12@pgrad.unimelb.edu.au |
| **JüRIADO Inga**<br>University of Tartu | TARTU | Estonia | inga.juriado@ut.ee |
| **KALIGARIC Mitja**<br>University of Maribor | MARIBOR | Slovenia | mitja.kaligaric@uni-mb.si |
| **KALUSOVA Veronika**<br>Masaryk University | BRNO | Czech Republic | kalveron@tiscali.cz |
| **KALWIJ Jesse**<br>University of Tartu | TARTU | Estonia | jesse.kalwij@ut.ee |
| **KANA Silja**<br>Estonian University of Life Sciences | TARTU | Estonia | silja.kana@gmail.com |
| **KASONGO MBIYA Herve**<br>Environnement Mining Service | LUBUMBASHI | Democratic Republic of the Congo | hervembiya@yahoo.fr |
| **KAZAKOU Elena**<br>Montpellier Supagro | MONTPELLIER | France | elena.kazakou@cefe.cnrs.fr |
| **KEDDY Cathy** | CARLETON PLACE | Canada | keddy01@gmail.com |
| **KEDDY Paul**<br>Professor | CARLETON PLACE | Canada | drpaulkeddy@gmail.com |
| **KERUZORé Antoine**<br>University of Stirling | STIRLING | United Kingdom | antoine.keruzore@stir.ac.uk |
| **KIEHL Kathrin**<br>University of Applied Sciences Osnabrueck | OSNABRUECK | Germany | k.kiehl@hs-osnabrueck.de |
| **KIM Daehyun**<br>University of Kentucky | LEXINGTON | United States | biogeokim@gmail.com |
| **KIM Jae-eun** | MUAN-GUN | South Korea | ecokimje@yahoo.co.kr |
| **KLAUS Valentin**<br>University of Münster | MüNSTER | Germany | valentin-klaus@gmx.de |
| **KLIMESOVA Jitka**<br>Institute of Botany AS CR | TREBON | Czech Republic | klimesova@butbn.cas.cz |
| **KNAPP Alan**<br>Colorado State university | FORT COLLINS | United States | aknapp@colostate.edu |
| **KNOPS Johannes m h**<br>University of Nebraska | LINCOLN | United States | jknops2@unl.edu |
| **KOERNER Christian**<br>University of Basel | BASEL | Switzerland | ch.koerner@unibas.ch |
| **KOIDE Dai**<br>Yokohama National University | YOKOHAMA | Japan | daikoide@hotmail.com |
| **KONDO Hirofumi**<br>Yokohama National University | YOKOHAMA | Japan | hs.kondo@gmail.com |
| **KOOREM Kadri**<br>University of Tartu | TARTU | Estonia | kadri.koorem@ut.ee |
| **KORMOCZI Laszlo**<br>Department of Ecology University of Szeged | SZEGED | Hungary | kormoczi@bio.u-szeged.hu |
| **KORSTEN Annika**<br>University of Otago | DUNEDIN | New Zealand | ackorsten@gmail.com |
| **KOTOWSKI Wiktor**<br>University of Warsaw | WARSZAWA | Poland | w.kotowski@uw.edu.pl |
| **KOZUB Lukasz**<br>University of Warsaw | WIELISZEW | Poland | lukasz.kozub@biol.uw.edu.pl |
| **KRATOCHWIL Anselm**<br>University of Osnabrück | OSNABRüCK | Germany | kratochwil@biologie.uni-osnabrueck.de |

| | | | |
|---|---|---|---|
| **KRUKOWSKI Marek**<br>Wroclaw University | WROCLAW | Poland | poloeschatolo@gmail.com |
| **KUTNAR Lado**<br>Slovenian Forestry Institute | LJUBLJANA | Slovenia | lado.kutnar@gozdis.si |
| **KWOGE EWANG Eddie karl**<br>AREMD-Cameroon | YAOUNDE | Cameroon | aremd2001@yahoo.com |
