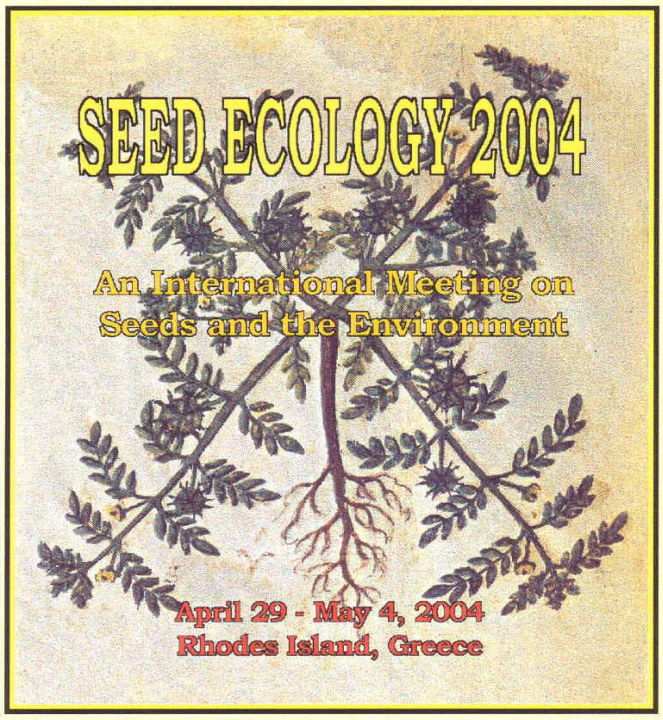
ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
NATIONAL & KAPODISTRIAN UNIVERSITY OF ATHENS



PROGRAMME & BOOK OF ABSTRACTS

An International Meeting on Seeds and the Environment

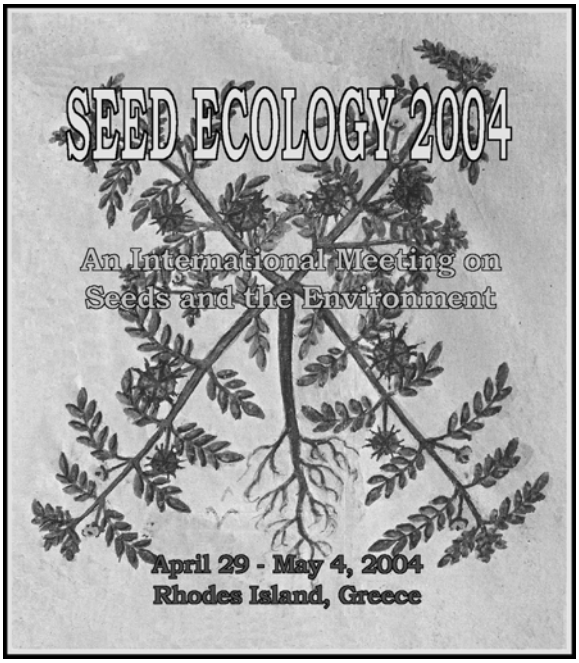
SEED ECOLOGY 2004

Rhodes, Greece, April 29 May 4, 2004

Sponsored by the University of Athens, MAICh, BES & ISSS

MAICh. British Ecological Society ISSS

Athens, April 2004



PROGRAMME
&
BOOK OF ABSTRACTS

Sponsored by the University of Athens, MAICh, BES & ISSS

Athens, April 2004

Welcome to Rhodes,
Welcome to SEED ECOLOGY 2004

Dear colleagues and friends,

SEED ECOLOGY 2004 is the first thematic, scientific conference devoted exclusively to ***Seeds and the Environment***. Seed ecology (dispersal, predation, soil and canopy seed banks, ecophysiology of dormancy and germination, seed research issues related to evolution, conservation and ecosystem functioning) is currently an extremely active area of ecology. It has profound implications for the composition and diversity of plant communities and, through seed dispersal and predation, has a remarkable capacity to promote collaboration between botanists and zoologists. Nevertheless, its practitioners are scattered throughout the world and rarely, if ever, have an opportunity to meet as a single research community.

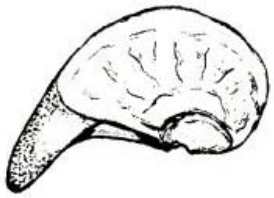
SEED ECOLOGY 2004 is also intended to make an international meeting of particular value to students and younger scientists, who would perhaps not otherwise have the opportunity to meet many of the leading researchers in the field. In addition, we think that such an opportunity would foster cooperation between scientists from different countries and lead to closer integration between researchers working on specific aspects of seed ecology, in particular seed ecophysiological studies and those focused on reproductive ecology and seedling recruitment.

Leading researchers are invited to review the latest progress and the most exciting challenges in their special fields. Thanks to your numerous contributions, the scientific programme covers in a balanced way all aspects of seed ecology and it is hoped to showcase the latest and most exciting developments in our discipline. The response to this meeting has been indeed enthusiastic: 60 lectures, 100 poster contributions and 180 participants from 33 countries. We feel, and we hope you agree, that this interest certainly merits further seed ecology meetings!

We express our sincere gratitude to the sponsors of SEED ECOLOGY 2004: the University of Athens (and especially Prof. Michalis Dermitzakis, Vice Rector), the Mediterranean Agronomic Institute at Chania (Mr Alkinoos Nikolaidis, Director), the British Ecological Society (BES) for the student scholarships and the International Society for Seed Science (ISSS). We also thank the Printing Department of the University of Athens, the Directorate of Tourism (Region of Southern Aegean), the Archaeological Ephorates of Rhodes, the Lyceum Club of Greek Women (Branch of Rhodes) and our hosts, Rodos Palace Hotel (especially Mr V. Pappas). Finally, we thank all the colleagues of the International Organising Committee for their help in shaping SEED ECOLOGY 2004 as well as all our Greek collaborators.

We wish you a very pleasant stay in Rhodes and a most fruitful (and 'seedful') meeting!

Costas A. Thanos – Ken Thompson
April 2004



SEED ECOLOGY 2004

Rhodes, Greece, April 29 - May 4, 2004

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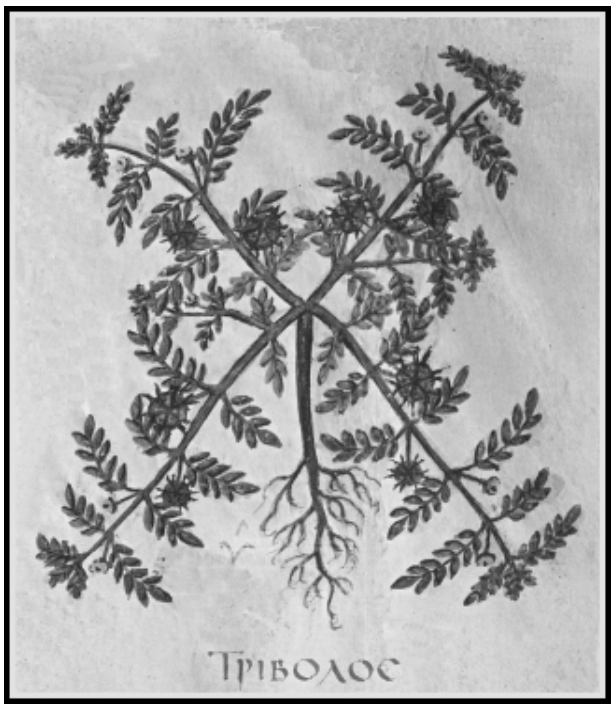


The plant shown in the logo background is ***Tribulus terrestris* L.** (Zygophyllaceae), a quite well known, pubescent, procumbent annual, 10-60 cm tall, typically growing in dry open habitats (including dry deserts).

A **cosmopolitan** plant, initially a native of Middle East and the Mediterranean rim, *Tribulus terrestris* is currently naturalised on all continents, in areas with warm temperate conditions (a summer annual). Its large geographical distribution is most probably due to **epizoochory**. The fruit is composed of 5 stellately arranged, hard schizocarps, each of which bears 2 or more (usually 4) stout spines on the sides. The spines of the 'woody burr' are so sharp and rigid that are strong enough to puncture bicycle tires, penetrate shoe soles and injure feet of humans and stock. Usually considered a noxious **weed**, *Tribulus terrestris* (puncturevine, caltrop) can grow on almost any type of soil and is found in pastures, roadsides, orchards, vineyards, waste places, parks, railway yards and agricultural areas.

The word *Tribulus* comes from the ancient Greek ΤΡΙΒΟΛΟΣ (trivolos), meaning 3-pointed and probably referring to the spined-schizocarp (which is usually 4-spined!). Its vernacular name in modern Greek is still 'trivoli'. The specific name *terrestris* is obviously due to the fact that the name 'trivolos' was applied to 2 different kinds of plants (as described by Theophrastus), the latter one being the aquatic species *Trapa natans* (Theophrastus *HP* 4.9.1.-3.). Moreover, Dioscorides, when describing the kinds of 'trivolos' names the former 'terrestrial'.

The plant is given considerable attention by Theophrastus. Its exceptional characteristic of bearing spines on the pericarp is mentioned twice (*HP* 6.1.3., 6.5.3.); further descriptions refer to the prostrate habit, the chick-pea-looking leaves and the sesame-like seeds (*HP* 6.5.3.). Finally, a striking citation concerns **soil seed banks**: 'trivolos' is reported to emerge when a partly saturated soil is stirred. (*HP* 3.1.6.: *'And in some places, if the ground is merely lightly worked and stirred, the plants native to the district immediately spring up; for instance the cypress in Crete. And something similar to this occurs even in smaller plants; as soon as the earth is stirred, wherever it may be, a sort of vegetation comes up. And in partly saturated soil, if you break up the ground, they say that 'trivolos' appears.'*)

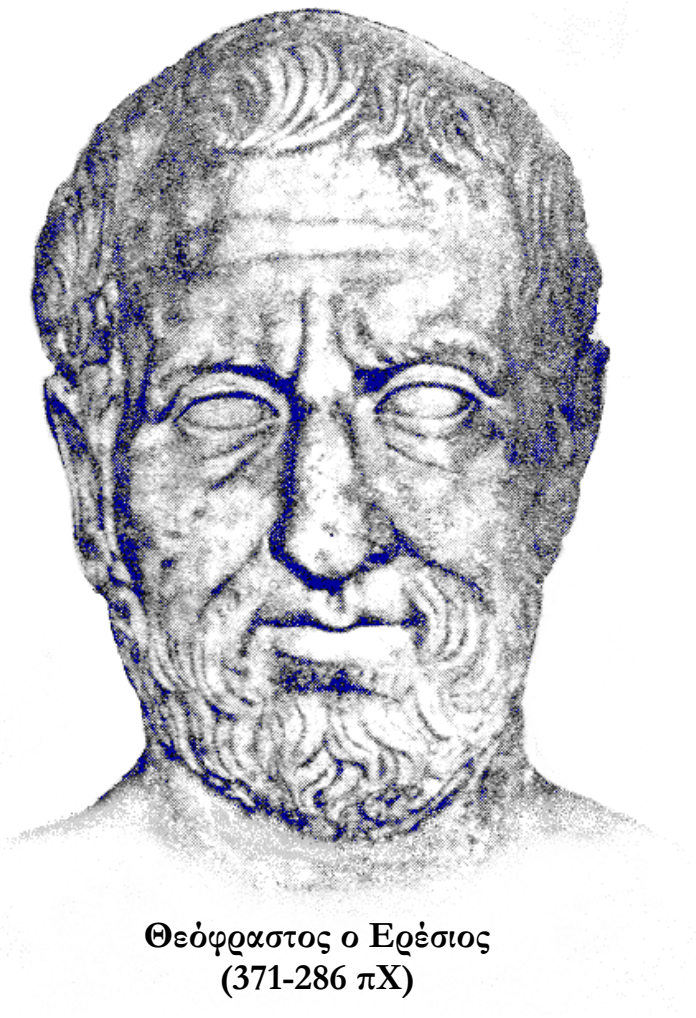
The plant is illustrated quite precisely (*) by an unknown Byzantine artist in the first-ever collection of botanical drawings (512 AD), which complemented the treatise of Dioscorides *ΠΕΡΙ ΥΛΗΣ ΙΑΤΡΙΚΗΣ* (*De Materia Medica*; 1st c. AD). (*) Fruits are consistently illustrated (there are 8 fruits in the drawing) as 6-merous while they are indeed 5-merous.

'Trivolos' is also found in Ancient Greek texts preceding Theophrastus (eg Alcaeus' poems, 6th c. BC; Aristophanes' *Lysistrata*, 412 BC) as well as in the Bible (Genesis 3.17, 3.18; Hosea 10.8; Matthew's Gospel 7.16-17 – '*are grapes gathered from thorns or figs from trivolos?*'; Paul's Epistle to the Hebrews 6.8).

Each schizocarp (dispersal unit) contains several, non-endospermic seeds which are known to be **dormant** (germination is manifested at relatively high temperatures and some, at least, afterripening is required; Ernst W.H.O., Tolsma D.J. 1988. Dormancy and germination of semi-arid annual plant species *Tragus berteronianus* and *Tribulus terrestris*. Flora 181, 243-251). Seeds germinate in late spring and early summer under suitably moist conditions but further research is needed for full elucidation of its **germination ecophysiology**.

(Costas A. Thanos, April 2003)

PROGRAMME



Θεόφραστος ο Ερέσιος
(371-286 πΧ)

Theophrastus of Eressus
(371-286 BC)

Theophrastus is the father of Botany
Carl von Linnaeus (1707-1778)

Theophrastus was the first seed physiologist and seed ecologist
Michael Evenari (1980/81)

THURSDAY, APRIL 29, 2004

17:00-19:00
REGISTRATION

19:00-20:00
WELCOME RECEPTION

FRIDAY, APRIL 30, 2004

8:30-9:00
OPENING SESSION

9:00-11:00

Session 1
Chairs: *Begoña Peco, Madrid-Spain*
Yitzchak Gutterman, Sede Boqer-Israel

9:00-9:40 INVITED LECTURE
The Ecology of Soil Seed Banks: from the Applicable Present to a Fruitful Future
Renée M. Bekker (The Netherlands)

9:40-10:00
Seed Banks in Mediterranean Gypsum Environments: Spatial and Temporal Patterns
J.M. Olano, I. Caballero, J. Loidi & A. Escudero (Spain)

10:00-10:20
Soil Seed Banks of Temperate Deciduous Forest
M. Jankowska-Błaszczuk (Poland)

10:20-10:40
The Response of Soil Diaspore Bank to the Long-term Experimental Treatments in Upland Vegetation in the UK
J. Ghorbani, M.G. Le Duc, H.A. McAllister, R.J. Pakeman & R.H. Marrs (UK)

10:40-11:00
Seed Bank Assembly Follows Vegetation Succession in Dune Slacks
Beatrijs Bossuyt (Belgium)

11:00-11:30
COFFEE BREAK

11:30-13:30

Session 2
Chairs: *Kingsley Dixon, Perth-Australia*
Chedly Abdelly, Hammam Lif-Tunisia

11:30-11:50
Prey Selection by Harvester Ants (*Messor barbarus*) and Seed Attributes in Mediterranean Grasslands
F.M. Azcárate & B. Peco (Spain)

11:50-12:10
Seed Predation in Mediterranean-type Agroecosystems
R.S. Gallagher, C. Borger, D. Minkey & H. Spafford-Jacob (USA)

12:10-12:30
Relationship between Vegetative Traits and Seed Production in Species from Mediterranean Old-field Succession
Denis Vile, Sophie Metge, Eric Garnier & Bill Shipley (France)

12:30-12:50
Why Reproductive Efficiency in Junipers is so Low? Facts and Hypothesis
J. Barbour, S. Mugnaini, M. Nepi, E. Pacini & B. Piotto (Italy)

12:50-13:10
Seed Crop Investigations of *Pinus sylvestris, Pinus nigra* subsp. *pallasiana* and *Pinus brutia* in Turkey – a Review
Melih Boydak, Adil Çalışkan & Mehmet Çalıkoğlu (Turkey)

13:10-13:30
Genetics of Stored Winged Seeds at the Population and Metapopulation Levels
L.G. Barrett, Tianhua He, Byron B. Lamont, S.L. Krauss, B.P. Miller & N.J. Enright (Australia)

13:30-15:00
LUNCH

15:00-17:00

Session 3 – COMMON SESSION MEDECOS X / SEED ECOLOGY 2004
Chairs: *Phil Rundel (Los Angeles-USA)*
Ken Thompson (Sheffield-UK)

15:00-15:40 INVITED LECTURE (SEED ECOLOGY 2004)
Seed Ecology: its Biogeographical and Ecological Relevance
William Bond (South Africa)

15:40-16:00 (MEDECOS X)

Bradychory - the Coining of a New Term
Costas A. Thanos (Greece)

16:00-16:20 (MEDECOS X)

Short- and Long-distance Seed Dispersal in a Metapopulation of *Banksia hookeriana* (Proteaceae)
Krauss S., T. He T., Lamont B., Miller B., Barrett L. & Enright Neal (Australia)

16:20-16:40 (MEDECOS X)

Soil Seedbanks in three Contrasting High Diversity Habitats in the Northern Sandplain Shrublands of SW Australia
Enright N., Johnson N., Lamont B. & Miller B. (Australia)

16:40-17:00 (MEDECOS X)

Similarity between Seed-Bank and Ensuing Vegetation is Productivity Dependent in a Semi-arid Mediterranean Annual Plant Community
Kigel J., Osem Y. & Perevolotsky A. (Israel)

17:00-17:40
COFFEE BREAK

17:40-19:00

Session 4
Chairs: *Jose Miguel Olano, Valladolid-Spain*
Claudio Barbedo, Sao Paulo-Brasil

17:40-18:00

Seed Mortality in Neotropical Soil-seed Banks: Patterns and Pathogens
R.E. Gallery & J.W. Dalling (USA)

18:00-18:20

Relationship between the Vegetation and Soil Seed Bank along a Community State Sequence
E.R. Chang, M. Wolters & J.P. Bakker (The Netherlands)

18:20-18:40

Spatial Distribution of Seeds in the Soils of a Mosaic Agricultural Landscape
R. Waldhardt & A. Otte (Germany)

18:40-19:00

Study of the Soil Seed Bank at Ecosystem Restoration Sites
Jun Nishihiro & Izumi Washitani (Japan)

SATURDAY, MAY 1, 2004

9:00-11:00

Session 5
Chairs: *Diana Tomback, Denver Co.-USA*
Juan Malo, Madrid-Spain

9:00-9:40 INVITED LECTURE
Long Distance Dispersal - in Pursuit of the Unknowable?
James Bullock (UK)

9:40-10:00
Estimating the Distance, Direction and Quantity of Seed Dispersal by Animals
A.M. Mouissie, R. van Diggelen & J.P. Bakker (The Netherlands)

10:00-10:20
Deer and Lagomorphs as Dispersers of Seeds in a Forest Mosaic
Amy E. Eycott, A.R. Watkinson & P.M. Dolman (UK)

10:20-10:40
Endozoochorous Seed Dispersal by the Arctic Fox
H.H. Bruun & B.J. Graae (Sweden)

10:40-11:00
Post-Dispersal Seed Removal of Hazel (*Corylus avellana* L.) in Grassland
F.J. Laborde & Ken Thompson (UK)

11:00-11:30
COFFEE BREAK

11:30-13:30

Session 6
Chairs: *Ettore Pacini, Siena-Italy*
Alois Honek, Prague-Czech Republic

11:30-11:50
Life on the Edge for Limber Pine: Seed Dispersal within a Peripheral Population
D.F. Tomback, A.W. Schoettle, K.E. Chevalier & C.A. Jones (USA)

11:50-12:10
Endozoochorous Dispersal of Inconspicuous Seeds: Cost or Benefit?
Eric Cosyns & Maurice Hoffmann (Belgium)

12:10-12:30

What does Seed Morphology Tell us about Epizoochory?
C. Römermann, O. Tackenberg & P. Poschlod (Germany)

12:30-12:50

Long-distance Epizoochorous Dispersal by Transhumant Sheep
P. Manzano & J.E. Malo (Spain)

12:50-13:10

Long-distance Seed Dispersal Pattern Generated by *Cebus* Monkeys in Iguazú, Argentina: Consequences for *Miconia* Seeds
E.W. Wehncke & C.A. Domínguez (Mexico)

13:10-13:30

Host-specific Pathogen Attack and Spatial Patterns of Mortality and Growth of Seedlings and Saplings in a Temperate Tree, *Prunus grayana*
K. Seiwa, Y. Miwa & N. Sahashi (Japan)

13:30-15:00
LUNCH

15:00-17:00

Session 7
Chairs: *Byron Lamont, Perth-Australia*
Kenji Seiwa, Miyagi-Japan

15:00-15:20

Predictability of Plant Species Composition from Environmental Conditions – The Influence of Dispersal Traits
W.A. Ozinga (The Netherlands)

15:20-15:40

Seed Migration and Colonization in Experimental Populations of an Annual Myrmecochore
T. Heinken (Germany)

15:40-16:00

Wind Dispersal of Alpine Plants: A Comparison with Lowland Conditions
Jürg Stöcklin & Oliver Tackenberg (Switzerland)

16:00-16:20

A Quantitative Look at the Role of Wind and Relative Humidity in Seed Abscission
C. Calogeropoulos, D.F. Green, M. Quesada & S. Dayanandan (Canada)

16:20-16:40

Post-Dispersal Seed Predation Modulates Recruitment Potential among Bird-Dispersed Trees in Cantabrian Forest
Daniel García, J. Ramón Obeso & Isabel Martínez (Spain)

16:40-17:20
COFFEE BREAK

17:20-19:00

Session 8
POSTER VIEWING A

SUNDAY, MAY 2, 2004

DAILY EXCURSION – A COACH TOUR OF THE ISLAND OF RHODES

MONDAY, MAY 3, 2004

9:00-11:00

Session 9
Chairs: *Daniel Côme, Paris-France*
Kyriacos Georghiou, Athens-Greece

9:00-9:40 INVITED LECTURE
Biogeography and Phylogeny of Seed Dormancy
Carol Baskin & Jerry Baskin (USA)

9:40-10:00
Environmental Control of Germination of *Orobanche ramosa* L. Seeds
S. Gibot-Leclerc, F. Corbineau, G. Sallé & D. Côme (France)

10:00-10:20
Inhibition of Dormancy Release by Light in Hydrated Annual Ryegrass Seeds
Kathryn J. Steadman & Robert S. Gallagher (USA)

10:20-10:40
Germination Ecology of Autumnal Mediterranean Geophytes
Isabel Marques, David Draper & M.A. Martins-Loução (Portugal)

10:40-11:00
Adaptations of Germination in Mediterranean Plants – Ancient Mechanisms and Modern Challenges
Costas A. Thanos & Christina Fournaraki (Greece)

11:00-11:25
COFFEE BREAK

11:25-11:30
GROUP PHOTO

11:30-13:30

Session 10
Chairs: *Paul Cavers, London, Ont.-Canada*
Josef Van Assche, Leuven-Belgium

11:30-11:50
Regeneration Strategies along Climate Gradients: an Experimental Test on four *Veronica* Species
V. Vandvik & I. Heuch (Norway)

11:50-12:10
Seed Germination and Dormancy in Response to Multiple Environments
C.J. Fotheringham, Jon E. Keeley & Phil W. Rundel (USA)

12:10-12:30
Changes in Sensitivity to Fire-related Cues during Burial of an Australian Fire Ephemeral, *Actinotus leucocephalus* (Apiaceae)
K.S. Baker, K.J. Steadman, J.A. Plummer, D.J. Merritt & K.W. Dixon (Australia)

12:30-12:50
Evolution of Smoke-Stimulated Germination
Jon E. Keeley & C.J. Fotheringham (USA)

12:50-13:10
Smoke-stimulated Seed Germination – Potential for Seed Technology
J. van Staden & M.E. Light (South Africa)

13:10-13:30
The Germination Active Principle in Smoke
G. Flematti, K.W. Dixon, E. Ghisalberti & R. Trengove (Australia)

13:30-15:00
LUNCH

15:00-17:00

Session 11
Chairs: *Johannes van Staden, Pietermaritzburg-South Africa*
Alma Orozco-Segovia, Mexico DF-Mexico

15:00-15:20
Validation of Ecological Models by *in situ* Germination Experiments
David Draper, Isabel Marques & J.M. Iriondo (Portugal)

15:20-15:40

Litter Effects on Seedling Emergence from Multi-species Artificial Seed Banks

P.B. Cavers, H. Wray, C.J. Somerville & M. Bertrand (Canada)

15:40-16:00

Environmental Maternal Effects on Seed Morphology and Germination Features in *Sinapis arvensis* under Controlled Field Conditions

A.L. Luzuriaga, Adrián Escudero & Félix Pérez-García (Spain)

16:00-16:20

Genotypic and Phenotypic Differences in Primary Germination Dormancy and Seedling Drought Tolerance among Local Genotypes, and the Upper and Lower Caryopses in the Dispersal Units of *Triticum dicoccoides* in Israel

Y. Gutterman & I. Bar-Av (Israel)

16:20-16:40

Fruit Position and Fruit-set Order Affect Seed Production and Germinability in Muskmelon

H. Nerson (Israel)

16:40-17:20
COFFEE BREAK

17:20-19:00

Session 12
POSTER VIEWING B

20:30-24:00
GALA DINNER

TUESDAY, MAY 4, 2004

9:00-11:00

Session 13
Chairs: *Martin Zobel, Tartu-Estonia*
Lars Andersson, Uppsala-Sweden

9:00-9:40 INVITED LECTURE

The Seed Size Synthesis: a Review of the Ecological Correlates of Seed Size

Angela Moles (Australia)

9:40-10:00

Positive Relationship between Seed Size and Pollen-ovule Ratio
L. Götzenberger, I. Kühn, W. Durka & S. Klotz (Germany)

10:00-10:20

Seed Set and Seed Mass of Five Forbs in Anthropogenically Fragmented Landscapes
Markus Fischer (Germany)

