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International Association for Vegetation Science
38th Annual Symposium

**The Importance of Spatial and Temporal Perspective for Understanding
Vegetation Pattern and Process**

**Rice University
Houston, Texas, USA
4 - 9 June 1995**

1995 PROGRAM COMMITTEE

Box, Elgene O. University of Georgia (President, IAVS)

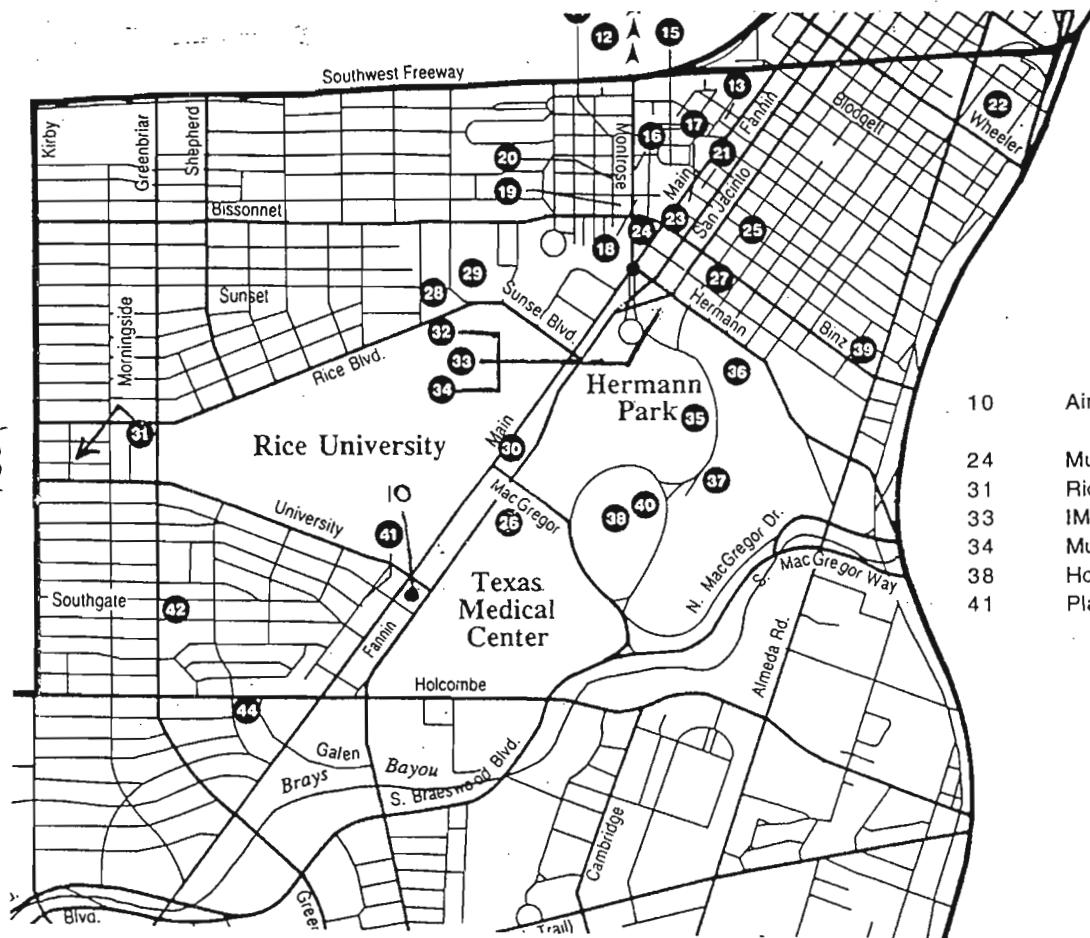
Canham, Charles D. Institute of Ecosystem Studies

Harcombe, Paul A. Rice University (Program Committee Chair)

Palmer, Michael W. Oklahoma State University

Peet, Robert K. University of North Carolina, Chapel Hill

White, Peter University of North Carolina, Chapel Hill



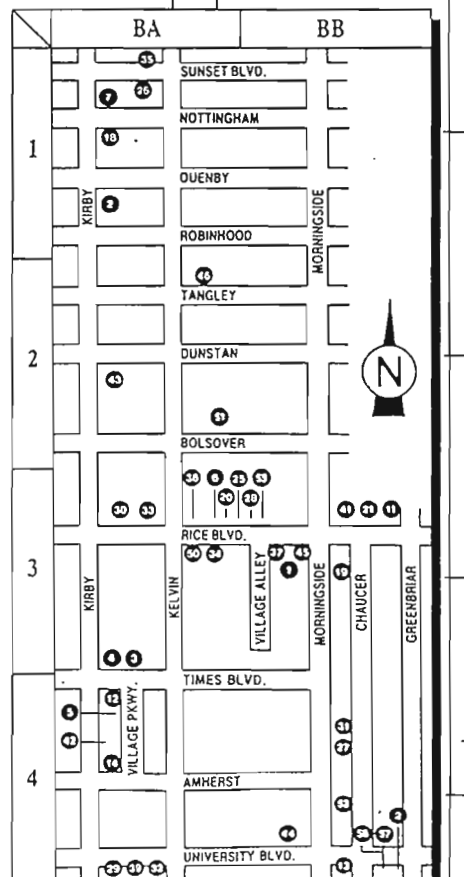
- 10 Airport Bus Terminal (Marriott Hotel)
- 24 Museum of Fine Arts
- 31 Rice Village
- 33 IMAX Theater
- 34 Museum of Natural Science
- 38 Houston Zoo
- 41 Plaza Hilton



RESTAURANTS

- | | | |
|----|---|-----|
| 1 | ALLEGRO THE ITALIAN CAFE & BAKERY
Breakfast, Lunches, Salads, Cakes, Catering - 2407 Rice 526-4200 | BA3 |
| 2 | THE BLACK LABRADOR ENGLISH PUB
The Campaile, 4100 Montrose 529-1199 | D3 |
| 3 | BLINPIE SANDWICHES & SALADS
Free delivery, 20% off with map, Open til 3AM - 2246 W. Holcombe 661-7384 | B5 |
| 4 | BRENNAN'S RESTAURANT
Houston's most romantic restaurant, serving Creole cuisine with a Texas accent, for lunch, dinner and weekend brunch. Open seven days a week.
3300 Smith Street. For reservations call 522-9711 | E2 |
| 5 | CAFE CHINO
Finest Hunan Cuisine in a Contemporary Setting - 6140 Village Parkway 524-4433 | BA4 |
| 6 | CHEZ EDDY
America's finest "lean-healthy haute cuisine" - 6560 Fannin 790-6474 | C5 |
| 7 | DOLCE Y FREDDO
Finest in frozen Italian desserts, espresso and cordial bar, Open: 12 p.m.-12a.m.
Sun-Thu, 12p.m.-12a.m., Fri-Sat - 5515 Kirby Dr. 521-3260 | BA1 |
| 8 | DONG TING RESTAURANT
One of the nine best Chinese restaurants in USA - 611 Stuart 527-0005 | E2 |
| 9 | DYNASTY GARDEN RESTAURANT
7 days a week 11-11 Chinese Vietnamese cuisine - 2404 W. Holcombe 663-6544 | B5 |
| 10 | EVAN'S RESTAURANT AND BAR
Seafood, Pasta, free range meats & vegetarian entrees - 3939 Montrose 526-7668 | D3 |
| 11 | HUNGRY INTERNATIONAL CAFE
Seafood, Pasta, Sandwiches, Gyros, Soup, Salads & Over 100 Imported Beers
Patio Dining - 2356 Rice Blvd. 523-8652 | BR3 |
| 12 | LE PEEP RESTAURANT
Serving breakfast and lunch daily 6:30-2:30p.m. - 6128 Village Parkway 523-7337 | BA4 |
| 13 | LUTHER'S BAR-B-Q
Real, slow-smoked, Texas Bar-B-Q and all the fixin's Drive-Thru and catering too!
8777 South Main 432-1107 | B6 |
| 14 | PREGO RESTAURANT
Neighborhood Bistro Serving Modern Italian Cooking - 2520 Amherst 529-2420 | BA4 |
| 15 | RED LION RESTAURANT
British Fare: Prime rib, fresh fish, chicken, Lunch M-F, Dinner 7 days, Live entertainment nightly - 7315 South Main 795-5000 | C5 |
| 16 | SOUTH MAIN SHOPPING CENTER
Good food at good prices. Open lunch and dinner - 6600 Bluck South Main St.
Barry's Pizza 6622 South Main 522-4656
Miller's Cafe 6630 South Main 528-7437
Subway Sandwiches 6638 South Main 520-8385 | C5 |

THE VILLAGE



Banquet. There will be a banquet on the evening of Thursday, 8 June at 7:30 p.m. in Cohen House (on Rice Campus). The price of the banquet is included in the registration fee. The cost for additional guests is \$25.00.

TRANSPORTATION

To and From Airport. The Airport Express, a shuttle service, leaves every half hour from Houston Intercontinental Airport or Hobby Airport during the week. Tickets may be purchased near the baggage claims areas of the airports (\$15.00 one-way from Intercontinental; \$16.00 from Hobby). Take the Airport Express to the Houston Medical Center. Transit time is approximately 45 minutes. You will be dropped off at the Medical Center Marriott; from there, call the Plaza Hilton (524-6633) to receive free transportation to the hotel.

From the Hotel to Rice. Walking time from the Plaza Hilton to Rice is about 15 minutes. There will also be a free shuttle bus running from the Graduate House to the inner loop of Rice University and back about every 30 minutes (both the Rice Memorial Center and Herring Hall are located on the inner loop). The bus stop at the Graduate House is located about a block from the hotel at the corner of University and Main. The Plaza Hilton provides shuttle bus service as well.

Parking. Free parking is available across the street from the Rice Memorial Center in Visitor's Lot L (Central Lot). It is most easily accessed from Entrance 13 off of Rice Boulevard, but can also be reached from Entrance 8 (off of University Boulevard).

FOOD

At the Plaza Hilton. Breakfast is not included in the price of the room, but the Plaza Hilton does have a restaurant which serves meals.

At Rice. Breakfasts and lunches may be purchased at the on-campus cafeteria, Sammy's, located in the Rice Memorial Center. Breakfast hours are 7:00 a.m. - 10:15 a.m.; lunch hours are 11:00 a.m. - 2:30 p.m. Sandwiches and drinks (take-out only) may be purchased at the lunch hour from the on-campus pub, Valhalla, located beneath the lecture hall of Dell Butcher Hall.

Off Campus. There are many restaurants located near Rice (see leaflet). There is probably not an adequate amount of time to eat lunch off-campus, but non-included dinners may be sought at any of these dining establishments.

LODGING

Roommates. Both roommates should be present at checkout time to assure the equitable division of the bill. If both parties are not checking out at the same time, please make arrangements for payment with the front desk prior to checkout. The hotel would be happy to provide separate checks for rooms that are shared. Please do not leave the full responsibility of payment to the last person who checks out!

VENUE

The 38th Symposium of the International Association for Vegetation Science will be held on the campus of Rice University. Rice is a small private, secular, coeducational university dedicated to the promotion of science, engineering, letters and the arts. Founded in 1912 by William Marsh Rice, it now consists of the schools of Natural Science, Engineering, Humanities, Social Sciences, Architecture, Business Administration, and Music. Throughout its history, first as Rice Institute and later as Rice University, the institution has enjoyed a reputation for excellence and selectivity in a quiet and spacious campus setting. Current enrollment is about 2,700 undergraduates and 1,500 graduate students, numbers that maintain a remarkable one-to-ten faculty-student ratio.

Set in a 300-acre academic park shaded by nearly 4,000 trees, the campus features a distinctive blend of Mediterranean and Renaissance architecture noted for its red tile roofs, courtyards, and whimsical sculptured details. The location, too, is a blend - near downtown Houston, but insulated by quiet residential neighborhoods and tall hedges. (Rice students speak of graduation as "going beyond the hedges.")

Just across South Main street, bounding the east side of the campus, lies the Texas Medical Center, where world-famous labs and medical schools offer added opportunities for collaborative research, and Herman Park, one of the nation's largest urban parks. Here one can enjoy hundreds of acres of picnic grounds, a zoo, a golf course, and an outdoor theater. In the summer, the theater offers operas, plays and concerts. Also within easy walking distance are the Museum of Fine Arts, the contemporary Arts Museum, and the Museum of Natural Science.

LOCATION OF EVENTS

Registration and Information. Registration will be in the Plaza Hilton hotel from 4:00 - 8:00 p.m. on Sunday, 3 June. During the week, registration and information will be in Farnsworth Pavilion, Ley Student Center, 7:00 - 9:00 a.m., 11:30 a.m. - 1:30 p.m., and 2:30-3:30 p.m. The program schedule, which contains abstracts for each talk and details the week's events, is included in the registration packet. Information on Rice University and Houston, Texas will be available at the Registration Desk.

Speakers. Oral presentations will be given in Herring Hall, rooms 113, 117, and 124. Plenary talks are scheduled for 30 minutes each, including question period; concurrent session talks are scheduled for 15 minutes each, including question period.

Posters. Posters will be on display throughout the week in the Farnsworth Pavilion, Ley Student Center.

Barbecue Dinner. The Texas barbecue on Monday, 5 June at 6:00 p.m. will be located in the Grand Hall of the Rice Memorial Center. The price of the barbecue is included in the registration fee.

Mid-Symposium Field Excursion. Excursion buses will leave from the Plaza Hilton at 7:00 a.m. and will return at approximately 10:00 p.m. The excursion will be to the Big Thicket, located north of Beaumont in east Texas. Lunch and dinner are included in the IAVS Symposium registration fee.