| **LAANISTO Lauri**<br>University of Tartu | TARTU | Estonia | laanisto@ut.ee |
| **LABROUSSE Pascal**<br>Université de Limoges | LIMOGES | France | pascal.labrousse@unilim.fr |
| **LANDI Sara**<br>University of Siena | SIENA | Italy | landsara@gmail.com |
| **LANDUCCI Flavia**<br>University of Perugia | TERNI | Italy | flavia.landucci@gmail.com |
| **LASKURAIN Nere amaia**<br>UPV/EHU | BERGARA | Spain | nereamaia.lascurain@ehu.es |
| **LAWRENCE LODGE Rachael**<br>University of Otago | DUNEDIN | New Zealand | rachael.lawrencelodge@botany.otago.ac.nz |
| **LEATHEM Jamie**<br>University of British Columbia | VANCOUVER | Canada | kermit@interchange.ubc.ca |
| **LEE Sung-je**<br>Yokohama national university | YOKOHAMA-SI | Japan | phytoeco@gmail.com |
| **LEïLA Allal-benfekih**<br>University Saad Dahleb of Blida | BLIDA | Algeria | acrido@yahoo.fr |
| **LEILA Kadik**<br>Faculté des Sciences Biologiques | ALGER | Algeria | l_kadik@yahoo.fr |
| **LENOIR Jonathan**<br>Aarhus University | AARHUS | Denmark | lenoir.john@gmail.com |
| **LEWIS Rob**<br>Macaulay Institute | ABERDEEN | United Kingdom | r.j.lewis@me.com |
| **LIIRA Jaan**<br>University of Tartu | TARTU | Estonia | jaan.liira@ut.ee |
| **LõHMUS Kertu**<br>University of Tartu | TARTU | Estonia | kertu.lohmus@ut.ee |
| **LOIDI Javier**<br>University of the Basque Country | BILBAO | Spain | javier.loidi@ehu.es |
| **LOSOSOVá Zde?ka**<br>Masaryk University | BRNO | Czech Republic | lososova@ped.muni.cz |
| **LUBKE Roy**<br>Rhodes University | GRAHAMSTOWN | South Africa | r.lubke@ru.ac.za |
| **LYSENKO Tatiana**<br>Institute of Ecology of the Volga River Basin RAS | TOGLIATTI | Russia | ltm2000@mail.ru |
| **MAALOUF Jean-paul**<br>INRA-Bordeaux 1 University | TALENCE | France | jeanpaul.maalouf@gmail.com |
| **MAANAVILJA Liisa**<br>University of Helsinki | HELSINKI | Finland | liisa.maanavilja@helsinki.fi |
| **MALANSON George**<br>University of Iowa | IOWA CITY | United States | george-malanson@uiowa.edu |
| **MANTHEY Michael**<br>Greifswald University | GREIFSWALD | Denmark | manthey@uni-greifswald.de |
| **MANTILLA CONTRERAS Jasmin**<br>University of Koblenz-Landau | LANDAU | Denmark | jasmin.mantilla@yahoo.de |
| **MARAGE Damien**<br>AgroParisTech | CHAMPDOTRE | France | damien.marage@agroparistech.fr |
| **MARIOTTE Pierre**<br>Laboratory of Ecological Systems | LAUSANNE | Switzerland | pierre.mariotte@epfl.ch |
| **FAGARAS Marius**<br>Ovidius University Constanta | CONSTANTA | Romania | marius_fagaras@yahoo.com |
| **MAROZAS Vitas**<br>Lithuanian University of Agriculture | KAUNAS DISTR. | Lithuania | vitas.marozas@lzuu.lt |
| **MARTEL Evelyne**<br>Université Lyon1 | VILLEURBANNE | France | evelyne.martel@univ-lyon1.fr |

| | | | |
|---|---|---|---|
| **MASON Norman**<br>Landcare Research | HAMILTON | New Zealand | masonn@landcareresearch.co.nz |