10:20-10:40

Ecological Correlates of Seed Desiccation Tolerance in Tropical African Dryland Trees
M.I. Daws, H.W. Pritchard, B.J. Fletcher, C.S. Gaméné, H.P. Msanga & W. Omondi (UK)

10:40-11:00

Seed Dispersal, Germination and Seedling Establishment in Arctic Vegetation
B.J. Graae, B. Strandberg, G. Bastholm & E.A. Fischer (Denmark)

11:00-11:30
COFFEE BREAK

11:30-13:30

Session 14
Chairs: *Rainer Waldhardt, Giessen-Germany*
Melih Boydak, Istanbul-Turkey

11:30-12:10 INVITED LECTURE

Seeding the Woods from the Trees: New Views on Seed Source and Dispersal Limitation in Tropical Forests
Jim Dalling (USA)

12:10-12:30

Seed Limitation, Disturbances and 'Window of Opportunity' – from Cases to General Pattern
M. Zobel, M. Moora & M. Otsus (Estonia)

12:30-12:50

Post-Dispersal Seed Predation in New Zealand: Consequences of Mammalian Introduction
Christopher Berry, Richard Duncan & Glenn Stewart (New Zealand)

12:50-13:10

Seed Predation in *Taraxacum officinale*
A. Honek & Z. Martinkova (Czech Republic)

13:10-13:30

Dispersal and Local Conditions Limit Plants to Acacia Canopies in the Kalahari
M. Kos & P. Poschlod (Germany)

13:30-15:00
LUNCH

15:00-16:20

Session 15
Chairs: *Matt Daws, Wakehurst Place-UK*
Ioannis Takos, Drama-Greece

15:00-15:20
Seed and Seedling Ecology of Three Rare Endemics from Western Australia: Important Factors in the Management of Threatened Species
S. Barrett & J.A. Cochrane (Australia)

15:20-15:40
Applied Seed Ecology for Bauxite Mining Restoration in Western Australia
Carl Grant, John Koch, Ian Colquhoun & Greg Mullins (Australia)

15:40-16:00
The Role of Regeneration by Seed in Semi-Natural Meadows
A. Stampfli & M. Zeiter (Switzerland)

16:00-16:20
Temporal and Spatial Distribution of Annual Weeds in California Vegetable Fields
Shachar Shem-Tov & Steven A. Fennimore (USA)

16:20-16:40
Climate does not Constrain Seed Production by *Brachypodium pinnatum* at its Northern Limit in the UK
Ken Thompson & Tim Yardley (UK)

16:40-17:20
CLOSING SESSION

17:20-18:00
COFFEE & GOODBYE

Session 8

Poster Viewing A
odd-numbered posters (1-95)

1 **The Role of the Soil Seed Bank in Maintaining Vegetation in a Semi-Natural *Phragmites australis* Community in Japan**
M. Ajima & S. Tsuda (Japan)

3 **Desiccation Tolerance and Storage Behaviour in *Cordeauxia edulis***
Lars Andersson, Josefine Liew & Asha Yahya (Sweden)

5 **Stem Diameter in Relation to Dispersal Behaviour and Properties of Garjan (*Dipterocarpus* spp.) Seed**
S.R. Biswas & K. Misbahuzzaman (Bangladesh)

7 **Loss of Genetic Diversity as Effect of Seed Disperser Behaviour**
S.P. Bravo (Argentina)

9 **Shrub Facilitation on Annual Communities: Effects on Seed Bank**
Caballero I., Olano J.M., Pardo I., Ezeiza G., Loidi J. & Escudero A. (Spain)

11 **Effect of Temperature and Photoperiod on the Germination of *Cleonia lusitanica* L.**
Carreño S., Conesa E., Vicente M.J., Bañón S. & Martínez-Sánchez J. (Spain)

13 **Vegetation Restoration of a *Quercus ilex* L. subsp. *ballota* (Desf.) Samp. Stand Commununity of Navarra (Spain): Seed Blends with Autochthonous Species**
Cavero R.Y., Alberdi L. & Zugasti B. (Spain)

15 **Evaluation of two Commercial Repellents as Seed Coating Materials for Deterring Seed Predation**
H.L. Chick (Hong Kong/China)

17 **Effects of Soil Nutrients and Fire on Seedling Establishment of Native Prairie Species**
Clark D.L., Wilson M.V. & Nelson M.A. (USA)

19 **Seed Consumption by Small Native Ground-foraging Mammals at Two Peoples Bay Nature Reserve, Western Australia**
J.A. Cochrane, J.A. Friend & S. Hill (Australia)

21 **Complementarity of Epi- and Endozoochory by Free-ranging Donkeys**
M. Couvreur, E. Cosyns, M. Hermy & M. Hoffmann (Belgium)

93 **Effects of Seed Origin and Habitat Quality on Recruitment of *Bromus erectus***
M. Zeiter & A. Stampfli (Switzerland)

95 **Vegetation Restoration of a *Quercus ilex* L. subsp. *ballota* (Desf.) Samp. Stand Commununity of Navarra (Spain): Germination and Seedling Establishment of Autochthonous Species**
Zugasti B. & Cavero R.Y. (Spain)

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2 **The Prospects for Smoke and other Fire-Simulation Treatments for the Germination Testing of Seed Conservation Collections**
Natasha S. Ali & Robin J. Probert (UK)

4 **Microhabitat-dependent Germination Dynamics of *Ilex aquifolium* L.**
S. Arrieta, F. Suárez & J.E. Malo (Spain)

6 **Effect of Priming on the Germination in *Crithmum maritimum***
Abdallah Attia, Karim Ben Hamed & Chedly Abdelly (Tunisia)

8 **The Role of Temperature in the Regulation of Dormancy and Germination of two Related Annual Mudflat Species**
M. Brändel, W. Schütz & K. Jensen (Germany)

10 **Variation in Cone Morphology and Seed Mass in Scots Pine Trees from a Mediterranean Population**
J. Castro (Spain)

12 **Germination Ecology of the Threatened Winter Annual *Sisymbrium cavanillesianum* and Other Associated Species**
M.A. Copete, J.M. Herranz & P. Ferrandis (Spain)

14 **The Millennium Seed Bank Project in Western Australia – Ensuring the Long Term Survival of "at risk" Species**
A. Crawford, A. Cochrane & L. Sweedman (Australia)

16 **Fire in the Mediterranean Basin Ecosystem: Effect of Smoke on Seed Germination**
R. Crosti, K.W. Dixon, P.G. Ladd & B. Piotto (Australia-Italy)

18 **Climatic Ecotypes of Seed Germination in *Pinus brutia* along a North-south Transect in Greece – Preliminary Results**

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ABSTRACTS

The Role of the Soil Seed Bank in Maintaining Vegetation in a Semi-Natural *Phragmites australis* Community in Japan

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To clarify the role of the seed bank in maintaining semi-natural vegetation characterized by high species diversity, we surveyed the soil seed bank, seed rain, emerged and established seedlings, and above-ground vegetation in two reed communities: one maintained by artificial winter burning and the other by mowing. In both communities, the seed bank included most of the species of vegetation. Populations of perennial graminoids that predominated in the vegetation, such as *Phragmites australis* and *Carex thunbergii*, were maintained by vegetative sprouts regardless of whether they had preserved seeds in the soil. By contrast, annuals and most perennial forbs, which were minor species in the coverage but major in the number of species, formed seed banks and established seedlings in disturbed areas. This suggests that regeneration from seeds is important for maintaining these populations, and opening an area by burning or mowing promotes seed germination and seedling establishment. Consequently, periodic disturbances should contribute to the maintenance of populations of minor species, and lead to high vegetation diversity.

The Prospects for Smoke and other Fire-Simulation Treatments for the Germination Testing of Seed Conservation Collections

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Seed germination in numerous species has been shown to be stimulated by smoke and its role in the natural regeneration process of plants from fire-prone habitats is unquestioned. However, despite the fact that smoke, applied as an aerosol or as an aqueous solution, is now widely used in habitat restoration projects for stimulating the germination of buried seeds, neither smoke on its own or in combination with other fire-related treatments are widely used in routine seed germination testing in seed banks. Thus a variety of smoke products applied factorially with surgical treatment, potassium nitrate, dry after-ripening and dry heat were tested on seed conservation collections with known dormancy problems. Forty-three species from 24 families were tested. Only five collections responded positively to smoke treatment alone, and a further 15 responded to smoke when additional dormancy breaking factors were also present. Twenty-one collections did not respond to smoke and in four collections germination was reduced by smoke. The study has shown that smoke treatment could be used as a germination cue in routine viability tests for some species especially when combined with other dormancy breaking factors.

Desiccation Tolerance and Storage Behaviour in *Cordeauxia edulis*

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Cordeauxia edulis (Hemsley), yeheb, is an endangered multi-purpose shrub, native to semi-desert areas in Somalia and Ethiopia. The seeds are known to remain viable during only a short period and sensitive to dehydration. Desiccation tolerance was studied in seeds collected in May 2003 by drying seeds in silica gel down to six specified target moisture contents. Viability was assessed with a germination test in moist sand at 25/15 °C. Results revealed that viability decreased from >70% at moisture contents of 24-39%, to 58% at 12% mc. After further drying to 9.5% mc, 41% of the seeds remained viable. In a second experiment, storage behaviour of *C. edulis* seeds at two moisture contents (9 and 27%) was tested at two temperatures (5 and 22 °C) for five months. Seeds were dried and stored at constant air humidity over sulphuric acid in airtight glass containers (2 L). The subsequent germination test showed that 2.5-9% of the seeds were viable. The results of the two experiments indicate that seeds of *C. edulis* are intermediate. Seeds are capable of withstanding dehydration down to 9% mc, but viability decreases with mc below 20%. Also, some seeds remain viable after a period of five months, which is equal to the time normally elapsing between two rainy seasons. However, to better characterise desiccation tolerance and storage behaviour further studies are needed. Hopefully, this will enable storage of seeds for sowing.

Microhabitat-dependent Germination Dynamics of *Ilex aquifolium* L.

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A three-year field sowing experiment was performed to analyse the germination dynamics of holly (*Ilex aquifolium* L.) in a holly open woodland and a pine forest, both located in a submediterranean region of central Spain. Ten triads of mesh bags (n=30 seeds per bag) were randomly buried at 4-5 cm depth in four different microhabitats of the holly woodland (inside of the holly wood, the woodland edge, the open grassland and under isolated shrubs) as well as in the pine forest. Bags were harvested annually and seeds analysed to report seed viability (tetrazolium test), embryo developmental changes and germination. Holly didn't germinate until the second year. Embryo development and seed germination was faster at the forest edge, with an estimated germination rate of 63.3%. Germination estimates inside the holly woodland (48.3%), under the shrubs (45.7%) and at the grassland (45.8%) were very similar. Under the pine forest germination was slower (29.1%). In the five microhabitats germination was higher in the second cohort (third spring). After the third year, seed bank in the holly woodland microhabitats is reduced by 80-90%. Thus, holly can be considered to develop a short-persistent seed bank. This work contributes to a deeper knowledge of *Ilex aquifolium* seed ecology, with special regard to the spatial variability of the germination process.

Effect of Priming on the Germination in *Crithmum maritimum*

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Crithmum maritimum or sea fennel (Apiaceae) is a spontaneous halophyte growing in Mediterranean rocky sea-cliffs. Oil extracted from C. *maritimum* seeds shows to possess nutritional proprieties. In the field, seeds of *C. maritimum* mature and fall in late autumn. The majority remains dormant until the next spring before germination occurs. This work emphasises (1) the germination pattern depending on O_2 availability and salinity, and (2) the effect of the priming using NaCl or an iso-osmotic solution of PEG 6000 on the germination in saline conditions. Whether in standard conditions (using Petri dishes) or under hypoxia, germination was not significantly affected up to 50 mM NaCl but was strongly inhibited at 150-200 mM NaCl. NaCl-pretreated seeds germinated faster than non-primed ones, while priming with PEG delayed seed germination. Germination of primed seeds was significantly reduced at 100 mM NaCl, but recovery germination in distilled water showed high percentages. These results are important to understand the ecology of his halophyte, which seems able to display adaptation strategies in its biotope characterised by frequent fluctuating levels of salinity and hydromorphy.

Prey Selection by Harvester Ants (*Messor barbarus*) and Seed Attributes in Mediterranean Grasslands

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Prey selection by harvester ants (*Messor barbarus*) in central Iberian Mediterranean grasslands was analysed, along with the effect of predation on the seed bank and vegetation. For the seed selection analysis, we sampled diet and prey availability in the environment in order to estimate selection indices for the main species. Diet was sampled by collecting prey being carried to the nest by workers, while prey availability was measured by collecting soil samples in the patches where foraging took place. For the study of the effects on the seed bank and the vegetation, we set up 5 ant exclusion plots with a 1.5 m diameter. In these and the 10 equivalent control plots, we surveyed the autumn seed bank prior to installing the enclosure. We also estimated species cover in the springs before and after enclosure. All of the species found were typified on the basis of their seed weight and dimensions. The data were examined using phylogenetically independent analysis, in which the selection indices and the exclusion effect were related to the seed features. The results show that the seeds selected by *Messor barbarus* are heavily dependent on their length. After a year of exclusion we found a differential increase of this type of seeds in the seed banks. However, no effect on the floristic composition of the spring vegetation was detected.

Changes in Sensitivity to Fire-related Cues during Burial of an Australian Fire Ephemeral, *Actinotus leucocephalus* (Apiaceae)

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Fire is an integral component of the Australian landscape, and plant species have evolved a number of different life history strategies in response to this environment. Fire ephemerals are a group of short-lived species with fire-obligate germination. *Actinotus leucocephalus* (Apiaceae) is an annual herb growing in the Mediterranean climate of south-west Western Australia. Germination of fresh seeds was negligible when tested at a range of incubation temperatures. Low levels of germination were stimulated by nitrate, smoke water and a heat treatment (70 ºC for 1 h). The heat and smoke treatments in combination were additive. Seeds buried in autumn in burnt and unburnt soils exhibited dormancy cycling. Germination of exhumed seeds in smoke water was suppressed after winter burial but was high after subsequent summer burial. At this time seeds were also able to germinate in the absence of the smoke stimulant. Laboratory seed storage trials were undertaken to simulate shifts in dormancy, and it was found that temperature and wet/dry cycles play important regulatory roles. These findings will be discussed in the context of these seeds forming a persistent seed bank and having an obligate requirement for fire to germinate.

Why Reproductive Efficiency in Junipers is so Low? Facts and Hypothesis

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The reproductive efficiency of the *Juniperus* genus is generally low due to the large number of empty seeds present in seedlots and the seeds' inherent multiple dormancies. Forty-one years (1961-2002) of seed testing data compiled by the USDA Forest Service Nat. Tree Seed Lab. on five North American *Juniperus* species have shown that the average lab germination varied from 10 to 42% with the number of empties ranging from 2 to 58%. The mechanisms that determine reproductive efficiency is presently being explored with European *Juniperus* species in Italy. This study is part of a research project, supported by APAT, the Italian agency for environment protection, dealing with three *Juniperus s*pecies. The paper presents the results of the effect of different particles interfering with pollination mechanisms of Gymnosperms, with particular emphasis on the *Juniperus oxycedrus* subsp. *oxycedrus* pollination pattern. Results suggest that the pollination mechanism in this species is highly non-specific because the micropylar drop may take into the inner part of the ovule non-viable pollen as well as a number of inorganic particles. In fact there is a lack of specificity to recognize its own pollen and this represents a weak point in the pollination process, especially if plants are exposed to contaminates (particulates, powder, pollutants, etc). This vulnerability may be one explanation for the poor production of seeds.

Genetics of Stored Winged Seeds at the Population and Metapopulation Levels

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Many species in SW Australia store their seeds in their crown (serotiny). These seeds are released after fire where they are dispersed by wind to establishment sites. We genotyped an isolated population of *Banksia hookeriana* using the DNA-fingerprinting technique, AFLP. Even though seeds were stored for > 9 years, indices of genetic variation (heterozygosity, H_j, and diversity, I) reached a maximum after only a few years. H_j increased slightly with increasing seed age. H_j and I were as high within the seed bank of 4 plants as among the 112 adults in the population. There was more genetic variation between crop years than between all adults in the population. We conclude that timing of fire is not critical for conserving genetic diversity in this population. For 21 adjacent populations, there was more genetic variation within populations than between. A log-likelihood population allocation test (AFLPOP) assigned 77.4% of individuals to the population from which they were sampled and 6.8% of individuals to a population other than the one in which they occur at a distance of 1.6–2.5 km, much greater than expected from direct observations of seed dispersal.

Seed and Seedling Ecology of three Rare Endemics from Western Australia: Important Factors in the Management of Threatened Species

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Southern Western Australia is internationally recognised for its species richness and endemism. Past land clearing and fragmentation of remnant vegetation now threaten many narrow range endemics due to low numbers of total individuals. Many threatened flora populations are even aged and in decline due to senescence. While fire has been an integral part of these shrubland ecosystems, many of the smaller remnants remain long unburnt. However, the introduction of fire to these small remnants and threatened flora populations poses risks. The ability of these species to recruit sufficiently to replace and or augment the population post-fire is frequently unknown and seedling survival may be poor due to drought and or grazing. Too frequent fire may also limit stand replacement if seed banks have not been adequately replenished. An understanding of the reproductive ecology of these threatened species is essential for effective management. This paper investigates seed and seedling ecology of three threatened species in the family Proteaceae, *Grevillea maxwellii, Dryandra anatona* and *D. ionthocarpa* from southern Western Australia, including on-plant and soil seed reserves, seed bank longevity, seed germinability and factors promoting recruitment and limiting seedling survival.

Biogeography and Phylogeny of Seed Dormancy

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Seeds of 70% of >7,300 species representing all major vegetation zones on earth are dormant at maturity. Physiological dormancy (PD) is the most common class of dormancy in all zones, followed by physical dormancy (PY) and/or morpho-physiological dormancy (MPD). Morphological dormancy (MD) and combinational dormancy (PY+PD) are unimportant in all zones. An update of world biogeography of these five classes of seed dormancy will be presented, with particular reference to the tropical montane, heretofore underrepresented. Phylogenetically, in angiosperms (1) the underdeveloped embryo, thus MD or MPD, is basal, but it also occurs in advanced taxa including Dipsacales (euasterid II clade); (2) PY and (PY+PD) are the most restricted classes of dormancy, with 13 of 16 families in the rosid clade; (3) PD is uncommon or absent in basal angiosperms, uncommon in magnoliids, and widespread in monocots and eudicots; and in gymnosperms (4) MD/MPD occurs in basal taxa (cycads, *Ginkgo*), PD in Gnetales and Pinaceae, and PD and MD/MPD in non-Pinaceae conifers. MPD occurs throughout the Dipsacales except in the most advanced clade Valerina (Caprifoliaceae), in which embryos are fully developed and seeds have PD or no dormancy. The fossil record and class of dormancy in extant taxa of Dipsacales suggest that MPD was present in this order at the time of its origin in the early Tertiary.

The Ecology of Soil Seed Banks: From the Applicable Present to a Fruitful Future

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Since the publication of the literature compilation on soil seed bank longevity of Thompson *et al.* 1997, the amount of soil seed bank papers is still growing rapidly. Despite the increased effort in research on soil seed banks, the development of knowledge concerning the total number of plant species with identified seed longevity and especially that of rare and endangered plant species did not proceed parallel to this. Consequently, lacunae in knowledge still exist. Underexposed species, communities and ecosystems in Europe could be identified and the outcome will be discussed in the light of the ecology, conservation and re-establishment of the plant species concerned.
Challenges for future research on the ecology of soil seed banks will be highlighted and illustrated with the ongoing debate on mechanisms governing seed persistence in the soil. This involves, among other items, the non-relatedness of seed dormancy to seed persistence and the variable hypotheses concerning genetically, physiologically, morphologically and ecologically based correlates to seed persistence in the soil.

Post-Dispersal Seed Predation in New Zealand: Consequences of Mammalian Introduction

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New Zealand's unique ecosystems evolved in the absence of mammalian seed predators. However, over the last 1000 years, 35 species of mammal have become naturalised in New Zealand several of which are known seed predators. While much work has focussed on the impact of larger herbivores on New Zealand plant communities, it is only recently that researchers have begun to focus on the impact of smaller mammals (four species of rodent and brush tail possum) on seed and seedling recruitment. We conducted an experimental study examining the patterns of post-dispersal seed predation in a New Zealand podocarp-hardwood forest, with the aim of investigating how the behaviour of introduced mammalian seed predators compared to remnant native seed predators, and how those differences impacted on early plant recruitment. Overall, our results show that introduced mammalian seed predators behave very differently from native seed predators, and we discuss the consequences of these changes in the seed predator guild to New Zealand forests.

Stem Diameter in Relation to Dispersal Behaviour and Properties of Garjan (*Dipterocarpus* spp.) Seed

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In Bangladesh, the natural garjan (*Dipterocarpus* spp.) forest has been degraded due to various reasons and realized the importance of natural regeneration to rehabilitate the forest in mixture with plantation programs. For reliance on natural regeneration it is necessary to gather sufficient knowledge on seed properties of the tree and its dispersal behavior. The study was undertaken in a dipterocarp dominated natural forest reserve of Bangladesh during 1999-2000 to 2001-2002 by selecting 15 trees of seven different diameter classes. 16 traps (area of each trap was 1sq meter) were placed around each tree and the number of seeds fallen within each trap were counted and averaged. Seed length, diameter and weight were also measured for each diameter class. Trees of moderate diameter classes (30.10-40.00 cm dbh) bear seed with maximum weight (3.95 gm), length (2.90 cm) and seed diameter (1.87 cm). Almost 95.62% seed fall within 40 m from the parent tree and it was also appeared that within 25 m from the parents' tree 90.84% seed fall but thereafter seed falling increase with a decreasing rate. Models for forecasting percentage of seed that can be dispersed for various diameter classes to various distances have also been developed. Finally 20-25 m from the tree was considered as reliable for successful natural regeneration.

Seed Ecology: its Biogeographical and Ecological Relevance

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What can seed ecology tell us about the evolutionary history of biomes, especially the importance of different gap-creating disturbances? The timing of seedling recruitment can be very informative. Fire-dependent biomes are widespread in Africa and generally in the southern hemisphere. Fire-stimulated recruitment has been widely studied in fire-prone shrublands and is a useful indicator of an evolutionary history of fire in these systems. However, where fires are more frequent and plant biomass recovers rapidly, as in mesic tropical grasslands and savannas, fire-stimulated recruitment is rare or absent. Severe droughts, occurring at decadal intervals, are a little studied disturbance, comparable to shrubland fires in their predictable but infrequent occurrence. They too, can be followed by a flush of seedlings which can exploit the open, post-drought conditions. The geographic extent of drought-stimulated floras is unknown but could indicate regions where drought has long been a predictable disturbance. In both cases, the frequency and severity of the disturbance appears to be critical in determining disturbance-stimulated recruitment. The ecological relevance of seed ecology in different biomes and species needs further study. Many woody plants seldom regenerate from seeds but persist for long periods by sprouting. Persistence has been somewhat neglected in plant population ecology yet seed ecology may be largely irrelevant for strong persisters. Using examples from the Cape fynbos and sub-tropical grasslands and savannas, I explore cases where seeds are the key demographic bottleneck limiting plant population growth and where seed and seedling stages seem of negligible ecological importance.

Seed Bank Assembly Follows Vegetation Succession in Dune Slacks

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Seed bank assembly during succession follows one of these pathways: the seed bank is during the whole successional range mainly composed of early successional species, or the seed bank composition varies according to the changing vegetation composition. In this study, we investigated the soil seed bank assembly pathway during primary succession in a chronosequence of 20 dune slacks at the Belgian coast, ranging in age from 5 to 55 years. The results of the germination experiment indicated that both seed density and species richness in the seed bank were very low in the first successional stages, and increased with age, mainly as a result of increasing seed production. Also the similarity between seed bank and vegetation was higher in older slacks. The seed bank was to a large extent composed of later successional species. Occurrence patterns of individual species also showed that seeds become incorporated in the soil after the species has established in the vegetation. Hence, the seed bank is not likely to be the driving force for successional changes in the vegetation, and successional changes rely on dispersal. Some early successional species persist in the seed bank, but generally only in low numbers. The results also confirm that most typical dune slack species do not form persistent seeds, so that re-establishment from the seed bank is not to be expected when the species has disappeared from the vegetation.

Seed Crop Investigations of *Pinus sylvestris*, *Pinus nigra* subsp. *pallasiana* and *Pinus brutia* in Turkey – a Review

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This article describes the quantity and quality of seed yields, their annual variations and periodical dispersal within the year at populations of different site classes and age categories together with effects of silvicultural treatments in *P. sylvestris*, *P. nigra* subsp. *pallasiana* and *P. brutia* in Turkey. The results revealed that seed yield was higher in good site classes. Population of middle age of each tree species, in general, may produce more seed crop at the same site classes and elevation zone. The less the seed weight the more the seed yield and more frequent seed years were among the three pine species. But as total average of research years the seed weights per m² produced by each species were rather close to each other's. Seed crop at middle belt zone populations were more abundant than lower and/or upper belt zones in all tree species. Silvicultural treatment slightly increased the seed crop in *P. brutia*. In general, empty seed percentages were positively correlated with poor seed years.