SCHEDULE OF MEETING SESSIONS

FINE-SCALE SPATIAL PATTERN

MONDAY MORNING PLENARY SESSION

HERRING HALL 124

CHARLES CANHAM, SESSION CHAIR

- 8:15 OPENING ASSEMBLY
 P.A. HARCOTBE, Program Committee Chair and Local Host
 D. AUSTON, Provost, Rice University
 E.O. BOX, President, IAVS
 R. SHARITZ, Vice Chair, Vegetation Section, Ecological Society of America
- 8:30 HARCOTBE, P.A. Pattern in time and space.
- 8:45 WILSON, J.B. Theories of community structure: a reductionist approach.
- 9:15 HERBEN, T. High fine-scale dynamics versus broad-scale stability of temperate grasslands: how are they related?
- 9:45 VAN DER MAAREL, E. & M.T. SYKES. Small-scale processes in semi-natural grasslands.
- 10:00 BREAK
- 10:30 PEET, R.K., C.N. NEWELL & R. DUNCAN. Patterns in species diversity in North Carolina vegetation.
- 11:00 GILLISON, A.N. & S.C.S. PUNTODEWO. Minimum spatial resolution for surveying and mapping the potential distribution of plants and animals in tropical forested lands.
- 11:30 MINCHIN, P.R. The role of interspecific competition in determining meso-scale community patterns.
- 12:00 LUNCH

GENERAL PROGRAM OF EVENTS

Sunday, 4 June

- Registration
- Meeting of IAVS program committee

Monday, 5 June

- Fine-scale spatial patterns (Plenary session in the morning, contributed paper sessions in the afternoon; posters all day)
- Texas barbecue dinner on campus (cost included in registration fee)

Tuesday, 6 June

- Long- and short-term temporal patterns (plenary session in the morning, contributed paper sessions in the afternoon, posters all day)

Wednesday, 7 June

- Mid-Symposium Field Excursion to the Big Thicket (transport and meal costs included in registration fee)

Thursday, 8 June

- Broad-scale spatial patterns (plenary session in the morning, contributed paper sessions in the afternoon; posters all day)
- Meeting of ESA Vegetation Classification Panel
- IAVS General Assembly
- Symposium banquet (cost included in registration fee)

Friday, 9 June

- Special plenary session on opportunities for new research using large standardized data sets

Saturday, 10 June

- Main Excursion begins

MONDAY AFTERNOON CONCURRENT SESSION 2
HERRING HALL 113
ANTONI DAMMAN, SESSION CHAIR

- 1:15 SOLOMESHCH, A.I. Parallel variation in plant communities.
- 1:30 DIAZ, S. & M. CABIDO. Plant functional types in the face of climatic change: a multiscale approach.
- 1:45 MORENO-CASASOLA, P. & G. VAZQUEZ. Spatial and temporal patterns resulting from disturbance in coastal vegetation.
- 2:00 BLASI, C., A. ACOSTA & L. FILESÌ. Post-fire patterns in the mediterranean macchia: phytosociological and structural approach.
- 2:15 STANDOVAR, T. Within-community vegetation patterns in relation to habitat factors in a sessile oak stand.
- 2:30 YASTREBOV, A.B. Impact of trees on subordinate layer structure in pine forest of South Karelia.
- 2:45 MARTI, K. & B. TSCHANDER. A new method for a fast and robust assessment of vegetation changes.
- 3:00 BREAK
- 3:30 PILLAR, V. de PATTA, M. CADENAZZI & P. BOGGIANO. Probabilistic recognition of homogeneity, edges and patch structure in grassland.
- 3:45 KUULUVAINEN, T. Three-dimensional structure and spatial autocorrelation in a mature *Pinus sylvestris* forest in Finland.
- 4:00 KAWLA-IERD, S., K. FUJIWARA, T. SMITINAND, & T. SANTISUK. Spatial perspective on dry evergreen and deciduous dipterocarp forests in Thailand.
- 4:15 MAYCOCK, P. Compositional variation within an environmentally uniform old-growth deciduous forest ecosystem in southern Ontario, Canada.
- 4:30 NAKAGOSHI, N. & M. TANAKA. Trends of community structure of rural pine forest in different sized forest-patches.
- 4:45 MAST, J.N. & T.T. VEBLEN. A spatial analysis of ponderosa pine patch structure along the forest-grassland ecotone of the Colorado Front Range.
- 6:00 BARBEQUE (Cost of this event included in the registration fee).
 RICE MEMORIAL CENTER, GRAND HALL

MONDAY AFTERNOON CONCURRENT SESSION 1
HERRING HALL 124
REBECCA SHARITZ, SESSION CHAIR

- 1:15 STADLER, J., & R. BRANDL. Early succession in abandoned fields: germination strategy and vegetation development.
- 1:30 KRUMBIEGEL, A. Succession on abandoned fields—the influence of species availability.
- 1:45 WINKLER, E., S. KLOTZ & C. WISSEL. Long-term control of species abundances in a dry grassland community—a lesson from small-scale mathematical modeling.
- 2:00 KLOTZ, S. & E. WINKLER. Long-term small-scale plant species turnover in a dry grassland—results of 15 years of permanent-plot research.
- 2:15 RAMSEIER, D. Influence of nutrient levels on the establishment of sown species and volunteers in "wandering fallows" in Switzerland.
- 2:30 KOST, C. Population-level response to fertilization in a Swiss chalk grassland.
- 2:45 DAEHLER, W. Long-term trends in a fertilized alpine pasture.
- 3:00 BREAK
- 3:30 PODANI, J. Space-series analysis of vegetation.
- 3:45 DALE, M.B. & P.E.R. DALE. Does scale matter? Assessing impacts of perturbation on density of *Sporobolus virginicus* in a subtropical saltmarsh.
- 4:00 THOMSON, J.D., G. WEIBLEN, B.A. THOMSON & S. ALFARO. Gopher-driven patchiness and source-sink effects in a subalpine lily: rock-refuge effects.
- 4:15 JACKSON, R.B. Integrating resource heterogeneity and plant plasticity: modeling N and P uptake in a patchy soil environment.
- 4:30 SLIVA, J. Investigation of safe sites within tussocks of *Eriophorum vaginatum* and their role in the secondary succession processes in milled bog areas.
- 4:45 AUGÉ, H. & R. BRANDL. Spatial pattern, density dependence, and scale in the seedling dynamics of an invasive *Mahonia aquifolium* population.

TUESDAY AFTERNOON CONCURRENT SESSION 1

HERRING HALL 124

LADISLAW MUCINA, SESSION CHAIR

- 1:15 IMM, D.W. & K.W. McLEOD. Interactive relationships between vegetation, disturbance, and time at small to intermediate scales.
- 1:30 COLLINS, B. & G. WEIN. Oldfield vegetation responses to disturbance frequency and intensity.
- 1:45 FERNANDEZ-PALACIOS, J.M. & J.R. AR ÉVALO. Approach to laurel forest stand dynamics on Tenerife, The Canary Islands.
- 2:00 GUZMAN, G.S., J.S. DENSLOW & R.A. CHAZDON. Spatial patterns of seedling abundance and composition across a long tropical moist-forest chronosequence.
- 2:15 PAKALNE, M. The development of the rich fen vegetation in the dune slacks of Latvia.
- 2:30 PEDROTTI, F. & D. GAFTA. Long-term changes in vegetation of a wetland area (Laghestel) of Italian Alps.
- 2:45 FUHLENDORF, S.D. & F.R. SMEINS. Importance of scale on long-term temporal vegetation patterns following removal of domestic herbivory.
- 3:00 BREAK
- 3:15 ROSA, C.M.M. & G. EITEN. Temporal patterns of first-year post-fire recuperation of ground-layer species in a cerrado near Brasilia.
- 3:30 SNYDER, J.R. Fire ecology of South Florida rockland pine forests.
- 3:45 GENTILE, S. *Robinia pseudocacia* L. community patterns in vegetation dynamic series of the northern Apennines (Italy).
- 4:00 KRAMER-MCKINNEY, K.A. & E.J. RYKIEL, Jr. Are Hardwood-Redcedar clusters expanding?
- 4:15 WALKER, S., A.F. MARK, & J.B. WILSON. Seasonal changes in semi-arid vegetation of New Zealand.
- 4:30 HOLZAPFEL, C. Temporal and spatial variation of vegetation dynamics in disturbed and undisturbed sites along an aridity gradient.
- 4:45 MYSTER, R.W. & J.R. THOMLINSON. Using landscape characteristics to predict the vegetation structural stages of landslide patches in the Puerto Rican rainforest.

LONG- AND SHORT-TERM TEMPORAL PATTERNS

TUESDAY MORNING

HERRING HALL 124

ELGENE BOX, SESSION CHAIR

- 8:15 PARKER, V.T. & S.T.A. PICKETT. Formalizing multi-level approaches to vegetation dynamics.
- 8:45 LEPS, J. Succession: predictability and scale dependence of temporal patterns.
- 9:15 ZOBEL, K. & L. EEK. Effect of illumination and fertilization on seasonal changes in canopy structure of a species-rich grassland.
- 9:45 SZWAGRZYK, J. Relationship between spatial and temporal scales in natural forest dynamics.
- 10:15 BREAK
- 10:30 WIEGAND, T. & S.J. MILTON. A simulation model on shrubland ecosystem dynamics in the semi-arid Karoo, South Africa.
- 11:00 LEGG, C.J., R.I. MUETZELFELDT & D.N. HEATHFIELD. Modeling vegetation dynamics in Mediterranean ecosystems: issues of scale.
- 11:30 MIYAWAKI, A. Phytosociological vegetation patterns applied to green environmental restoration.
- 12:00 LUNCH

BROAD-SCALE SPATIAL PATTERNS

THURSDAY MORNING

HERRING HALL 124

PETER WHITE, SESSION CHAIR

- 8:30 UDVARDY, M.D.F. The world system of biogeographical provinces of IUCN based on the largest scale of vegetation patterns.
- 9:00 WALKER, M.D. Biodiversity of arctic ecosystems: patterns within and among communities and landscapes.
- 9:30 SILANDER, J.A., Jr., J.G. MICKELSON, Jr., D.L. CIVCO & C.D. CANHAM. The structure and dynamics of forest communities in northeastern North America: scaling from the individual to the landscape.
- 10:00 BREAK
- 10:30 WALKER, R., F.W. DAVIS & J.W. VAN WAGTENDONK. Remote sensing and geographic information system integration for monitoring dynamics of natural vegetation in California.
- 11:00 FUJIWARA, K. Spatial and temporal aspects of forest species diversity from boreal to tropical regions in eastern North America, Japan and Southeast Asia.
- 11:30 ROBERTS, D.W. Species vital attributes, environmental heterogeneity, and the pattern of vegetation.
- 12:00 LUNCH

TUESDAY AFTERNOON CONCURRENT SESSION 2
HERRING HALL 113
MICHAEL PALMER, SESSION CHAIR

- 1:15 JIMERSON, T.M. Spatial and temporal patterns of vegetation in the Klamath Mountains of northern California, USA and their implications to ecosystem management.
- 1:30 KNOX, R.G. & A.D. FRIEND. Vegetation dynamics from a functional-physiological basis and the paradox of reduction in biology.
- 1:45 MARTYNOVA, A. Individual variety in cenopopulations of saline soils in the South Ural Mountains.
- 2:00 PIETSCH, W.H.O. Time-dependent succession of the vegetation in the post-mining landscape of the Lusatian Lignite Mining District, Germany.
- 2:15 MAEDA, H. & K. FUJIWARA. Spatial and temporal processes in vegetation changes on highway embankments.
- 2:30 ALIAS, M.A. & K. FUJIWARA. Rehabilitation of the tropical rainforest with indigenous species on degraded areas in Sarawak, Malaysia, based on temporal process data.
- 2:45 BREAK

THURSDAY AFTERNOON CONCURRENT SESSION 2
HERRING HALL 113
STEPHEN JACK, SESSION CHAIR

- 1:15 GRACE, J.B. & B.H. PUGESEK. A general model for predicting plant species richness.
- 1:30 PALMER, M.W., G.L. WADE & P.R. NEAL. Large-scale patterns of vascular-plant species richness.
- 1:45 WITHERS, M.A. Relevance of the "Peninsular Effect" hypothesis for floristic diversity in Baja California.
- 2:00 PHILIPPI, T.E. & P.M. DIXON. Initial steps toward a method of analyzing vegetation samples including temporal change.
- 2:15 CHONG, G.W., L.D. SCHELL, & T.J. STOHLGREN. Multi-scale vegetation sampling in the Colorado Rockies: the Modified-Whittaker technique.
- 2:30 VAN KLEY, J.E., R.L. TURNER & M. CLENDENIN. An ecological classification system for the Western Gulf coastal plain: preliminary results.
- 2:45 CHIMVUKWA, P.H., F.E. SMEINS & D.K LOH. A landscape vegetation classification of the Edwards Plateau of Texas using Landsat TM data.
- 5:15 GENERAL ASSEMBLY
- 7:30 BANQUET
COHEN HOUSE

THURSDAY AFTERNOON CONCURRENT SESSION 1

HERRING HALL 124

ROSINE HALL, SESSION CHAIR

- 1:15 PARUELO, J.M., E.G. JOBBAGY, O.E. SALA, W.K. LAUENROTH & I.C. BURKE. Regional models in ecology: an evaluation of their predictive power.
- 1:30 GAVILAN, R. & F. FERNANDO-GONZALES. Climatic gradients of different scales in Spanish Sistema Central forests.
- 1:45 HOAGLAND, B.W. & S.L. COLLINS. Heterogeneity in shortgrass prairie vegetation on the southern High Plains, U.S.A.: the role of playa lakes.
- 2:00 PFISTER, R.D. Stand structure foundations for forest landscape evaluation.
- 2:15 DAMMAN, A.W.H. Climatic and topographic controls on the vegetation pattern of northern peatlands.
- 2:30 WILL-WOLF, S., B. McCUNE, J.P. DEYS, J. PECK & K. HEIMAN. Regional gradients in lichen communities in eastern USA forests.
- 2:45 TUOMISTO, H. Amazonian rain forests: how studies at different scales help understand a complex whole.
- 3:00 BREAK
- 3:30 VELAZQUEZ, A. & G. ISLEBE. Spatial and temporal community patterns of high mountains in Megamexico.
- 3:45 JELTSCH, F., S.J. MILTON, W.R.J. DEAN & N. VAN ROOYEN. Pattern formation as a "keystone" process in semi-arid savannas.
- 4:00 MENENTI, M. & S. AZZALI. Monitoring and mapping of soil-vegetation-climate complexes in South America using time series of satellite observations.
- 4:20 AZZALI, S. & M. MENENTI. Fourier analysis of time series of NOAA-AVHRR NDVI monthly composites to monitor and map vegetation-soil-climate complexes in southern Africa.
- 4:35 GONZALEZ LOYARTE, M.M. Vegetation growth in Argentina by means of Fourier analysis of time series of NOAA/NDVI images.
- 5:00 GENERAL ASSEMBLY
- 7:30 BANQUET (Cost included in registration fee)
COHENHOUSE

POSTER LIST

RICE MEMORIAL CENTER, FARNSWORTH PAVILION

Fine-scale spatial pattern

- 1 BATTAGLIA, L.L. A conceptual view of disturbance and heterogeneity: the "wrinkling" of environmental gradients.
- 2 HOSHINO, Y., K. TANNO, J. HOSHINO-IMAKIIRE, & T. ISEKI. Regional distribution pattern of riparian vegetation along the Tama river, central Japan.
- 3 MAREK, U. & F. ROMANE. Cluster-pine regeneration processes and their effects on landscape changes in southern France.
- 4 MULDAVIN, E.H. & J.A.R. LADYMAN. Spatial distribution of herbaceous plants in a low-disturbance piñon-juniper woodland in the southwest U.S.A.
- 5 NORTHUP, B.K., S.F. ZITZER, S. ARCHER & T.W. BOUTTON. Shoot allometry and biomass allocation in a sclerophyllous evergreen shrub.
- 6 OKSANEN, J. Neighbourhood diversity.
- 7 ROMERO, F.J. & A. VELAZQUEZ. Spatial and temporal variation of montane temperate Neotropical communities: a small-scale spatial scenario.
- 8 SCHELL, L.D., T.J. STOHLGREN, M.B. FALKNER, & G.W. CHONG. Estimating plant species composition and cover from subplots: improving multi-scale sampling designs.
- 9 STANISCI, A., A. ACOSTA, P. DI MARZIO, G. DOWGIALLO & C. BLASI. Plant communities in relation to soil and water persistence in subcoastal ponds (Central Italy).
- 10 ZITZER, S.F., S.R. ARCHER & E.J. RYKIEL. Temporal variation in seedling growth among contrasting growthforms: a mechanism for succession from hardwood savanna to evergreen woodland?

Short-term temporal processes

- 11 ABE, S. Primary succession on torrent-bed deposits along streams in the Tanzawa Mountains, Japan.
- 12 RAUS, T. Short-term temporal processes in eastern-Mediterranean therophytic vegetation monitored on permanent plots in Thessaly, Greece.

**SPECIAL SESSION
BROAD-SCALE NORTH AMERICAN MAPPING AND CLASSIFICATION**

FRIDAY

HERRING HALL 124

ROBERT PEET & PAUL HARCUMBE, SESSION CHAIRS

- 8:00 HARCUMBE, P., R.K. PEET, O.L. LOUCKS. Introduction.
- 8:15 GROSSMANN, D. The TNC/NPS mapping effort.
- 8:45 JENNINGS, M. GAP analysis: applied plant community ecology writ large.
- 9:15 HEMSTROM, M.A. Classification of existing and potential vegetation, USDA Forest Service approaches.
- 9:45 MUCINA, L. European Vegetation Survey: aims, status, perspectives.
- 10:15 BREAK
- 10:30 REID, E. & S.Y. ROSS. Mapping and quantifying the natural heritage status of semi-natural vegetation in Great Britain.
- 11:00 LOUCKS, O.L. The original Ecoregion Concept contrasted with Smalley (1986) and Bailey (1976) as frameworks for vegetation and land classification in the Cumberland Plateau.
- 11:30 SHARITZ, R.R. & W.D. MARSHALL. Vegetation classification as a framework for environmental management.
- 12:00 LUNCH
- 1:15 MOLONEY, K. Ecological pattern: a twofold template for understanding plant community dynamics as a spatial process.
- 1:45 DIXON, P.M. Vegetation analysis—is there anything new under the sun?
- 2:15 SPIES, T.A. & W.B. COHEN. Mapping forest structure and dynamics in the Pacific Northwest using remote sensing.
- 2:45 ZIMMERMANN, K. & F. KIENAST. Climatically sensitive modeling tools to predict vegetation patterns at the landscape level.
- 3:15 BREAK
- 3:30 CANHAM, C.D. Integrating across scales from individual trees to landscapes: linkages between tree population dynamics and forest ecosystem processes.
- 4:00 LENIHAN, J.M. & R.P. NEILSON. Vegetation classification issues in the application of MAPSS for global change research.
- 4:30 BOX, E.O. Static and dynamic models of global terrestrial vegetation.
- 5:00 WHITE, P. Concluding Remarks.