| **MASSON Solène**<br>Université d'Avignon | AVIGNON | France | solene6@wanadoo.fr |
| **MAZé Elise** | BREST | France | nelize35@gmail.com |
| **MEKSEM-AMARA Leila**<br>Biologie végétale | ANNABA | Algeria | meksem54@yahoo.fr |
| **MERILä Päivi**<br>Finnish Forest Research Institute (Metla) | PARKANO | Finland | paivi.merila@metla.fi |
| **MERLIN Amandine**<br>Université de Rennes | RENNES | France | merlin.amandine@gmail.com |
| **MERUNKOVá Kristina**<br>Masaryk University in Brno | POLNá | Czech Republic | merunkova@sci.muni.cz |
| **MESLEARD François**<br>Université d'Avignon | ARLES | France | mesleard@tourduvalat.org |
| **METSOJA Jaak-albert**<br>University of Tartu | TARTU | Estonia | albert@ut.ee |
| **MICHALET Richard**<br>Université Bordeaux 1 | TALENCE | France | r.michalet@ecologie.u-bordeaux1.fr |
| **MICHEL Pascale**<br>Manaaki Whenua | HUTT CITY | New Zealand | michelp@landcareresearch.co.nz |
| **MINAMI Yoshi**<br>Tamagawa University | KAWASAKI CITY | Japan | yoshi-min@agr.tamagawa.ac.jp |
| **MINCHIN Peter**<br>Southern Illinois University Edwardsville | EDWARDSVILLE | United States | pminchi@siue.edu |
| **MLADEK Jan**<br>Palacky University | NEDASOV | Czech Republic | jan.mladek@upol.cz |
| **MLADKOVA Pavla**<br>Palacky Univeristy | NEDASOV | Czech Republic | pavla.mladkova@seznam.cz |
| **MOGHA Neema** | BONN | Germany | moghang@yahoo.com |
| **MOLINA José antonio**<br>Universidad Complutense de Madrid | MADRID | Spain | jmabril@farm.ucm.es |
| **MONY Cendrine**<br>Université de Rennes1 | RENNES | France | cendrine.mony@univ-rennes1.fr |
| **MOORA Mari**<br>University of Tartu | TARTU | Estonia | mari.moora@ut.ee |
| **MORETTI Marco**<br>Swiss Federal Research Institute WSL | BELLINZONA | Switzerland | marco.moretti@wsl.ch |
| **MOSTARI Abbassia**<br>Université Abdel Hamid Ibn Badis Mostaganem | MOSTAGANEM | Algeria | mostari_abie27@yahoo.fr |
| **MUCINA Ladislav**<br>Curtin University | PERTH | Australia | L.Mucina@curtin.edu.au |
| **MULLER Isabelle**<br>IMEP | AVIGNON | France | isabellemuller@hotmail.fr |
| **MYEONG Hyeon-ho**<br>Mokpo National University | MUAN-GUN | South Korea | ecomyung@empal.com |
| **NAGAMATSU Dai**<br>Tottori University | TOTTORI | Japan | daina@rstu.jp |
| **NAKANO Takashi**<br>Yamanashi Institute of Environmental Sciences | FUJI-YOSHIDA | United Kingdom | nakano@yies.pref.yamanashi.jp |
| **NALIAN Armen**<br>Stephen F. Austin State University | NACOGDOCHES | United States | nalianarmen@sfasu.edu |
| **NAQINEZHAD Alireza**<br>University of Mazandaran | BABOLSAR | Iran | a.naqinezhad@umz.ac.ir |
| **NARIJAUSKAS Ri?ardas**<br>Station of Nature Research and Environmental Education | MARIJAMPOL | Lithuania | richard_narij@yahoo.co.uk |
| **NAVAS Marie-laure**<br>Montpellier SupAgro | MONTPELLIER | France | navas@supagro.inra.fr |