The Role of Temperature in the Regulation of Dormancy and Germination of two Related Annual Mudflat Species

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Effects of temperature on the level of dormancy were investigated in the summer-annuals *Bidens cernua* and *B. tripartita* by means of a long-term burial experiment and a laboratory study. In the laboratory, the effectiveness of storage temperatures between 3 and 18 °C in relieving primary dormancy in freshly matured seeds were tested at germination temperatures between 8 and 25 °C. In *B. cernua*, primary dormancy was relieved if seeds were stratified at 3, 8 and 12 °C, while temperatures of 15 and 18 °C had no effect. Temperatures between 3 and 18 °C were effective in relieving primary dormancy in *B. tripartita*. With prolonged incubation time, secondary dormancy was induced at 12 °C in *B. cernua* and at 18 °C in *B. tripartita*. Stratified *B. tripartita* seeds germinated at high constant (>21 °C) and fluctuating temperatures, while *B. cernua* seeds showed a requirement for fluctuating temperatures. In the burial experiment, both species exhibited annual dormancy cycles. In spring seeds came out of dormancy at soil-temperatures <15 °C (*B. cernua*) and <12 °C (*B. tripartita*). In *B. cernua* secondary dormancy was induced in summer (>15 °C) and in *B. tripartita* at soil-temperatures >7 °C in spring and summer. Nevertheless, *B. tripartita* seeds germinated (>40%) during the whole year at high constant and at fluctuating temperatures, while *B. cernua* showed no germination during late autumn in any temperature treatment.

Loss of Genetic Diversity as Effect of Seed Disperser Behaviour

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Seed dispersers favored gene flow, reducing the endogamy and promoting genetic diversity within the population. However, depending on the level of food choice by the disperser and if the seed shadow that it generate is clumped, the disperser could produce an opposite effect on population genetic diversity. The seed dispersal pattern produced by howler monkeys (*Alouatta* spp) is characterized by a high level of clumping. Black howlers (*Alouatta caraya*) is the main disperser of *Ocotea diospyrifolia* in the Argentinean flooded forest, 90 % of the renewals grow in black howler's latrines. I observed during 2 years that 2 black howler groups would not feed from any *O. diospyrifolia* tree, but they used those with a greater proportion of *Heilipus* sp larva infested fruits. *Heilipus* sp larvae develop in seeds consuming endosperm and embryo completely. It has been observed that trees with a great percentage of infested fruits also have a slow germination speed. The passage through black howler digestive tract eliminates the larvae and the seed germinates with the same speed as those seeds from trees with a low proportion of infested seeds. So, black howler food choice would facilitate the reproduction of the slow germination and high probability of infestation phenotype, promoting a loss of genetic diversity in the *O. diospyrifolia* population.

Endozoochorous Seed Dispersal by the Arctic Fox

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Complementary studies on endozoochorous seed dispersal by the Arctic Fox (*Alopex lagopus*) are presented. A feeding experiment using seeds of 25 arctic species fed to caged foxes showed mean passage rates between 16 and 25 h. Some species showed inhibited germination, some enhanced. Two observational studies from Northern Sweden and NE Greenland show which species are actually found in scats of arctic fox in the field. By combining passage rate data with telemetry data on animal movement patterns during summer and autumn, potential dispersal distances have been estimated.

Long Distance Dispersal – in Pursuit of the Unknowable?

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Long distance dispersal (LDD) of seeds is one of the great ecological problems of our time. Models of population spread and metapopulation dynamics, and empirical studies of invasions, responses to climate change, effects of habitat fragmentation, and potential harm from genetically modified crops, all indicate that (LDD) is a key, rate-limiting process. So, a few seeds which travel very far compared to the mode of the dispersal curve can have an overwhelming influence on spatial dynamics. The problem is that the very nature of LDD – being composed of rare and extreme events – makes it incredibly difficult to quantify. This also means that LDD can be extremely stochastic – the longest dispersal distance varies hugely over time and space. Some ecologists have advocated accepting imperfect knowledge and using stochastic modeling approaches which give imprecise predictions. However, there have been a number of recent advances in predicting and understanding LDD. These include: mechanistic models of wind dispersal; improved approaches to fitting mathematical functions to dispersal data; methods which combine a variety of dispersal data to better represent LDD; and developments in models of spatial dynamics using dispersal data. I will discuss these advances and what they mean for empirical ecologists wanting to make good measures of dispersal, and will look ahead to further potential advances.

Shrub Facilitation on Annual Communities: Effects on Seed Bank

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Clumped pattern of vegetation, with shrub patches interspersed within a bare surface, is a common phenomenon in most arid environments. In this context, facilitative effects of shrubs on annual plants have been widely recognised. Even more, water balance and soil conditions under patches, compared to inter-patch area have been credited for enhanced growth and/or survival. Secondary seed dispersal is a common phenomenon in arid environments, with seeds tending to concentrate in cracks or depressions in the soil surface, this process being more intense in slope structured communities, where run-off may wash out seeds far from their sources. In this context, shrub patches may have a relevant effect on community structure acting as seed-traps, and therefore increasing community spatial heterogeneity.
In this poster we report the effect of patch on the seed bank of a semiarid gypsum community. We compare the effect of three patch positions (in, edge, out) on seed bank size and composition. We also check whether there is an effect of patch size, shape or composition on seed bank traits.

A Quantitative Look at the Role of Wind and Relative Humidity in Seed Abscission

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Despite the undisputable influence of wind on seed abscission, few studies attempt to quantify the wind speed distribution during the time of abscission. Using photography, we determined for *Ceiba aesculifolia* (Bombacaceae) (1) the optimal wind conditions for inducing abscission and (2) the subsequent velocity of the seeds in flight. Results showed that unlike the mean wind speed, the maximum wind speeds recorded within 1-minute time frames correlated well with the proportion of seeds abscising (r^2=0.57; p=0.001). Abscission events were also found to be inversely correlated with the ambient relative humidity. Data showed that the relative humidity played a pivotal role in determining the direction of seed dispersal. The exponent on the power-law equation of the velocity of seeds in flight versus the ambient wind speed was 0.814. The results from this investigation will greatly improve the precision of dispersal models and allow us to quantify the fraction of the seed crop involved in long distance dispersal.

Effect of Temperature and Photoperiod on the Germination of *Cleonia lusitanica* L.

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Cleonia lusitanica L. is a plant belonging to Labiatae with good ornamental characteristics for pot plant and dry flowers use. In this work we tried to determine the effect of temperature and photoperiod on *C. lusitanica* seeds germination in order to know the optimum temperature range for germination and the aptitude of the sexual reproduction as a commercial propagation method. The experiment was carried out in germination chambers with constant temperatures (5, 10, 15, 20, 25 and 30 ºC) and combined temperatures (30/20, 25/15, 20/10 and 15/5 ºC) in darkness and 12 h photoperiod. The results showed an optimum temperature range between 10 and 20 ºC with the maximum germination percentage on 10 ºC (89%). For those temperatures, the germination average ratio (GAR) and the T_{50} parameter varied from 6.5 to 9 days. The use of a photoperiod of 12 hours of total darkness was not significant, though the best results (89%) were obtained with 10 ºC and 24 hours of darkness. In general terms, the sexual reproduction of *C. lusitanica* is a suitable method for its propagation and with a great potential if it is considered to a commercial production.

Variation in Cone Morphology and Seed Mass in Scots Pine Trees from a Mediterranean Population

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Higher seed mass usually translate in higher seedling performance and chances for establishment. Thus, collection of larger seeds is a common practice in nurseries for ensuring seedling success. Selection of largest fruits may be a method for selecting the largest seeds. Here, I relate cone morphological parameters in Scots pine with seed mass in order to establish guidelines to collect the best seeds for planting. Seed mass was highly determined by maternal origin. Seeds were heavier when matured under more appropriate conditions (e.g. dry vs rainy years). Seed mass was weekly correlated to seed number in a cone basis. Cone morphology was also highly determined by maternal origin, and the length:width ratio was also determined by maternal origin. Within maternal plants, seed mass correlated better with cone length than with cone width. There was an overall weak correlation between individual seed mass and morphological characters related to cone size. The selection of the best seeds for planting may therefore require the laboratory screening of maternal plants producing the heaviest seeds.

Vegetation Restoration of a *Quercus ilex* L. subsp. *ballota* (Desf.) Samp. Stand Commununity of Navarra (Spain): Seed Blends with Autochthonous Species

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Due to the high disturbance of the mediterranean ecosystems, studies of accelarate vegetation regeneration in an evergreen oak stand, burned ten years ago, is being made during the last four years by the Botanical Department. One area with sixteen squares of one metre square each one had been chosen on this stand, which is placed in Nazar (Northwestern Navarra, Northern Spain) Different seed blends, made with forty-seven autochthonous collected species, were placed in half of them and the others were left like control. (natural revegetation) The monitoring has been made ones a month in the first two years and each season the next two ones. There were presented the results obtained of floristic richness, coverage, density and vitality found on this squares that show the importance of seedling to accelerate the vegetation regeneration in post-fire or other degraded mediterranean ecosystems.

Litter Effects on Seedling Emergence from Multi-species Artificial Seed Banks

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Propagules of ruderal weed species are dispersed into a variety of microsites; some on bare soil and many in areas covered by dead leaves and other plant litter. Usually, there are many weed species in the seed bank and several kinds of litter are involved. We established multi-species (5 to 7 species) seed banks, 100 seeds per species per 25 cm pot, in the greenhouse in two years. Treatment pots were covered with leaves of one species per treatment and there were two non-litter controls, one with seeds sown on the surface and one with seeds 1 cm deep. *Cirsium vulgare*, *Thlaspi arvense* and *Barbarea vulgaris* were in the seed banks in both years but the other species used were different. Dead leaves of *Acer saccharum*, *Pinus strobus*, *Populus deltoides* and *C. vulgare,* plus live leaves of *Verbascum thapsus* were used as litter in both years. Seedling establishment was monitored over 3 months each year; then the pots were harvested with numbers of plants and dry weights taken for each species. There were large differences in relative performance of weed species among treatments. *Conium maculatum* thrived under all treatments; whereas all litters suppressed establishment of *Oenothera biennis*. The other species responded differently to the different litters; with some litter promoting growth of some species. In summary, leaf litter must influence the make-up of ruderal communities and contribute to their diversity.

Relationship between the Vegetation and Soil Seed Bank along a Community State Sequence

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An important topic in community ecology is how communities are developed and maintained. Weiher & Keddy (1995) compare community assembly to a process where species in a "species pool" are sieved out as they progress through a hierarchy of filters, which may include both biotic and abiotic constraints. The island of Schiermonnikoog in the Dutch Wadden Sea, where there is a chronosequence of salt-marsh development over a hundred-years along the southern coast, presents a unique opportunity to study this process. Studying the relationship between the vegetation (community) and soil seed bank (a component of the species pool) provides insight into identifying filters in the community assembly process. The vegetation and soil seed bank were sampled at different community states along the chronosequence in 1996 and five years later in 2001. Results indicate that patterns in the vegetation composition along the spatio-temporal gradient are reflected in the soil seed bank suggesting limited seed dispersal between community states. Dispersal constraints may restrict the composition of the species pool and thus influence community assembly in this system.

Evaluation of two Commercial Repellents as Seed Coating Materials for Deterring Seed Predation

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Severe rodent seed predation problems are present in degraded shrublands and grasslands in Hong Kong. The present study aims to investigate the repellence of two non-lethal seed coating repellents, Thiram 42S and Deer Off®, to rodents and other local seed predators. Repellence was assessed in laboratory 2-choice feeding test and field seed predation test. The two major local seed-consuming rodent species, *Rattus sikkimensis* and *Nivienter fulvescens*, were served as subjects in the laboratory test. The field test was preformed at one shrubland and one grassland site in Hong Kong. Thiram 42S significantly reduced the seed damage and removal rate under both test regimes while Deer Off® showed some protection in laboratory test but no protective effect under field condition. This study suggested that coating plant seeds with repellent has the potential to protect seeds from severe predation stress in local direct seeding practice for reforestation.

Effects of Soil Nutrients and Fire on Seedling Establishment of Native Prairie Species

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We sought to determine 1) the relationship between seedling establishment rates of target native prairie species and field levels of three soil nutrients (phosphate, nitrate, and ammonium) recorded in fall, winter, and summer, 2) the effect of fire on these three nutrients, and 3) the overall effect of fire on seedling establishment rates of the target native prairie species. Seedling establishment rates were not significantly correlated with soil nitrate or ammonium. Phosphate was significantly correlated with seedling establishment rates but the direction and strength of the relationship depended on the species, with three species showing positive relationships and three species showing negative relationships. Soil phosphate increased significantly in the burned plots compared to the unburned plots, soil ammonium decreased significantly in the burned plots, and soil nitrate showed no significant differences. These nutrient patterns successfully predicted the overall fire effects on seedling establishment in a separate experiment. The three species with positive correlations between seedling establishment and phosphate had greater seedling establishment rates in the burned plots compared to the unburned plots (two significantly, $P \leq 0.1$), and the three species with negative correlations had fewer seeds establish in the burned plots (two significantly ($P \leq 0.1$).

Seed Consumption by Small Native Ground-foraging Mammals at Two Peoples Bay Nature Reserve, Western Australia

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Many seeds, and their associated mycorrhizal fungi, are spread across the landscape through the action of intermittent soil disturbance. Animals have the ability to move seeds to new sites passively either on body surfaces or by ingestion, or actively by consuming fruits or hoarding seeds. Animals also play an active role in seed dispersal through digging and burrowing activities. Small animal diggings can trap plant litter and seeds, forming nutrient-rich microsites for the germination and establishment of seeds. In addition, ingestion of seeds may increase their germinability by removal of dormancy. These actions may play a key role in vegetation dynamics, and may be integral forces in plant succession and maintenance of floral diversity. In southern Western Australia, many small mammals create soil disturbance through their foraging for seeds, fungi, roots and invertebrates, but these native ground-foraging mammals have suffered a dramatic decline or complete extinction in many parts of Western Australia due to land clearing, changed fire regimes and the introduction of exotic predators such as foxes and cats. This project investigates the relationships between four small native ground-foraging mammals (bandicoots, potoroos, bush rats and quokkas) and native seeds in a Western Australian south coast nature reserve.

Germination Ecology of the Threatened Winter Annual S*isymbrium cavanillesianum* and Other Associated Species

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Sisymbrium cavanillesianum is a rare annual herb endemic to the Iberian Peninsula, co-occuring with other weeds associated with dry farming crops. The seasonal cycles in germinability for seeds of this species were recorded for two years and compared to those of three species from its habitat, including the closely related taxon *Sisymbrium runcinatum*. Seed samples were buried in a nonheated greenhouse, and were exhumed in monthly intervals. Seeds recovered from soil were tested for germination at 5, 15/4, 20/7, 25/10, 28/14 and 32/18 ºC, both in darkness and with a 12-h photoperiod. Seeds buried of *S. cavanillesianum* exhibited an annual dormancy/non-dormancy cycle, with seeds mostly germinating to 90-100% both in light and darkness over all the range of thermoperiods during summer and autumn, but acquiring dormancy in early winter. Most germination of sown seeds took place in autumn of the first year, although it expanded for two years. The response of dormant and non-dormant seeds to temperature was also tested with the same thermoperiods mentioned above. Non-dormant seeds of *S. cavanillesianum* entered conditional dormancy with the three lower thermoperiods after burial for 8 weeks. However after burial for 16 weeks at 20/7 and 25/10 ºC dormant seeds gained the ability to germinate to 80-100 % at 5 and 15/4 ºC, whereas seeds buried at 28/14 and 32/18 ºC germinated to 80-100 % at 15/4, 20/7, 25/10 and 28/14 ºC.

Endozoochorous Dispersal of Inconspicuous Seeds: Cost or Benefit?

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Plant species without attractive fleshy fruits, producing small, hard seeds might nonetheless, be depending on endozoochory for their seed dispersal (Janzen, 1984). To estimate some of the costs, we performed feeding and germination experiments in greenhouse and field conditions. Germination success after gut passage, is dramatically reduced, and generally is in the range of 0.1 to 30%. Field experiments revealed that germination success of seeds that are part of herbivore dung is in the range of 5-15% in the first year after dung deposition. This means that each individual plant has to produce at least some thousands of seeds to get its offspring successfully established after endozoochorous seed dispersal, Therefore, a large 'cost' seems to be associated with endozoochory. On the other hand these plant species may benefit from some aspects inherent to endozoochory. Vertebrate herbivores are able to move through their whole home range during seed gastero-intestinal passage time, hence, potentially providing long distance seed dispersal. Selective habitat use by large herbivores furthermore may induce some degree of directness in seed dispersal, which, at least for some plant species, may enhance germination and recruitment possibilities because of the suitable environment seeds are deposited in. We will discuss several of these aspects.

Complementarity of Epi- and Endozoochory by Free-ranging Donkeys

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Zoochory is a well-recognized long-distance seed dispersal mechanism, but it is subject of relatively few studies. Here, epi- and endozoochory were compared on donkeys in an 80 ha coastal dune reserve, through *in vitro* germination of zoochorous material collected by fur brushing and dung collection. We identified 6693 seedlings of 68 plant species, covering 20% of the species recorded in the study area. Of the 68 species, only 16 occurred in both epi- and endozoochorous samples, demonstrating the complementarity of both dispersal mechanisms. The species composition in the zoochorous samples reflected a strong seasonality, and seedling numbers were correlated with species abundance in the vegetation. The non-zoochorously dispersed species in the vegetation differed from the zoochorous species in diaspore dimensions, plant height, life span and forage value. A selection of dispersal-relevant plant traits was used to derive dispersal-functional plant types for all species in the study area. Epizoochory showed to be more specific than endozoochory and was associated with a more narrow range of dispersal-functional plant types.

An Experimental Assessment of Seed Adhesivity on Animal Furs

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Epizoochory is widely recognized as an effective long-distance seed dispersal mechanism. Nevertheless, few studies focus on the investigation of its influencing factors. One of the key aspects of epizoochory is the adhesive interaction between seeds and furs. We describe a new method to experimentally quantify and standardize the adhesivity of seeds to animal fur, as a measure of epizoochorous dispersal potential. The method excludes the impact of animal behaviour and environmental factors, and allows the ranking of species according to their adhesivity score. We measured adhesivity scores for 66 species on the furs of seven mammals. Deep furs with long, rough, undulated hairs implanted at a large angle were most suited for seed adhesion, while shallow furs with short, smooth, straight hairs implanted at small angles performed less. Seeds with specialized adhesive appendages had higher adhesivity scores than seeds with unspecialised appendages and seeds without appendages. However, an interaction-effect between certain seed and fur types exists. Although seed morphology is a good predictor for seed adhesivity on fur, less-performing seed types often still have relatively high adhesivity scores. Therefore, it is likely that nearly all species are to some extent able to disperse epizoochorously.

The Millennium Seed Bank Project in Western Australia – Ensuring the Long Term Survival of "at risk" Species

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The flora of Western Australia is both diverse and unique. There are more than 5000 endemic native species in the state, with over half of these growing in the South-west botanical province, an area recognized as being one of the world's 25 biodiversity hotspots. Putting this diversity at risk is a range of threatening processes including accidental destruction, invasive weeds, dryland salinity and introduced pathogens. Combating this potential loss of species is a coordinated partnership between The Millennium Seed Bank (Royal Botanic Gardens, Kew) in England with two long term seed storage facilities in Western Australia, The Threatened Flora Seed Centre (Department of Conservation and Land Management) and The Western Australian Seed Technology Centre (Botanic Gardens and Parks Authority). Over the life of this project more than 2000 species will have been collected and stored, providing some level of insurance against the potential loss of these species in the wild. In addition, the material stored will provide an invaluable resource for translocation, restoration and scientific investigation in the future.

Fire in the Mediterranean Basin Ecosystem: Effect of Smoke on Seed Germination

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In regions with a mediterranean-type climate wildfires are a frequent occurrence. In such habitats fire tolerant/favoured species (which propagate in different ways after fire including resprouting, seeding, flowering) are frequently encountered. In the Mediterranean basin, many species of fire prone habitats are resprouters while only few are known to germinate after fire. In other regions with mediterranean-type vegetation including the Californian, South African and Western Australian, fire is an important component in the seed bank dynamics with species having enhanced germination following fire; smoke has been found to be the most significant agent responsible for much of the germination. For Mediterranean basin species the role of smoke in germination is not fully understood. This study investigated the response of seeds of some species from the Med basin to application of smoke. Results showed that 30% of species (e.g. *Cistus incanus*) significantly increased germination ($P<0.05$), 20% (e.g. *Rhamnus alaternus*) had an earlier emergence of seedlings, 30% (e.g. *Asphodelus microcarpus*) showed reduced germination, while 20% (e.g. *Lavandula angustifolia*) exhibited no difference in germination at the tested smoke concentration. The data confirms that smoke-stimulated germination occurs and outcomes of further research on a broader range of species from across the Med basin would have important impacts for horticulture and restoration.

Seeding the Woods from the Trees: New Views on Seed Source and Dispersal Limitation in Tropical Forests

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Renewed interest in seed dispersal in tropical forests has been spurred by theoretical work highlighting the role of *seed limitation* in facilitating species coexistence. Seed limitation describes the failure of seeds to arrive at sites suitable for seedling recruitment. Widespread seed limitation is thought to slow the loss of species through competitive exclusion as only a subset of potentially competing species contest individual recruitment sites. I will review current definitions and measures of seed limitation and its component processes, and describe field, molecular and statistical approaches used to infer dispersal patterns. I will use data on light-demanding tree species from Barro Colorado Island, Panama, to illustrate the scale of variation in seed limitation among species with similar regeneration requirements and describe how limits to dispersal in space can be partially compensated by long-term seed persistence. Finally, I will take a look at the future of dispersal studies in tropical forests and suggest how new treatments of dispersal may help us re-evaluate the contribution of post-dispersal processes as determinants of species abundance and distribution.

Climatic Ecotypes of Seed Germination in *Pinus brutia* along a North-south Transect – Preliminary Results

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A comparative study of *Pinus brutia* seed morphology and germination along a north-south climatic gradient is currently under implementation. This assessment is a follow up of a previous investigation (Skordilis & Thanos, Seed Science Research 5, 151-160, 1995) on ten provenances of East Mediterranean pine (*Pinus brutia*) seeds, collected from regions located in the western limits of the species natural distribution (Soufli, Thasos Island, Lesbos Island, Samos Island, Rhodes Island, Anopolis Sfakia and Lasithi from Crete, Pafos, Panagia and Platania from Cyprus). Mean seed weight and seed coat contribution were determined in each provenance. Germination experiments were carried out in plant growth chambers at constant (5, 10, 15, 20 and 25 °C) and alternating temperatures (20/15 °C). The effect of increasing durations (1, 2 and 3 months) of a cold-moist stratification (at 2-4 °C in the dark) was also tested Final dark germination as a function of temperature was found to vary considerably according to seed origin but, overall, germination was manifested mainly at 10-20 °C. White light partially promoted seed germination. In agreement to our working hypothesis, the southern provenances (Crete, Cyprus) were stratification-indifferent while the northern ones showed a gradually increasing degree of dormancy that could be relieved by longer durations of chilling.

Developmental Heat Sum Influences Recalcitrant Seed Traits in *Aesculus hippocastanum* L. across Europe

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An analysis was made of seed traits along a north-south gradient, and thus a range of climate conditions, spanning 19° of latitude in Europe using *Aesculus hippocastanum* L. We tested the hypothesis that the heat sum during seed development influences physical, physiological and biochemical seed traits. Seeds from Greece (within the natural range) had a fresh mass five times higher than those from Scotland (introduced range and the most northerly seed lot), and a lower axis moisture content and solute potential. In addition, Greek seeds germinated at cooler temperatures, and were more desiccation tolerant. Principal Component Analysis showed that the observed patterns in seed characteristics were consistent and predictable: a single PCA axis explained 87% of the variation in the dataset and correlated strongly with heat sum.

Ecological Correlates of Seed Desiccation Tolerance in Tropical African Dryland Trees

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Species with recalcitrant, Type III seeds do occur in drylands, although little is known about ecological adaptations to minimize seed death in these environments. Here we present data for the seed desiccation tolerance of 10 African dryland species and examine the relationships between seed size, rainfall at the time of seed shed, and desiccation tolerance for these and a further 70 species from the scientific literature. The recalcitrant species investigated and analysed had large (> 0.5 g) seeds, germinated rapidly, and had comparatively small investments in seed physical defences. Furthermore, seed was shed in months of high rainfall (> 60 mm). In comparison, for species with desiccation-tolerant seeds, seed mass varied across five orders of magnitude, and seed was shed in wet and dry months. Although infrequent in dryland environments, species with recalcitrant seeds do occur; large size, rapid germination, and the timing of dispersal all reduce the likelihood of seed drying. Furthermore, having recalcitrant seeds may be advantageous for large-seeded species by increasing the efficiency of resource use in seed provisioning.

Salinity Effects on the Germination Kinetics and the Root Elongation of *Cakile maritima*

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Cakile maritima (Brassicaceae) colonises the dunes along the Tunisian Mediterranean seashore. Besides its ecological interest, this halophyte produces seeds rich in lipids. The response of this species to increasing salinity at the germination stage was studied. NaCl inhibited germination only at concentrations higher than 200 mM, mainly by an osmotic reversible effect. After 9 days, moderate salinity had no significant effect on seed germination in the 50-100 mM NaCl range. However, germination was virtually suppressed at NaCl concentrations higher than 200 mM. Considering the germination kinetics, $T_{50\%}$, the time for 50% germination, increased significantly with NaCl levels, suggesting that the germination process was delayed by salt. The pattern of root elongation rate was similar to that of germination, being not significantly affected at concentrations equal or lower than 100 mM NaCl, and 50% inhibited at 300 mM. Seed viability was not affected by salinity: transferring non germinated seeds under salt-treatment resulted in high germination recovery percentages, similar to those reached without salt, except for seeds pre-treated with 500 mM NaCl.

Does Seed Dispersal from the Forest into Adjacent Cropland Occur? - Evidence from the Soil Seed Bank

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In view of a growing effort to restore field boundary vegetation, the mutual influence of field boundaries and forest edges and their adjacent croplands receives increasing attention. The objective of this study was to assess the contribution of forest edge vegetation to the invasion of weeds in croplands. As the seed bank is a good indicator of the long-term availability of weed seeds, seed bank research was performed in seven croplands adjacent to mature deciduous forest. Our results indicated that the influence of the proximity of a forest stand was qualitative, rather than quantitative. Most distinct influences were limited to a field edge zone of 3 m from the border. There, density and species richness of the seed bank were significantly higher and declined sharply with distance into the field. Although the majority of species in the field seed bank presumably dispersed from the forest and forest edge vegetation, it concerned very low seed densities. Furthermore, the most frequent species in the seed bank did not disperse from the nearby forest. Dispersal distances of individual species into the field were very limited, based on presence and on abundance variables. We thus conclude, based on these results, that the forest edge cannot be regarded as an important source for weed infestation of the adjacent cropland. On the contrary, there is evidence for *vice-versa* dispersal of seeds from the field into the forest edge.