MID-SYMPOSIUM EXCURSION

MID-SYMPOSIUM EXCURSION

The mid-Symposium excursion will depart the Plaza-Hilton Hotel at 7:00 AM, Wednesday, June 7, 1995, for the Big Thicket National Preserve, a unit of the US National Park System, in southeast Texas. We will arrive back at the Plaza-Hilton around 10:00 PM. Driving time to the area is about 2.5 hours. Lunch and dinner will be provided. Participants should wear sturdy shoes, and they should be prepared for rain showers. The weather will be very warm and humid. Drinking water will be provided. Aside from the heat, the chief annoyance is biting insects--mosquito (Diptera) and chiggers (Trombiculid mites). Spraying repellent on socks and lower pant legs will help limit chigger bites, as will a hot, soapy bath afterward.

The plan for the day will be to visit three sites (Hickory Creek, Turkey Creek, and the Roy Larson Preserve), so as to see examples of most of the major vegetation types in the area (according to Marks & Harcombe 1981; see fig 1), which are more-or-less representative of the vegetation of the coastal plain of the southeastern United States (the Southern Mixed Hardwood Forest of Kuchler [1964]). As we approach the areas of interest, one bus will proceed to each of the three areas. Over the course of the day, each group will spend 1-2 hours at each of the three sites. At each site, each busload will be divided into two, and will tour the areas in opposite directions. Each group will have a local guide and a plant ecologist with some knowledge of coastal plain vegetation patterns. At about 6 PM, all three buses will converge at the Roy Larson Preserve for an outdoor supper of fried catfish, a typical meal of the deep south. We will board the buses at about 8:00 PM for our return to Houston.

The Big Thicket is an area of forests, thickets, and savannas on the Gulf Coastal Plain of the United States between the Sabine and Trinity Rivers in southeast Texas (latitude 30-31° N, longitude 94-95° W). It presumably takes its name from the relatively dense understory shrub layer and from bands of evergreen shrub thicket that frequently line small streams in the region. It is bounded on the south by the coastal prairie and on the north oak-hickory-pine forest. The underlying geologic formations are broad bands of Pleistocene fluvial and marine deposits. The southerly latitude of the study area and its proximity to the Gulf of Mexico (60-120 km) insure a warm, humid climate during most of the year. Average annual temperature is 19.5°C with an average monthly minimum of 10.6°C in January and a maximum of 27.6°C in August. The frost-free season is 210-240 days. Precipitation averages 132 cm annually, and is well-distributed through the year, the difference between the extremes (March vs April) being 5 cm. The Big Thicket is slightly warmer and drier than the rest of the southeastern United States. Mean daily temperature in July is about 2° higher than in most of the rest of the southeast. Average annual water deficiency is 8-25 cm vs 0-8 cm for the rest of the Southeast. Hurricanes are common; 34 struck the upper Texas coast between Houston and Beaumont in the 1899-1986 interval. The frequency of lightning strikes is as high as anywhere in the United States outside peninsular Florida. Tornadoes are common, but they affect extremely small areas, so the return time exceeds 500 yr.

The Big Thicket region was settled by anglo-americans beginning in about 1820. Until 1880, population density remained very low, and the forests remained largely untouched. Development of strong demand for lumber in the midwest following 1875 led to a logging boom that lasted roughly from 1880 to 1930. During that period, nearly all

Broad-scale spatial patterns

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- 14 DE STEVEN, D. Hydrologic and landscape-level structuring of vegetation pattern in Carolina bay wetlands.
- 15 FULTON, M.R. Applying fuzzy-set ordination to regional tree-habitat evaluation for environmental assessment.
- 16 HONG, S.-K. & N. NAKAGOSHI. Rural forest management in the Far East: a proposal of new utilization.
- 17 MENGHI, M. & M. HERRERA. Biomass and diversity relationships in inland wetlands.
- 18 SHARITZ, R.R., E.F. PAULEY, & B.P. ALLEN. Spatial patterns of disturbance and recovery from hurricane winds in an old-growth floodplain forest.
- 19 WOHLGEMUTH, T.M. Some ecological implications of phytogeographical distribution patterns in Switzerland.
- 20 WOLFE, D.W., C. LUI, J. MARESH, S. PERRY & G. ROWELL. A land cover analysis of Texas National Guard training areas.

Long-term temporal patterns

- 21 CHINEA, J.D. Fifty-eight years of natural forest recovery in the Municipality of Humacao, Puerto Rico.
- 22 HALL, R.B. & P.A. HARCOMBE. Sapling demographics and growth as affected by flooding and canopy gap formation in a river floodplain forest in southeast Texas.
- 23 KALIGARIC, M. Abandoned vineyards: an example of a method used to define a long-term temporal process.
- 24 LIIRA, J. & K. ZOBEL. Evenness as key characteristic of successional changes in limestone grassland.

per annum). Farther to the east, we pass through a forest island named Fannet Woods, which occupies a sandy outcrop of the Ingleside Barrier, a Pleistocene barrier island formation.

As we pass through the city of Beaumont, we cross the northern boundary of the coastal prairie, and enter the forest, locally known as the "pineywoods." For the most part, this boundary is coincident with the boundary between the Beaumont and the Montgomery Geologic Formations. Soils of the former are predominantly dense fluvial and marine clays; the terrain is mostly flat and poorly drained. The Montgomery formation is older, higher, better drained; soils are somewhat coarser.

The native forests of the region can be divided into three major units, hardwood, mixed pine-hardwood, and pine. Hardwood forest is mostly restricted to river and stream floodplains. Mixed forest occupies mesic-to-dry uplands. Pine forest occurs on dry uplands and wet flats. Driving north from Beaumont, we begin on low, flat terrain, which almost imperceptibly becomes more rolling and dissected by the time we reach our destination near Village Mills, TX, about 65 km N of Beaumont. The highway follows a broad SE-NW band of poorly-drained soils with a sandy surface. Originally this geomorphic unit would have supported open *Pinus palustris* forest or savanna interspersed with bands of mixed forest or hardwoods along the major streams. Now, much of the forested land is commercial pine stands, many of them planted. Near Beaumont there are some plantations of *Pinus elliottii* (the natural range of this species is east of the Mississippi River into Florida). Farther north, the plantations are mostly the native *Pinus taeda*.

The vascular flora of the Big Thicket region of southeast Texas (an area approximately 120,000 ha) consists of approximately 1500 species, 10-15% of which are woody. A number of species typical of the eastern Gulf and Atlantic coastal plain are not found west of the Mississippi River in the western Gulf coastal plain. Some that come to mind are *Pinus elliottii*, *Quercus laevis*, and the evergreen shrub bog species, *Gordonia lasianthus*

HICKORY CREEK

The original vegetation of the Hickory Creek Savanna Unit of the Big Thicket National Preserve was probably open pine savanna containing stringers of shrubs and trees along the intermittent drainages. Natural lightning-ignited fires kept the woody plants from replacing the species-rich graminoid-dominated ground layer. The area was logged in the 1920s. From 1929 to 1967, fires occurred at intervals of 2-7 yr. Fires were suppressed from 1967 to 1980. Since 1980, prescribed burns have occurred at 3-7 yr intervals, mostly in March and April. Soils are acid loams or clays with a fragipan at varying depths.

Two savanna types occur here, poorly-drained grass-sedge meadows, and well-drained pine-bluestem savanna. The dominant graminoid in both is *Schizachyrium* (= *Andropogon*) *scoparium*. In the former, other common plants include *Cyperaceae* (especially *Rhynchospora* and *Eleocharis squarrosa*), and other distinctive wetland herbs (e.g. *Drosera*, *Eriocaulon*, *Lycopodium*, *Xyris*). In the pine-bluestem savanna, associated species are mostly upland grasses (*Paspalum* spp, *Muhlenbergia capillaris*, *Dichanthelium angustifolium*) and herbs (*Helianthus angustifolius*, *Silphium simpsonii*, *Tephrosia onobrychoides*). Important woody species include *Pinus taeda*, *P. palustris*, *Quercus falcata*, *Ilex vomitoria*, *Myrica cerifera*, *Cornus florida*, *Sassafras albidum*. In wet drainages, the shrubs, *Cyrilla racemiflora*, *Ilex coriacea*, and *Magnolia virginiana* are common to abundant.

the uplands were selectively cut for pine. In the 1960s, a second wave of cutting began. This time, many areas were clearcut and converted to pine plantations.

We will proceed via Interstate Highway 10 (I-10) east to Beaumont, TX (approx 130 km), and then head north on US Highway 69 to units of the preserve (another 80 km) in the vicinity of Warren, TX. After leaving the hotel, we get on the US 59 and skirt the south edge of downtown Houston. This is the financial center of the region; many of the large buildings house headquarters of international oil companies. Headed east from downtown, we get on I-10. About 20 km from the hotel, we pass under a loop freeway (I-610). The major petrochemical plants and port facilities of Houston are located just to the south along Buffalo Bayou, which parallels the highway. At km 35, we cross the first major water body, the San Jacinto River, at its mouth, where it empties into Galveston Bay. Galveston bay is one of the largest and most commercially productive bay systems on the US coast of the Gulf of Mexico. To the south on the horizon is a tall spire, the San Jacinto Monument, which commemorates a famous battle in the Texas war of independence against Mexico in 1836. After crossing the river, we begin to see abandoned fields among the residential and commercial properties. Most of these fields were originally coastal prairie (Smeins et al 1991), a variant of Eastern Tallgrass Prairie (*Schizachyrium scoparium*, *Andropogon gerardi*, *Panicum virgatum*, *Sorghastrum avenaceum*). They were used for pasture and rice fields until about 15 yr ago. After abandonment, they were invaded by the shrub, *Baccharis halimifolia* (Asteraceae) and the naturalized Chinese tree, *Sapium sebiferum* (Euphorbiaceae). One of the common grasses of abandoned rice fields is *Paspalum urvillei*.

At km 50, we cross Cedar Bayou. The petrochemical plant on the north side of the highway is responsible for the moribund condition of the pines in the area.

At km 65, we cross the Trinity River, which drains a very large area to the north and west. Because the headwaters are in the semi-arid region west of Dallas, the floodplain soils have a higher base content than smaller rivers that drain only the humid coastal region. Note the steep bluff on the west side and the wide, flat floodplain, which are typical of coastal plain rivers. The water body near the west bluff is the confluence of two abandoned channels, Old and Lost Rivers. The highway is near the boundary between fresh marsh (*Phragmites australis* fringing waterways; mixed grassland-shrubland on flats) and brackish marsh (*Spartina patens*, *Distichlis spicata*). The communities visible from the road are still recovering from heavy grazing in the past. The sandy levee deposits just west of the main channel of the river (high bridge) are populated by floodplain tree species that are common in riparian zones along the western margin of the eastern forests (*Celtis laevigata*, *Ulmus americana*, *Ulmus crassifolia*, *Fraxinus pennsylvanica*), as well as southern floodplain species (*Quercus nigra*, *Q. michauxii*, *Liquidambar styraciflua*, *Nyssa sylvatica*). As we reach the high point of the bridge, look southeast across a *Taxodium distichum*-*Salix nigra* swamp.

East of the Trinity River, we pass through a large lobe of low upland forest associated with Pleistocene-age sandy deposits of the river. This forest has been heavily exploited for a century. Dominant trees include *Pinus taeda*, *Liquidambar styraciflua*, and *Quercus nigra*. There are several patches of dead *Pinus* along the roadway. The agent of death was southern pine beetle (*Dendroctonus frontalis*), a serious native pest that shows outbreaks at approximately 10-yr intervals.

At km 80, we move again from forest to coastal prairie. At this point, we are approximately 30 km from the Gulf of Mexico. The upland soils here are mostly heavy clays (vertisols). Both fire and the heavy clay soils inhibit tree growth, thereby helping prevent trees from displacing grasses in this high-rainfall area (ca 1200 mm

are common. Few herbs are present. Stand basal area is approximately 35 m²/ha; Characteristic PPFD at the ground surface is 3-4% of midday full sun. The soil is a fine-loamy, siliceous, thermic Typic Glossaqualf. Median values for texture fractions are 64.5% sand, 27.3% silt, and 7.8% clay. History of this stand is unknown, but it is likely that mature pines were removed about 1930.

In the lower, wetter spots along the trail and in the woods, species characteristic of river floodplains, especially *Quercus michauxii*, *Liquidambar styraciflua* and *Carpinus caroliniana* become more important (see description of river floodplain forest below), as do swamp species, such as *Nyssa sylvatica* var *biflora* and *Taxodium distichum*. Along narrow streams and drains, "baygall" (evergreen shrub bog) species such as *Magnolia virginiana*, *Cyrilla racemiflora* and *Ilex coriacea* will be found.

ROY LARSON PRESERVE

The Roy Larson Preserve is owned and managed by The Nature Conservancy one of the world's largest and best-known private, non-profit nature conservation organizations. The preserve contains an excellent example of the dry sandhill forests common in the southeastern United States. In addition to the sandhill, bottomland (floodplain) hardwood forest and "baygall" (wetland shrub thicket) will be seen here. In clockwise order, the tour path traverses three principal habitats:

1. Bottomland hardwood forest occurs in active floodplains of major streams and rivers of the southeastern United States. Soils are waterlogged every winter, usually from January to April; flooding occurs at 1-10 yr intervals for periods of several days to several months. The vegetation on such sites corresponds to Southern Floodplain Forest (Kuchler 1964) or River Floodplain Forest (Marks and Harcombe 1981). It is dominated by widely spaced large individuals of *Liquidambar styraciflua*, *Quercus michauxii* and *Q. nigra*. Other common overstory species include *Acer rubrum*, *Ulmus americana* and *Q. pagoda*. There is often a dense mid-canopy layer of *Carpinus caroliniana*. *Ilex decidua* is the only common shrub species. *Sebastiania fruticosa* is often a conspicuous herb. The ground layer may vary from bare under dense canopy to grassy, to dense herbs and tree saplings in canopy gaps. Gap-phase regeneration is more strongly evident in river floodplains than in upland forests in this area. *Taxodium distichum* and *Nyssa aquatica* are important in sloughs and abandoned oxbows. On low flats near sloughs, *Quercus lyrata* and *Carya aquatica* may be found. In bottomland hardwood forest, characteristic photosynthetic photon flux density (PPFD) at the ground surface is 2-6% of midday full sun. Soils are predominantly fine, montmorillonitic, acid, thermic Aeric Fluvaqueunts. From a similar site, median values for texture fractions are 23.5% sand, 37.9% silt, and 35.9% clay.