| **NISHIMOTO Takashi**<br>Okayama Pref. Nature Conservation Center | WAKE | Japan | taknishi@js4.so-net.ne.jp |

| | | | |
|---|---|---|---|
| **NJOCK Tanyi mathias**<br>AREMD-Cameroon | YAOUNDE | Cameroon | ceprosudcam@yahoo.com |
| **OGURCAK Danielle**<br>Florida International University | MIAMI, FL | United States | dogur001@fiu.edu |
| **OLVERA VARGAS Miguel**<br>Universidad de Guadalajara | AUTLÁN DE NAVARRO | Mexico | molvera@cucsur.udg.mx |
| **OTSUS Merit**<br>Estonian University of Life Sciences | TARTU | Estonia | merit.otsus@emu.ee |
| **OUDOT-CANAFF Jehanne**<br>LEHNA | CHALAMONT | France | joudotcanaff@gmail.com |
| **OUESLATI Souha**<br>Institut National Agronomique de Tunisie | KORBA | Tunisia | souha_oueslati@yahoo.fr |
| **PAKALNE Mara**<br>University of Latvia | RIGA | Latvia | mara@lanet.lv |
| **PALMER Michael**<br>Oklahoma State University | STILLWATER | United States | mike.palmer@okstate.edu |
| **PARADIS Étienne**<br>Université Laval | QUEBEC | Canada | etienne.paradis.2@ulaval.ca |
| **PARK Jung won**<br>Mokpo University | MUAN-GUN | South Korea | nexan@mokpo.ac.kr |
| **PAUSIC Andrej**<br>Slovenian Academy of Sciences and Arts | LJUBLJANA | Slovenia | andrej.pausic@zrc-sazu.si |
| **PAUSIC Igor**<br>Maribor SLO | LENDAVA | Slovenia | igor.pausic@uni-mb.si |
| **PECO Begoña**<br>Universidad Autonoma de Madrid | MADRID | Spain | begonna.peco@uam.es |
| **PEDROTTI Franco**<br>Universite' de Camerino | CAMERINO | Italy | franco.pedrotti@unicam.it |
| **PEET Robert**<br>University of North Carolina | CHAPEL HILL | United States | peet@unc.edu |
| **PENNINGS Steven**<br>University of Houston | HOUSTON | United States | spennings@uh.edu |
| **PETERSON Urmas**<br>Estonian University of Life Sciences | TARTU | Estonia | urpe@aai.ee |
| **PEYRE Gwendolyn**<br>Universidad de Barcelona | BARCELONA | Spain | lunariaster@gmail.com |
| **PIELECH Remigiusz**<br>Wroclaw University | NOWA SóL | Poland | remekpielech@o2.pl |
| **PILLAR Valério**<br>Universidade Federal do Rio Grande do Sul | PORTO ALEGRE | Brazil | vpillar@ufrgs.br |
| **PIOLA Florence** | VILLEURBANNE | France | piola@univ-lyon1.fr |
| **PIPENBAHER Natasa**<br>Faculty of natural sciences and mathematic | MARIBOR | Slovenia | natasa.pipenbaher@uni-mb.si |
| **PIVELLO Vania**<br>Universidade de São Paulo | SãO PAULO | Brazil | vrpivel@usp.br |
| **PLUE Jan**<br>Stockholm University | STOCKHOLM | Sweden | jan.plue@natgeo.su.se |
| **POLI MARCHESE Emilia**<br>Catania University | CATANIA | Italy | epolimar@unict.it |
| **PORTELA-PEREIRA Estevão**<br>IGOT-University of Lisbon | PONTE DE LIMA | Portugal | estevao@campus.ul.pt |
| **PRAKASH SHARMA Gyan**<br>University of Delhi | DELHI | India | gyanprakashsharma@gmail.com |
| **PRAT Daniel**<br>UCBL | VILLEURBANNE | France | daniel.prat@univ-lyon1.fr |
| **PRICE Jodi**<br>University of Tartu | TARTU | Estonia | Jodi.Price@ut.ee |