Seed Information Database - SID

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The Seed Information Database forms part of the Royal Botanic Gardens Kew's electronic Plant Information Centre (ePIC). As part of the Millennium Seed Bank Project it is being developed as a means of compiling large amounts of taxon-based seed biological information from the Project's growing numbers of conserved seed collections from wild species. This information is analysed in various ways, to help answer questions posed by our seed conservation activities. It is also delivered freely via the internet - http://www.kew.org/data/sid/

The database currently has modules covering: seed storage behaviour; germination; seed mass; dispersal mode; parent life form; and seed chemistry (oil content and protein content). We plan to begin delivering information on seed structure – anatomy and morphology – over the next year, including images.

While the main 'in-house' application of analyses is related to seed conservation, we are always keen to use the data-sets in collaboration with others, to investigate wider seed biological or ecological questions; and we are likewise pleased to consider offers of data, which will be appropriately acknowledged, if included.

Soil Seed Banks under Various Grazing Regimes in a Deciduous Oak Forest of NW Greece

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The soil seed bank of a deciduous *Quercus frainetto* forest was studied in relation to the impacts of grazing on the plant diversity of the aboveground vegetation. The fenced study area (112 ha) is divided into two fenced parts, one of which is grazed by ruminants (86 ha) and the other by wild boars (26 ha). Outside the fenced area grazing is only practiced by a small number of goats. Soil cores (at two depths, 0–5 and 5–10 cm) were collected from five macroplots (two inside and three outside the fenced study area) and after a 3-month-long chilling treatment, the soil seed bank was evaluated by the germination method. The average total seed density was found 2241 seeds/m^2; however, seed density in the wild boar grazing area was significantly lower, 662 seeds/m^2, in the upper 5 cm and only 51 seeds/m^2 in the deeper layer. In the area grazed by ruminants, seed densities were 1171 and 1477 seeds/m^2, respectively. It is suggested that a significant, persistent seed bank is accumulated in this forest-type; grazing by wild boars (but not by ruminants) causes a dramatic depletion of this seed bank. Moreover, 48 plant taxa were identified in the soil seed bank of the area grazed by ruminants while 6 taxa were found in the area grazed by wild boars. It is concluded that different grazing management practices in oak forests affect extensively the vegetation and floristic composition, both above ground and below, in the soil seed bank. The role of these practices on the potential of forest succession merits further investigation.

Validation of Ecological Models by *in situ* Germination Experiments

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In the last few years several statistical models have been used to explain species distribution. However, a major objection to this approach is that predictive models are seldom externally validated and, thus, we remain uncertain of how accurate they are.

The present work compares two ecological models for *Narcissus serotinus* L. obtained by logistic regression and provides field validation. The first model was developed using climatic and geo-morphological variables, whereas, in the second model, soil types were also included. *N. serotinus* presence/absence data were the same in both models. ROC curves, Kappa and Mann-Whitney tests were used to assess the fitness of both models. Furthermore, a field validation experiment was designed to evaluate the biological fitness of both models. Twenty-six germination sites were selected by stratified random sampling, considering the main geographical areas and the suitability values for each model. Four replicates of 25 seeds each were used in each site. Seeds were sown in the local soil and data were collected after 2 months. Results and applications of this external validation approach are discussed.

Effects of Salinity *in vivo* and *in vitro* on the Activities of Antioxidant Enzymes in Germinating Seeds of *Rumex dentatus*

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The effects of NaCl stress on the activities of peroxidase (POD: EC 1.11.1.7), glutathione reductase (GR: EC 1.6.4.2), superoxide dismutase (SOD: EC 1.15.1.1), rate of lipid peroxidation were investigated in germinating seeds of *Rumex dentatus*. *Rumex* seeds were treated with three salt concentrations (50, 100 and 200 mM NaCl). The SOD activity in the seeds increased with the increase of NaCl stress. The POD and GR activities showed similar trends under salt stress. There was an average increase in GR activity of about 60 % but there was no further increase at high NaCl concentrations. The *in vitro* experiments have shown that 100 mM NaCl added to the assay medium did not affect the activities of the enzymes, and gave support to the hypothesis that *in vivo* effect of salinity should be on enzyme solubilization/activation or enzyme turnover. NaCl treatments led to a significant increase in the levels of MDA content in germinating seeds. These results suggest that *Rumex dentatus* may have a better protection against reactive oxygen species by increasing the activity of antioxidant enzymes under stress.

Soil Seedbanks in three Contrasting High Diversity Mediterranean-type Shrublands from SW Australia

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The fire-prone northern sandplain shrublands of SW Australia are renowned for their high plant species diversity, and unusually high proportion of species (up to 30%) characterized by canopy seed storage (serotiny). This study investigated species composition and abundance for the soil seed bank for sample plots at three locations with different substrate conditions and high species turnover (~50%) among sites. In each plot the spatial position of all extant plants was mapped, and 90 soil samples were collected from a random set of (known) spatial locations. Samples were treated with heat and smoke to simulate the effects of fire on germination, and seedling emergence was followed in the glasshouse over 4 months. Soil seed bank richness, composition and abundance patterns were compared among sites in relation to abundance hierarchies for extant species, species richness of the serotinous flora, and the spatial locations of potential parent plants. Seed bank densities were variable but generally low (234, 270 and 1435 seeds m^{-2}), and were lowest for the two sites with the highest proportions of species with canopy seed storage and lowest nutrient availability. The distributions and abundances of species in the soil seed bank were mostly random and did not match the strongly aggregated patterns shown by perennial plant species in the extant vegetation. There was no difference in the abundances of seeds of fire-killed and fire-tolerant species in the soil seed bank, although annual plants showed high abundance in the site with highest nutrient supply.

Deer and Lagomorphs as Dispersers of Seeds in a Forest Mosaic

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The dispersal of species is increasingly important as habitat fragmentation continues and communities are restored in areas isolated from patches of the desired habitat. Seeds of many vascular plant species may be consumed by herbivores alongside plant leaf matter and deposited, viable, in faeces. We present results from the largest ever study of endozoochorous dispersal of viable plant seeds by deer.
1121 faecal pellet groups of red deer (*Cervus elaphus*), fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), chinese muntjac (*Muntiacus reevesi*), rabbit (*Oryctolagus cuniculus*) and brown hare (*Lepus europaeus*) were collected from Thetford Forest, a 200 km^2 commercial conifer forest managed on a clearfell rotation basis. 85 plant species were recorded by incubation of samples and subsequent germination of viable seeds. A large number of the plant species recorded have no physical mechanism for dispersal, and dispersal by large herbivores may therefore play a vital role in the meso-scale dispersal of seeds in patchy landscapes. Results are compared between disperser species and are related to the composition of regional plant communities, deer population densities and faecal deposition rates.

The Role of Temperature, Stratification and Light on Germination of *Pinus pinaster* Seeds from Six Provenances

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The objectives of the present study were threefold: (i) to study dark/light, temperature and chilling effect on germination of *Pinus pinaster* seeds, (ii) to evaluate whether intraspecific variation in germination behaviour existed within the species; (iii) to determine if seed germination requirements of the different geographic provenances were related to their growing environment. Seeds were collected from six different natural insular and continental populations located both in Italy and France. Germination parameters (germination percentage, speed and value) of 30-day chilled and unchilled seeds was analysed in the temperature range 13-27 °C in the dark and in the 10-31 °C range under a 12-hour white light. Response to temperature, chilling and light varied, escalating from the southern-most population germinating to the highest percentage and speed over a wide range of temperatures, especially at the highest ones. The northern-most provenance showed a narrow temperature range for germination and low germination capacity at high temperatures. In all provenances cold stratification and light always promoted germination but light could not completely substitute for cold requirement. Chilling beneficial effect suggested the presence of non-deep physiological dormancy (shallow dormancy). Light sensitivity indicated the potential of colonising open habitats (pioneer species) as already demonstrated for other Mediterranean pine species.

Contribution of the Fructification and Seed Germination to the Taxonomy of the *Teucrium* grex *pumilum*

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Teucrium pumilum L. is an endemic species of the central and south eastern Spain. The great morphological variability has led to some authors to consider it as a whole of different species. The most spread classification includes five species in the subsection *pumilum* (*T. pumilum* L., *T. libanitis* Schreber, *T. lepicephalum* Pau, *T. carolipaui* C. Vicioso ex. Pau and *T. turredanum* Losa & Rivas Goday). The aim of the present work is to evaluate fructification rate and seed germination as differential characters of taxonomic value for discriminating populations of the five mentioned species. According to the fructification rate, *T. lepicephalum* showed mostly 1 to 3 fertile nutlets per flower, while the remainder species produced mostly 0 to 1. On the other hand, the germination rate at different temperatures for each species was calculated. The optimal germination temperature was identical for *T. pumilum* and *T. carolipaui* (18 ºC), while those of *T. lepicephalum*, *T. turredanum* and *T. libanitis* were lower (10, 12 and 14 ºC, respectively). These results can be correlated with the bioclimate in which these species grow.

Seed Set and Seed Mass of five Forbs in Anthropogenically Fragmented Landscapes

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In small and isolated populations seed set may be reduced due to pollination limitation, inbreeding depression, or reduced mate availability. However, reduced seed set might be compensated by increased seed mass. I report seed set and individual seed mass of five forbs from fragmented Swiss and S German grasslands, *Gentianella germanica*, *Swertia perennis*, *Lychnis flos-cuculi*, *Primula farinosa* and *Cochlearia bavarica*. For each species seeds were counted and weighed of one fruit of 160-540 plants representing 16-27 small and large remnant populations. In addition, for all species but *Primula* inbreeding depression on seed set and mass was measured by comparing fruits after experimental selfing and outcrossing of 30-190 plants. In four species there was a trade-off between seed set and mass. Reduced seed set and mass after experimental inbreeding in *Swertia* illustrate that inbreeding depression can negatively affect both, despite the trade-off between the two. Seed set was reduced in smaller populations of *Lychnis*, *Gentianella* and *Cochlearia*. Seed mass was independent of population size in four species, and decreased with smaller population size in *Lychnis*. In conclusion, observed negative effects of habitat fragmentation on seed set are, despite trade-offs between seed set and mass, not compensated by higher seed mass.

The Germination Active Principle in Smoke

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Attempts have been made to determine the compound(s) from charred wood or smoke that is/are responsible for triggering the germination of seeds of many different species. As yet, there has not been a definitive chemical(s) successfully identified capable of inducing the high germination response that is observed with smoke. Therefore, the aim of our study has been to identify the active component(s) in smoke, responsible for breaking seed dormancy, as an aid to developing a more cost-effective and efficient means for delivering of the smoke-like benefits for germination of native species. Presented are steps undertaken to achieve this goal using conventional extraction and purification steps, together with identification of potential active compounds by analytical methods. Moreover, the results will be presented that indicate the potent germination-promoting activity of the active compound(s), with concentrations less than 1 ppb required to elicit a significant response in the indicative bioassay species Grand Rapids lettuce seed, two highly smoke-responsive Western Australian species, *Stylidium affine* and *Conostylis aculeata* and key smoke responsive taxa from South Africa and California. The agent identified conforms with the expected ecological activity of smoke (stable at high temperatures, water soluble, active at a range of concentrations, capable of germinating a wide range of fire-following species). In addition, the chemical species is produced from the combustion of pure cellulose which, as a ubiquitous component of all higher plant cells represents a universal combustion substrate during wild fires.

Interyear Variation in Germination of *Cistus clusii* and *C. salvifolius* Seeds

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Cistus clusii and *C. salvifolius* are two Cistaceae species widely distributed in the Mediterranean region. *Cistus* seeds have a primary dormancy imposed by the seed coat and only a small fraction of a given *Cistus* seed population can germinate each year. The softening of the larger fraction of hard-coated seeds can be promoted under natural conditions. Germination of six seed lots of *C. clusii* (collected at 1991, 1997, 1999, 2000, 2001 and 2002) and six seed lots of *C. salvifolius* (collected at 1990, 1994, 1997, 1998, 1999 and 2000) were studied. Seeds were collected from wild populations in Natural Park of El Saler, Valencia, Spain. In addition two different pretreatments for promoting germination were applied: dry heat at 100 ºC for 10 minutes and hot water. Germination tests were performed under controlled conditions, at 25 ºC and 16 h light and 8 h darkness. The results indicated that the seed germination was higher in oldest seed than in younger seed of *C. clusii* but not in the case of *C. salvifolius.* Dry heat and hot water treatments were only effective to increase germination in *C. clusii* younger seeds. Only hot water treatment was shown to break dormancy in *C. salvifolius* seeds.

Seed Germination and Dormancy in Response to Multiple Environments

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It is estimated that species persist on the order of 20 million years but environments are much more transitory. For instance, in the Pleistocene most locations have experienced dramatic fluctuations in climatic regimes with an estimated 18-20 glacial cycles and species have reassembled to form different communities. When addressing specialized seed germination/dormancy strategies inferences about the evolution of traits is largely based on the environment in which they currently occur with little thought to previous environments and corresponding selective pressures. In this paper I discuss germination behavior of species that occur under radically different environmental regimes (fire-prone shrublands and desert ecosystems) but share similar germination cues. I also address the role that fluctuations in environmental regimes play in germination behavior and the implications for understanding germination and other adaptations.

Germination Ecophysiology in three Endemic and Threatened Plants of Crete (Listed as Priority Species in the Annex II of the Habitats Directive 92/43 EEC)

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Bupleurum kakiskalae, *Nepeta sphaciotica* and *Hypericum aciferum* are endemic plants of the island of Crete, Greece, known only from critical, small-sized populations, are restricted to the Lefka Ori (White Mountains) massif. These species are regarded as threatened and, according to the 92/43 EEC Directive, are considered priority species for protection. The aim of the present work is to contribute to the *ex situ* conservation of these taxa.

B. kakiskalae is a monocarpic perennial - it flowers after approximately 12 years - and its mature seeds are described for the fist time in this work. Preliminary experiments have shown that germination takes place slowly, at a rather narrow range of low temperatures (5-10 °C). *H. aciferum* seeds were tested for germination at three different temperatures (10, 15, 20 °C) and it was found that 15 °C was optimal; light conditions (darkness or white light) showed no effect on germination. The germination of *N. sphaciotica* seeds took place relatively slowly, at a rather narrow range of 'warm' temperatures (15-20 °C) while it was totally suppressed at 10 °C. Germination in darkness was fully inhibited.

Seed Predation in Mediterranean-type Agroecosystems

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The wheat-growing region of southern Australia is characterized by a Mediterranean-type climate with hot, dry summers followed by cool, wet fall and winter seasons. Seed of many annual weeds are dispersed in the late spring. These seed are a major food source for numerous ant species as well as rodents. We evaluated the effects of seed type, predator exclusion, and spatial factors on weed seed removal in wheat fields located in Western Australia during the summer months. There was evidence that ryegrass seed were removed more readily that either wild oat or wild radish seed, although removal for all species was quite high. Seed removal tended to be less pronounced in the center of the field when compared with the field edges that were bordered by wooded vegetation. There was also evidence that ants removed approximately 70% of the seed, whereas rodents removed 30%. Seed predator activity was influenced both seed density and spatial dispersal patterns. Reduced tillage, avoiding insecticides, and creating refuges for potential seed predators may all be ways to enhance weed seed removal in agricultural fields in this type of climate. To test these hypotheses, collaboration among plant, soil, insect, and animal ecologists will be essential.

Seed Mortality in Neotropical Soil-seed Banks: Patterns and Pathogens

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Successful recruitment for many light-demanding species depends upon seed survival in the soil-seed bank. Experiments conducted with the common pioneer tree species, *Cecropia insignis* (Cecropiaceae) at Barro Colorado Island, Panama and La Selva Biological Station, Costa Rica demonstrate that fungal pathogens severely reduce seed survival in the soil. Results from reciprocal transplant experiments between the two populations show that mortality in the seed bank is high (65-70% after 5 months), and suggest specialization of pathogens to local host genotypes; local seeds suffered higher mortality than seeds introduced from the foreign population (df: 1, F: 45.2, $p<.0001$). Fungicide experiments increased seed survival up to 50%, and the identities and host specificities of the fungi are under investigation. Seeds buried beneath conspecific crowns showed significantly higher mortality than those buried beneath heterospecific crowns (df: 1, F: 28.5, $p<.0001$). Furthermore, seed survival increased with distance (and decreasing seed-bank density) from *C. insignis* crowns. These results indicate the potential for host-specificity of soil-borne fungi in this system, which could influence local species composition through host-specific recruitment limitation.

Reduction of Seed Predation by Ant Dispersal

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Myrmecochorous plants have a mutualistic interaction with ants. Their seeds have elaiosomes; appendages rich in fats, sugars and other nutrients which are thought to be an adaptation inducing ants to disperse the seed. Seeds with elaiosomes may be collected by mutualistic ants, reducing the number available to seed predators. It has been shown that if seeds are not found by mutualistic ants within a couple of hours, they may be eaten by predators. It has even been suggested that the presence of an elaiosome may increase the probability the seed is taken by a mutualistic ant rather than a granivorous ant. However, this hypothesis has not been well investigated. *Ulex* species have seeds with elaiosomes, which are attractive to the mutualistic ant *Myrmica ruginodis.* Field experiments were carried out to discover the number of *U. minor* and *U. europaeus* seeds taken by *M. ruginodis* ants and seed predators in Southern England. Different treatments were used to exclude ants or seed predators (such as birds and rodents), along with a control to allow open access. When *M. ruginodis* was excluded a large proportion of seeds were eaten by wood mice, *Apodemus sylvaticus*. Allowing access by ants meant that most seeds were removed by *M. ruginodis* and so avoided predation. This has a substantial influence on plant fitness and population growth rate.

Post-Dispersal Seed Predation Modulates Recruitment Potential among Bird-Dispersed Trees in Cantabrian Forest

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Seed predators may influence plant community structure by affecting relative recruitment success for different species. We investigated the role of post-dispersal seed predation by rodents in the recruitment of yew *Taxus baccata*, holly *Ilex aquifolium* and hawthorn *Crataegus monogyna* in montane secondary forests of the Cantabrian range (NW Spain). For two years and four localities, we evaluated specific seed predation rates, the availability of viable dispersed seeds, and seedling establishment. Seed predation strongly differed among tree species, predators' preference (yew>holly>hawthorn) being consistent among sites and years. Seed selection is probably related to seed profitability, measured as the endocarp: endosperm dry weights ratio. Recruitment potential, measured as the ratio emerged first-year seedlings to viable dispersed seeds, was negatively related to seed predation. Highly profitable and available seed species (yew) suffered heavy recruitment limitation due to seed predation, whereas lowly profitable, scarce seed species (hawthorn) achieved enhanced long-term seedling establishment. We conclude a plant coexistence promoting effect of seed predation, mediated by seed traits.

Spatial Concordance among Seed Rain and Seedling Recruitment in a Fleshy-Fruited Woody Plant Community: a Local or Landscape Scale Matter?

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Population and community-level effects of seed dispersal depend on the coupling among successive regeneration stages at different spatial scales. We evaluated the spatial scale (microhabitat, site, landscape) at which different regeneration processes perform, for three montane secondary forests species of the Cantabrian range in NW Spain (yew *Taxus baccata*, holly *Ilex aquifolium*, hawthorn *Crataegus monogyna*). We seek to determine: 1) the occurrence of concordant patterns among seed rain and seedling recruitment; and 2) the consistency of concordance across spatial scales. For all species, most of variance in bird-generated seed rain was accounted for by differences among microhabitats and plots within site. Conversely, seed predation and seedling emergence and survival mainly varied at the landscape scale. Due to these scale differences, local patterns of seed rain were not screened-off by late-acting processes, leading to spatial concordance in most of sites. However, the positive relationship among seed rain and recruitment was seldom expressed at the landscape scale, given the low among-sites variance on seed rain as well as the local differences in the magnitude in post-dispersal processes.

Variability of the Seed Morphology and Oil Composition in the Oleaginous Halophyte *Cakile maritima*

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The annual coastal halophyte *Cakile maritima* displays ecological and economical importance owing to its salt-tolerance, and the high amount of oil within its seeds. The variability of fruit and seed-oil characteristics in twelve accessions of this species, harvested along the Tunisian littoral was investigated. Seed-oil amount seemed to be highly variable among the accessions, ranging from 25 to 39 %. Reserve lipids represented by Triacylglycerols (TAG) were predominant, reaching 80 to 97 % of the lipid categories. Erucic acid, highly present in *C. maritima* seed-oil (25 to 35 % of the total fatty acids), was found only in TAG and this fact confers to this oil potential industrial applications. Fruit morphology and ion status within stems, silica, and seeds showed great fluctuations among the studied accessions. However, the repartition of the both ions suggests the ability of *C. maritima* to protect its reproductive organs from their harmful accumulation. This propriety is of high significance for the ecology of this plant, since it determines the seed viability and thus the species establishment and survival in saline biotopes.

The Response of Soil Diaspore Bank to the Long-term Experimental Treatments in Upland Vegetation in the UK

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We studied the effects of bracken control and vegetation restoration treatments on the diaspore bank (seed and spore bank) nine years after their first application at two contrasting sites in the UK. The seed bank was largely made up of *Agrostis capillaris, Juncus effusus* and ferns at an acid grassland and *Calluna vulgaris*, *J. effusus*, and *A. capillaris* at a moorland. The majority of seedlings originated from the bracken litter and surface soil (0-5 cm), with 38% and 53% of the total germination. There was only one significant response to grass seeding at the acid grassland, but at the moorland site there were several significant effects of treatment on all the main species as well as on the diaspore bank community. The individual species responses showed that *A. capillaris* seed density was greater in the most disturbed treatment (cut twice yearly and no fencing), whereas the greatest *C. vulgaris* seed density was found in low disturbed treatments (spray and experimental control). Continued cut twice yearly with grazing significantly increased the seed bank size of grasses in the bracken litter and *C. vulgaris* in the soil. The application of *C. vulgaris* seeds, especially by brash addition, increased seed density greatly in the bracken litter layer. There is also clear evidence of the existence of a varied bryophyte flora in the diaspore bank that could influence post-disturbance species composition and diversity.

Environmental Control of Germination of *Orobanche ramosa* L. Seeds

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The objective of this work was to investigate the effects of the main environmental factors on the germination of seeds of Broomrape (*Orobanche ramosa* L.), a root holoparasite responsible for important yield losses in numerous crops, particularly in the Mediterranean area. In the absence of the host plant, seeds became able to germinate in the presence of a strigol analogue (GR 24) only after a preincubation period in a wet medium. Their responsiveness to GR 24 increased with increasing duration of their preconditioning at 20 °C, and was optimal after 2-3 weeks. The preconditioning treatment was effective at temperatures ranging from 10 to 30 °C. At the optimal temperature (20 °C), it required only at least 1% oxygen in the atmosphere and remained effective at a water potential of the medium of -2 MPa. A too prolonged preincubation of seeds at 5 or 30°C resulted in induction of a secondary dormancy. Seeds preconditioned for 14 days at 20 °C germinated in the presence of 1 ppm GR 24 at temperatures ranging from 10 to 25 °C, the thermal optimum being 20 °C. They were also able to germinate at 20°C under an oxygen concentration as low as 3% and at a water potential of the medium as low as -3 MPa. The results obtained might help to better understand the regulation of *O. ramosa* spread in temperate areas.

Seed Germination of 20 High Mountain Mediterranean Species: Altitudinal, Interpopulation and Interannual Variability

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The effects of altitude, population of origin and interannual variation on seed germination were analysed in 20 species from high altitudes of the Spanish Central Range, most of them endemics of the Iberian Peninsula. Seeds were collected at four different locations always above the treeline, from 1900 to 2400 m. a.s.l. in two consecutive growth seasons (2001-2002). Seeds were submitted to three different temperatures (10, 15 and 20 ºC) and a constant photoperiod of 16 h light/8 h darkness. Some authors have previously reported higher temperatures for optimal germination of many alpine and arctic species around the world at higher altitudes. The aim of this study was to evaluate this general rule for alpine Mediterranean environments, and to elucidate the effect of other factors such as spatial and temporal short gradients on germination characteristics.

Positive Relationship between Seed Size and Pollen-ovule Ratio

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Seed size and Pollen/Ovule-ratio are two key features for the reproduction of seed plants. As many works have shown, seed size is important for dispersal, germination and establishment and is also associated with other plant traits such as plant height and growth form or leaf size. The P/O-ratio can be considered as an indicator for the efficiency of pollination in the way that plants with a high P/O-ratio and therefore a high number of pollen grains are more likely to perform a successful pollination. Charnov suggested that, basing on sex allocation theory in plants, P/O ratios should increase with increasing seed masses. Until today no work has investigated this suggestion on a species set across families. Therefore we tested this assumption for a wide range of species from the German flora, incorporating phylogenetic information. A positive relationship between seed mass and P/O ratio could clearly be found but varies between different families. Nevertheless the relationship does not seem to be "phylogenetically constrained".

Seed Dispersal, Germination and Seedling Establishment in Arctic Vegetation

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Arctic vegetation recovers very slowly after disturbance and for many arctic species seedlings are rare in the field. In 1991, a project on reestablishment of the vegetation was started making experimentally disturbed plots in Greenland. We revisited the plots in 2002 and recorded vegetation cover in the plots as well as distances to seed sources around the plots. These data are compared with data on seed germination, diaspore weight and morphology and with seed dispersal data from a seed trap experiment in the area. Also data on seedling emergence in the first three years after the disturbance are included in the comparison and the relative influence of seed dispersal, germination, and seedling establishment is analysed. The results are discussed focussing on the response of arctic species to climate change.