2. Sandhill vegetation occurs on deep, coarse sands, usually deposited during Pleistocene episodes when local streams were larger than they are today. In this region, they are dominated by *Quercus margaretta*, *Q. stellata*, *Q. incana* and *Pinus palustris*. (*Q. laevis* does not occur west of the Mississippi River). Common shrubs include *Vaccinium arboreum* and *Bumelia lanuginosa*. The herb layer is characteristically rich, though frequently sparse. Often it is dominated by graminoids, particularly *Aristida* spp., *Dichanthelium* spp. and *Schizachyrium scoparium*. Conspicuous or common herbaceous plants include *Opuntia lindheimeri*, *Yucca louisianensis*, *Pityopsis graminifolia*, *Stylisma pickeringii*. Most of the sandhill area at this site has a long history of human influence, mostly involving logging around 1900 and sporadic firewood cutting. Merchantable stems were removed around 1970, and *P. elliotii* was planted in 1973. The planting was done by pulling a planting trailer behind a bulldozer with a

TURKEY CREEK

The part of the Turkey Creek Unit (Big Thicket National Preserve) which we will visit contains almost the full array of plant communities from upland pine to bottomland hardwoods. The main focus will be the mixed pine-hardwood types, particularly a *Pinus* - *Quercus stellata* - *Q. falcata* stand, and an area dominated by *Pinus taeda*, *Fagus grandifolia*, *Magnolia grandiflora*, and *Ilex opaca*. Following is an abbreviated trail guide. Groups making the tour clockwise should follow it in reverse order.

1. *P. palustris* stand on the E side of the road. Here, natural regeneration of *P. palustris* was abundant and fire frequency was apparently high enough to reduce hardwood establishment and growth. Since 1980 this stand has been burned three times, most recently in March, 1995.
2. Mixed stand along paved trail. Pines were cut here in 1930. It is known that no fires occurred between 1968 and 1983. Prescribed burns were conducted in 1985, 1989 and 1994.
3. Wetland meadow (Pitcher Plant Bog). This poorly-drained site has a shallow fragipan. *Pinus elliottii* was planted here in 1962 and 1967. Prescribed burning was initiated in 1980, and has continued at 3-4 yr intervals; the *P. elliottii* was removed by hand in the early 1980s, and some shrub removal was done by hand in the late 1980s.
4. Baygall. "Baygall" is a local term for wetland shrub bogs characterized by dense thickets of *Cyrilla racemiflora* and *Ilex coriacea* under an emergent canopy of *P. taeda*, *Magnolia virginiana* and *Quercus laurifolia*. Note the sharp transition between wetland meadow and baygall. Although this may be partly a consequence of past land use, such sharp boundaries are known to occur naturally. The long, straight stretch of trail here follows a 1930s logging tram route.
5. The *Pinus* - *Quercus stellata* - *Q. falcata* stand was logged in 1930. *P. palustris* was the dominant pine; *Quercus stellata*, *Q. falcata*, and *Carya texana* were the most important overstory hardwoods (10-25% of stand basal area); *Q. incana* was common. Now the hardwoods constitute approximately 60% of stand basal area; they form a relatively open canopy 15-20 m tall, below emergent *Pinus taeda*, *P. palustris* and *P. echinata*. The understory is a moderately dense mixture of tree saplings and shrubs; *Cornus florida* and *Ilex vomitoria* are particularly abundant, and *Callicarpa americana* is common. The most distinctive herb is *Cnidoscolus texanus* (Euphorbiaceae), which has palmately lobed leaves covered with stinging hairs (take care not to brush against this plant--it can be very painful). Characteristic PPFD at the ground surface is 9-13% of midday full sun. The soil is a loamy, silicious, thermic Grossarenic Paleudalf. Median values for texture fractions are 80.0% sand, 14.2% silt, and 5.7% clay. Natural fires probably occurred, possibly at highly variable frequency. Fires were probably infrequent until 1967. Since then the stand is known to have gone unburned.
6. The *Pinus taeda*-*Fagus grandifolia*-*Magnolia grandiflora*-*Ilex opaca* stand is representative of the type that has been variously referred to as Southern Mixed Hardwood Forest, Beech-Magnolia-Holly, or Lower Slope Hardwood Pine. The closed canopy of tall trees (25-40 m) is dominated by *Pinus taeda*, *Quercus nigra*, *Fagus grandifolia*, *Magnolia grandiflora*, and *Quercus alba*. *Acer rubrum*, *Liquidambar styraciflua*, and *Nyssa sylvatica* are abundant as small-to-medium stems, but are infrequent as large trees. *Ilex opaca*, *Cornus florida*, and *I. vomitoria* are important understory woody species; *Ostrya virginiana*, *Persea borbonia* and *Symplocos tinctoria*

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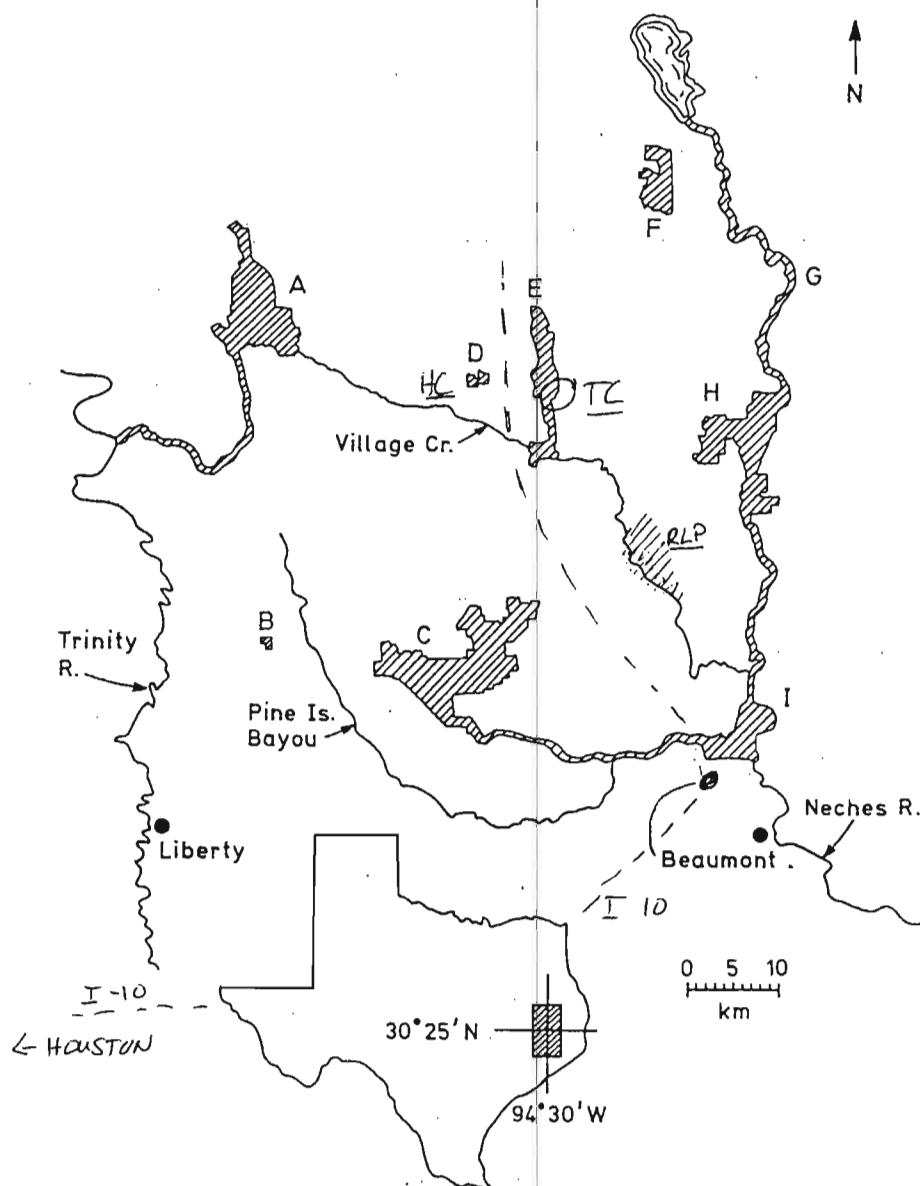


FIG. 1. Map of study region showing major creeks and rivers as well as the units of Big Thicket National Preserve labeled as follows: A, Big Sandy/Menard Creek Unit; B, Loblolly Unit; C, Lance Rosier Unit; D, Hickory Creek Unit; E, Turkey Creek Unit; F, Beech Creek Unit; G, Neches River Corridor; H, Jack Gore Baygall; I, Beaumont Unit.

blade to remove the hardwoods along the planting lines. Plantation success was very poor. Nonetheless, in some places it is still possible to see the old bulldozer lines or lines of *P. elliotii*. Since acquisition for a preserve in 1976, the sandhill has been burned at 3-5 yr intervals

3. Upland swamp/baygall. Along the eastern edge of the preserve the trail dips down into a wet flat dominated by *Quercus laurifolia* and *Magnolia virginiana*, with characteristic baygall shrubs (*Cyrilla racemiflora* and *Ilex coriacea*) in the understory. This site is typically flooded by 5-10 cm of water each winter. Note the sharp transition from baygall to sandhill. A native azalea (*Rhododendron oblongifolium*) is common along this boundary.

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ABSTRACTS

ABE, S. Yokohama National University, Japan

Primary succession on torrent-bed deposits along streams in the Tanzawa Mountains, Japan

In Japan the gradients of river beds are usually steeper than other in countries. On the upper parts of some rivers, especially where the mountain slopes along the rivers were heavily disturbed, pioneer tree species appeared on landslides or volcanic sites and were dominant on the newly deposited areas. The species composition of the forest dominated by these pioneer trees was reported in some regions, but few studies were done on short-term compositional change of these forests. In this study, I examined the floristic change of the forest related to the development of the forest stands on the deposits of the valley bottom in the Tanzawa Mountains. The forest plots surveyed were divided into four stages by maximum size of the pioneer trees, which indicate the age of the deposits. From early to late stage, their floristic compositions gradually changed, and these stages corresponded well to their ordination scores using reciprocal averaging. Moreover, the species groups, which were arranged by appearance or disappearance pattern, have some relation to their life forms and disseminule forms.

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Rehabilitation of the tropical rainforest with indigenous species on degraded areas in Sarawak, Malaysia, based on temporal process data

A study was conducted using dense plantation of potted species of indigenous species to create a stand of native Malaysian primary forest (Dipterocarps and non-Dipterocarps). Phytosociological surveys in natural areas were conducted at Kuching, Bintulu and Miri for comparing growth of planted seedlings with natural trees. The results suggest that planting in open areas involving three site conditions and under secondary forest with 3 planting methods can be very successful. Species recommended for planting on degraded open areas and in secondary forest were based on their good growth performance in basal diameter and height. The mortality rate cannot be used as an indicator for species suitability, since it was not yet fully understood and other conditions might be contributing to mortality of seedlings after planting. Phytosociological studies show that seedlings from the *Hopea kerangasensis* - *Allantospermum borneense* community, *Cryptostachys lakka* - *Whiteodendron moulitianum* community, *Eusideroxylon melangangai* - *Pometia pinnata* community, *Shorea parvifolia* community and *Dryobalanops beccarii* community had good growth in basal diameter and height. A few species such as *Hopea kerangasensis*, *Calophyllum ferrugineum*, *Eugenia* sp. and *Durio carinatus* did not show good growth when planted. The technique developed in this study could be adopted to rehabilitate degraded forest areas and could also be employed in rehabilitating previous mining areas and in landscaping projects in urban areas, along highways and railway lines in the country.

TABLE 1. Mean total basal area (square metres per hectare) by species for each of the 11 vegetation types. Basal area values are for all stems of a species in a stand sample. Only species with mean basal area >0.05 m²/ha are included in table. Vegetation types are as follows: 1 = Sandhill Pine Forest (SH); 2 = Upland Pine Forest (UP); 3 = Wetland Pine Savanna (WPS); 4 = Upper Slope Pine Oak Forest (USPO); 5 = Mid Slope Oak Pine Forest (MSOP); 6 = Lower Slope Hardwood Pine Forest (LSHP); 7 = Floodplain Hardwood Pine Forest (FHP); 8 = Floodplain Hardwood Forest (FLH); 9 = Flatland Hardwood Forest (FH); 10 = Wetland Baygall Shrub Thicket (BG); 11 = Swamp Cypress Tupelo Forest (SW). Species are arranged in order from those abundant in dry (low-numbered) to those abundant in wet (high-numbered) vegetation types.

	1 SH	2 UP	3 WPS	4 USPO	5 MSOP	6 LSHP	7 FHP	8 FLH	9 FH	10 BG	11 SW
Number of stands	2	3	2	7	2	9	2	15	9	4	1
<i>Quercus incana</i>	4.7	0.5									
<i>Quercus marilandica</i>		0.2		2.4							
<i>Quercus stellata</i>	3.7	0.1		1.3	0.2						
<i>Pinus palustris</i>	0.6	9.3	6.6	2.6							
<i>Pinus echinata</i>	1.3	0.4		7.3	4.1						
<i>Myrica cerifera</i>			0.1								
<i>Carya tomentosa</i>				0.2	0.1						
<i>Quercus falcata</i>		0.2	0.3	3.0	4.6	1.1					
<i>Cornus florida</i>	0.1			0.2	0.9	0.2	0.2				
<i>Callicarpa americana</i>				0.1							
<i>Ilex vomitoria</i>	0.1			0.3	0.5	0.2			0.1		
<i>Pinus taeda</i>	2.4	0.7	3.6	2.6	6.5	5.1	10.2	1.6	2.4	0.4	
<i>Quercus alba</i>				0.5	3.9	3.8	1.6		0.6	0.1	
<i>Persea borbonia</i>					0.1	0.1					
<i>Symplocos tinctoria</i>					0.2	0.2					
<i>Sassafras albidum</i>				0.1	0.1	0.1					
<i>Magnolia grandiflora</i>					0.1	3.8	2.3	0.3			
<i>Ostrya virginiana</i>						0.5	0.4				
<i>Cyrilla racemiflora</i>			0.1							0.3	
<i>Fagus grandifolia</i>						4.7	7.3	1.2			
<i>Ilex opaca</i>				0.2	1.1	1.6	0.9	1.1	0.1	0.3	
<i>Magnolia virginiana</i>			0.1			0.3	1.1			2.8	
<i>Nyssa sylvatica</i>			0.5	0.5	1.1	0.9	3.1	1.3	1.6	15.7	10.8
<i>Quercus laurifolia</i>					0.7	1.3	1.0	0.3	2.1	8.0	
<i>Acer rubrum</i>				0.1	1.2	0.4	0.2	0.9	0.7	3.1	2.5
<i>Liquidambar styraciflua</i>	0.1	0.1	0.6	1.1	1.1	1.0	2.3	5.9	2.0	1.7	0.6
<i>Quercus phellos</i>					0.6	1.2		0.9	3.4		
<i>Quercus nigra</i>			0.1		0.5	2.7	1.9	6.1	1.2	0.4	
<i>Quercus falcata</i> var. <i>pagodaefolia</i>								0.9	2.3		
<i>Quercus michauxii</i>						0.1	0.6	2.1	3.2	0.6	
<i>Fraxinus pennsylvanica</i>					0.1	0.1	0.4	0.4	2.3	0.4	
<i>Ulmus alata</i>							0.2	0.1	0.3		
<i>Carpinus caroliniana</i>						0.1	1.4	4.1	0.1		
<i>Sabal minor</i>									0.1		
<i>Diospyros virginiana</i>									0.1		0.1
<i>Carya aquatica</i>							0.1	1.0	0.4		0.3
<i>Ilex decidua</i>								0.1	0.1		
<i>Taxodium distichum</i>								0.2	0.2	0.6	22.5
<i>Quercus lyrata</i>								0.5	1.8		0.4
<i>Crataegus</i> spp.									0.5		
<i>Carya glabra</i>						0.4	0.1	0.2	0.2		
<i>Nyssa aquatica</i>										1.7	95.1
<i>Planera aquatica</i>											0.3
<i>Cephalanthus occidentalis</i>											0.6
<i>Fraxinus caroliniana</i>										2.4	4.9
Total	13	12	12	26	32	37	35	28	24	38	138

BATTAGLIA, L.L. Savannah River Ecology Laboratory, Aiken, South Carolina, USA

A conceptual view of disturbance and heterogeneity: the "wrinkling" of environmental gradients

Spatial heterogeneity is typically examined as discrete patches in which the investigator subjectively designates patch boundaries. Environmental conditions, however, may be spatially continuous, or may vary at different scales along underlying environmental gradients. If heterogeneity of an environmental variable can be defined as its rate of change over space, disturbance disrupts environmental gradients and results in a population of "wrinkles" at a given position and scale. Spatial heterogeneity along a gradient can be modelled using a sine wave function in which amplitude and frequency of an arbitrary environmental variable are varied across distance. Theoretically, species richness should increase with amplitude, and species abundance should increase with period. Depending on selection of species and scale, characteristics of the "wrinkles" define environmental conditions that affect population dynamics and species diversity.