| **PUIJALON Sara**<br>CNRS | VILLEURBANNE | France | sara.puijalon@univ-lyon1.fr |
| **PÄRTEL Meelis**<br>University of Tartu | TARTU | Estonia | meelis.partel@ut.ee |

| | | | |
|---|---|---|---|
| **RAPSON Jill**<br>Massey University | PALMERSTON NORTH | New Zealand | G.Rapson@massey.ac.nz |
| **REDZIC Sulejman**<br>Academy of Bosnia-Herzegovina | SARAJEVO | Bosnia and Herzegovina | sredzic@anubih.ba |
| **REITALU Triin**<br>Tallinn Technical University | TALLINN | Estonia | reitalu@gi.ee |
| **RIIS Tenna**<br>Aarhus University | AARHUS C | Denmark | tenna.riis@biology.au.dk |
| **ROCCHINI Duccio**<br>Edmund Mach Foundation | SAN MICHELE ALL'ADIGE | Italy | ducciorocchini@gmail.com |
| **RODRIGUEZ Célia**<br>LEHNA | VILLEURBANNE | France | celia.rodriguezRhomeo@gmail.com |
| **RODRíGUEZ-GONZáLEZ Patricia**<br>Universidade Técnica de Lisboa | LISBOA | Portugal | patri@isa.utl.pt |
| **RODWELL John**<br>Self-employed consultant | LANCASTER | United Kingdom | johnrodwell@tiscali.co.uk |
| **ROUIFED Soraya**<br>Université Lyon 1 | LYON | France | soraya.rouifed@univ-lyon1.fr |
| **ROZBROJOVA Zuzana**<br>Masaryk University | MODRICE | Czech Republic | zuzkaroz@sci.muni.cz |
| **SACCONE Patrick**<br>CNRS, UJF | CHAMONIX | France | patrick.saccone@gmail.com |
| **SAJNA Nina**<br>University of Maribor | MARIBOR | Slovenia | nina.sajna@uni-mb.si |
| **SAMMUL Marek**<br>Estonian University of Life Sciences | TARTU | Estonia | marek.sammul@emu.ee |
| **SAUCIER Jean-pierre**<br>Université Laval | QUEBEC | Canada | jean-pierre.saucier@sbf.ulaval.ca |
| **SAWTSCHUK Jérôme**<br>Université de Bretagne Occidentale | BREST | France | sawtschuk.jerome@gmail.com |
| **SCHAMINEE Joop**<br>Alterra WUR | WAGENINGEN | Netherlands | joop.schaminee@wur.nl |
| **SCHMIDTLEIN Sebastian**<br>University of Bonn | BAD HONNEF | Germany | s.schmidtlein@uni-bonn.de |
| **SCHWABE Angelika**<br>Technische Universität Darmstadt | DARMSTADT | Germany | schwabe@bio.tu-darmstadt.de |
| **SEKULOVá Lucia**<br>Masaryk University | BRNO | Czech Republic | sekulova@sci.muni.cz |
| **SENDZIKAITE Jurate**<br>Institute of Botany | VILNIUS | Lithuania | jurate.sendzikaite@botanika.lt |
| **SFAKSI Nafissa**<br>Université de Toulouse II | TOULOUSE | France | nafissa.sfaksi@univ-tlse2.fr |
| **SHIMODA Michiko**<br>Fuji Tokoha University | FUJI | Japan | shimoda@fuji-tokoha-u.ac.jp |
| **SIBIKOVA Ivana**<br>Slovak Academy of Sciences | PRIEVIDZA | Slovakia | ivana.sibikova@savba.sk |
| **SIERRA Arévalo**<br>Universidad de La Laguna | LA LAGUNA | Spain | jarevalo@ull.es |
| **SILC Urban**<br>Institute of Biology SRC SASA | LJUBLJANA | Slovenia | urban@zrc-sazu.si |
| **SIZYKH Alexander**<br>Siberian Institute of Plant Physiology and Biochemistry | IRKUTSK | Russia | bogard66@rambler.ru |