Applied Seed Ecology for Bauxite Mining Restoration in Western Australia

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Alcoa World Alumina Australia has been restoring bauxite mines in the jarrah (*Eucalyptus marginata*) forest of Western Australia for more than 35 years. Each year about 550 ha are mined and rehabilitated. The understorey of the jarrah forest is very species rich and one of the challenges has been to return the floristic richness through the restoration process. Plants can be established in restored areas from the returned topsoil, applied seed or from planted seedlings. A substantial research and development program over the last 25 years has led to significant advances in restoration techniques and major contributions to applied seed ecology. Advances in topsoil management to enhance establishment from the topsoil seed store include double stripping topsoil, handling topsoil in the dry summer, maximising return of fresh rather than stockpiled soil, spreading topsoil thinly, and the development of screening and fractionation techniques to concentrate the topsoil seed store. Advances relating to applied seed include documenting seed phenology, improving seed collection and storage techniques, and the breaking of seed dormancy. Significant seed ecology research has been undertaken relating to temperature, heat, smoke, gibberellic acid, seed scarification and multiple dormancy cues on a wide variety of species. This is a comprehensive example of seed ecology research being directly implemented in a large-scale mining operation to return a diverse Mediterranean forest ecosystem.

Genotypic and Phenotypic Differences in Primary Germination Dormancy and Seedling Drought Tolerance among Local Genotypes, and the Upper and Lower Caryopses in the Dispersal Units, of *Triticum dicoccoides* in Israel

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Triticum dicoccoides (wild emmer wheat) is a self-pollinating plant. The caryopses (grains) are enclosed in spikelets, which are the dispersal units that are distributed to short distances. Therefore, local genotypes have developed, even along one hill slope, according to the diverse environmental factors. Differences were found in the primary germination dormancy of genotypes originating from various locations in Israel. When dispersal units, that each contains two caryopses, were wetted, only the upper caryopses germinated. When caryopses were removed from their spikelets but were still enclosed in their hulls, the upper caryopses germinated to higher percentages than the lower. However when naked caryopses were germinated these differences in germination decreased and both types germinated to higher percentages, although the rate and percent of the upper caryopses were still higher in all the genotypes. The caryopses of the various genotypes and position plasticity, differed in their primary dormancy depth even though they were from parents that were grown at the same time and in the same place for 2 generations.

Seed Migration and Colonization in Experimental Populations of an Annual Myrmecochore

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A seed sowing experiment was conducted in mixed secondary woodland on acidic soils in NE Germany with *Melampyrum pratense*, an annual ant-dispersed forest herb which lacks a natural population in the study area, but is abundant in similar habitats. A set of 300 seeds was sown within one square metre at each of three sites in 1997, and the development of populations was recorded from 1998 until 2001. Additionally, seed fall patterns were studied in a natural population by means of adhesive cardboard. All trials resulted in the recruitment of populations, which survived and increased in both individual number and area throughout the tudy period. Total individual number increased from 105 to 3,390, and total population area from 2.07 to 109.04 m^2. Mean migration rate was 0.91 m per year, and the highest migration rate was 6.48 m, suggesting exclusive short-distance dispersal. As primary dispersal enables only distances of up to 0.25 m, ants are presumed to be the main dispersal vectors. Migration rates did not differ significantly between the experimental populations. They were significantly higher in the last year possibly due to an increased population size. Colonization patterns were characterized by a rapid, negative exponential decrease of population density with increasing distance from the sown plot, suggesting colonization by isolated outposts of individuals and a subsequent gradual infill of the gaps between. My results correspond to myrmecochorous dispersal and migration distances which were observed earlier in temperate woodlands. Therefore my data may serve to parametrize colonization models of *Melampyrum pratense* after accidental long-distance dispersal.

Seed Predation in *Taraxacum officinale*

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Before dispersal dandelion seed was mainly consumed by larvae of 2 beetle species, *Glocianus punctiger* (Curculionidae) and *Olibrus bicolor* (Phalacridae). Their abundance varied between sites and was not correlated. The larvae damaged up to 25% of seed by making scares or eating them partly. The damage was proportionate to cumulated numbers of both species. Most damaged was seed of plants flowering early and late, out of the main flowering period. Any damage decreased seed germinability, which fell to nearly zero when more than 1/3 of seed volume was eaten. After dispersal up to 2.0×10^4 seeds$\cdot$m^{-2} was deposited at the sites where flowering was massive. About 90 % of this seed disappeared within 5 weeks, mostly because of predation. Important invertebrate predators were beetle adults, *Amara montivaga* and *Harpalus luteicornis* (Carabidae). These species aggregated on dandelion patches after seed dispersal. Under laboratory conditions they were the top consumers of dandelion seed among adults of 26 carabid beetle species tested.

AFLP Analysis Reveals Seed Limitation in the Clonal Herb *Maianthemum bifolium*

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In fragmented forest landscapes a whole suite of forest plant species are confined to ancient forest patches. This phenomenon has been explained by i) the inability of the species to disperse its seeds across the landscape matrix (dispersal limitation) and ii) the inability of the species to recruit in recent forests due to competition with highly competitive species (recruitment limitation). Here we suggest that an additional mechanism (seed production limitation) may hamper the species colonization process. Using *Amplified Fragment Length Polymorphism* we studied the genetic structure of clonal populations of the obligate outcrosser *Maianthemum bifolium* in ancient forest patches in Belgium. Mantel tests and autocorrelation analysis confirmed that seed dispersal between forest patches was absent. We found that almost half of the genotypes in a typical population of *M. bifolium* belonged to the same clonal lineage. Both the relatively low remaining compatible genotypic diversity and the typical phalanx growth form reduce the chance that genotypes receive compatible pollen and successfully set seed. We suggest that extended periods of clonal growth have lead to outcompetition of locally less adapted genotypes and that seed production is severely reduced by the absence of sufficient compatible genotypes (so called *sexual extinction* of the species). Additionally, the accumulation of mutational load in the long lived genets (>100 yrs) may have negatively affected seed production.

The Best Treatment for Germination of *Dalbergia sisso* Seeds

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Dalbergia sisso is one of the most valuable Iranian native species and its natural distribution is found within the Irano-Touranian biome. Its capability including nitrogen-fixing ability, dry tolerance, medical usage and valuable wood made this species an important alternative for use in agroforestry, urban forestry and development of green space in Iran. Its natural stands has not suitable situation and its artificial planting by growing the seedlings in nursery is a must. The current method of nurseries in seedling production had not suitable efficiency due to low germination rate of the seeds. This research is trying to introduce suitable treatments for seeds of this species. Imbibing in cold water is the most current method for the seeds of this species. This treatment in durations of 0 (untreated seeds), 4, 6 and 8 days was applied. The results show moisture of seeds was 59%, weight of 1000 seeds was 31.593 gr. 43% of legumes had 1 seed, 39% of legumes had 2 seeds and 18% of legumes had 3 seeds. The germination percent was 5%, 9%, 22% and 39% respectively for 0 (untreated seeds), 4, 6 and 8 days treatment in cold water. In total the longer of imbibition in cold water the better results in seed germination.

The Effect of Stratification on Germination of *Cupressus arizonica* Seeds

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Forest areas cover only 7% of the Iranian surface. 12 million hectares of Iranian forest resources are unique ecosystems that their conservation is a must. Forest plantation is very common in Iran due to low forest cover. The Mediterranean areas cover considerable surface in Iran that *Cupressus arizonica* is one of the most important alternatives for plantation for rehabilitation of natural ecosystems and urban green space in these areas. Due to this case the study on its seeds for production of suitable seedlings in the nurseries is necessary. In this research physical characteristics and germination capacity of seeds of *Cupressus arizonica* were studied. Various treatments including cold stratification at 4 ^{o}C in wet sand for periods 2, 3, 4, 5 and 6 weeks long in four replication and 100 seeds per replication were performed and the process of seed germination was studied. The results show a seed humidity of 6.35%; weight of 100 seeds was 7.73 g and 1 kg of seeds was including 129349 seeds. The lowest amount of germination (35%) was observed in untreated seeds. The best germination level (46%) was observed after 6 weeks of cold-water stratification. The start of germination was 18 days for untreated seeds and 3 days for 6 weeks stratification.

Germination From Seed Banks Under Natural and Optimal Temperatures and Optimal or Varying Amounts of Irrigation in a Natural *Hammadetum* Habitat in the Negev Desert of Israel

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The seed banks and seedling emergence from loess soil samples from a natural *Hammadetum* in the central Negev were checked before the season with rains. We found 42 ± 5.4 seedlings/350 cm^2 that emerged from 0 to 10 mm deep natural top soil and crust but only 10.5± 1.9 from 10 to 20 mm deep soil under optimal amounts of water at natural temperatures, and 60 ± 7.5 at 15 °C in light. Seedling emergence was also checked in a natural desert habitat following an irrigation regime of 0, 25, 50, 100 or 150 mm of water in one day, or each amount of water divided into daily equal amounts over 9 days. Soil samples containing seeds were sieved and washed so that the seeds separated from the soil particles. The seeds of each species were identified and counted. The top soil contained the great majority of the seed bank as well as the greater number of seeds that were ready to germinate. The highest number of seedlings emerged at 15 °C. The higher the amounts of irrigation given over 9 days in the natural habitat, the greater were the number of seedlings that emerged, up to 50.3 ± 12.2 seedlings/350 cm^2.

Nitrous Oxide and its Effect on Metabolism of Recalcitrant Species

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The need to store recalcitrant seeds is still an unsolved issue. Atmospheric storage techniques could contribute in increasing length of storage. We hypothesized that nitrous oxide (N_2O) would reduce the metabolism of recalcitrant seeds, and ultimately expand their storage lifespan. Containers of white (*Q. alba*) and bur (*Q. macrocarpa*) oak seeds were placed under three different atmospheric treatments: air, 80/20% of nitrous oxide/oxygen (N_2O/O_2), and 98/2% (N_2O/O_2). Every two weeks a set of seeds was used to evaluate respiration (R), and moisture content (MC). Another set of seeds was placed in growth chambers to evaluate seedling performance (SP) by measuring root length (RL), root width (RW), and epicotyl length (EL). The results revealed an effect of species and time for all studied variables (R, MC, RL, RW, EL). Also, there was a treatment*time (trt*t) interaction for the R, RL, and EL. Analysis of each species indicated an effect of time for all studied variables for both species. For white oak there was a trt*t interaction for the MC, RL, RW, and EL with the overall mean decreasing as time progressed for the RL, RW, and EL. For bur oak, there was a trt*t interaction only for R. Our results suggest that N_2O seem to have an impact on the metabolism of the seeds as reflected by R and SP. However, caution should be taken on any interpretations due to the large effect of species and time.

The Effect of Seed Size and Parent Tree on Seedling Performance of Oak Species

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Oak regeneration is limited by environmental factors. Increased seed size should favor the initial period of seedling establishment and growth. We hypothesized that seedling performance would be associated with specific parent trees and seed sizes, with larger seeds performing better. Seeds of white (*Q. alba*) and bur (*Q. macrocarpa*) oak were separated based on their diameter into 1mm wide categories. For white oak, two parent trees gave three seed sizes (17 to 19 mm). For bur oak, two parent trees gave five "small" seed sizes (13 to 18 mm), while three parent trees gave five "larger" sizes (18 to 23 mm). After the first 4 weeks in a growth chamber, growth was determined by measuring the root width (RW), root length (RL), and epicotyl length (EL). Then, after seedlings were transplanted and grown under greenhouse conditions for 8 more weeks, leaf area (LA), and the dry weights of leaves (DWL) and stem (DWS) were measured. For seedlings growing in the growth chamber, seed size had an effect on RL, and EL for white oak, and RL and RW for "large" bur oak seeds, while parent tree had an effect on all measured variables. Under greenhouse conditions, bur oak seed size had an effect on the DWL, DWS, and LA. Parent tree also affected the DWS of "large" oak seeds, and the LA of white oak. Our results confirm that larger seed sizes give rise to more vigorous seedlings that could promote a more successful establishment.

Germination Characteristics of 15 Greek Endemic Taxa of Sterea Ellas

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Within the framework of the first author's PhD Thesis, entitled 'The biology of seeds of the endemic, rare and threatened plants of Sterea Ellas', the germination characteristics of 15 Greek endemic taxa were studied. Seeds of 12 taxa, namely *Silene holzmannii* Boiss., *Bupleurum capillare* Boiss. & Heldr., *Scorzonera crocifolia* Sibth. & Sm., *Cerastium candidissimum* Correns, *Campanula drabifolia* Sm., *Cephalaria flava* (Sibth & Sm.) Szabo subsp. *setulifera* (Boiss. & Heldr.) Kokkini, *Centaurea attica* Nyman subsp. *pentelica* (Hausskn.) Dostal, *Silene oligantha* Boiss. & Heldr. subsp. *parnesia* Greuter, *Silene spinescens* Sibth. & Sm., *Centaurea attica* Nyman subsp. *asperula* (Halacsy) Dostal, *Stachys spruneri* Boiss., *Bolanthus graecus* (Schreber) Barkoudah were found to be non-dormant. Their final germination percentage in the darkness exceeds 50%. Germination takes place in a range of relatively low temperatures (10-20 ºC) and is completed within a period of few days (T_{50}=1-8 d). Three taxa have dormant seeds. Alternating temperature and light conditions are effective for the dormant seeds of *Campanula celsii* A. DC. subsp. *celsii* and *Campanula celsii* A. DC. subsp. *parnesia* Phitos. Among several conditions tested in *Inula verbascifolia* (Willd.) Hausskn. subsp. *methanea* (Hausskn.) Tutin, only Red light pulses induced germination to about 30%.

The Chemical Composition of Soil Modifies Germination Capacity and Seedling Performance for Some Type of Alpine Species

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Species composition of a plant community partly reflects the chemical nature of bedrock and soil. Some authors point out the prominent role of physical constraints or competition in the determinism of community structure. Regeneration of severely disturbed communities like ski runs occurs in several stages. Because of failure of seed germination or seedling growth, recovery of vegetation is unpredictable. In this study we want to know to what extent the chemical nature of soil alters germination capacity and seedling growth of alpine plant species. We selected different plant functional types: (1)- early-successional vs mid-(late)-successional species to explore the chemical regeneration requirements, and (2)- seeded vs. natural species to explain the failure of revegetation in some plots. This study was conducted in growth chamber then in-situ for seedling experiment. We tested 3 substrates: gypsum, quartzite, and ophiolite. We measured germination time and rate, as well as aboveground seedling biomass and root specific surface. Firsts results show differences between species and functional group: some substrate delay seedling emergence or decrease germination rate of late successional species and revegetation species. Implications are important both for the determinism of community structure and for revegetation success.

Soil Seed Banks of Temperate Deciduous Forest

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In the late 1980s it was generally agreed that the species in the seed bank of temperate deciduous forest need canopy gaps for establishment. In the last 15 years the evidence accumulated for temperate forest deciduous forest has shown that some species in the seed bank do not require canopy gaps for establishment, but benefit from formation of gaps in the litter layer/or tree roots in the topsoil. Earlier work on seed banks did not explicitly contrast species with 'risk-spreading' and 'disturbance broken' dormancy. Recent work in temperate deciduous forest has provided evidence of the existence of considerable risk-spreading among some shade-tolerant herbaceous species. Another issue on which the ideas have evolved is the shape and size of the most species in the soil bank in northern temperate vegetation. Many ecologists have pointed out the strong correlation between light requirement for germination and longevity seeds in soil and there is general agreement that seed persistence is negatively correlated both with seed size and dispersal. Here I review each of these points in turn. The emphasis is on the result of my long-term study of the seed bank in the natural deciduous forest in the Białowieża National Park, but I put these results into global setting.

Variability of Seed Production of Herb Layer in the Course of the Secondary Succession Process

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A number of generative shoots, seeds number and mass of produced seeds of all species in herb layer on three patches A, B, C (3x100m^2), situated in consecutive phases of secondary succession were compared. Plots A represented the open area 2-3 years after clearing of the late successional pine forest. It was found that patch B showed the highest number of produced seeds (total number: 1042904/100 m^2, mean 41362,5±11848,9 per 4 m^2 plot) and the lowest variability in the number of seeds production (V=28%), on the contrary, the lowest mean number of seeds was observed in late successional forest (3235,5±1478,6/4m^2) with the highest variability V=46%.The number of species diminished from 34 species on patch A to 8 on species on patch C. The total seed mass produced in the herb layer was very similar in patch A and B (472,2; 473,2 g /100 m^2 respectively) and was distinctly lower in the late successional pine forest (only 56,39 g /100 m^2).

Influence of Cotyledon Removal on Early Growth of Containerised *Quercus suber* L. Seedlings

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The effect of cotyledon excision on growth and nitrogen transfer from cotyledons to the plant was studied in *Quercus suber* L. seedlings grown in the nursery for six months. Cotyledons were removed at plumular emergence (d0) and at days 15, 45, 90 and 180. Nitrogen content in the excised cotyledons was determined. Seedling growth was monitored by shoot height measurements 10 days after cotyledon excision and at 15 days interval afterwards. Shoot and root dry weight and leaf content was determined at harvest. Cotyledon removal after shoot emergence (d0, d15) resulted in a significant reduction in shoot growth, though the influence of cotyledons on seedling growth declined with time. The excision had no effect when it was performed later than d45. At the end of the experiment the cotyledon removal had no effect on shoot height or on dry weight. Nitrogen content in excised cotyledons decreased through the experiment to a minimum threshold reached at d90. Nitrogen concentration in excised cotyledons was also affected by the moment of cotyledon removal, though with a lower rate of decrease. The lowest content of nitrogen in leaves was shown in seedlings which cotyledons were removed just after emergence (d0).

The Effects of Fire Heat on the Germination from the Seed Bank of a Coastal Prairie

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In temperate grasslands the effects of fire on the seed germination has been studied seldom. This paper presents results on the composition of a seed bank of a North American coastal prairie. The samples were collected in spring 2000 with a corer 5.5 cm in diameter in Texas, USA (50 samples, 4 replica at each site). Samples were divided according to depth: 0-2.5 cm, 2.5-5 cm and 5-10 cm. Fire effect was studied by mimicking it with two heat treatments [soil with seeds was incubated 15 min at 80^{o}C (H1) and 25 min at 100^{o}C (H2); thirdly there was a control (C)]. Samples were put to germinate in a greenhouse immediately after the treatments and were germinated for 4 months until the seedlings were removed and then germinated for another 2 months. The numbers of germinating seeds decreased with increasing depth. In the upper samples (>5 cm) the number of germinating seeds decreased with increasing heat, but in lower samples (5-10 cm) the most seeds germinated from the milder heat treatment (H1) and the least from the stronger heat treatment (H2). Altogether 3099 seeds germi-ated and 60 taxa were identified. Almost 70% of the seedlings in the lower samples were monocots, but in upper samples there were almost the same amounts of mono- and dicots (52.6% and 47.4%). In these grasslands fire does not only kill the seeds, but enhances flowering, seed production and germination due to increased light levels.

Germination and Afterripening in the Annuals *Conyza bonariensis* and *Conyza canadensis* (Asteraceae)

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Germination preferences and afterripening were used to compare two widespread *Conyza* species; *C. bonariensis* collected in Ethiopia, Mexico and Morocco, and *C. canadensis* from three sites in Sweden. Germination tests were performed with fresh achenes and after dry storage for one year. In fresh achenes there were high germination percentages in light but low in darkness. Temperatures favouring germination differed between species; only *C. bonariensis* germinated at low temperature. There was an afterripening effect, manifested by an increased germination in darkness, in both species. *Conyza bonariensis*, which occurs in tropical to warm temperate regions, did not germinate in darkness at warm temperatures, but to a high degree at intermediate and low temperatures. *Conyza canadensis*, which occurs in cold to warm temperate regions, did germinate to some degree in darkness at warm and intermediate temperatures, but not at low temperatures. The detected difference in species' responses to temperature suggests differences in timing of emergence in cold temperate areas. There, *C. canadensis* achenes would postpone germination during autumn and produce seedlings the following spring. In contrast, *C. bonariensis* would germinate directly after dispersal, even late in autumn.

Evolution of Smoke-Stimulated Germination

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Deeply dormant seed banks are prevalent in Mediterranean-climate ecosystems. Dormancy is broken immediately after fire and there are two general germination syndromes represented. Species that germinate in response to heat shock and ones that germinate in response to chemicals from combustion of organic matter, e.g., charred wood or smoke. Uncommonly there are a few species, e.g., the Californian *Adenostoma fasciculatum*, in which dormancy can be broken completely by either heat or smoke. In general there is a strong phylogenetic component to being either heat-stimulated or smoke-stimulated and it is hypothesized that this is tied to evolutionarily conservative traits associated with seed coat structure. There are many unanswered questions concerning this phenomenon. Some have argued that because species in other non-fire prone ecosystems have dormant seeds that can be triggered by smoke that this signal can not be adaptive. We hypothesize that this argument stems from a weak understanding of the active chemical components in smoke. In some California chaparral species this signal is highly oxidized nitrogenous compounds, a signal that could be selected for in other ecosystems. There is also evidence that the chemical signal in smoke may be different between species. Thus, model systems with species from non-fire prone ecosystems may tell us relatively little about the variety of germination mechanisms in these species.

Effects of Different Stockpiling Procedures on Topsoil for Open Cut Coal Mine Rehabilitation in the Hunter Valley, Australia

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The most common rehabilitation objective of open cut coal mines in the Hunter Valley, Australia is to return mined land to pasture ecosystems for low intensity cattle grazing, as existed prior to mining. Topsoil management is often the most important factor in determining the success of rehabilitated areas. While it is generally accepted that topsoil should be stored in small stockpiles for as short a period of time as possible, no recent studies have directly assessed the effect of height and age of stockpiles on soil quality in this area. A field trial was established at three mines in the Hunter with stockpiles of 2, 4 and 6 m heights created and sampled periodically over 30 months. Biological analyses showed that a significant amount of deterioration in soil quality was recorded immediately after stockpile establishment with soil quality always lower than the original 'undisturbed' condition. As stockpiles aged, most mines showed species richness and plant numbers declining by 12 months, indicating storage time affects seed viability of buried seeds. For height, higher levels of species richness were found at the 2 and 4 m stockpiles, while plant numbers decreased with depth, indicating higher seed mortality as depth increased. This is an example of topsoil research being implemented in a large-scale field trial to return an effective pasture ecosystem.

Plant Hormones in Tomato Seed Germination under High Temperature Conditions

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Tomato seed germination (*Lycopersicon esculentum* Mill. cv. New Yorker) is completely inhibited under high temperature (35 ºC). This inability of seeds to germinate at supraoptimal temperatures, called thermoinhibition, was partially restored by exogenously applied gibberellins (GA_{4+7}) alone or in combination with ACC or ethephon. The latter compounds used alone were not able to induce germination at 35 ºC. Thermoinhibition of seeds at 35 ºC was also partially restored by fluridone, an inhibitor of ABA biosynthesis known as the stress hormone. Since fluridone incompletely (70%) overcame tomato seed thermoinhibition it was interested to check if the inhibition of jasmonate biosynthesis, other stress hormones, can also induce germination of seeds at the same temperature. Ibuprofen, indoprofen, antypiryne and salicylic acid, the inhibitors of jasmonates biosynthetic pathway, did not remove this thermoinhibition. Matriconditioning with Micro Cel-E did not reverse thermoinhibition, but its beneficial effect appeared when seeds were germinated after priming in the presence of fluridone. Jasmonates biosynthetic inhibitors did not affect germination of matriconditioned seeds at 35 ºC
The results of the study suggest that gibberellins and ABA but not jasmonates regulate tomato seed germination at supraoptimal temperatures.

What Drives Recolonization Patterns of *Carex* spp. in Hydrologically Restored Prairie Wetlands – The Role of Seed Arrival and Seed Germination

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Recolonization of plants after disturbance is driven by processes at both the landscape (like seed dispersal) and site levels (including seed germination). In the prairie region of the U.S., thousands of wetlands have been hydrologically restored with no effort placed on revegetation. In these naturally recolonizing wetlands the characteristic *Carex* spp. (sedges) are generally absent. We investigated whether sedge recolonization is driven by seed arrival or germination limitations. We placed seed traps in restored and natural wetlands to investigate seed arrival of sedges. We conducted field germination trials in restored vs. natural wetlands to determine whether sedges are germination limited in restorations. In the germination experiment, we found germination rates in restorations were as high as 50% while in natural wetlands rates were rarely higher than 1%. In the seed arrival study, we found that sedge seed arrival is a very rare occurrence. Findings from these studies indicate that seed arrival limitations are what drives recolonization of sedges post-restoration in the highly fragmented prairie landscape. To achieve the diversity characteristic of natural wetlands, seed arrival limitations will have to be overcome through management activities like seeding or planting.

Similarity between Seed-bank and Ensuing Vegetation is Productivity Dependent in a Semi-arid Mediterranean Annual Plant Community

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Variation in similarity between seed bank and ensuing vegetation along a productivity gradient was analyzed in a semiarid Mediterranean annual plant community. Species composition and density of seed bank and vegetation were compared during three years in grazed and ungrazed plots, in four neighboring topographic sites differing in vegetation, physical characteristics and soil resources. Seed bank was sampled in autumn, just before onset of the rainy season. Vegetation was sampled in spring, at peak aboveground biomass.

Quantitative similarity varied between 0.14 and 0.61 (Sorenson's quantitative index). Both productivity and similarity were affected by year and site conditions. The relationship between quantitative similarity and productivity was unimodal, with higher similarity (0.5-0.6) at intermediate productivity (150-250 gm^{-2}), and decreasing similarity towards both lower and higher productivity. Grazing exclusion hardly affected seed bank-vegetation similarity along the productivity gradient. It is proposed that at low productivity (<200 gm^{-2}) germination and plant survival are limited by soil resource availability, mainly water. Increasing soil resources within this productivity range probably increase germination and survival and, consequently, enhance the quantitative similarity between the seed bank and vegetation. At higher productivity (>200 gm^{-2}), denser surface cover and stronger competition for light may inhibit germination and reduce plant survival, thus diminishing quantitative similarity.