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BLASI, C., A. ACOSTA & L. FILESÌ. Università "La Sapienza", Roma, Italy

Post-fire patterns in the mediterranean macchia: phytosociological and structural approach

In this work we discuss the results of a phytosociological study according to the European Sigmatis school complemented with a spatial pattern analysis in post-fire communities of Circeo National Park (Central Italy). The vegetation series of this macchia environment presuppose the *Quercus ilex* forest (*Quercion ilicis* Br.Bl. (1931) 1936 em. Riv. Mart. 1974; *Quercetia ilicis* Br.Bl. 1947) and coenoses belonging to *Pistacio-Rhamnetalia alaterni* Riv.-Mart. 1975 and *Rosmarinetalia officinalis* Br.-Bl. 1931. Soil characteristics were recorded in order to establish vegetation-soil relationships. Each community type was also sampled using transects with contiguous quadrats with the aim to study the spatial arrangement of species through a multispecific and multiscale technique of pattern analysis. The combination of a classical phytosociological approach with a spatial pattern analysis showing small scale association between species allows improvement of the understanding of macchia vegetation considering different but complementary views of plant communities.

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AUGE, H. & R. BRANDL. UFZ Centre for Environmental Research, Leipzig, Germany

Spatial pattern, density dependence, and scale in the seedling dynamics of an invasive *Mahonia aquifolium* population

Oregon grape (*M. aquifolium*, Berberidaceae), a shrub from western North America, has become a successful invader in Central Europe. Besides clonal growth, sexual reproduction may also contribute to the growth rate of local populations. Since mortality is highest in the first year after germination, the patterns of seedling emergence and survival determine the future spatial structure of the population. With a demographic study at different spatial scales (4 m² and 0.16 m² plots, 0.03 m² neighborhood areas), we tested, in a local population, whether seedling emergence is spatially predictable and clumping results in density-dependent mortality. Seedling emergence was clumped at all scales and was not correlated with distance to the nearest fruiting shrub. However, spatial pattern of seedlings from previous years was a good predictor of new seedling density, but only at the largest scale considered. Thus, the processes predominantly affecting the spatial distribution of seedlings at this scale are spatially consistent across consecutive years. In contrast, as a result of neighborhood competition, density-dependence was detectable only at the smallest scale and only beyond a certain density threshold. Because the underlying processes depend on scale, the predictability of seedling density and the analysis of density-dependence are affected by spatial scale in a different way.

AZZALI, S. & M. MENENTI. DLO-Winand Staring Centre for Integrated Land, Soil and Water Research, Wageningen, The Netherlands

Fourier analysis of time series of NOAA-AVHRR NDVI monthly composites to monitor and map vegetation-soil-climate complexes in southern Africa

The distribution of vegetation is largely associated with climate, terrain characteristics and human activity. Time series of satellite data provide the opportunity to monitor the dynamics of vegetation, its change and its impact on the environment. A time series of monthly NDVI composites (Aug. 1981 through July 1990; spatial resolution 7.6 km x 7.6 km) was decomposed using a Fast Fourier Transform algorithm into a set of amplitude and phase images covering Africa south of the Equator. The dominant (highest amplitude values) periodic components are identified first to reduce the amount of data (number of images) which have to be considered in the subsequent steps. By applying numerical classification algorithms a map of zones homogeneous with respect to vegetation dynamics (amplitude and phase values is a measure of vegetation dynamics) was obtained. The map units are vegetation-soil-climate complexes; a high correlation was observed of map units with a radiational index of dryness or Budyko ratio as well as with the spatial distribution of vegetation types according to White vegetation map.

CANHAM, C.D. Institute of Ecosystem Studies, Millbrook, New York, USA

Integrating across scales from individual trees to landscapes: linkages between tree population dynamics and forest ecosystem processes

A recently developed model of forest dynamics (SORTIE) predicts that tree population dynamics within stands of the transition oak-northern hardwood forests of the Northeastern US are (1) non-equilibrium, (2) strongly dependent upon initial conditions, and (3) become increasingly patchy over time. These dynamics occur even in the absence of any underlying variability in environmental conditions. Physical variation in soil properties, particularly cation chemistry, produces more predictable variation in tree species abundance at the landscape scale. However, during all stages of succession, local and essentially stochastic variation in the relative abundance of successional equivalent species can lead to significant variation in ecosystem processes at both the stand and landscape level. While groups of functionally redundant tree species can be identified for any particular ecosystem process, the groupings do not appear to be consistent across even basic processes such as nitrogen cycling, cation chemistry, and hydrology. Current vegetation mapping efforts generally do not allow resolution of the relative abundance of tree species except in very species-poor systems. I will argue that these efforts will have limited success in accurately predicting landscape-scale patterns of ecosystem structure and function in forests, and that real progress will occur only when emerging technology allows accurate resolution at the level of individual tree species.

CHIMVUKWA, P.H., F.E. SMEINS & D.K. LOH. Texas A & M University, College Station, Texas, USA

A landscape vegetation classification of the Edwards Plateau of Texas using Landsat TM data

Remotely sensed data offers an opportunity for landscape scale vegetation studies. The objective of this investigation was to explore the utility of Landsat TM data with ancillary data in a Geographic Information System environment to describe the vegetation patterns for the western portions of the Edwards Plateau, Texas. The Sonora Agricultural Experiment Station was utilized to develop an initial classification due to the availability of long-term ground truth data at the Station. This classification was then applied to the area of Sutton County, Texas. Preliminary results show about 7 distinct vegetation classes, which are not uniformly distributed over the area. The classes represent varying degrees of woody/herbaceous cover and to some extent growth form and species differences. Landsat TM bands 1, 5, and 7 appear most useful for distinguishing these classes. Mesquite dominated classes appear to have one distinct signature regardless of underlying geology, although they occur most commonly on buda limestone areas in the eastern portion of the county. Topography, soil type and land use history appear to enhance the interpretation of the vegetation classes.

BOX, E.O. University of Georgia, Athens, Georgia, USA

Static and dynamic models of global terrestrial vegetation

Global ecological modeling efforts are coordinated largely by the International Geosphere-Biosphere Program (IGBP), which has identified the production of Dynamic Global Vegetation Models as a high priority. These and other mechanistic global ecological models, including primary productivity and carbon budget, however, require ecologically and geographically accurate global vegetation maps, as well as plant and vegetation classifications, for development, parameterization and/or validation. The map of world potential natural vegetation (PNV) presented here is based on the main determinants of vegetation at global scale, i.e. climatic conditions. Vegetation types are defined pheno-physiognomically, for compatibility with other models and for potential monitoring by satellite data to discern patterns of actual land covers. Development of the PNV model and map also involved construction of a site PNV data-base, which can be used for evaluating other models and maps. The PNV types identified for this map suggest a manageable set of main plant functional types (PFTs) for dynamic global vegetation models. An initial dynamic model using these structural-functional PFTs shows some promise of predicting stable potential vegetation types without empirical guidance but requires better development of physiological and successional (competitive) mechanisms.

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BREDENKAMP, G.J. University of Pretoria, South Africa

Vegetation patterns in the grassland biome of South Africa

The grassland biome of South Africa covers 351814 km², covers a rainfall gradient of 400 to >1200 mm and a temperature gradient from frost free to snow-bound, ranges in altitude from sea-level to >3 300 m, and occurs on a spectrum of geological and soil types, ranging from humic clays to well drained sands. A new vegetation classification, synthesized from numerous surveys and including all available classical phytosociological data, and a new map of the grasslands of South Africa were prepared. Fourteen major vegetation types were distinguished. The spatial pattern of these is determined by an east-west rainfall gradient, partly coinciding with an high to low altitude gradient. Low rainfall, western grasslands are strongly influenced by geology and soil type, but in high rainfall eastern grassland communities the availability of water overrides the influence of other environmental factors. This causes amazing inter-community variability in the dry western grasslands, while the moist eastern grasslands are relatively homogeneous, but with very high biodiversity and endemism within the community. The vegetation map with habitat interpretation, biodiversity and endemism will be discussed.

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COLLINS, B. & G. WEIN. Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Oldfield vegetation responses to disturbance frequency and intensity

We varied the frequency (2x/yr, 1x/yr, 1x/2yr, no clipping) and intensity (all removed, dominants removed, no removal) of clipping oldfield vegetation in a dry, upland field and a wetter bottomland field in order to determine effects on species composition and turnover. As long as seeds are available, more frequent and intense clipping would be expected to prevent establishment or competitive dominance by later successional perennials and to maintain annuals. By the fourth year, plots that had all vegetation clipped twice yearly continued to be dominated by annual *Setaria* species in the upland field and by annual *Ambrosia* or *Microstegium vimineum* in the bottomland field. In the upland field, plots that received less frequent and intense clipping did not differ significantly in species composition or turnover from unmanipulated plots. In the wetter field, removing *Microstegium* led to an increase of both annual and perennial species. We conclude that initial plot composition has a lasting influence on oldfield responses to the frequency and intensity of a disturbance.

DAEHLER, W. University of Bern, Switzerland

Long-term trends in a fertilized alpine pasture

The oldest experiment on alpine pastures, located in the Swiss Alps, was performed from 1930 to 1956 to improve the productivity of the *Geo montani-Nardetum*. All the 340 permanent plots of the experimental site were reconstructed. In 1981 and 1989 the plots were re-examined. Together with the available old data, the new data were analysed to compare the long-term trends in differently fertilized communities. New results show that (1) there is a trend in the unfertilized control plots; (2) the strongest effect occurred about 10 years after fertilization was started and decreased after fertilization was stopped; and (3) differences between fertilized plots and unfertilized control plots can be detected even 50 years after the last fertilization.

CHINEA, J.D. Department of Forestry, University of Illinois, Urbana, Illinois, USA

Fifty-eight years of natural forest recovery in the Municipality of Humacao, Puerto Rico

Puerto Rico was almost totally deforested by the 1940s, yet changes in economic emphasis resulted in natural forest recovery in extensive areas of this tropical island. Aerial photos from 1936 to 1990 and soil survey maps were used to assemble a geographical information-system database to study the recovery process in the Municipality of Humacao, in eastern PR (moist forest life zone, sensu Holdridge). The area increased its forest cover from 3 to 23% in the 1936-90 period, mostly on very steep slopes. Also, 19 permanent samples were randomly located within one of the physiographic sectors of the area to study composition and structural changes of the vegetation. Assuming that these samples represent a true chronosequence, tree species richness and diversity reach an asymptote at about 32 years. The importance value of exotic tree species decreases from 100% to 6%, and that of animal dispersed species increases from 4% to nearly 100% from the youngest to the oldest forest age category, respectively. The spatial configuration of these forests and the temporal changes in landuse are discussed to account for these results.

CHONG, G.W., L.D. SCHELL, & T.J. STOHLGREN. Colorado State University, Fort Collins, Colorado, USA

Multi-scale vegetation sampling in the Colorado Rockies: the Modified-Whittaker technique

We used the nested, multi-scale Modified-Whittaker plot for measuring plant diversity to evaluate the effects of different land management practices on vascular-plant species richness. Collecting species richness data at multiple spatial scales, using 1 m², 10 m², and 100 m² subplots within a 20 m x 50 m (1000 m²) plot allows for a fast, reliable comparison of paired sites under different management regimes or in different vegetation communities. The multi-scale sampling also allows us to construct species-area curves to predict the number of species present without sampling the entire area. For example, species richness was four times greater inside the Rocky Mountain National Park Ouzel Burn (1978) than outside the burned area. There was only a 13.7% overlap in species composition (Jaccard's Coefficient = 0.137) between the species found in the burned area and outside the burned area indicating the relative uniqueness of the burned area and its potential importance for landscape-scale biodiversity. Using a species-area curve we estimated that 75 species would be found inside the 390 ha burn while outside the burned area only 17 species would be found in an equal area (390 ha). This nested plot design may allow for rapid analysis of plant-diversity spatial patterns at landscape scales for improved resource management and biological conservation.

DE STEVEN, D. University of Wisconsin-Milwaukee, Milwaukee, Wisconsin, USA

Hydrologic and landscape-level structuring of vegetation pattern in Carolina bay wetlands

In the Atlantic Coastal Plain Province of southeastern United States, numerous shallow depressions known as "Carolina bays" support diverse wetlands with seasonally fluctuating hydrologies. At the largest scale, there appears to be a regional gradient in hydrologic regime and wetland type from the Upper to the Lower Coastal Plain. There is also within-region variation. Among bays on the Upper Coastal Plain, the dominant vegetation can range from aquatic macrophytes to herbaceous marsh/meadow to hydric or mesic forest. To identify the major processes structuring this diversity, bays from an 800km² area in the Upper Coastal Plain of South Carolina were surveyed for plant composition and were analyzed with respect to a corresponding environmental database. Twenty-eight wetlands were selected in a stratified design across a landscape-level gradient in soil types from upland sands to alluvial-terrace clays. Indirect gradient analysis was used to test the influence of hydroperiod, historic disturbance, soils, and landscape distribution on vegetation pattern. Hydroperiod is the principal influence on vegetation pattern and appears correlated with soil type. However, vegetation composition is also differentiated spatially across the landscape gradient in relation to both soils and past disturbance history. The gradient-analysis approach has proved useful as a basis for development of a community classification and a vegetation model to be applied to conservation and management of these distinctive habitats.

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DÍAZ, S. & M. CABIDO. Universidad Nacional de Córdoba, Argentina

Plant functional types in the face of climatic change: a multiscale approach

We present a protocol for identification of plant functional types, together with an application to the flora of west-central Argentina. The cover of the most abundant species was recorded along: (1) a precipitation gradient and (2) an altitudinal gradient. We performed multivariate analyses of 100 plant species using 24 key traits. The most discriminating characters were SLA, LWR, leaf turnover, succulence, palatability, longevity, reserve and drought-avoiding organs, seed number and size and pollination mode. We identified eight plant functional types, which were partially dependent on phylogeny, and should exhibit differential responsiveness to climate change. Our approach is a quantitative, bottom-up, a *posteriori* one, and allows scaling up from the individual to the community-ecosystem and regional levels. By combining information on key traits of the most abundant species with their cover at different sites, we predicted the relative magnitudes of major community-ecosystem processes along the two gradients. We hypothesized the most likely trends of change (direction and rate) at the regional level under a doubling-CO₂ scenario. Two points are stressed in order to lower the risks involved in scaling up: incorporation of individual plant traits that are relevant to higher hierarchical levels, and empirical testing of predictions any time that a step up the hierarchy is taken.

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DALE, M.B. & P.E.R. DALE. Griffith University, Nathan, Queensland, Australia

Does scale matter? Assessing impacts of perturbation on density of *Sporobolus virginicus* in a subtropical saltmarsh

A subtropical intertidal saltmarsh in Queensland, Australia, was modified in 1985 for mosquito management purposes. The state of the environment has been monitored regularly since then on a quarterly basis, with spatial sampling of small quadrats spaced along short transects. The impacts of the modification on the density of the dominant plants (*Sporobolus virginicus*, Marine Couch, and *Sarcocornia quinqueflora*, Samphire) have been assessed at different levels of both spatial and temporal resolution, using multivariate analysis. Depending on the scale of analysis the results varied, with no significant impact if we consider individual sites along transects or months within years but with significant effects identified when sequences (time or space) are analysed as a whole. At the level of the whole transect and over the entire temporal sequence the density of *Sporobolus* increased with distance from the water body for the treated sites, whereas for untreated sites it decreased. For *Sarcocornia* the effects were opposite, that is, density decreased for treated sites and increased for untreated ones.