| **SKORNIK Sonja**<br>University of Maribor | MARIBOR | Slovenia | sonja.skornik@uni-mb.si |
| **SMITH Melinda**<br>Yale University | NEW HAVEN | United States | melinda.smith@yale.edu |
| **SMITS Nina**<br>Alterra WUR | WAGENINGEN | Netherlands | nina.smits@wur.nl |
| **SOSNOVA Monika**<br>Institute of Botany AC CR | TREBON | Czech Republic | sosnova@butbn.cas.cz |
| **SOUSSANA Jean-françois**<br>INRA | PARIS | France | dsenv@paris.inra.fr |

| | | | |
|---|---|---|---|
| **SPADA Francesco**<br>Sapienza University of Roma | ROMA | Italy | francesco.spada@uniroma1.it |
| **SPEARPOINT Owen**<br>Greater Wellington Regional Council | LOWER HUTT | New Zealand | owen.spearpoint@gw.govt.nz |
| **STACHNOWICZ Wojciech**<br>Adam Mickiewicz University | POZNAN | Poland | wsta@op.pl |
| **STACHOVA Terezie**<br>University of South Bohemia | CESKE BUDEJOVICE | Czech Republic | terezas007@yahoo.com |
| **STELLA John**<br>SUNY Syracuse | SYRACUSE | United States | stella@esf.edu |
| **STOECKLIN Juerg**<br>University of Basel | BASEL | Switzerland | juerg.stoecklin@unibas.ch |
| **STOFFELLA Susana**<br>Florida International University | MIAMI | United States | stoffell@fiu.edu |
| **STRAZDINA Liga**<br>University of Latvia | RIGA | Latvia | liga.strazdins@gmail.com |
| **STROH Peter**<br>Anglia Ruskin University | ISLIP | United Kingdom | peter.stroh@anglia.ac.uk |
| **SZOSZKIEWICZ Krzysztof**<br>Poznan University of Life Sciences | POZNAN | Poland | kszoszk@up.poznan.pl |
| **TAMME Riin**<br>Tartu University | TARTU | Estonia | riin.tamme@ut.ee |
| **TANG Cindy**<br>Yunnan University | KUNMING | China | cindyqtang@aol.com |
| **THEBAUD Gilles**<br>Clermont-Université | CLERMONT-FERRAND | France | gilles.thebaud@univ-bpclermont.fr |
| **THEURILLAT Jean-paul**<br>Fondation J.-M. Aubert | CHAMPEX-LAC | Switzerland | jean-paul.theurillat@unige.ch |
| **THIELE Jan**<br>University of Muenster | MUENSTER | Germany | Jan.Thiele@uni-muenster.de |
| **THOMAS Hilary**<br>University of Glamorgan | PONTYPRIDD | United Kingdom | hsct2@yahoo.co.uk |
| **THOMAS Siegmar**<br>Dresden University of Technology | RADEBEUL | Germany | siegmar.thomas@mailbox.tu-dresden.de |
| **TICHY Lubomir**<br>Masaryk University | BRNO | Czech Republic | tichy@sci.muni.cz |
| **TORMOS Thierry**<br>Onema | LYON | France | thierry.tormos@onema.fr |
| **TRUUS Laimdota**<br>Tallinn University | TALLINN | Estonia | laimdota.truus@tlu.ee |
| **TSUYAMA Ikutaro**<br>FFPRI | IBARAKI | Japan | Aquarianleo@gmail.com |
| **TUITTILA Eeva-stiina**<br>University of Helsinki | HELSINKI | Finland | eevastiina.tuittila@helsinki.fi |
| **UGURLU Emin**<br>Celal Bayar University | MANISA | Turkey | ugurlu@yahoo.com |
| **URRUTIA GUEVARA Diego**<br>University of Otago | DUNEDIN | New Zealand | Diego@urrutia.com |
| **VALERA-BURGOS Javier**<br>University of Seville | SEVILLE | Spain | jvalera@us.es |