Germination and Emergence of *Bromus sterilis* Seeds

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Seed germination was studied in the weed species *Bromus sterilis* in laboratory conditions within the range of temperatures 0, 5, 10, 15, 20 and 30 ºC. Germination was examined in climate chambers under controlled conditions. The highest germination rate of 99% was proved at temperatures of 25 ºC. The respective germination rates at temperatures of 5 and 0 ºC were 77 and 0.5%. Germination energy was investigated in the months of July, August and September in 2001, 2002 and 2003. The fastest germination was observed in September, lower germination energy was determined in August and germination energy in July was the lowest. The emergence of *Bromus sterilis* seeds was examined in climate chambers. Seeds were planted into these depths: soil surface, 0.5, 1, 2, 4, 6 and 8 cm. Plants were grown at temperatures of 22 ºC in light and 16 ºC in dark. The photoperiod and dark were 12 h, respectively. The respective emergence rates from the depth of 0.5, 1, 2, 4, 6 and 8 cm were 94, 95, 96, 91, 25 and 14%. The emergence rate from the soil surface amounted to 35%.

Dispersal and Local Conditions Limit Plants to Acacia Canopies in the Kalahari

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In Kalahari savanna a set of fleshy-fruited perennials and annual plants is associated with *Acacia erioloba* canopies. To determine the causes for this pattern, field and laboratory experiments were carried out. Seed rain of fleshy fruited perennials was practically limited to sub-canopy areas. Annual canopy species were found in the seed bank outside the canopy (matrix) as well as under the canopy, whereas seeds of fleshy-fruited species were found only under the canopy at minimal densities. Sod transplant and sowing experiments confirmed that annual species were able to germinate and establish in open areas. Fleshy-fruited perennials, however, did not emerge outside canopies. In laboratory experiments we found that, compared with matrix perennials, fleshy fruited species showed strongly reduced germination at high daily temperature fluctuations and low moisture levels. Annual canopy species showed no differences with matrix annuals in germination at simulated matrix conditions. However, they had longer induction times than open area annuals. It is concluded that annuals are limited by local conditions whereas perennials are limited by both dispersal and conditions.

Seed Ecophysiology in Plants of Crete – the Role of Temperature and Light

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Germination mechanisms and adaptations towards temperature and light were investigated in 5 plants of Crete (4 of them endemic to the island). *Ebenus cretica* (Leguminosae) is a small shrub endemic to Crete, which, strangely but consistently produces 'soft' seeds. Germination of isolated seeds is both light indifferent and notably fast. However, in the field, seeds are dispersed within the persistent calyces and germinate within them; the rate of germination within the dispersal unit shows a considerable delay, similarly to the typical germination rate of Meditteranean plants. The tiny seeds of *Petromarula pinnata* (Campanulaceae), an endemic plant of Crete, are significantly induced by light although some germination is also manifested in darkness at 15 °C. A similar germination behaviour is shown by the seeds of *Verbascum spinosum* (Scrophulariaceae), also an endemic plant of Crete,. In addition, a prolonged imbibition in darkness imposes a secondary dormancy. On the other hand, the seeds of *Verbascum arsturus* (Scrophulariaceae, a Cretan endemic as well). show an absolute germination requirement for light (shown to be under phytochrome control) while darkness imposes skotodormancy as in the previous species. Finally, a similar, absolute light requirement is demonstrated by the seeds of *Satureja thymbra* (Labiatae), a common, east Mediterranean plant.

Short- and Long-distance Seed Dispersal in a Metapopulation of *Banksia hookeriana* (Proteaceae)

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We assess here short- and long-distance seed dispersal in *Banksia hookeriana*, a fire-killed serotinous shrub restricted to sandy dune crests in fire-prone shrublands of the Eneabba sandplain in SW Australia. Short distance seed dispersal was assessed by moving 11 seed-bearing plants to a newly burnt location, torching cones to stimulate the release of seeds and subsequently monitoring the distance of seedlings from source plants. For 337 seedlings, 50% occurred within 5 m from the source plant, 87% within 15 m, up to a maximum distance detected of 36 m. Long distance inter-population seed dispersal was assessed indirectly from population genetic data for 221 individuals sampled from 21 adjacent dune-crest populations using amplified fragment length polymorphism (AFLP). A log-likelihood population allocation test (AFLPOP) assigned 177 of 221 (80.1%) individuals to a single population. Of these, 171 (77.4% of total) were assigned to the population from which they were sampled and six (2.7% of total) were assigned to a known population other than from which they were sampled. A further nine (4.1% of total) were assigned to outside of the sampled metapopulation area, and 35 individuals (15.8%) could not be unambiguously assigned to any particular population. These results suggest that both the extent (15 of 221 (6.8%) individuals originating from a population other than the one in which they occur) and distance (1.6 km to > 2.5 km), of seed dispersal between dune-crest populations is greater than expected from direct observations of seed dispersal.

Post-Dispersal Seed Removal of Hazel (*Corylus avellana* L.) in Grassland

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Scatter hoarding rodents and birds are predators as well as dispersers of Hazel seeds; these animals are particularly responsible for the great success of Hazel in the colonization of grasslands. By burying the seeds beneath the grassland turf they avoid other granivores, placing the seed in a highly favourable habitat for establishment, if not recovered. In this study seeds of Hazel were buried (2-3 cm depth) in a calcareous grassland (Cressbrook Dale, Derbyshire, UK) at two distances from scrub vegetation (main habitat of predators and source of nuts), assessing if the rate and intensity of removal differed between sites 'far' away (>60 m) from those 'close' (<10 m) to the scrub edge, during three years. Rate and intensity of removal varied between sites and years, being faster and more intense always at sites close to the scrub edge, than at sites far away from it. During two of the studied years more than 95% of seeds buried close to the scrub were removed in less than a week, reaching total removal in less than a month. At 'close' sites lowest removal was 84%, whereas for the same year removal at 'far' sites was only 30% of buried seeds. Nevertheless, even when buried 60 m away from scrub vegetation, post dispersal removal in grassland surpassed 80% during the other two years. Repercussion of results on secondary succession as well as on the supposed benefits of scatter hoarding hazel nuts in grasslands, are discussed.

Environmental Maternal Effects on Seed Morphology and Germination Features in *Sinapis arvensis* under Controlled Field Conditions

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This study analyses the effect of the morphological features and environment of the mother plant on several seed characteristics, such as seed size, colour and germination response. The study was carried out with *Sinapis arvensis* plants that had grown in four experimentally manipulated resource availability scenarios: addition of 1) nitrogen, 2) water, 3) nitrogen and water simultaneously, and 4) control (five replicates and four mother plants each, i.e. 80 plants). Plants grew immersed in the corresponding community. Nitrogen addition caused an increase in plant height, but not in seed weight, probably due to the *Sinapis arvensis* phenotypic plasticity. The interaction between nitrogen and water addition decreased mean seed weight, caused by harsher resource competition conditions in quadrates with addition of both resources. Nitrogen in the maternal environment caused induction of dormancy and thus, a decrease in germination rate. Water addition in the maternal environment caused a decrease in germination percentage and germination rate. The transmission mechanism probably deals with the effect of irrigation on changes in hormone or enzyme activity. The greater dormancy of black seeds observed may be mechanically induced by their thick covering, and higher germination of red seeds may be due to the higher seed concentrations of GA_3.

Establishment of Woody Species by Hydro-seeding in Roadcut Slopes

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Six hydro-seeding treatments were applied at two ecological zones of Egnatia Highway (high and low) in two seasons (autumn 2001 and spring 2002): a) woody species with fertilisers and cellulose, b) woody species and cover with juta net, c) woody species mixed with herbaceous species, d) woody species mixed with herbaceous species and cover with juta net, e) woody species and cover with straw and f) woody species, cover with juta net and straw. The highest vegetation cover was found in the treatment with pure woody species covered with juta net and straw in both seasons and ecological zones. Only three species were successful established at the high zone namely *Nerium oleander, Spartium junceum* and *Colutea arborescens* while at the low zone the successful ones were *Spartium junceum, Colutea arborescens, Coronilla emeroides, Pistacia terebinthus, Cistus incanus* and *Medicago arborea*. The presence of juta net and straw increased the density of established woody species in autumn seeding while in spring seeding the density of woody plants increased by cover of juta net.

Long-distance Epizoochorous Dispersal by Transhumant Sheep

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Little is known about the significance of traditional movements of livestock for the dispersal of seeds at long distances, and especially so for epizoochory. Seed persistence on fleece and potential ability of Spanish transhumant sheep to disperse them was measured. Marked seeds of four species with different external structure (*Trifolium angustifolium*, *Hordeum murinum*, *Daucus carota* and *Plantago lagopus*) were put on five castrated rams and their loss was quantified during 1 month by counting the remnant seeds at every sampling. The flock covered a total distance of about 400 km in this time. In the first hours, a major loss of seeds is observed (only 36% remaining in the first 2.5 h). This initial loss is followed by a slower loss phase (13% remaining after 1 week) and a more stabilized phase (8% remaining after 1 month). *T. angustifolium* (22% remaining after 1 month) showed the highest adherence, while *P. lagopus* (1% remaining) showed the lowest. Data point out the possible importance of sheep displacement for long distance seed dispersal until recently and their potential effects on vegetation on a large scale.

Seed Dormancy and Germination Strategies of Glacier Foreland Species

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How can plants colonize a harsh and changing habitat such as the glacier foreland? There are different ways: by seeds or by clonal propagation or by a mix of the two. Both strategies are poorly understood in this environment. Regarding colonization by seeds, germination ability is one of the most important steps for plants involved connected with seed longevity in the soil and seed dormancy.
Germination tests of 21 species were carried out. The seeds were collected during summer 2002 on the three main moraine stages (1858, 1923, 1971) of the Rotmoos glacier foreland (Ötztal, Tyrol, Austria). 5 replications of 100 seeds for each species from each moraine age were stratified for 100 days in darkness at 4 °C. Germination was analysed for 100 days in the growth chamber (16 h light, 25 °C; 8h dark, 10 °C; 60% humidity). Twice a week new seedlings were counted. Four categories of germination types were observed: germination rate <1% for seeds with a hard seed-coat, immediate germination mainly for pioneer species collected on the younger moraine, germination after 30 days and germination after 60 days for species with deep seed dormancy.

Seed Longevity and Influence of Depth in the Germination Ability of the Invasive Species *Acacia longifolia* Seeds in Dune Ecosystems. Preliminary Results

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Biological invasions represent an important threat to the Earth's biodiversity, contributing to the loss of native vegetation. In the Portuguese dunes, exotic species such as *Acacia* spp. became invasive, representing nowadays an environmental problem of increasing proportions. Several *Acacia* species success is partially due to the abundant seed production, with high longevity in the soil. Successful results of control measures in invaded areas depend not only on the efficiency of the applied method, but also on the availability of invasive species in the seed bank. The present work aims to evaluate the viability of *A. longifolia* (Andrews) Willd. seed bank. Ripe seeds were collected from dehiscent pods and sub-samples were sown inside bags at different depths and collected after 4, 9 and 18 months to evaluate germination and viability. First results show that a relatively high number of seeds were not recovered from the buried bags. Opposed to other studies, *A. longifolia* seeds do not show high germination rates but mean values between 10 and 30%. Nevertheless, after stimulated by scarification very high percentages of seeds were still viable with values close to 100%. The effect of the time of burial was not evident until now, but the experiment will be running 4 more years.

Evaluation of the Seed Bank Composition by Seedling Emergence Approach in Areas Invaded by *Acacia Longifolia* (Andrews) Willd.

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Many natural and semi-natural areas are being invaded by exotic plant species, process that is leading to the degradation of many ecosystems in the world. In the Portuguese dunes ecosystems *Acacia* spp. became invasive, representing an environmental problem of increasing proportions. The Natural Reserve of S. Jacinto Dunes was selected for this study due to its high conservation value. Successful rehabilitation of natural habitats, including re-establishment of native species depends not only on abiotic conditions, but also on the availability of seeds. The present work aims to evaluate composition of the soil seed bank in invaded *versus* non-invaded areas. *A. longifolia* long invaded and recently invaded areas were selected, the invasive species removed and different treatments applied. Control plots were installed in areas with native vegetation. Soil samples were collected to test soil seed bank availability using the seedling emergence approach. The results indicate that species richness is higher in recently invaded areas, particularly in areas where litter was maintained. Control plots have a slightly lower number of species, but some of the perennial only appearing in them. *A. longifolia* seedlings are more frequent in long invaded areas, particularly in those with litter.

Ex situ Conservation of Endemic Plants in Crete

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The *ex situ* conservation of the endemic and threatened plants of Crete is the primary mission of the Seed Bank at the Mediterranean Agronomic Institute of Chania. At the present study information is given for 17 endemic *taxa* of the flora of Crete concerning: seed weight, storage behaviour, dormancy types and dormancy release treatments, temperature requirements of germination and rate of germination.
The endemic *taxa* studied are: *Cerastium scaposum* Boiss. & Heldr, *Dianthus juniperinus* Smith subsp. *bauhinorun* (Greuter) Turland , *Ebenus cretica* L., *Erysimum creticum Boiss. & Heldr., Erysimum raulinii* Boiss., *Inula pseudolimonella* (Rech. fil.) Rech.fil., *Limonium cornarianum* Kypriot. & Artel., *Origanum microphyllum* (Benth.) Vogel, *Petrorhagia candica* P.W. Ball & Heywood, *Petrorhagia dianthoides* (Sibth. & Sm.) P.W. Ball & Heywood, *Satureja cretica* (L.) Briq., *Satureja candica* Greuter & Burdet, *Securigera globosa* (Lam.) Lassen, *Sideritis syriaca* L. subsp. *syriaca, Silene antri-jovis* Greuter & Burdet, *Staechelina petiolata* (L.) Hilliard & B.L. Burtt., *Verbascum spinosum* L.

Germination Ecology of Autumnal Mediterranean Geophytes

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The ecophysiology of seed germination was investigated in five representative autumnal geophytes belonging to two major Mediterranean families: Amaryllidaceae (*Leucojum autumnale*, *Narcissus cavanillesii* and *N. serotinus*) and Liliaceae (*Scilla autumnalis*, *Urginea maritima*). Experiments were performed in the dark and under temperature and light conditions simulating the Mediterranean climate, i.e., temperatures of 15, 20, 25 and 15/25 ºC with 16/8 h daily photoperiod. Seeds from the autumn of 2003 and from 18-months storage at room conditions were used. Different populations of the same species were used. At the end of each experiment non-germinated seeds were checked for viability. In this study the following aspects were examined: 1) temperature range and rate of germination; 2) the effect of light on germination; 3) dormancy status of the seeds; 4) seed viability between two following years; 5) germination behaviour among different populations of the same species. The present experiments show different geophyte strategies associated with autumn/winter seed dispersion, germination and establishment, in the Mediterranean climate.

Seed Age and Germination of Barnyardgrass, *Echinochloa crus-galli*

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Germination at 5 temperatures between 17-35 °C was investigated in 1-year and 8-year old seed materials of barnyardgrass each of which was divided into a part stored dry at 25 °C (afterripening) and a part buried in the field (stratification). The afterripened seed lost dormancy within 2 years after dispersal, buried seed passed through annual dormancy/non-dormancy cycles. Germination percentage and rate in 8-year afterripened, 1-year stratified and 8-year stratified seed materials varied with temperature. Optimum temperatures were 27–30 °C and the range of convenient temperatures increased with seed age, a common base temperature was 11.7 °C. In 1-year afterripened material <5% seed germinated at all temperatures with similar germination rate. Base temperature therefore was 1.1 °C. Thus a small proportion of seed could germinate shortly after dispersal, at a wide range of temperatures. Winter stratification removed dormancy but narrowed the range of temperatures convenient for germination. This constraint on optimum germination temperature gradually ceased with increasing seed age.

Distinctive Features of Fruits and Seeds of Typical Representatives of the Family Compositae in the Mediterranean Floristic Region

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Representatives of Mediterranean flora are distinguished by distinctive features according to seeds and fruits' structure in taxonomic groups of family Compositae. It becomes apparent in Cardueae Cass. and Lactuceae Cass. tribes. Data of research of some genera and species are given below. Strong development of a palisade sclerenchyma cells' layer is a peculiar feature of seed rind in Cardueae tribe. 2 cells' layers of a palisade sclerenchyma are typical of monotype genus *Notobasis* Cass. (*N. syriaca* (L.) Cass.). Disappearance of the palisade sclerenchyma cells is observed in *Carthamus tinctorius* L. There is a gummified layer as in *Bidens* (tribe Heliantheae Cass.) in the pericarp of *Carthamus lanatus* L. that is beyond the bounds of typical Cardueae tribe features. Genus *Scolymus* L. is a carpological phenomenon of the Mediterranean floristic region. Genus *Scolymus* is distinguished by original anatomical-and-morphological structure of fruits and cannot be joined any of Compositae family tribes. Usually this genus is applied to Lactuceae tribe. But mesocarpic mechanical tissue and specialized structures (hydrocytes, slimy cells) typical of Lactuceae are absent in achenes' covers structure of genus *Scolymus*. Macromorphological features of this genus are also significant: a conic receptacle (a flat one is typical of the Lactuceae), leathery – cartilaginoid bracts.

Tolerance to Freezing Temperatures in Seeds of *Caesalpinia echinata* Lam. (Brazilwood), a Tropical Woody Species from the Brazilian Atlantic Rain Forest

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Caesalpinia echinata Lam. (brazilwood, pernambuco), a Brazilian tropical woody species, is at risk of extinction due to the economic exploitation of its heartwood. In the past, this species was extensively used as source as dyestuff. Nowadays, its heartwood is utilized for the manufacture of high-quality bows of stringed instruments. In natural environment, under warm temperatures, seeds of *C. echinata* germinate immediately after shedding, keeping their viability only up to 3 months after harvesting. These seeds are tolerant to desiccation (until 7.6% wet basis) maintaining their viability (more than 80%) until 18 months when stored at 7 ºC, but the final percentage of seedlings produced from those seeds is lower than 25%. We analysed the effect of freezing temperatures on the storability of *C. echinata* seeds, aiming to increase the period in which seeds are capable to produce vigorous seedlings. Our results showed that *C. echinata*, in spite of being a tropical species, has seeds tolerant to freezing, germinating 93% after 12 months of storage under –25 ºC and producing 80% of vigorous seedlings. These data add new information to the seed physiology of *C. echinata* and can be useful to improve seedling production and for germoplasm conservation of this important species native from the Brazilian Atlantic Forest.

Ecotypic Variation within *Malva parviflora* (Small-flowered Mallow) Populations in the South-west Agricultural Region of Western Australia

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In Australia, little is known about the ecology or biology of small-flowered mallow, *Malva parviflora*, which exists as a weed of wasteland, crops and pastures. Small-flowered mallow can be difficult to control chemically and changing farming practices, such as minimum tillage have facilitated its spread. A common garden experiment was undertaken to observe phenotypic differences between populations collected across the south-west agricultural region of Western Australia. It was determined that due to the inbreeding nature of small-flowered mallow, there was little genetic variation between populations. However, cluster analysis revealed that Northern populations flowered earlier and had heavier seeds than Southern populations. Further studies were undertaken to explore the variation in seed dormancy strategies of environmentally contrasting populations. Optimal breakdown of the physical dormancy occurred under diurnal fluctuating temperatures, such as those experienced over summer, rather than constant temperatures. It was found that populations in low rainfall areas had fewer dormant seeds than high rainfall areas, regardless of latitude.

Germination and Emergence of *Cirsium arvense* Seeds

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Experiments were conducted to study the number of flower heads per stem and seed number per flower head. It resulted from the evaluation that the number of flower heads ranged from minimum number of 6 heads to maximum number of 66 heads per 1 stem. The number was determined from 100 stems. The determination of seed number per flower head indicated the ratio of mature to immature and parasitised achenes 1.2:1. Maximum number of ripe seeds per flower head ranged from 4 to 65. Average germination rate of seeds at a temperature of 18 ºC was 29%. Emergence was investigated in climate chambers. Seeds were planted onto the soil surface and into the depth of 1, 2, 4, 6 and 10 cm. Plants were grown at temperatures of 22 ºC in the light and 16 ºC in the dark. The photoperiod and darkness were both 12 h each. The respective emergence percentages for soil surface and for the depths of 1, 2 and 6 cm were 10, 40, 33 and 10% while seeds planted into a depth of 10 cm did not emerge at all. Vegetative reproduction occurred in 45-day-old seedlings.

The Seed Size Synthesis: a Review of the Ecological Correlates of Seed Size

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I will review the correlations between seed mass and traits such as dispersal syndrome, persistence in the soil, genome size and plant height. I will then describe geographic patterns in seed mass strategies at a global scale, and discuss the environmental variables most likely to underlie these patterns. Next, I will summarize the relationships between seed size and survival through each of the hazards plants experience between seed production and plant maturity: pre-dispersal seed predation, post-dispersal seed predation, survival in the soil to germination, survival through germination and seedling establishment, and survival to adulthood, and the relationship between seed mass and seed production. This summary reveals important shortcomings in our previous understanding of a species' seed size as the result of a trade-off between producing many small seeds, each with a low probability of establishment, or a few large seeds, each with a high probability of establishment. I will finish by describing how a body of theory originally developed for understanding vertebrate life histories might provide a useful framework for understanding the ecology of seed size.

Fruit Position Effects on the Fruit Weight and Germination in *Heracleum mantegazzianum*

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Within the EU 5 Framework Project, reproductive ecology of *Heracleum mantegazzianum* (Apiaceae), a Caucasian species invasive in Europe, was studied in the Slavkovský les Protected Landscape Area, Czech Republic. Eight plants were sampled in each of 7 study sites dominated by this species. Six fruit positions were distinguished according to the umbel position on the plant and fruit position within the umbel. Flowering pattern was followed in each plant in 3 - day intervals. The effect of flower position as well as fruit position and time of flowering on germination (final germination percentage and germination velocity) and fruit weight were analysed. Final germination percentages did not differ with respect to positions. Terminal umbels were most fecund and produced heaviest fruits that matured first and germinated most rapidly. The results were related to the characteristics of individual plants (size, age) and site characteristics (altitude, nutrients).

Effect of the Seed Storage Period in Germoplasm Bank and the Growth Medium on the Germination of *Iberis carnosa* Willd. subsp. *granatensis* (Boiss. y Reut) Moreno

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The interest, due to its ornamental potential, on the commercial production of *Iberis carnosa* subsp. *granatensis* explains the conduction of germination trials to determine the incidence of two factors: the storage of seeds in a germoplasm bank and the growth medium used in the nursery. The seeds used in this experiments were collected from wild populations located in SE Spain. In order to know the effect of storage on the viability of seeds, the following materials were used: (1) seeds with no previous storage, (2) seeds with 58 weeks storage, (3) seeds with 168 weeks storage and (4) seed with 252 weeks storage. The following treatments were adopted to determine the effect of the growth medium factor: (1) sowing in commercial plug trays with blonde peat, (2) the same but using coir as substrate, (3) sowing in petri dishes, (4) sowing in petri dishes with blonde peat, and (5) in petri dishes with coir. All trials were conducted in a greenhouse with climate control. No loss of germination power was detected for any of the considered storage periods. The final results, between 74-86%, did not show significant differences in relation to the final percentage of germinated seeds in the different growth media.

Reproductive and Genetic Characteristics of Small, Disjunct Pitch Pine Populations at the Northern Limits of its Range in Canada

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Pitch pine, *Pinus rigida* Mill, is a rare species in Canada where it reaches the northern limits of its range along the Canada-U.S.A. border. Reproductive and genetic characteristics of this geographically disjunct population were investigated to develop a foundation for its management and restoration. Seed yield and quality traits appear to be comparable to pitch pine at the center of its geographic range. Most of the variation in seed and seedling growth traits was attributable to differences among trees within stands and among stands within populations, with a non-significant population effect. High levels of variation among different stands in reproductive traits indicate that stand structure (e.g., stand size and tree density within stands) may play an important role in pollination environment and overall reproductive success. Cone and seed traits showed evidence of genetic drift. Nevertheless, these small, isolated stands have maintained relatively high levels of genetic diversity, suggesting that they may be the declining remnants of a much wider distribution during warmer climates of the present interglacial period, rather than an advancing population expanding its range northwards.

Estimating the Distance, Direction and Quantity of Seed Dispersal by Animals

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Animals are potentially important long distance seed dispersal vectors, but this is still poorly quantified and apparently more complex than seed dispersal by wind. Using experimental feeding of seeds to fallow deer, a survey of deer, cattle, horse and sheep dung, experimental tests of seed attachment and detachment on sheep and cattle skin, in combination with modelling techniques, we aimed to estimate the quantity of seeds dispersed inside and on animals, the distance and direction of dispersal. We present ecological correlates of seed survival in herbivore guts, dung seed density, seed intake, seed attachment and detachment. Free-ranging large herbivores disperse, through their alimentary tract, more seeds from nutrient rich habitat to nutrient poor habitat than vice versa. Seed dispersal on animals having a smooth fleece, such as cattle and deer, is more selective, involves fewer seeds of fewer species, and takes place over shorter distances, than seed dispersal on animals having curly wool, such as sheep. Finally, consequences of seed dispersal by animals, between different habitats and towards ecological restoration sites, are discussed.

Fruit Position and Fruit-set Order Affect Seed Production and Germinability in Muskmelon

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Domestication of wild plants for agricultural purposes was always accompanied by selection against variability. Muskmelon is a main horticultural crop grown all around the world. The present study aim was to evaluate the effects of fruit position and timing of fruit-set on the variability of seed yield production and germination. Field experiments were conducted during two growing seasons, using the open-pollinated cultivar Noy Yizre'el. Plants were allowed to set 1, 2, 3, 4 or 5 fruits over 2-3 day intervals, whereas all other fruits were removed within one week past pollination. The results showed that fruit weight and the seed yield per fruit decreased with fruit order, but in most cases there were no significant differences among fruits of the same order in plants bearing different numbers of fruits. The decrease in fruit weight in later fruits was always larger than the decrease in seed yield, resulting a more efficient seed production ability by small, late-produced fruits. In both experiments, the decrease in seed yield in later fruits was based mainly on a decrease in mean seed weight rather than on a decrease in seed number per fruit. Fruit order and the number of fruit per plant had a significant effect on seed germination. Generally, germination was improved later in the order. These effects were most pronounced when fruits were harvested at early or over-maturation stages.