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DAMMAN, A.W.H. University of Connecticut, Storrs, Connecticut, USA

Climatic and topographic controls on the vegetation pattern of northern peatlands

Peatland development is controlled by complex interactions among climate, hydrology, nutrient supply and vegetation. Ultimately, these determine the topography and the often striking surface morphology. Within the ombrotrophic part of raised bogs, water level changes control the floristic composition and structure of the vegetation. We studied the topography and water level fluctuation in raised bogs on a south-north transect from Maine to Labrador and on a west-east transect from Maine and Quebec to Newfoundland to explain regional patterns in peatland vegetation. I will illustrate the effect of: 1) water-table fluctuation on vegetation, 2) position within a peat bog and bog topography on water level changes, and 3) climate on water-level properties and vegetation pattern.

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FUHLENDORF, S.D. & F.E. SMEINS. Texas A&M University, College Station, Texas, USA

Importance of scale on long-term temporal vegetation patterns following removal of domestic herbivory

Temporal vegetation patterns of a semi-arid grassland community were evaluated at two spatial scales under two grazing histories. Basal area of *Hilaria belangeri*, the dominant grass, was periodically measured from 1948 to 1992 in 36 permanent quadrats in two replicates each of ungrazed and heavily grazed pastures. Differences in scale were determined by examining the relationship of basal areas between pastures (pasture scale) and between individual quadrats within grazing history (quadrat scale). Data support the hypothesis by Wiens (1989) that different spatial scales produce different dynamic patterns in terms of predictability, variability, states of equilibrium, and pattern-driving processes. In addition we found that interpretation of vegetation dynamics associated with the removal of longterm domestic herbivory is confounded by these scaling influences and relationships between the different scales varies with the longterm history of each pasture. Replicates of the same grazing history had highly correlated and predictable patterns at the pasture scale. Preliminary results suggest that trajectories of paired quadrats within pastures over time are unpredictable and uncorrelated in the ungrazed pastures but convergent, predictable and correlated in the heavily grazed pastures.

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FUJIWARA, K. Yokohama National University, Japan

Spatial and temporal aspects of forest species diversity from boreal to tropical regions in eastern North America, Japan and Southeast Asia

The similarity of vegetation, flora, latitude, climate, etc. in eastern North America and Japan is frequently discussed. Forest species diversity follows a similar pattern. The secondary forests are richer in species than natural forests. This includes the warm-temperate evergreen broad-leaved forests, temperate deciduous forests and boreal forests. The natural tropical and subtropical forests have more species than their secondary forests. In the subtropical forest of the Florida Keys, however, this rule does not work. The subtropical forest on limestone is relatively simple and occurs under drier conditions including shallow and rocky soil. Severe natural conditions usually lead to poor species composition. On the other hand, the species richness of tropical forests in Southeast Asia is high, but not in secondary forests. The natural subtropical forests have fewer species than tropical forests, but secondary subtropical forests are richer than secondary tropical forest.

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DIXON, P.M. Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Vegetation analysis—is there anything new under the sun?

The common vegetation analysis techniques are now 10, 15, and 60 years old. They have matured and moved from topics for research to commonly accepted practices. This is desirable if the techniques are to be used for large-scale mapping and analysis of vegetation. However, I see three areas for improvement: the assessment of variability, the assessment of model fit, and the assessment of vegetation change. Each of these problems and some potential solutions will be described.

FERNANDEZ-PALACIOS, J.M. & J.R. ARÉVALO. Universidad de La Laguna, Tenerife, Spain

Approach to laurel forest stand dynamics on Tenerife, The Canary Islands

The laurel forest of the Canary Islands is a typical mountain cloud forest characterized by its high richness in endemic tree species. In order to understand the spatial and temporal processes that allow such diversity, an analysis of different laurel forest stands of the Anaga massif (Tenerife) was performed. We assumed that under similar environmental conditions canopy differences between the plots analyzed should reflect differences in stand histories; thus the random occurrence of forest gaps in space and time, as is the case for tropical forests, should be responsible for the high local diversity found in those forests. In order to accept or reject this hypothesis, three 20x20 m plots, varying in canopy tree-species structure and composition but similar in altitude, wind exposure, lithology, inclination, soil and nutrient availability, were selected. For each plot, i) the basal area of the canopy trees, ii) the density of suckers, and iii) the density of seedlings were recorded. Results show similar regeneration patterns in the three plots analyzed, independent of the differences existing in canopy structure and composition. The "loro" (*Laurus azorica*) prevails clearly among the seedlings, whereas the "hija" (*Prunus lusitanica*) prevails among the suckers. Neither "brezo" (*Erica arborea*) nor "faya" (*Myrica faya*), the two main canopy trees of plot "B" was found in any of the stands as seedlings or suckers, thus arguing in favour of their character as pioneer trees, with seeds not able to germinate under shade conditions. On the other hand, both "loro" and "hija" can be regarded as mature-phase trees, growing under shade conditions independently of their abundance in the canopy.

GENTILE, S. Università degli Studi, Genova, Italy

Robinia pseudacacia L. community patterns in vegetation dynamic series of the northern Apennines (Italy)

In several European countries the spread of exotic plants has reached a remarkable level. Many trees of different species have initially been introduced and cultivated as ornamental plants and for wood production. Some of these have subsequently escaped, and they have assumed an important role in the dynamism of some vegetation types, altering the original local patterns. Undoubtedly, the most wide-spread exotic species in our country is *Robinia pseudocacia* L., coming from North America. Now we consider some vegetation patterns of *Robinia pseudocacia* communities in the northern Apennines in order to attempt an evaluation of the role and impact of this species in the syndynamic series of vegetation. For the most part, *Robinia pseudocacia* becomes important and finds optimal conditions for reproduction in areas degraded by human activities. If these interferences are reduced, when the situation becomes more similar to the natural state, *Robinia pseudocacia* specimens diminish in time and at last disappear, to the advantage of native forest species. Generally, the recovery of native vegetation patterns requires a certain amount of time, usually not longer than 25-30 years.

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GILLISON, A.N. & S.C.S. PUNTODEWO. CIFOR, Bogor, Indonesia

Minimum spatial resolution for surveying and mapping the potential distribution of plants and animals in tropical forested lands

Tropical forests harbour some of the world's most diverse flora and fauna. While there is global concern to conserve and effectively manage this valuable resource, there are major problems in developing appropriate designs for natural resource survey and in estimating the distribution of key taxa. The paper examines the consequences of using different spatial resolutions in sample design and in the subsequent generation of potential distribution maps of taxa with varying range distributions and habitats. We conclude that grid resolutions coarser than 60 x 60m are likely to exclude important habitat features for certain arthropods, herpetofauna and vascular cryptogams. Habitats for charismatic megafauna such as Sumatran rhinoceros and elephant are less sensitive and as with certain forest tree species may be mapped effectively at a 400 x 400m grid resolution. The implications for biodiversity assessment in general are briefly discussed.

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FULTON, M.R. Tennessee Valley Authority, Norris, Tennessee, USA

Applying fuzzy-set ordination to regional tree-habitat evaluation for environmental assessment

One of the needs for the assessment of air pollution impacts on forests is the extrapolation of laboratory and field exposure experiments to conditions across a region. A physiologically based model of tree growth, TREGRO, is being used in this way to evaluate potential impacts of tropospheric ozone on forest growth within a region encompassing the eastern Tennessee river valley and adjacent areas of the coastal plain of the southeastern USA. To guide model parameterization, a regional data set of forest composition and site conditions was analyzed to establish the characteristic habitats of the four species being simulated. Fuzzy-set ordination of tree presence/absence data was chosen as a strategy to produce a ranking of sites in terms of species habitat suitability with a minimum of noise contamination from disturbance, stand development stage, and small sample-plot size. The method allowed the identification of modal soil and site conditions for each species, and appears to be particularly useful for species with moderately small representation within the area.

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GAVILAN, R. & F. FERNANDO-GONZALES. Universidad Complutense de Madrid, Spain

Climatic gradients of different scales in Spanish Sistema Central forests

The Spanish Sistema Central is an east-west oriented mountain range which divides the Duero and Tajo watersheds in the central Iberian peninsula. This area seems to be suitable for bioclimatic studies due to the wide altitudinal range, the thermal continentality gradient from the Atlantic coast inward, the asymmetry between north and south slopes and the homogeneous siliceous substrata. We studied the different forest types of this territory, from general to fine scales. This involved questions ranging from deciduous versus evergreen physiognomy to comparison among phytosociological associations, in order to clarify the climatic gradients causing the distribution of forest types. We used monthly temperature and precipitation records as well as bioclimatic indices for 260 meteorological stations. Vegetation data were collected and analysed according to the Braun-Blanquet method. Multivariate methods such as cluster and PCA analyses (SYNTAX, 5.0) and discriminant analysis (SAS) were used, both for vegetation and climatic data. Results suggest that annual or summer aridity and water availability seem to be the most important factors controlling the distribution of these vegetation types. The pluvial component of continentality and amount of winter rainfall also seem to be important factors, while the thermal continentality component seems not to be important. Some seasonal temperatures were also able to separate some forest types, but only at the most local scale.

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GUZMAN, G.S., J.S. DENSLOW & R.A. CHAZDON. Louisiana State University, Baton Rouge, Louisiana, USA

Spatial patterns of seedling abundance and composition across a long tropical moist-forest chronosequence

Information on patterns of seedling composition across tropical secondary successions are scarce, perhaps because old tropical secondary forests are rare. We hypothesized that seedling abundance and diversity should each be correlated with available light levels and that light patterns should become increasingly heterogeneous as gap structure develops in older forests. We identified 8 stands ranging in age from approximately 20 to more than 500 years since abandonment on the watershed of Lake Gatun, Barro Colorado National Monument, Panama. Seedling abundance and composition were sampled from contiguous 1-m² quadrats in two 160-m transects in each stand. Leaf area index was estimated using a LiCor Plant Canopy Analyzer over the same quadrats. Neither mean LAI nor seedling diversity changed monotonically across this chronosequence. Although mean stand seedling diversity was significantly correlated with seedling density, neither density nor diversity was correlated with mean light availability as estimated by LAI. We used spatial statistics to analyse changes in forest structure and regeneration at a finer scale.

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HALL, R.B.W. & P.A. HARCOMBE. Rice University, Houston, Texas, USA

Sapling demographics and growth as affected by flooding and canopy gap formation in a river floodplain forest in Southeast Texas

We used sapling population data collected over 10 years to investigate how canopy disturbance interacts with chronic understory disturbance to determine regeneration patterns. We reconstructed flooding history using a combination of river gauging, a local water-level recorder, and contour maps. 1979 was an extreme flood year for this site, as was 1989. Reduction in flooding frequency since dam construction in 1965 was significant for all elevations, while reduction in flooding duration was significant only for the upper half of the site. Using constrained ordination, we showed that sapling occurrence varies primarily along a flooding/soil moisture gradient, and secondarily along a canopy-openness gradient. This confirms that both flooding and light influence local variation in species composition.

Small sapling density increased more than five-fold during the decade, while large sapling density increased over 70%. This increase may be related to a decrease in flooding for the period 1980-1989, following severe floods in 1979. Sapling survivorship also responded to temporal variation in flooding over the decade: mean elevation of saplings dying was lower in years of high flow and higher in years of low flow. This suggests that the effects of elevation are related to flooding in wet years, but to soil moisture in dry years. Analyses of sapling growth patterns also suggests that there is a trade-off between tolerating flooding in wet years and being subject to moisture stress in dry years.

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GONZALEZ LOYARTE, M.M. Instituto Argentino De Investigaciones en Zonas Aridas (IADIZA), Mendoza, Argentina

Vegetation growth in Argentina by means of Fourier analysis of time series of NOAA/NDVI images

A time series of 9 years of monthly NOAA/NDVI GAC images (July 1982 through June 1991) is analyzed by means of a Fast Fourier Transform algorithm in order to detect the main vegetation growth variations in Argentina. Unsupervised classification of amplitude and phase images of 1-year and 6-month periods was applied to map so-called isogrowth zones. Almost the whole country presents a vegetation growing period of 1 year. Only special areas of Patagonia and rainfed cultivation zones present a second growing period in a year. The transition from the humid eastern part to the arid western zone of Argentina is rather sharp and known as the "Diagonal Argentina". Although the arid zone of the country presents smaller variation in vegetation growth, phase images are able to distinguish different areas along this arid diagonal. Vegetation reaction to the main rainfall systems of Argentina (Atlantic and Pacific influences) is also distinguished through the analysis of the phase images.

GRACE, J.B. & B.H. PUGESEK. National Biological Service, Lafayette, Louisiana, USA

A general model for predicting plant species richness

Numerous studies have revealed geographic gradients in plant species diversity. These gradients in diversity are believed to result from spatial variation in conditions affecting the pool of species in that area. At the other extreme, fine scale variations in diversity have often been explained in terms of disturbance and productivity variations with biomass being used to predict richness patterns (the so called "humped-shape model"). In our research we have been attempting to understand and predict the factors controlling plant species richness in a complex coastal marsh system. Structural equation modeling has been used to test hypotheses about the direct and indirect effects of environmental variables on richness in 190 plots located at 19 sites throughout the basin. The results of these analyses indicate that richness is controlled by a balance between environmental factors, disturbance, and density effects. It is argued that the direct effects of environmental factors are a function of scale; at finer scales density and disturbance effects predominant whereas at larger scales, richness is more strongly influenced directly by environmental gradients. The model presented here includes both the direct and indirect effects of environmental factors and, in so doing, has the ability to include both fine-scale and broad-scale influences on richness.

HOAGLAND, B.W.¹ & S.L. COLLINS². ¹University of Oklahoma, Norman, Oklahoma, USA;
²National Science Foundation, Arlington, Virginia, USA

Heterogeneity in shortgrass prairie vegetation on the southern High Plains, U.S.A.: the role of playa lakes

We examined the role of playa lakes in promoting regional heterogeneity on the southern High Plains. The goals of this paper were to: (1) describe vegetation types and zonation patterns within playas, (2) evaluate patterns of species distribution and abundance within and among playas, and (3) assess patterns of heterogeneity within and among playas on a portion of the southern High Plains. Perennial grasses were the most abundant species in playa vegetation. Playa vegetation exhibited distinct and repeatable vegetation zones at the majority of sites. The number of distinct zones varied from site to site. *Agropyron smithii*, *Buchloë dactyloides*, and *Panicum obtusum* were the most important species of playa interiors, and *Bouteloua gracilis*, *Buchloë dactyloides*, and *Schedonnardus paniculatus* were important upland species. Species distribution-abundance was positively correlated at 38 of 40 sites. Species distributions were unimodal both locally and regionally. The degree of heterogeneity was variable from playa to playa. Local heterogeneity within playas was found to increase regional heterogeneity. Long-term monitoring will be necessary to understand the spatial and temporal variability of vegetation fully within and among playas on the southern High Plains of North America.

HOLZAPFEL, C. University of California, Santa Barbara, California, USA

Temporal and spatial variation of vegetation dynamics in disturbed and undisturbed sites along an aridity gradient

Vegetation change was followed over a six-year period on permanent plots located along a Mediterranean to desert gradient in the Judean Mountains and Judean Desert (Israel and adjacent areas). The development of the predominantly annual vegetation was recorded on artificial soil disturbances in comparison to undisturbed sites. The impact of changing precipitation regimes on vegetation structure and composition was assessed. Along the gradient, a general increase of spatial heterogeneity in the composition of vegetation with increasing aridity was observed. The strong inter-annual fluctuation of rainfall in the desert caused a pronounced temporal vegetation change in both disturbed and undisturbed sites. In the relatively stable and mesic Mediterranean environment, within-site spatial heterogeneity was comparably small and directional development after impact was detected. Over the observed time period, no directional vegetation change in the desert could be distinguished from fluctuations due to year-to-year variation in rainfall.