| **VALLE Cipriano j.**<br>University of Salamanca | SALAMANCA | Spain | cvalle@usal.es |
| **VAN LOOY Kris**<br>CEMAGREF | LYON | France | kris.van-looy@cemagref.fr |
| **VAN ROOYEN Margaretha (gretel)**<br>University of Pretoria | PRETORIA | South Africa | gretel.vanrooyen@up.ac.za |
| **VAN ROOYEN Noel**<br>University of Pretoria | PRETORIA | South Africa | gvrooyen@icon.co.za |
| **VANDERPLANK Sula**<br>University of California | CLAREMONT | United States | sula.vanderplank@gmail.com |
| **VENANZONI Roberto**<br>University of Perugia | PERUGIA | Italy | rvenanzo@unipg.it |

| | | | |
|---|---|---|---|
| **VILCHES DE LA SERNA Beatriz**<br>Complutense University of Madrid | MADRID | Spain | bvilches@farm.ucm.es |
| **WAMELINK Wieger**<br>Alterra | WAGENINGEN | Netherlands | wieger.wamelink@wur.nl |
| **WARDELL-JOHNSON Grant**<br>Curtin University | PERTH | Australia | g.wardell-johnson@curtin.edu.au |
| **WELLSTEIN Camilla**<br>University of Bayreuth | BAYREUTH | Germany | camilla.wellstein@uni-bayreuth.de |
| **WHITE Jacqueline**<br>University of North Carolina | CARRBORO | United States | jackie.white@unc.edu |
| **WHITE Shannon**<br>University of Alberta | EDMONTON | Canada | shannonrwhite@gmail.com |
| **WILDI Otto**<br>Swiss Federal Institute | BIRMENSDORF | Switzerland | otto.wildi@wsl.ch |
| **WILSON Bastow**<br>University of Otago | DUNEDIN | New Zealand | bastow@bastow.ac.nz |
| **WISER Susan**<br>Landcare research | LINCOLN | New Zealand | wisers@landcareresearch.co.nz |
| **WONG Megan**<br>Monash University | VIC | Australia | megan.wong@monash.edu |
| **WONG Nathan**<br>Trust for Nature | WELSHMANS REEF | Australia | nathanw@tfn.org.au |
| **YANG Hyo-sik**<br>Mokpo National University | MUAN-GUN JEONNAM | | South Korea pinus77@gmail.com |
| **YOSHIKAWA Masato**<br>Tokyo University of Agriculture and Technology | TOKYO | Japan | masato@cc.tuat.ac.jp |
| **YOUSFI Haifa**<br>National Gene Bank-INAT | ARIANA-TUNIS | Tunisia | haifayousfi@yahoo.fr |
| **YU Fei-hai**<br>Beijing Forestry University | BEIJING | China | feihaiyu@bjfu.edu.cn |
| **ZANINI Kátia**<br>Universidade Federal do Rio Grande do Sul | PORTO ALEGRE | Brazil | Katyjz2009@gmail.com |
| **ZEGRAR Ahmed**<br>Centre of Spaces techniques | ARZEW | Algeria | z_ahmed65@yahoo.fr |
| **ZELENY David**<br>Masaryk University | BRNO | Czech Republic | zeleny.david@gmail.com |
| **ZHANG Yunchun**<br>Estonia University of Life Science | TARTU | Estonia | yunchunzhang@163.com |
| **ZHAO Mengli**<br>Inner Mongolia Agricultural University | HOHHOT | China | menglizhao@yahoo.com |
| **ZOBEL Martin**<br>University of Tartu | TARTU | Estonia | martin.zobel@ut.ee |
| **_UMBEROVA Katerina**<br>Academy of Sciences of the Czech Republic | BRNO | Czech Republic | katerina.sumberova@ibot.cas.cz |

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