Study of the Soil Seed Bank at Ecosystem Restoration Sites

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Knowledge of soil seed banks is indispensable for designing restoration programs for a plant population or ecosystem. Sufficiently large-scale soil seed bank experiments can be performed in a vegetation restoration project using the soil seed bank as the source for revegetation. With water development, most Japanese lakes have lost ecotone vegetation, which contributed to high biological diversity. A pilot project for restoring lakeshore vegetation from the seed bank in lake sediments has been implemented at Lake Kasumigaura, Japan. This project was designed as a large-scale soil seed bank experiment to answer questions about the range of plant species that can be restored from a seed bank, the artificial shore conditions needed to establish highly diversified vegetation or individual species, and the amount of soil needed to evaluate the restored flora.

Reproduction of Common Plant Species in Early Post-fire Regeneration in South-eastern Spain (Province of Murcia). Are they Highly Adapted to Fire?

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Mediterranean-type ecosystems are highly influenced by wildland fires. In our research project, the mechanisms of regeneration of 20 different plant species common in early post-fire succession in south-eastern Spain (Murcia) are studied. The impact of heat (various temperatures for different periods of time) and the impact of ash, liquid smoke and charred wood are tested. The results show a large variety of reactions of the different species. For example *Calicotome intermedia* (Fabaceae) is favoured by heat of about 80 °C whereas *Gladiolus illyricus* (Iridaceae) or *Teucrium pseudochamaepitys* (Lamiaceae) both very abundant at the regenerating sites are very negatively influenced by temperatures higher than 50 °C. Their high abundance at the burned sites is explained by their ability to resprout. Seeds of *Dipcadi serotinum* (Liliaceae), another resprouter, are resistant to very high temperatures and germinate to almost 100% within the first days. The reactions on ash and charred wood are very diverse as well. Most taxa are hindered but species of *Teucrium* react in a positive way. The liquid smoke, which is known to trigger germination especially in plants in California, did not influence the germination rate. In most cases mechanisms of regeneration are adapted to disturbance-regimes but not necessarily to fire.

Seed Banks in Mediterranean Gypsum Environments: Spatial and Temporal Patterns

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Gypsum communities, occurring almost exclusively in gypsum outcrops under arid or semiarid climates, host a diverse set of specialised taxa. Most of these plants are a global biodiversity priority, because many of them are narrowly distributed and seriously threatened. In this sense, Mediterranean gypsum ecosystems are considered one of the most threatened habitats in the Mediterranean Basin.

Although the relevance of seed bank in arid communities is widely recognised, little effort has been done in order to understand the role and importance of seed bank in gypsum communities. In this communication, we summarise the results of an ongoing project aiming to understand seed bank dynamics within these environments (Caballero et al. 2003, Caballero et al. *submitted*). We try to answer several key questions: What is the pattern of seed bank along a gypsum community gradient? Which factors affect the density and composition of seed bank within this system? Is this pattern maintained during the whole year? Which are the strategies for the main community species? Is seed bank in autumn a good predictor for annual spring community?

Complex Dormancy Mechanisms of *Leucopogon* (Ericaceae) Species from the Fire-prone Habitats of South Eastern Australia

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Dormancy in plant propagules contributes to plant survival strategies by ensuring that germination is spread across several occurrences of suitable environmental conditions. Many species in fire-prone environments have dormancy breaking cues related to fire but not all species have dormancy broken solely by fire. In Australia, germination studies of species from fire-prone vegetation have focussed on fire cues. However, other dormancy-breaking cues, occurring either independently or interactively with fire, are not well studied or understood. The genus *Leucopogon* (Ericaceae), like many co-occurring species in the region, displays a pulse of germination after fire. Unlike many species though, this pulse is often delayed and/or seasonal. To unravel the complex dormancy mechanisms of *Leucopogon*, this study investigated embryo morphology and ran germination trials using seasonal stratification, burial *in situ,* and fire treatments. All species have an underdeveloped linear embryo and are described as having morphophysiological dormancy. Germination trials at simulated seasonal conditions show that ambient temperature experienced by seeds is a primary factor for controlling the timing of germination. It is likely that dormancy is broken by combinations of seasonal stratification and direct or indirect fire cues in this group of species.

Physiological and Biochemical Responses of Mustard Seeds to Allelopathy Stress - Induction of Oxidative Stress

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The term allelopathy refer to the biochemical interactions between all types of plants. We investigated the influence of allelopathic compounds on physiological and biochemical processes occurring during germination of mustard seeds and growth of young, heterotrophic seedlings. The purpose of our works was to answer the question whether allelopathy stress evokes secondary, oxidative stress in germinating seeds of white mustard. The obtained data show that allelopathy compounds from sunflower leaves causes: (i) increase in the concentration of reactive oxygen species (H_2O_2) in the tissue, (ii) enhancement in activity of antioxidative enzymes, especially SOD, POX and CAT (iii) increase in plasma membrane permeability. Western blot analyses indicate that enhancement of CAT activity was associated with synthesis of CAT 5 and CAT 6 isoforms. All these changes lead to decrease in seed germination ability and gradual loss of their vigour.

Seed Characteristics of Endangered, Rare, Common and Invasive Arable Weeds and Ruderals in Germany

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At the landscape scale the frequency of occurrence of species depends on many features of both landscapes and species. In this context seed characteristics may play an important role since morphologic seed characteristics such as seed size and weight and seed germination characteristics such as specific temperature demands and germination rates are considered to influence the establishment success of species. Since about 15 years we have investigated about 200 arable weeds and ruderals by means of field, greenhouse and germination chamber experiments and have generated an extensive dataset on the seed characteristics of each species. With the help of ordination techniques we related the dataset to the frequencies of occurrence of the species at the landscape scale.

Predictability of Plant Species Composition from Environmental Conditions – The Influence of Dispersal Traits

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Despite recent modelling approaches integrating the effects of niche-based processes and dispersal-based processes on local plant species composition, their relative importance is still not clear. We tested whether the predictability of local species composition from environmental conditions is influenced by dispersal traits. For the quantification of inter-specific differences in dispersal capacity we have compiled a large database with relevant traits for the Dutch flora. This database was combined with a large database with species co-occurrence data. For each species the percentage of explained variance in occurrence was quantified and related to dispersal traits. Predictability of species occurrence patterns was increased by a greater capacity for long-distance dispersal, greater adult longevity and the capacity to build a persistent seed bank. The results indicate that the predictability of species composition from environmental conditions is reduced by a few orders of magnitude by dispersal limitation.

Effect of Seed Size and Sowing Depth on Seedling Growth in Common Vetch under Mediterranean Climate Conditions

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Growth pattern of seedling is important for any species to achieve successful establishment (Qiu *et al*., 1994) A frequent consequence of deep planting is delayed or reduced emergence (Hasking and Gorz, 1975) and poor seedling vigor (Fulbright *et al*., 1985). One way to improve emergence and seedling vigor for deep planting is to use larger seeds. This makes good sense because a large seed has greater a store of reserve energy that can be used by the seedling in the early stages of growth, giving a greater initial growth rate (Baskin and Baskin, 2001). Common vetch is an important annual forage legume that is widely grown in many countries for hay and grain production. The objective of this study was to evaluate effects of genotype, seed size, and planting depth on emergence and seedling growth parameters in a field experiment carried out in Southern Italy, on a deep clay-loam soil. Seeds of three size groups (< 4, 4÷5, and >5 mm diameter) of each of three cultivars (Itria, Sauro, and Murgia) were placed at depths of 3 and 6 cm. Values of studied parameters were higher at 6 cm than at 3 cm. An increase in dry weight and plant height was associated with increased seed size. Interactions among cultivars, seed size and planting depth were found.

Seed Ecology of *Pinus nigra* subsp. *pallasiana* in Greece

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The European black pine (*P. nigra* Arn.) is distributed mainly on the Mediterranean basin (from Africa to Eastern Turkey). Our study is focused on *P. nigra* subsp. *pallasiana*, the only subspecies in Greece, which grows in numerous populations all over the country, at relatively high altitudes, in isolated 'island, mountainous refugia'. Seeds were collected for 3 consecutive years from various, wide-ranging, indigenous populations, in an effort to investigate potential differences. Despite certain variability in the numerical values of morphometric characteristics among different populations, an overall uniformity is deduced. A similar consistency is obtained from the ecophysiological study of germination behaviour. Optimal germination occurs at 15-20 ^{o}C, in darkness. White light (applied diurnally) does enhance, though to different extents, both rate and final percentage of germination (compared to dark) in all populations examined. On the other hand, *Pinus nigra* seeds seem to be unaffected by 'canopy' (far-red) light or chilling. These data are in conformity with the ecophysiological strategy of the species: cone opening and seed dispersal takes place in late winter, germination is manifested immediately thereafter (at warming spring conditions), seeds are chilling and light-indifference (which enables germination under the pine forest canopy) while a minor, only, light requirement is detected (in 10-20% of seed populations) that could be viewed as an alternative, additional mechanism (bet hedging) for open space colonization.

Interpopulation Variation in Germination of *Hypericum perforatum* Seeds

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Germinative behaviour of twenty nine wild populations of St. John's wort (*Hypericum perforatum* L.), collected from just as many locations in the five provinces of Castilla-La Mancha Community, Spain, has been studied. *H. perforatum* is a perennial Gutiferae species widely distributed in the Iberian Peninsula, listed as a noxious invasive weed, but having a great medicinal interest. Seeds germination tests were carried out at 25/15 ºC and 16h light / 8h darkness. Germination percentages ranged between 6 to 80% depending on the accession considered. These results revealed the existence of a high intraspecific variability in the germination of *H. perforatum* seeds. Seeds belonging to the four accessions showing the lower germination percentages were assayed at constant temperatures of 15 and 25 ºC. Incubation temperatures had not a significant effect on final germination percentages. Seeds belonging to the two accessions showing the lower germination percentages were submitted to different pretreatments for increasing germination: dry heat at 100 ºC for 1, 5 and 15 minutes and GA_3 (250 mg/L). The results showed that germination was promoted significantly by GA_3 in both accessions, but the dry heat treatments did not enhance effectively germination percentages. The effect on germinability of seed desiccation with silica gel was also studied.

Germination Strategies of Annual Plants in Variable Rainfall Conditions: Adaptive or Passive Responses?

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Our investigations are part of a project dealing with climate change effects in the Jordan River basin (GLOWA Jordan River). We studied regulation of seed dormancy for three annual plants representing different germination strategies: a grass with low, a crucifer with intermediate and a legume with high dormancy. We utilized a steep natural rainfall gradient in Israel, field rainfall manipulations (rain-out shelters and irrigation) and controlled-condition studies for testing the following theoretical predictions: (1) Germination fractions increase from arid towards mesic Mediterranean climate and (2) Germination fractions are proportional to the favorability of a season. Preliminary results did not support either of the theoretical models. There were species-specific responses to the rainfall gradient, with either increasing or non-directional germination responses to increasing rainfall amounts. The favorability of a season was a weak predictor for seed germination rates. We discuss our findings with respect to the evolution of germination strategies in variable environments.

The Soil Seed Bank in a *Quercus ilex* L. subsp. *ballota* (Desf.) Samp. Stand in Northern Spain

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The soil seed bank composition of an evergreen oak stand from Nazar (Northwestern Navarra, Northern Spain) is being studied. The study aims to verify the relation between the aerial vegetation, which has been studied since 1999, and the soil seed bank, studied during a year; as well as its function in natural restoration. Samples are taken twice a year, in autumn and in spring. A 2 cm-mesh sieve is used to reduce the volume of soil in the laboratory before applying indirect and direct methods to collect the seeds. The indirect or seedling emergence technique is carried out in *Viveros y Repoblaciones de Navarra*, an enterprise which provides us a greenhouse to put our black plastic pots filled with sterile substrate (2 cm) on which soil is placed. Emerging seedlings are counted and identified. To apply the direct or physical separation technique, samples are divided into two subsamples and washed one with water and the other with sodium metaphosphate through a 0.5 cm-mesh sieve, to see which is the most efficient method. When the soil is dried, seeds are extracted under a binocular stereomicroscope. A comparison method between found seeds and a seed bank made from autochthonous vegetation is used to identify. The partial results from the study are presented in this poster.

Evolution of Seed Germination Capacity in Relation to the Climatic Conditions. Application to Some Shrubland Species of Eivissa (Balearic Islands, Spain)

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Studies on the evolution of seed germination capacity of some species growing in the thermophilous shrublands of Eivissa (Balearic Islands) were performed. The results showed the existence of time variations in the germination rates of several species (*Fumana ericoides*, *Coris monspeliensis* subsp. *fontqueri*, *Viola arborescens* and *Thymus inodorus*). The phenology of these species coincides. They show a maximal seed dispersion period at the beginning of spring and bloom preferentially in autumn or winter. The basic germination pattern was similar. The germination rates were low or null in a first period, and progressively increased in a second period. On the one hand, this strategy avoids the germination of the seeds in spring. On the other, it allows the maximal germination rates in autumn or early winter (of the first or second year), which are the most favourable seasons for the seeding survival.

Maturation Temperature Regulates Structural Characteristics and Germination Patterns of *Onopordum acanthium*

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Most weeds produce seeds with different degrees of dormancy, which germinate intermittently and cause problems in agricultural systems. Temperature can affect the structural and physiological characteristics of plants and seeds, as well as seed germinability. We examined the effects of temperature on plant growth and cypsela (seed) maturation of a Scotch thistle (*Onopordum acanthium*) population grown under two contrasting temperatures. During the developmental stages, structural characteristics such as plant height and leaf area were monitored. From each temperature regime, early and late collections were made and the structural characteristics of the cypselas recorded. Fresh cypselas were germinated under 25 ^{o}C for 14h light and 10 ^{o}C for 10h dark. The surface and transverse structures of cypselas from each temperature regime were examined by stereo-zoom microscopy and/or scanning electron microscopy. We found that plants from the cooler condition had taller and thicker shoots, larger leaves and larger capitula. They also had more and larger cypselas with smoother surfaces and thicker coats. However, the germination percentages of cypselas matured under the lower temperature regime were much lower than the percentages of those matured under the higher temperatures.

Inducing the Germination by Seed Treatments in Arecanut (*Areca catechu* L.)

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Arecanut palm (*Areca catechu* L.) is one of the important commercial plantation crops of India and India is the largest producer, which accounts for 85% of world's output. The crop is propagated through seed and the seed takes longer time to germinate. Hence rapid as well as enhanced germination are essential for better plant performance and uniform plantation. To induce early germination pre-sowing seed treatments of physical and chemical means were given to the seeds. The result indicates that the physically dehusked seeds were recorded the higher germination (100%), speed of germination (0.20), seedling vigour and vigour index (3889) followed by soaking in 2,4-dinitro phenol at 10^{-3} M. Dehusked seeds also takes minimum number of days to start germination (34 days) when compared with control (58 days) and other chemical soaking treatments.

Seed Germination Response to a Temperature Gradient in five Populations of *Wigandia urens* Distributed in an Altitude Gradient

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Wigandia urens is a tropical tree that is widely distributed in Mexico, from 2300 to 1200 m. a.s.l. Along altitudinal gradients, temperature varies 2 °C / 100 m, then affects sharply plant reproduction, particularly, seed germination response to temperature and sharing of dormancy among seed populations have been related to the ecological and geographical distribution of species and ecotypes. Therefore, germination of five populations growing at different altitudes was tested in a temperature gradient from 5 to 41 °C. Populations were selected in base to temperature distribution along the altitude gradient (1260-2700 m. a.s.l.). Germination capacity and subpopulation germination rates of each subpopulation were analysed. Germination capacity, was related to altitude. It was higher at 1600 m. a.s.l. Variation in base temperatures among population was higher (8 and 11 °C) than ceiling temperatures (34-35 °C). Thermal time varied more widely among populations than cardinal temperatures. Nevertheless, the main effect of altitude was found on germination capacity.

Effect of Ungulate Herbivores on Seed Dispersal and Germination of six Cistaceae Species

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We analyse the effect of consumption by ungulates (sheep) on seed dispersal and germination of six Cistaceae species (*Helianthemunm apenninum*, *H. violaceum*, *Fumana thymifolia*, *F. ericoides*, *Cistus laurifolius* and *C. monspeliensis*). Seed recovery was high in all species, ranging from 35 to 50% of ingested seeds except for *F. thymifolia*, where it was lower. Recovery was concentrated during the first 48 h, but few seeds were found in dung even in the fourth day. Passage through the digestive tract promoted germination to around 30% versus <10% in controls. We conclude therefore that domestic livestock is an effective disperser of Cistaceae species.

Seed Dispersal, Predation and Germination in Relict Populations of *Laurus nobilis* in SW Spain

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The bay laurel (*Laurus nobilis* L.) is one emblematic tree of the subtropical so-called lauroid forests that covered large parts of Europe in the Tertiary. As most members of the Lauraceae, it produces relatively large, heavy-seeded and lipid-rich drupes and relies on medium- or large-sized frugivorous birds for seed dispersal. As part of a broader study of the reproductive ecology of this dioecious species, we studied seed dispersal, seed predation and germination in two populations in SW Spain, in the southern limit of its distribution range. Crop size varied from one to 9700 fruits (mean=450 fruits, n=75 trees), following a negative exponential distribution, with only six individuals bearing more than 1000 fruits at the beginning of the ripening season. Only four bird species (out of 16 species recorded in the area) were observed eating fruits, of which two (*Turdus merula, T. iliacus*) swallowed them, thus potentially acting as seed dispersers. Throughout the fruiting season very few seeds were recorded away from the canopy of female trees, thus suggesting strong dispersal limitation in both populations. Seed predation by rodents varied among microhabitats. Seed germination varied between maternal plants (78±26.1%, mean±sd) but not between microhabitats. These results may throw some light on the factors affecting regeneration in range limits.

What does Seed Morphology Tell us about Epizoochory?

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Dispersal, especially long-distance seed dispersal, is a key feature of plant dynamics. It is essential for the colonisation of new habitats, influences the continuity of metapopulations and promotes gene flow. One possibility for seeds to be dispersed over long distances is in the fur of large mammals, e.g. sheep or cattle. Typically species are classified as being epizoochorous dispersed or not. However, it is more realistic to assume gradual differences in the attachment capacity of the plant species. The present study measures gradual differences in the attachment capacity of 120 different species for sheep and cattle fur using a jiggling-machine ("Rüttelmaschine").
The results show that all investigated species may be dispersed by sheep or cattle, regardless of which seed structures or appendages they have. However, seed morphology determines how many seeds can be dispersed over long distances.

Comparative Seed Germination Study of *Pinus peuce* and *P. wallichiana*

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P. peuce Griseb. (Balkan pine) and *P wallichiana* A. B. Jacks (blue pine) is a pair of 5-needled pines with common phylogeny and quite similar morphology. Both belong to the subgenus *Strobus* (soft pines) and bear soft cone scales, adnate seed wings and almost similar-looking seeds. *P. peuce* is confined to the high mountains of south-eastern Europe, southern Yugoslavia, western Bulgaria, northern Greece and Albania while *P. wallichiana* ranges throughout the Himalayan Mountains. Although the pines are morphologically identical, they are considerably diverse in their seed germination behaviour. Seeds of *P. peuce* are deeply dormant and require a prolonged stratification before they can germinate in the laboratory. Their dormancy can be broken after more than 300 d of stratification. After a very prolonged stratification (700 d.) seeds can germinate to their full capacity even at low temperatures (5 °C). Various treatments (including stratification and seed coat removal or 'cracking' were all proved ineffective *P. wallichiana* seeds are less dormant as compared to *P. peuce* and 30 d of stratification and light can break the dormancy. The effect of light on the germination of non-stratified seeds is considerable but decreases with increasing durations of stratification.

A Seed Burial Experiment in a Glacier Foreland of the Central Alps

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The seed germination of alpine species and the persistence of their seeds in the soil of a recently deglaciated area were studied to evaluate the potential importance of seed dormancy and persistent seed banks as survival strategies of plant populations in glacier forelands.
Seeds of nine different species were collected on the glacier foreland and subdivided into four groups. The germination ability of 'fresh seeds' was examined in a growth chamber after stratification. The other three seed groups were buried in the field. The germination of the second and third group was tested after one and after two winters of burial, respectively. The fourth group of seeds will be tested similarly after five years of burial in the field.
Germination rates of fresh seeds were highly variable, but most species germinated to a significant extent. Germination during the first winter in the field was mainly low, whereas after two winters of burial an increase of the germination rates was observed for several species. The post-burial germination tests in the growth chamber showed that germination rates after one winter and after two winters of burial were strongly reduced compared to fresh seeds in almost all species. Scarification of seeds of the legumes was very effective in stimulating the germination. Even after 2 winters of burial all remaining seeds germinated.

Host-specific Pathogen Attack and Spatial Patterns of Mortality and Growth of Seedlings and Saplings in a Temperate tree, *Prunus grayana*

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The Janzen-Connell hypothesis that negative density-dependent and positive distance-dependent performance of the progeny provide species diversity within plant communities has intensively examined in tropical forests but rarely in temperate forests. To examine whether this hypothesis is valid for tree species in temperate forests, we investigated seedling survival of *Prunus grayana* and the causes of mortalities at three different distances (under, 0-2 m; near, 6-10 m; far, 16-26 m) from conspecific adults in a temperate forest of Japan. Although seedling density was highest at under but lowest at far, greatest mortality was observed at under, mainly due to density-dependent attack by the species-specific pathogen *Phaeoisariopsis pruni-grayanae* and generalist pathogens, resulted in little differences in the seedling densities among densities. Sapling sizes and the growth rate were also lowest at near but greatest at far, suggesting that distance-dependent negative effects by the pathogens on growth continued throughout juvenile stages. These results suggest that Janzen-Connell hypothesis is valid for *P. grayana*, even in a temperate forest of low species-diversity.

Temporal and Spatial Distribution of Annual Weeds in California Vegetable Fields

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We monitored the temporal and spatial distribution patterns of annual weeds in Salinas Valley vegetable fields, an area with low seasonal fluctuations. Emergence in the field and seedbank densities were monitored every 45 d from April 1998 to November 2001. Seedbank content of 25 organic fields was surveyed to evaluate the relationships between soil properties and weed seed distribution. The results indicate that most weeds are able to emerge all year round. Only *Poa annua* and *Portulaca oleracea* had a clear repeatable seasonal emergence pattern. For most species only part of the seedbank was germinable suggesting that a long-term seedbank enables persistence of weeds under intensive management practices. The potential for most weeds to emerge all year may be an adaptation to frequent soil disturbance and irregular planting schedule typical of vegetable production in the area. Seed densities of the most common winter annuals e.g.; *P. annua, Capsella bursa-pastoris* and *Stellaria media,* in the soil seedbank correlated with the soil organic matter content. The correlation between soil properties and weed seed distribution, could aid selection of fields for sensitive crops or organic production.

The Role of Regeneration by Seed in Semi-Natural Meadows

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Insight from long-term monitoring in southern Switzerland suggests a high sensitivity of species-rich meadows to variation in climatic humidity during the growing season and a high importance of regeneration processes in periods following extremely dry summers. After such a perturbation in 1991, the capacity to recruit from seed affected the rate of change in relative abundance of component species and directed species composition towards a new state. During 4 years the meadow changed from a graminoid dominated (two-fold superiority) towards an equally balanced community of graminoids and forbs. At this stage, we wish to know how the dynamics and functioning of species-rich meadows is affected by the particular climatic conditions which follow extreme droughts in different seasons. The outcome of succession after perturbation further depends on the mode of colonisation of the component species (recruiting capacity, speed of vegetative propagation), their ability to invade gaps at different times after perturbations (seasonality of seed shedding, germination, and vegetative propagation), and their persistence (time to first fruiting, longevity of adults and longevity of dormant seeds in the soil). In a field experiment with simulated drought scenarios, we will test hypotheses concerning the role of regeneration by seed.

Inhibition of Dormancy Release by Light in Hydrated Annual Ryegrass Seeds

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Annual ryegrass (*Lolium rigidum*) is the primary weed of cropping systems across southern Australia. Most seeds are dormant at maturity, and dormancy release occurs by after-ripening of dry seeds on the soil surface over summer, the method common to winter annual grass species, resulting in anywhere between 40 and 80% emergence with the opening rains of the winter growing season. However, dormancy can also be relieved during burial in moist soil, equivalent to hydrated storage (stratification) in darkness. Dormant seeds become sensitive to light during dark-stratification for 2 to 4 weeks, enabling them to germinate when subsequently exposed to extended periods of light. Stratification in darkness or far-red light promotes dormancy release, but stratification in white or red light inhibits dormancy release. Dormancy release during dark-stratification is temperature and moisture dependent, being faster at warmer temperatures and requiring >40 g H_2O 100 g^{-1} FW. This response to dark-stratification enables seeds that are still dormant at the end of summer to become light-sensitive if buried in moist soil at the start of the winter growing season. Seeds that are moved to the soil surface during a disturbance event a few weeks later will germinate.