HEMSTROM, M.A. USDA Forest Service, Portland, Oregon, USA

Classification of existing and potential vegetation, USDA Forest Service approaches

Existing vegetation conditions and the potential of land to support different kinds of vegetation are important and basic map themes for USDA Forest Service managers. Many approaches exist across the National Forests to obtain these map themes, ranging from plot based efforts on small areas to classifications using remotely sensed information and ancillary data. The variety of scales used and differing methodologies make generalization difficult. Development of landscape analyses for large areas (the upper Columbia River Basin, for example) drive the emerging needs for consistency. These efforts to map potential and existing vegetation for large landscapes provide a context in which to frame discussions about scales and standards.

HERBEN, T. Institute of Botany, Academy of Sciences, Czech Republic

High fine-scale dynamics versus broad-scale stability of temperate grasslands: how are they related?

At fine scale (cm/yr), grasslands are very dynamic, with high spatio-temporal dynamics of most of the component species. This is due both to clonal growth and seedling recruitment. In contrast, the grasslands are rather stable at larger scale (metres/years), though with a high potential for change if the management changes. The fine and broad-scale dynamics seem to be "uncoupled" in most situations; fine-scale processes yield a stable pattern at the larger scale. This has to involve processes which make the fine-scale dynamic processes cancel each other. Models of systems with high dynamics at the fine scale (cellular automata or neighbourhood models) often show that species coexistence and maintenance of stable species proportions at large scale are quite sensitive to the parameter values of the fine-scale processes. In grasslands, some mechanisms should therefore constrain the fine-scale processes to avoid the positive feedback which would amplify the fine-scale dynamics to affect the large scale. Among potential mechanisms there are (i) architectural constraints in clonal species (limited number of meristems capable of activation), (ii) competitive networks between species, and (iii) climate variation affecting different species in different ways. Evolutionary significance of these processes will be discussed.

IMM, D.W. & K.W. McLEOD. Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Interactive relationships between vegetation, disturbance, and time at small to intermediate scales

Pre-disturbance resource and vegetation patterns may interact with disturbance type and magnitude to determine biotic and abiotic responses. We compared small-scale disturbance magnitude as well as pre- and post-disturbance patterns of vegetation and resources between two disturbance types, fire and tornado. Permanent plots were established in wind-damaged upland and bottomland forests, and in burned mesic and xeric hardwood-pine forests. Tornado and fire effects were patchy in three of the four sites. Fire decreased below-ground resource variability at large scales but increased variability at small scales. Tornado damage increased light heterogeneity at all scales. Over time, resource heterogeneity increased in wind-damaged systems at all scales, but declined or remained constant in fire-damaged systems. Small-scale vegetative patterns varied in response to both disturbances, and depended on patch type and disturbance magnitude. With time, large-scale patchiness and species diversity increased following disturbance.

JACKSON, R.B. Department of Botany, University of Texas, Austin, Texas, USA

Integrating resource heterogeneity and plant plasticity: modeling N and P uptake in a patchy soil environment

Plants acquire resources in environments that are decidedly patchy, both above and below ground. Despite many excellent examples of resource heterogeneity and plant plasticity in the literature, integrating their importance remains difficult. In this study I draw upon five years of field experiments in the sagebrush steppe to model the importance of soil heterogeneity and root plasticity mechanistically for nutrient uptake from soil. Phosphate uptake from relatively rich soil patches was 4 to 7 times greater than from control patches. For soil nitrate, uptake was as much as 20 times greater in relatively rich patches, and more than half of this increase was due to root proliferation and altered uptake kinetics. In this system, soil heterogeneity is apparently important for both N and P uptake. It may be especially important for N uptake, primarily because of the greater N variation observed in the field (over an order of magnitude, on average, around individual plants).

HONG S.-K. & N. NAKAGOSHI. Hiroshima University, Higashi-Hiroshima, Japan

Rural forest management in the Far East: A proposal of new utilization

Secondary vegetation induced from human activities in rural Korea and Japan has been developed and maintained by human and natural factors. It has momentous ecological functions with respect to forestry, conservation of local landscape systems and biodiversity, and environmental purification of urban areas. Landscape management of secondary forests for ecological function is expected to modify land-use strategies. We applied two ecological approaches to elucidate the dynamics of secondary vegetation: population ecology and landscape ecology. Cyclic use of by-products and sustainable management of pine forest have created high efficiencies of biomass increase in rural Korea. Its NPP is nearly equal to that of natural pine forests in Korea. If proper management is continued, sustainable use might be possible. In addition, new techniques to provide grassland-like understory for conservation of the local biota in pine forests are required in both countries.

HOSHINO, Y., K. TANNO, J. HOSHINO-IMAKIIRE & T. ISEKI. Tokyo University of Agriculture & Technology, Japan

Regional distribution pattern of riparian vegetation along the Tama river, central Japan

Distributional patterns of riparian and wetland plant communities were surveyed in the basin of the Tama river, central Japan. Regional distributions of the plant communities recorded in this region mainly corresponded to the land forms. *Carex curvicolis* community and *Elatostema umbellatum majus* community were found in the valleys of the mountainous region. *Miscanthus sacchariflorus* community and *Polygonum nodosum* community were found along the streams in the plain or hilly regions. Small-scale distributional patterns of the riparian vegetation in the middle part of the river were clearly explained by the structure and dynamics of the alternating bars. *Salix subfragilis* community and *Miscanthus sacchariflorus* community occur along the shoreline of the bars with silty and/or sandy sediments. *Phragmites japonica* community occurs on the gravelly bars. These patterns remained for some decades and influenced the vegetation mosaic of the whole floodplain of the river.

JIMERSON, T.M. USDA Forest Service, Eureka, California, USA

Spatial and temporal patterns of vegetation in the Klamath Mountains of northern California, USA and their implications to ecosystem management

Within the Klamath Mountains of northern California, vegetation series were arrayed along an elevation, moisture, and parent-material gradient and were found to be spatially related to landscape position. Temporal patterns in the form of seral-stage distribution were also found to be related to these series and influenced by landscape position. Natural disturbances, primarily in the form of stand replacing wildfire frequency, were specific to each series and influenced the temporal patterns within each series. Understanding these relationships and utilizing them in ecosystem management will enable us to manage for a balanced distribution of vegetation types and their seral stages, and to plan for functional ecological corridors and connectivity. This will help meet the primary objective of ecosystem management; maintenance of ecological processes and function in order to maintain biological diversity.

KALIGARIC, M. University in Maribor, Maribor, Slovenia

Abandoned vineyards: an example of a method used to define a long-term temporal process

It is frequently impossible to describe the process of succession over quite long periods of time. Some ten years ago many terraced vineyards in northwest Istria (Mediterranean Slovenia) were abandoned. These vineyards were primarily overgrown by weeds and ruderal vegetation and afterwards by grasses, bushes and finally by trees. Forest represents the final phase of succession. By means of contemporarily taken phytosociological relevés comprising all the phases from a vineyard to a forest, processed by a statistical package, we tried to describe the time course of this process and its characteristics. On the basis of graphically illustrated results one can conclude which phases in the process are more stable and how qualitative and quantitative changes of floristical composition follow in that process. The results are comparable to the empirical understanding of overgrowing of the area.

JELTSCH, F.¹, S.J. MILTON², W.R.J. DEAN² & N. VAN ROOYEN³. ¹Centre for Environmental Research, Leipzig, Germany; ²University of Cape Town, Rondebosch, South Africa; ³University of Pretoria, South Africa

Pattern formation as a "keystone" process in semi-arid savannas

Spatial processes and effects are of considerable importance in many ecosystems. In the debate on the stability of savanna vegetation this aspect is often neglected. A spatial simulation model based on a cellular-automata approach was built in order to identify the crucial factors and processes determining tree-grass coexistence and the spatial arrangement of these life forms in arid and semi-arid savannas. The spatial arrangement is of crucial importance for the ecosystem since scattered savanna trees often fulfill a "keystone" role in savannas. It is shown that the traditional key determinants of savannas - rain, fire, and grazing - are insufficient to generate and sustain a coexistence with a scattered tree distribution on a large time scale. The formation of small-scale heterogeneities that predetermine the spatial distribution of savanna trees is an additional "keystone" factor in the dynamics of semi-arid savannas.

JENNINGS, M. GAP Analysis Program, National Biological Service, University of Idaho, USA

GAP analysis: applied plant community ecology writ large

Gap Analysis is a method for assessing the conservation status of general habitats, as represented by dominant natural vegetation or non-vegetated land cover types, as well as of each native vertebrate species. The approach is geographically comprehensive and work is done at a 1:100,000 scale. The Gap Analysis Program implements this method on a state-by-state basis and its purpose is to prevent future conservation crises. To achieve this, state projects are mapping actual land cover, vertebrate species distributions, land ownership, and land management status. When state projects are completed the data are matched with those of adjacent states, resulting in data sets that cover large regions. For most states, these are the first readily available maps of existing natural land cover and species distributions and the products from this program are beginning to affect natural resources policies substantially. In this paper, I provide a brief overview of the program and its present status. Then, I discuss the role of plant community ecology in achieving the conservation goals of this program. Gap Analysis represents ongoing advancements in coarse, landscape-level inventory and conservation assessment as well as in coalescing factious groups of scientist, resource managers, and policy makers around a common framework of biogeographic information.

KNOX, R.G. & A.D. FRIEND. NASA Goddard Space Flight Center, Greenbelt, Maryland, USA; Institute of Terrestrial Ecology, Penicuik, Midlothian, United Kingdom

Vegetation dynamics from a functional-physiological basis and the paradox of reduction in biology

As part of a multidisciplinary project involving field measurements, modeling, and remote sensing, we estimated parameters to distinguish among species and among soil series for simulations of forest dynamics for a landscape in central Maine, USA. Using the Hybrid v3.0 model, we simulated plant competitive interactions and predicted differences in dominance for various wetland and upland soils. Spatiotemporal scaling of soil dynamics from a more detailed model met classical expectations for explanatory reduction. In contrast, reducing tree growth dynamics to a functional physiological basis proved more problematic. Differences in carbon balance were particularly sensitive to species parameter estimates for average specific leaf area and leaf area-per-sawood area. In the field, those attributes are plastic and thought to be regulated at the whole-plant level.

KOST, C. Systematisch-Geobotanisches Institut, Universität Bern, Switzerland

Population-level response to fertilization in a Swiss chalk grassland

The effect of four treatments (P, PK, NPK and manure) on population structure (age-state composition), population dynamics and morphology of three perennial herbs *Salvia pratensis*, *Ranunculus bulbosus*, *Sanguisorba minor* and on the grass *Bromus erectus* was tested in a low-level fertilization experiment. In order to quantify spatial gradients the experiment was set up in a 5 x 5 Latin-Square design.

For all four species, the influence of fertilization on the composition of age states became more obvious only after the second year. The effect of NPK and manure was just the opposite. The three herbs showed a decrease in the total number of individuals in the manure plots as well as in the number of juvenile and reproductive states, whereas the number of individuals in mature states increased. Morphological parameters showed the same opposite effect of manure with a negative effect on *Salvia* (reduced shoot and inflorescence height) and a positive effect on growth of *Bromus*. NPK accelerated population dynamics of *Salvia*, whereas on manure plots dynamic processes seemed inhibited and mortality increased. Population dynamics involving marked individuals was used in a state-based population model to predict population development. The morphological results were evaluated using redundancy analysis. The influence of climatic and treatment factors was separated by variation partitioning, and direct and indirect effects of fertilization on reproductive and vegetative variables were estimated.

KAWLA-IERD, S.¹, K. FUJIWARA¹, T. SMITINAND² & T. SANTISUK². ¹Yokohama National University, Japan; ²Royal Forest Department, Thailand

Spatial perspective on dry evergreen and deciduous dipterocarp forests in Thailand

Dry evergreen forest (DEF), a dominant form of evergreen forest in Thailand, occupies low hill ranges up to ca. 900 m. Deciduous dipterocarp forest (DDF) occurs on annually burned areas on hillsides up to 800-1000 m. Phytosociological surveys, to investigate plant communities in these natural and secondary forests, were conducted at Sakaerat Experimental Research Station, in the Northeast region. The study shows that the canopy of dry evergreen forest is closed but that deciduous dipterocarp forest has an open canopy. Gaps on the forest floor of DEF are scattered and small, but gaps in DDF are larger. The stratification of DEF is layered as follows: emergent tree layer (ST) 40 m high, upper tree layer (T1) 30m high, lower tree layer (T2) 16-25m high, shrub layer (S) 5 m high and herb layer (H) 0.8 m high. The characteristic species are Dipterocarpaceae: *Hopea ferrea* and *Hydnocarpus ilicifolius*. In case of burning, DEF is converted into DDF. The structure of DDF involves small to medium-sized trees and treelets. The heights of the T1, T2, S and H layer are 24, 15, 4 and 1 m respectively. The dominant species are the deciduous dipterocarps: *Shorea obtusa* and *S. siamensis*.

KLOTZ, S. & E. WINKLER. Centre for Environmental Research Leipzig-Halle Ltd., Bad Lauchstädt, Germany

Long-term small-scale plant species turnover in a dry grassland—results of 15 years of permanent-plot research

This study reports on long-term changes in a dry grassland community on shallow, dry, nutrient-poor soils on porphyritic rocks in 1 m² plots with subplots of 1 dm² in the dry region of Central Germany. Starting in 1980 plant individual-based records were made yearly. The number and size of all individuals of all species were monitored in a grid system. For each individual we observed the life history in detail. We posed two questions: 1. What are the main biological and ecological characteristics of the species within the community? 2. Is there a microsite differentiation among the species within the plots? The regeneration of the main grass populations by seedlings is very low. The dominant grass (*Festuca cinerea* VILL.) has a normal lifespan of 15-20 years and a very low regeneration rate by seedling establishment. Species number varied from 6 to 13 throughout the study period. Cumulative species richness increased over the same period from 10 to 20. All species obviously can reach all microsites within the plot. Most of the species found in the community could appear in any unoccupied subplot within relatively short time, depending on the life form, the lifespan of the species and the regeneration strategy. The main differentiation among the species is their individual ability to establish or to re-establish. The main reason for the spatial and temporal pattern within the community could be the extremely dry, nutrient-poor soil conditions and the species' demography in complex with climatic variability.

KUULUVAINEN, T. University of Helsinki, Finland

Three-dimensional structure and spatial autocorrelation in a mature *Pinus sylvestris* forest in Finland

Structural heterogeneity of a mature post-fire *Pinus sylvestris*-dominated forest was analysed by means of a complete spatial mapping of tree locations and dimensions over an area of 4 ha. Pines dominated the main canopy, together with some *Betula* spp. and *Picea abies*. These three species occurred throughout the vertical forest depth. *Alnus incana*, *Populus tremula*, *Salix caprea*, *Sorbus aucuparia* and *Juniperus communis* occurred only in the understory. Autocorrelation analysis (semivariance) indicated small-scale spatial autocorrelation in tree height, which was largely a result of the understory trees. Division of the 4 ha area into 64 subplots of 25x25 m revealed high local variation in tree height diversity (THD), species composition and autocorrelation of tree height. This structural heterogeneity is the result of local regeneration and competition processes operating in the spatially heterogeneous environment created by the stand-initiating fire disturbance and subsequent disturbances of smaller spatial scale (e.g. windthrows).

LEGG, C.J., R.I. MUETZELFELDT & D.N. HEATHFIELD. University of Edinburgh, Scotland

Modeling vegetation dynamics in Mediterranean ecosystems: issues of scale

There are rapid changes taking place in the shrub-dominated vegetation of the Mediterranean Basin due to recent abandonment of marginal land. The sudden release from grazing and changes in fire frequency in several countries have resulted in the widespread development of woody vegetation. The ModMed project is devoted to the prediction of changes to the vegetation of these areas. Successional models are being used to investigate the development of vegetation within the landscape mosaic. The successional patterns are in turn predicted by the modeling of individuals within plant communities under different environments and grazing regimes. The growth of individuals is simulated in terms of physiological processes. A hierarchical modular modeling approach will allow information collected at the level of the individual plants to contribute to the prediction of patterns in the landscape. Some of the practical and theoretical considerations that are raised by this approach will be discussed.