Wind Dispersal of Alpine Plants: A Comparison with Lowland Conditions

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We simulated wind dispersal of nine plant species characteristic for Alpine glacier forelands using PAPPUS, a mechanistic wind dispersal model. We calculated distance spectra for weather conditions measured on a glacier foreland in the Swiss Alps and compared it to distance spectra calculated for lowland weather conditions. Falling velocity of the diaspores (V_{term}) ranged from 0.15 to 1.4 m/s, release height from 0.05 to 0.5 m. Diaspore production of the populations varied over more than two orders of magnitude. The proportion of diaspores dispersed > 100 m was considerably higher under alpine conditions compared to lowland conditions for all species but the one with the lowest V_{term}. Under alpine conditions all species were dispersed by wind > 100 m and 8 of 9 species > 1000 m. Under lowland conditions only 6 species were dispersed > 100 m and 2 species > 1000 m. Under alpine conditions even species with unspecialised diaspores were dispersed by wind over long distances as long as V_{term} was smaller than 1.2 m/s, whereas under lowland conditions V_{term} must be smaller than 0.7 m/s. Diaspore production per population was not significantly correlated with the number of diaspores dispersed > 100 m. Our results suggest that alpine habitats are considerably more favourable for wind dispersal than lowland habitats and that alpine species are generally better adapted to dispersal by wind than species from the lowland.

The Seed Germination of *Erythronium japonicum* Decne. under Natural Conditions

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Erythronium japonicum (E. j.) plants are represented for a spring ephemeral in Japan. The seed contains elaiosomes and is dispersed with a myrmecochory. In room experiments, the seed germination rate was found to be increased by placing at a low temperature (ca. 5 ºC) after a warm temperature (ca. 20 ºC). It was also suggested that seed germinability was lost during storage under dry condition. Subsequently, we investigated the dispersion site (above or below the litter) of *E. j.* seeds and the temperature and relative humidity, and many *E. j.* seeds were found dispersed under the litter. The temperature under the litter 20 – 25 ºC in the summer, even though the open air temperature was 30 ºC or higher. While, the temperature under the litter in the winter was maintained 2 – 4 ºC. The relative humidity was 60 - 70% under the litter when it was about 20% above the litter. The germinability were lost by placing seeds at above 30 ºC (warm treatment) - or at 0 ºC or lower (cold treatment) in room experiments. It is concluded that the litter is a factor for optimal condition (warm temperature of about 20 ºC and cold temperature of about 2-4 ºC) for seed germination. The litter is also suggested important to avoid seeds dried and decrease in germinability.

Impact of Leaf Miner (*Cameraria ohridella* Deschka and Dimic) on Field Germination and Seedling Vitality of *Aesculus hippocastanum* L.

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The horse chestnut leaf miner *Cameraria ohridella* is a new pest of *Aesculus hippocastanum* in Europe, who recorded for the first time in 1985 attacking horse chestnut trees close to Ohrid Lake. Since its first discovery the moth has spread very rapidly in Europe. The first occurrence of the moth in Greece is reported by Skuhravy in 1996 near to Florina. The damages by *C. ohridella* lead to total browning of the leaves and finally cause an early leaf-fall in July-August. In this study, field germination differences between seeds of *A. hippocastanum* from infested and chemically controlled uninfected trees were investigated. Growth and the survival of seedlings were examined as well. Seeds were collected in Tsotyli (Greece) from artificial growing horse chestnut trees. Seedlings from seeds of infested trees achieved smaller height and base diameter and they had less dry weight of root and sprout than seedlings from uninfected trees. On the contrary, the length of the main root and seed germination were slightly higher for the seedlings of the infested trees. In both cases, the survival percentage of seedlings was very high (about 99%). In conclusion, the leaf miner *C. ohridella* affects negatively the growth of seedlings but not the germination and the survival of seedlings.

Early Canopy Seed Storage in a Serotinous Population of *Pinus pinaster*

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The onset and early evolution of the aerial seed bank were studied in a highly serotinous population of *P. pinaster* from NW Spain. Three young post-fire stands were selected and multiple sampling plots were established within each stand. Both backwards whorl-counting and wood ring counting were used to determine the onset of flower production and the age of each cone for every sampled individual. This allowed assessing the variation with age of cone number and status (aborted, closed, open or damaged by insects), cone and seed sizes, the percentage of pollinated and fully developed ovules, the number of ovuliferous scales (related to the number of potential ovules) and the number and weight of sound and empty seeds per cone. The viability of sound seeds was also analysed. Aerial seed bank started as early as 5-6 years of age. Cone number (40 to 2700 cones ha^{-1}), cone size (56 to 99 mm), number of scales per cone (98 to 155 scales), number of seeds per cone (65 to 105 seeds) and number of sound seeds per scale (0.42 to 0.62 seeds $scale^{-1}$) increased with stand age but with marked inter-annual fluctuations. The number of cones attacked by insects also tended to increase with stand age. A model was adjusted to predict the evolution of stand's seed bank with time by incorporating the variation of each analysed component with age.

Seed Germination in a Highly Serotinous Population of *Pinus pinaster*

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Pinus pinaster Ait. from Teleno Mountains (NW Spain) has closed-cones. This character has been extensively studied in other pines due to its meaning as a fire adaptive strategy. This paper analyses seed innate dormancy of this pine population according to stand altitude and year of ripening. Seed extracted to cones from three stand and different year of ripening was germinated under standard condition. The results indicate that seed from low altitude stand germinate faster than high altitude located seeds. Seed germination rates are correlated to mean daily maximum summer temperature in maturation year. On the contrary, different summer temperatures do not correspond to different percentage of seed viability. We interpret the germination - maturation temperature relation as an efficient mechanism to diversify the length of seed innate dormancy and, in this way, to get an extended germination in time.

In vitro Germination of three Medicinal Plants

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Rhodiola rosea L. (Crassulaceae), *Gentiana lutea* L. (Gentianaceae) and *Arnica montana* L. (Asteraceae) are valuable medicinal plants. These species are included in the List of protected plants in Bulgaria, Germany, France, Romania, Russia and other countries. They are widely used in medicine and pharmacy. Their germination *in viv*o is low. The purpose of our experiments was to elaborate an efficient method for *in vitro* propagation of *Rh*. *rosea, G. lutea* and *A. montana*. To stimulate seed germination the seeds were treated with 0.03% gibberellic acid (GA_3) for 24 and 48 h. Eight variations of Murashige & Skoog (MS), (1962) nutrient medium containing 50, 60 and 100 mg/l gibberellic acid respectively and 4-6 g/l agar-agar were tested. The following results were obtained: 1. The seeds of *Rh. rosea* L. pretreated with 0.3% GA_3 for 24 h. Highest germination was obtained at MS nutrient medium containing 50 mg/l gibberellic acid and 4 g/l agar-agar - 73.8% on the 20-th day. Germination lasted from the 8-th until the 40-th day. 2. *G. lutea* L. Highest germination (36%) resulted from the treatment with 0.03% GA_3 for 48 h followed by cultivation on Murashige and Skoog nutrient medium enriched with 50 mg/l gibberellic acid and 6 g/l. 3. In the case of *A. montana* L. highest germination (72.5%) resulted from the treatment with 0.03% GA_3 for 24 h followed by cultivation on MS nutrient medium enriched with 50 mg/l gibberellic acid and 6.0 g/l agar. The possibility for efficient *in vitro* propagation of *Rh. rosea, G. lutea* and *A. montana* was established aiming at their application in pharmacology and agriculture.

Bradychory - the Coining of a New Term

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A newly coined term, bradychory, is put forward. Bradychory (literally meaning 'slow dispersal') is defined as 'delayed dispersal' and is suggested to fully replace bradyspory, a seldom used term. Bradychory is also suggested to replace serotiny in all the uses of the latter in the field of dispersal. On the other hand, serotiny is proposed to denote only the structural aspect of reproductive units that remain closed at maturity (thus retaining their seeds enclosed for months or years and eventually leading to the accumulation of a canopy - aerial - seed bank). Bradychory is wider as a term than serotiny (at its current use) and encompasses all cases of delayed dispersal: closed cones or fruits as well as all additional instances of seasonal delay of seed dissemination. Bradychory is common not only in the well-known cases of fire-prone ecosystems but also in seasonally dried environments, such as deserts and Mediterranean-type habitats. Bradychory is viewed as a mode of dispersal which comprises the entire group of adaptations that share the common trait of delayed dispersal; it can be distinguished further into two main subgroups: seasonal bradychory (delay of a few months up to one year) and episodic bradychory (one to many years). The underlying mechanisms of seed retention on the mother plant are diverse and similarly are the cues for seed liberation (fire and rain being the most important among them). The postulated advantage of bradychory is the timing of seed dispersal at conditions that maximise and optimise seedling recruitment and establishment; in this aspect, bradychory can be regarded as a strategy complementary to seed dormancy.

Adaptations of Germination in Mediterranean Plants – Ancient Mechanisms and Modern Challenges

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During the last three decades, Seed Ecology has emerged as an increasingly important scientific field both on its own and by complementing laboratory research on seeds. In particular, the ecophysiology and ecology of germination in Mediterranean plants has focused on the investigation of diverse types of dormancy and adaptations of germination behaviour, in general. Some prominent findings concern universally occurring 'strategies' such as hardseededness and afterripening while a number of 'peculiarities' have been well established: a germination 'preference' at a relatively cool temperature range, a markedly slow rate of germination and among the diverse adaptations towards light, photoinhibition of germination (observed in numerous Mediterranean plants). The investigation and eventual elucidation of the mechanisms underlying these three 'Mediterranean germination peculiarities' constitute a keen challenge for future research.

Climate does not Constrain Seed Production by *Brachypodium pinnatum* at its Northern Limit in the UK

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Brachypodium pinnatum is a large rhizomatous grass, largely confined to limestone soils. Its current north-western and altitudinal limit in the UK is in the Peak District National Park in Derbyshire. *Brachypodium* occurs in the Peak District only as small, isolated patches. These plants rarely, if ever, produce any seed, a fact normally attributed to climate. However, an experimentally-established population at Buxton (at a higher altitude than any natural population) produces abundant seeds every year. We suggest that *Brachypodium* seed production is not prevented by climate: rather, it is self-incompatible and each of the Derbyshire patches is a clone derived from a single colonisation event. If this is true, *Brachypodium* could potentially spread very rapidly in the UK, even without any further climate warming. We will present the latest genetic evidence concerning the nature and origin of *Brachypodium* in the Peak District.

Life on the Edge for Limber Pine: Seed Dispersal within a Peripheral Population

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Species may experience different biotic and abiotic environments at the limits of their range. Throughout its core range, limber pine (*Pinus flexilis*, Pinaceae) relies on Clark's nutcrackers (*Nucifraga columbiana*, Corvidae) for seed dispersal. Nutcrackers, however, rarely visit the "Pawnee" peripheral population of limber pine on the eastern Colorado plains. By using live mammal trapping, fluorescent pigment tracking, and seed cache germination experiments, we tested the hypothesis that limber pine seeds in the Pawnee isolate are dispersed by nocturnal rodents. Results indicated that deer mice (*Peromyscus maniculatus,* Muridae) and Ord's kangaroo rats (*Dipodomys ordii,* Heteromyidae) disseminate limber pine seeds in this population. Seeds buried under soil and plants, as opposed to seeds placed on substrate surfaces, had a higher probability of seed germination and recruitment. Seed dispersal distances ranged from 5.5 m to 20.6 m. Thus, rodents disseminate seeds over shorter distances than do nutcrackers, explaining previously observed genetic substructuring in the Pawnee population. Seed dispersal by rodents also precludes the metapopulation dynamics typical of limber pine in its core range, and may lead to the loss of peripheral populations over time.

Seed Ecology of *Aesculus hippocastanum* from Three Native Locations in Central and Northern Greece – Preliminary Results

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Aesculus hippocastanum (horse chestnut) has a quite narrow, natural distribution, restricted in the southern Balkans. Within the context of the doctoral thesis of the first author, the reproductive biology of the species is investigated for the first time on native individual trees and stands. Trees were tagged and seeds were collected from 3 localities situated around the plain of Thessaly, at least 50 km apart from each other (Kissavos Mountain, Karditsa - Agrafa mountains and Grevena - northern Pindos range). Besides morphometric analysis, moisture evaluation and imbibition kinetics, seeds were subjected to several preliminary germination tests. Freshly collected seeds were partially dormant: germination to a certain degree was manifested only at 30 ºC and a clear seed size effect on germinability was detected. When seeds were either stratified or 'dry-stored' (at 3-7 ºC) both the rate and 'temperature window of germination' were dramatically enhanced. Finally, seeds treated for five months were enabled to germinate fully to as low a temperature as 10 ºC while a considerable portion were even seen germinating under chilling conditions.

Germination Ecology of Geraniaceae and Malvaceae

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Seeds of most *Geraniaceae* and *Malvaceae* have water-impermeable seed coats and show physical dormancy. We investigate possible environmental cues wich can induce germination. Seeds of *Erodium* and of several *Geranium* and *Malva* species were buried outside in soil for up to 2.5 year. At regular intervals, seeds were exhumed and germination tested. We did not found any marked seasonal cycle in the germination capacity. Seeds of *Malva* species became gradually permeable and germinated in situ. Seeds of *Erodium* remained dormant in the soil. Several weedy *Geranium* species had mostly soft seeds which did not survive in the soil. Dormancy of *Erodium* and some *Geranium* species was broken by drying for one week. In natural conditions germination of these winter annuals would be made possible after a dry period in summer.

Smoke-stimulated Seed Germination – Potential for Seed Technology

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Many species from fire-prone ecosystems are dependent on fire to provide suitable germination cues. In recent years, cold aerosol smoke and smoke solutions have shown the ability to promote the germination of many species within these ecosystems. Furthermore, some species from fire-free habitats also respond positively to smoke treatments. As a result, smoke and smoke solutions can potentially be used for a variety of applications. These include uses in horticulture, agriculture, ecological management and rehabilitation of disturbed land. This report highlights these potential uses and some recent findings related to smoke-stimulated seed germination.

Regeneration Strategies along Climate Gradients: an Experimental Test on four *Veronica* Species

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For species with large ecological amplitudes, or with wide geographical or altitudinal distributions, the factors and processes controlling seedling mortality risk are unlikely to be constant throughout the range. Such differential selection pressures may result in variation in germination responses among local populations. The effect of local climate has received particular attention, but the results have been partly contradictory. Two alternative hypotheses predict that germination rates should decrease and dormancy increase with the (1) severity or (2) predictability of the local winter climate. Empirical studies that can discriminate between these hypotheses are scarce, however. We investigated the variation in phytotron germination responses among 111 populations of four *Veronica* species along broad-scale geographic (65 °C – 76 °N), climatic (mean January temperatures -14 – 2 °C) and altitudinal (3 – 1480 m asl) gradients in Norway. Failure-time methods were used for the statistical analyses to take account of the time-to-event structure of germination data. The dual replication (different species, different gradients) enables a more general evaluation of the results.

Relationship between Vegetative Traits and Seed Production in Species from Mediterranean Old-field Succession

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Seed production is a key component of community structure and functioning. Seed production is the product of plant biomass, plant biomass proportion allocated to the seeds and the number of seeds per unit mass. The objective of this study is to relate plant vegetative functioning and components of the regenerative niche (*sensu* Grubb 1977) via seed production. The experiment concerned 35 herbaceous species belonging to 11 monocotyledonous and dicotyledonous families and characterising Mediterranean old-fields succession stages (South France). Vegetative (leaf and whole plant traits) and reproductive (e.g. flowers and fruits numbers, total seed production, seed size) functional traits were monitored during one growth period; phenological stages were followed and included in statistical analyses. Germination rate and chemical composition (seed "quality") of seeds were determined. Seed production was positively allometrically related to plant size at the intraspecific level, and negatively related to reproductive investment at the interspecific level. The relationships among the different variables were analysed in a path analysis model.

Ecophysiology of the Germination of *Dahlia coccinea*

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After 1998 fires *Dahlia coccinea* (Asteraceae) proliferated in a xerophilous shrubland near to Mexico City. To test the role of fire on seed germination, an experiment was performed to prove the effect of fire and high temperatures (dry and moist heat) on germination. Seeds of *D. coccinea* were indifferent to light. After harvest seeds showed physiological dormancy, which it was lost after-ripening. Four months old seeds, collected in 2000, presented secondary dormancy. Additionally, seeds showed a partial dormancy imposed by seed covers, which was broken by dry heat treatment. During fires dry seeds tolerated high temperatures of short duration and also withstood prolonged exposure to 60 °C. Ash and prolonged exposition to moist heat inhibited germination. The effect of cold stratification was related to the seed physiological stage and to light conditions and suggest that stratification in darkness could favor seed bank formation. Since substrate and micro-topography in the reserve creates a complex and discontinuous environment, a wide variety of safe sites could provide adequate environmental conditions that protect seeds during fires and/or turn extreme temperatures in factors that improve seed germination and/or seed bank formation.

Spatial Distribution of Seeds in the Soils of a Mosaic Agricultural Landscape

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In agricultural landscapes the spatial distribution of seeds in the soils mainly depends on the site conditions and on the spatio-temporal patterns of both the recent and the former land-use practices. In mosaic agricultural landscapes of Central Europe that were formerly characterised by small-parcelled crop and grassland rotation the landscape structure has changed in favour of grasslands over large areas since about six decades. In the soils of those landscapes a wide variance of seed diversity may be expected depending on the degree and the direction of land-use changes at the local scale. Based on (i) soil maps, (ii) the analysis of time-lapse aerial photos (reconstruction of the land-use dynamics between 1945 and 1998), (iii) soil seed bank analyses of 70 fields (arable land, grassland and old fields), and on (iv) probability calculations (estimation of the probability of occurrence and the numbers of seeds at the local scale for landscape tracts with an area of 10 ha) we modelled the spatial distribution of seeds in the soils of about 20 km² of the Lahn-Dill-Highlands (Hesse), a mosaic agricultural landscape in Germany. We identified hot spots of seed diversity at the local scale and will discuss their significance for ecologically sustainable land use.

Long-distance Seed Dispersal Pattern Generated by *Cebus* Monkeys in Iguazú, Argentina: Consequences for *Miconia* Seeds

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We compared the natural seed rain of *Miconia pusilliflora* with the pattern of seed dispersal generated by brown capuchin monkeys, *Cebus apella*. Our objectives were to: 1) describe the shape of the seed shadow generated by focal trees, 2) determine the dispersal curve generated by *Cebus*, 3) identify events of long-distance seed dispersal in a natural population of *M. pusilliflora*, and 4) evaluate the effect of *Cebus* on seed germination and seedling emergence. We concluded that dispersal by *Cebus* significantly increases the instances of long-distance seed dispersal, which in turn augments the chances of seed germination and seedling survival of *Miconia*.

Seed Evolution and Seed Dispersal in the Tribe Massonieae (Hyacinthaceae)

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The biggest subfamily of the Hyacinthaceae, the Hyacinthoideae, consists of 2 tribes: the north-hemispheric Hyacintheae and the Massonieae. The latter comprises 16 genera and about 230 species, which occur from Africa south of the Sahara to Madagascar and the Arabian Peninsula to India. The definite centre of diversity is Southern Africa. Within this area the seasonality and the amount of rainfall varies considerably. Most genera show a preference to one of these climatic regimes, with the more ancient genera in the summer rainfall area and the more derived ones in the mediterranean winter rainfall area. Seed morphology has proven to discriminate the genera very well and in comparison with phylogenetic analyses of plastid-DNA sequences the following trends in seed evolution can be observed: An increase of the number of seeds per locule; a reduction of seed-size and weight; a trend from brown to black seed coat colours; a reduction of the thickness of the seed coat; a transition from wrinkled and sculptured seed coat surfaces to smooth ones. There also is a considerable differentiation in the dispersal mechanisms of the seeds with the wind-dispersed seeds of *Merwilla*, some most likely myrmecochorous *Ledebouria* species and the hollow seed appendages of unknown function of several *Lachenalia* species being the most peculiar ones.

Aspects of the Post-harvest Seed Biology of *Welwitschia mirabilis* Hook. Fil.

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Very little is known about the biology and storage behaviour of the seeds of *Welwitschia mirabilis*, the unique desert gymnosperm endemic to the Kaokoveld Centre of Namibia. The effects of various pre-germination treatments on the seed responses were studied. These included the effects on germination of soaking, presence/absence of the outer seed covering and freezing at –20 ^{o}C and –196 ^{o}C. It was found that soaking was deleterious to the seeds. In contrast, removal of the outer seed coverings was sufficient to promote germination. It was further found that seeds could be hydrated at 100% RH, to a water concentration of 0.34 g.g^{-1} dry mass, and then dried back to the original level of *ca* 0.05 g.g^{-1} dm. Measurements continued over 10 d of drying demonstrated that the seeds retained viability at *c.* 0.021 g.g^{-1} dm after this period. The seeds were also found to tolerate freezing to –20 ^{o}C and –196 ^{o}C in the natural state. It was concluded that the seeds of this species are orthodox. Several species of fungi were isolated from the seeds; therefore surface-sterilisation treatments with sodium hypochlorite, calcium hypochlorite, ethanol and Sporekill® (ICA Laboratories) were assessed. Sporekill was found to be the most effective fungicide (if the accession was not heavily infected) and least damaging to the seeds.

Are there Differences in Seed Size between two Soil Layers in Undisturbed Forest?

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We studied differences in length and width of seeds in the upper (0-5 cm) and lower (5,1-10 cm) layer of soil in a primeval oak-hornbeam stand in Bialowieza National Park in Eastern Poland. In both soil layers (160 samples of 100 cm^3) we identified 1531 seeds of 16 herb and 5 woody species. Floristic similarity (Soerensen index) between plant cover and soil seed bank was 60%, and 74% between seed bank of upper and lower soil layer. Seeds of only three species (*Carex remota*, *Juncus effusus* and *Urtica dioica*) were significantly smaller in the lower then in the upper soil layer, and this difference did not exceed 5% of seed size. Mean length and width computed for all seeds in the upper soil layer was significantly higher than in the lower soil layer. This was caused by seeds of only one species (*Juncus effusus*), which constituted about 50% of all seeds in the lower soil layer (about 25% in the upper layer). Thus the difference in mean seed size between soil layers is highly dependent on the species composition of a studied forest stand and may be influenced by patchy distribution of species producing small seeds. Therefore the hypothesis that seeds of species producing larger diaspores tend to be confined to upper soil layer was not supported by this study.

Variation in Plant-Frugivore Mutualism across a Successional Mosaic

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Because populations located in primary succession likely experience different environments and species interactions than those located in secondary succession, the dispersal outcome of a plant-frugivore mutualism may vary depending on the successional context. To understand the variation in plant-frugivore mutualism, we examined *Vaccinium membranaceum* and its frugivores in a mosaic of primary and secondary succession at Mount St. Helens. We conducted experiments to investigate the species interactions affecting fruit crop size, and to test the effect of fruit crop size on fruit removal (fruit crop size hypothesis). We found that *V. membranaceum* in different successional stages did not have the same interactions with pollinators and herbivores, resulting in differences in fruit set. We also found that fruit crop size affected fruit removal rates, demonstrating that different species interactions in primary and secondary succession can affect the *V. membranaceum*-frugivore mutualism and resulting seed dispersal. This variation may then result in differential selection on traits that enhance seed departure and subsequent seed arrival into suitable microsites for establishment. A more complete understanding of seed dispersal dynamics includes the plant-frugivore mutualism within the context of other community interactions.

Effects of Seed Origin and Habitat Quality on Recruitment of *Bromus erectus*

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A seed-addition experiment was performed to investigate the chances of re-establishment of species in semi-natural meadows which had suffered a reduction in species richness due to abandonment. The experiment was replicated at three sites in southern Switzerland and repeated in two successive years. Seeds of *Bromus erectus,* one of 22 species added, were reciprocally sown at all sites to investigate the effects of seed origin and habitat quality of the target communities (i.e. productivity, potential insolation) on recruitment and to test the hypothesis that the three populations are locally adapted. The fate of 18.000 *Bromus* individuals (3 origins, 10 plots, 100 seeds, 3 locations, 2 years), sown one by one, were regularly monitored over 36 months to determine rates and timing of seed germination, seedling establishment and growth rates of individuals. Preliminary analyses of the data show significant site and origin effects on recruitment of *Bromus*. Local adaptation could be detected as a home-site advantage, whereby each population performed best at its site of origin.

Seed Limitation, Disturbances and 'Window of Opportunity' – from Cases to General Pattern

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Sowing experiments conducted with single or a few species have shown that populations are more frequently seed limited than previously expected. Multiple species experiments on a community level have demonstrated that species diversity may be seed limited as well. Huston (1999) put forward the hypothesis that plant diversity in moderate stress conditions is primarily diaspore limited, while in productive environments, competition inhibits establishment and diversity is disturbance-limited. This hypothesis has received experimental support. It is not known, however, what happens in stress conditions, where still remarkably diverse plant communities occur. Sowing experiments in dry oligotrophic communities may result in negligible establishment. We hypothesized that core species in dry oligotrophic grasslands recruit normally in droughty conditions, while regeneration of satellite species follows the 'window of opportunity' model and takes place only in exceptionally rainy years. This hypothesis was controlled in an experiment, where three fescue species were sown in grassland patches with artificial irrigation regime, aimed to mimic dry, average and rainy year. The core species (*Festuca ovina*) was able to recruit in dry conditions, while satellite species either demanded higher precipitation (*F. pratensis*) or coincidence of higher precipitation and disturbance (*F. rubra*). One may conclude that while in productive conditions diversity may be disturbance-limited, then in oligotrophic conditions, fluctuation of the physical environment is of primary importance.

Vegetation Restoration of a *Quercus ilex* L. *subsp ballota* (Desf.) Samp. Stand Commununity of Navarra (Spain): Germination and Seedling Establishment of Autochthonous Species

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The present investigation is complementary with the recuperation studies of an evergreen oak stand in Nazar (Northwest of Navarra, North of Spain) after a fire, that it is being monitored in the Botanical Department since 1999. In a revegetation context, available and specific seeds are essential for successful restoration. Fifty eight species were collected from autochthonous material, in different years, and germination tests were made in temperature-controlled growth chambers and under field conditions. Their optimal germination rates, the influence of time storage on seed viability and their development are investigated for each species studied. With their ecological characteristics it would be easier to search for a suitable blend of species for restoration in degraded situations. At the same time, the creation of a seedbank and a catalogue which these species of a *Quercus ilex* L. subsp. *ballota* (Desf.) Samp. community would be made.

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