KRAMER-MC KINNEY, K.A. & E.J. RYKIEL, Jr. Texas A&M University, College Station, Texas, USA

Are Hardwood-Redcedar clusters expanding?

Vegetation clusters are spatially distinct structures which may represent an intermediate stage of succession in many systems. It has been hypothesized that over time tree clusters may expand and coalesce with one another and form closed-canopy woodlands. Spatial patterns of tree size classes in Hardwood-Redcedar (HWRC) clusters were examined for patterns in cluster expansion. Hardwood-Redcedar clusters of the Post Oak Savanna in Texas are composed of a central hardwood, usually a post oak (*Quercus stellata*), surrounded by 1 - 35 eastern redcedar (*Juniperus virginiana*). 641 trees were mapped on a 0.50 hectare plot, with species and basal diameter recorded for each tree. Results from a Ripley's K analysis were: 1) Redcedar were clustered around the largest oaks within a 10 m radius, quantifying HWRC cluster structure. 2) Sapling redcedars were clustered around small redcedar trees within a 12 m radius, indicating some expansion of redcedar on the cluster perimeter. 3) Sapling and seedling oaks were also shown to cluster around the largest oaks, at distances of 17m and more, suggesting an outer layer of smaller oak trees bordering the HWRC clusters. These results indicate that Hardwood-Redcedar clusters are expanding and that oaks as well as redcedar are part of this expansion process.

KRUMBIEGEL, A. Centre for Environmental Research Leipzig-Halle, Bad Lauchstädt, Germany

Succession on abandoned fields—the influence of species availability

Knowledge of the accessibility of diaspores as well as of the abiotic factors influencing vegetation admit some conclusions about the pathway of succession of a given area. These predictions are useful for the selection of fields within the scope of long-term following programs (commonly five years). These programs are mostly concentrated on sites of low fertility or on sites which are difficult to cultivate. Nevertheless, such sites are of interest for nature and landscape conservation. This applies especially to fields that are situated between different biotopes with numerous stable plant communities. It might be expected in this case that abandoned fields are quickly invaded by typical plants of meadows, and dry and semidry grasslands of the adjoining habitats, which are few and locally fragmented. Therefore, abandoned fields give especially such species a chance to enlarge their populations, which have low seed dispersability. The vegetation of abandoned fields may adapt to the neighboring plant communities sooner or later. In the case that the surrounding plant communities are of high value for nature conservation purposes, one should suggest either to extend the fallow period or even to take the abandoned fields out of agricultural use completely. This would mean both an enrichment of the landscape with new habitats close to natural and a simplification for the agricultural companies. Investigations from Central Germany dealing with the influence of species diversity of the surroundings of abandoned fields on their succession are presented and discussed from the viewpoint of nature and landscape protection.

LIIRA, J. & K. ZOBEL. Tartu University, Estonia

Evenness as key characteristic of successional changes in limestone grassland

Several studies have discussed successional changes of plant community structure in species-rich grasslands. A two-year survey in a limestone grassland near Uisu (western Estonia) showed that 20 years after the cessation of grazing by cattle there were practically no changes detectable in floristic composition, species richness, diversity and evenness of abundance, as compared to a continually grazed site. However, the ungrazed community is clearly successional. Juniper has started to overgrow the area (as it typically does in ungrazed limestone grasslands of this type). Also, the non-grazed site has greater standing biomass ($p=.032$) and fewer ramets per unit area ($p=.058$). An interesting feature of the successional processes is a noticeable decrease of spatial variability of evenness. Variance of evenness in the ungrazed area is much less than expected from the null model of independent distribution of species; while variance of evenness in the paddock meets the expectation from the null model. Species abundance relationships are somehow more constant in the ungrazed area than they would be in the case of independent (neutral) coexistence of species.

LOUCKS, O.L. Miami University, Oxford, Ohio, USA

The Original Ecoregion Concept Contrasted with Smalley (1986) and Bailey (1976) as frameworks for vegetation and land classification in the Cumberland Plateau

The first use of the term "ecoregion" (Loucks 1962) emphasized an integration of climate, soils, macrotopography, and tree and understory species distributions. It was adapted from the work of G.A. Hills in Ontario and Rubner and Reinhold in Germany, and was designed specifically to improve reproducibility of silvicultural treatments in forestry. However, the mapping of boundaries between ecoregions relied heavily on the distributions or range-limits of uncommon understory, shrub, or tree species, and the maps of ecoregions have served extensively in recent years for biodiversity conservation planning by The Nature Conservancy. In the Cumberland Plateau and Mountain areas this ecoregion approach can be contrasted with the larger-scale and more general approach of Bailey (1976) and the detailed work of Glendon Smalley (1986). The former does not allow readily for altitudinally overlapping ecoregions, where more northerly systems can be in the same area but at higher altitude than southerly systems. Smalley's work for the U.S. Forest Service uses physical/geological units as a classification within a physical area, and landtype associations and landtypes under that category. Delineations are precise, but species distributions are not used as a characterizing element, only as an outcome. The issues underlying differences in the three approaches are partly due to scale questions from the viewpoint of users, and partly due to the difficulty of obtaining comprehensive data on local species distributions and climate in regions of complex topography.

LENIHAN, J.M. & R.P. NEILSON. Oregon State University and U.S. Forest Service, Corvallis, Oregon, USA

Vegetation classification issues in the application of MAPSS for global change research

The needs of different user groups require that vegetation models used in global change research simulate the dynamics of a few distinct vegetation types with a fairly coarse spatial resolution as well as a much larger number of types at a higher resolution. MAPSS, an integrated vegetation and hydrologic model, generates vegetation type predictions at coarse and more finely resolved levels of a vegetation classification hierarchy that closely parallel the physiognomically-defined levels of the modified UNESCO classification scheme. MAPSS currently predicts the distribution of potential natural vegetation under long-term, average climatic conditions. Problems encountered using potential vegetation maps for model calibration and verification have included indistinct definitions of mapping units in terms of vegetation structure and density, the inclusion of disclimax types, and related difficulties posed by multiple steady-states. Large-scale maps of actual vegetation will prove useful in the ongoing development of a more dynamic version of MAPSS capable of simulating the transient response of vegetation to a changing climate. Indeterminate historical influences on vegetation development will preclude exact predictions of the actual vegetation at a site, thus information regarding successional relationships among related vegetation types will be critical for the calibration and validation of the transient model. Several scaling issues will have to be resolved to allow for a consistent development of the transient model at both coarse and fine spatial resolutions, including the question of how to aggregate vegetation types mapped at the scale of the minimum mapping unit in order to best represent distributions at the coarser scales of model application.

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LEPS, J. University of South Bohemia, Ceske Budejovice, Czech Republic

Succession: predictability and scale dependence of temporal patterns

The course of succession is influenced both by the measurable characteristics of environment and "chance factors". It seems that the importance of the latter is higher in early succession; nevertheless, the initial conditions sometimes determine the course of succession for many years. For example, in early old-field succession in South Bohemia, one of the experimental plots was colonized by willows during the first year after abandonment. During the first eight years of succession, no self-thinning was found, but also no new individuals were found starting with the third year of succession. In an adjacent field, under the same environmental conditions but abandoned in another year, willows were not established and herbaceous vegetation developed. For many years, the course of succession has been determined by chance factors and, consequently, the predictability of succession is low. Some temporal patterns in vegetation succession depend on the spatial scale of observation. This is particularly conspicuous for species richness. In old-field succession in Central Bohemia, the number of species is steadily increasing, when observed within 0.01 sq. m plots, and shows typical humped response to time, when observed on a "relevé" size plot, i.e. about 25 sq. m. This suggests that the mechanisms of species coexistence at very fine scale are different from mechanisms of coexistence at a broader scale.

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MARTI K. & B. TSCHANDER. topos Marti & Müller, Zürich, Switzerland

A new method for a fast and robust assessment of vegetation changes

A new method of vegetation mapping for monitoring long-term changes in fen vegetation was tested and evaluated. Spatial variability in species composition of a fen in Hirzel, Switzerland, was recorded by a grid mapping. 220 relevés of 9 m² in a 20m grid were made in an area of 15ha. Grid mapping was used to avoid decisions about vegetation units and their limits. Results obtained with the 20m grid were compared with subsets of samples in a 40m grid. Cover of 90 species chosen in advance was recorded in these plots. Criteria for the choice of these species were that they should indicate certain environmental conditions and that they should be easily recognized. The effect of different persons doing the recordings was analysed. The results of principal component analysis show a slight gradient in the relevés within the 20m grid. 16 typical relevés explain 75% of the variation in the whole data set. Assessment of rare plant communities in this fen was inadequate with the 40m grid. Groups of similar relevés were formed and classified. Distribution of the relevé groups and of single species is presented on a grid map.

MARTYNOVA, A. Bashkirian Research Center, Russian Academy of Sciences, Ufa , Russia

Individual variety in cenopopulations of saline soils in the South Ural Mountains

The phenotypic heterogeneity of cenopopulations is an adaptive property which increases the population stability under changeable conditions of the environment. The degree of phenotypic heterogeneity under stress also depends on plant species. We have studied the reaction of five-year succession of cultivated grasses *Bromopsis inermis*, *Elitrigia intermedium*, *Elymus junceus*, *Chenopodium album*, *Amaranthus retroflexus*, and *Saussurea amara* on saline soils of the South Urals. The experimental field with uneven SO₄ - Na - Ca salinity had plots of different grass density—from high (weak salinity) to low and even no vegetation at all (strong salinity). We have revealed two reaction types of cenopopulations to the changes of grass density under salinity: 1. The population structure changed, the shoot weight and height as well as the root density decreased to half as much, and the water flow via roots slightly decreased under strong salinity (*Chenopodium album*, *Amaranthus retroflexus*, *Saussurea amara*); and 2. The population structure remained stable, the shoot weight slightly decreased, the root density remained stable and even slightly increased, and the water flow via roots increased under strong salinity (*Bromopsis inermis*, *Elitrigia intermedium*, *Elymus junceus*).

MAEDA, H. & K. FUJIWARA. Yokohama National University, Japan

Spatial and temporal processes in vegetation changes on highway embankments

The construction of highways in Japan requires embankments along the highways. These embankments were planted with meadow species such as European *Lolium perenne*, *Festuca rubra* and *Agrostis alba* during the construction period. After 30 years, this planted vegetation changed into two associations and 27 communities under human management, such as cutting once in a year, no management, or influence of adjacent vegetation around the highway. The annual and perennial herb communities, such as *Hypochoeris radicata* community, *Artemisia princeps* community, *Miscanthus sinensis* - *Solidago altissima* community, *Rhus javanica* community and *Sambucus sieboldiana* community on sunny areas and *Houttuynia cordata* community, *Kalimeris pinnatifida* community, *Rubus parvifolius* community and *Rubus hirsutus* community on shady areas, occur on the embankment undercutting once a year. *Pleiblastus chino* community and *Clematidetum terniflorae* occur on the no-management areas even 30 years after construction. As temporal processes, the annual herb community on the embankments changed into many communities (except forests) over the 30 years after construction. The reasons for this change are considered to be environmental factors and species composition.

MAREK, U. & F. ROMANE. Centre d'écologie fonctionnelle et évolutive (CNRS),
Montpellier, France

Cluster-pine regeneration processes and their effects on landscape changes in southern France

A man-introduced tree, the cluster pine (*Pinus pinaster* Ait.), quickly invaded the Cevennes Mountains (southern France) one century ago. This invasion was certainly favoured by (i) the landscape type at that time (a large area of old fields that had recently been abandoned, in between the chestnut groves) and by (ii) a scattered introduction of the pine seeds by the landowners. Nowadays there are no special needs of pine timber in this area. What is the future of this "pine invasion" now that the landscape has changed (few old fields exist, ...)? We studied the ability of pine to scatter its seeds from a pine wood and tried to establish what are the environmental factors affecting this scattering (light, vegetation, ...). The results suggested that the dispersal area remained near the adult trees, particularly in chestnut groves, and that the role of this species in landscape changes could be less important in the future than in the past.

MENENTI, M. & S. AZZALI. DLO-Winand Staring Centre for Integrated Land, Soil and Water Research, Wageningen, The Netherlands

Monitoring and mapping of soil-vegetation-climate complexes in South America using time series of satellite observations

A time series of monthly NDVI composites (July 1982 through June 1991; spatial resolution 7.6 km x 7.6 km) was used to study vegetation dynamics in South America. Two different algorithms were applied: a) a Fast Fourier Transform algorithm (periods factored into 2,3,4 and 5); b) a curve fitting procedure based on harmonic analysis, which gives the possibility of choosing the most significant periodic components. Both algorithms were applied and the resulting sets of amplitude and phase values used to map homogeneous vegetation-soil-climate complexes. Differences in the Fourier spectra due to the algorithms were assessed by comparing the spectra of selected sites and map units. The significance of mapped vegetation-soil-climate complexes was assessed by correlation with the map given by Cabrera, with the Budyko aridity index and with other climate data.

MENGHI, M. & M. HERRERA. Universidad Nacional de Rio Cuarto, Argentina; Universidad Nacional de Córdoba, Argentina

Biomass and diversity relationships in inland wetlands

Species composition and above-ground biomass of herbaceous communities varying in standing crop were recorded in six wetlands of the Rio Dulce floodplain (central Argentina). In 159 quadrats, the species richness, density (spp/0,25m²), evenness, diversity (Shannon-Wiener), and total biomass variation trend were analyzed at among- and within-community levels. A plant spatial pattern correlated with a complex hydro-topographical and saline gradient was detected at large scale. Along that gradient, diversity was negatively correlated with standing crop and the relationship fit a gamma-type distribution function. Distinct trends were detected at the within-community level. The species richness and evenness variability suggest that local stressing abiotic factors interacting with phenological and competitive processes should regulate the diversity and biomass patterns detected at smaller scale.

MAST, J.N.¹ & T.T. VEBLEN².¹Northern Arizona University, Flagstaff, Arizona, USA;
²University of Colorado, Boulder, Colorado, USA

A spatial analysis of ponderosa pine patch structure along the forest-grassland ecotone of the Colorado Front Range

Patterns of stand development may be interpreted from spatial analyses, based on variables such as tree age and size, together with past records of climate and disturbance. In this study, tree spatial patterns identified even-aged patches within 20 lower ecotone stands in the Colorado Front Range in order to investigate the scale of establishment. Several techniques, including Ripley's K(t), Ripley's K12(t) and Moran's I, identified even-aged patches of trees, which may indicate the effects of past disturbances or periods of favorable climate for establishment. Results show that the scale of patchiness ranged from small canopy-gap disturbance to broad-scale patterns of tree establishment related to larger-scale disturbance or climatic factors. Spatial pattern analyses indicated small patches of seedlings, probably established during favorable climatic conditions following small-scale disturbances, among randomly distributed older trees. At a broader scale, spatial pattern analyses identified moderate-sized patches of mixed mature trees and small clusters of seedlings, probably explained by competitive thinning of even-aged seedling clusters.

MAYCOCK, P. University of Toronto (Erindale Campus), Mississauga, Ontario, Canada

Compositional variation within an environmentally uniform old-growth deciduous forest ecosystem in southern Ontario, Canada

Southern Ontario is decidedly flat with topographic variation often less than a meter per kilometre. Springwater Forest, Aylmer, is centrally situated in the Norfolk sandplain, with modest elevational differences between 225 m (highest ridge) and deeply cut creek bottoms (205 m). While some sites are on slopes, they are no greater than 5 degrees, and more than half are on flat terrain. The only important environmental site to site variation is thus small elevational and slope differences, and the influence these have on site moisture and drainage. Despite these site similarities, there are substantial community compositional differences from one location in the complex to another. Twenty-seven tree species (30% of the regional tree flora), between 10 and 18 (average 14) species per stand, are included in the 12 stands quantitatively sampled. Several species, *Quercus rubra*, *Fagus grandifolia*, *Prunus serotina*, *Acer rubrum*, *Fraxinus americana*, *Betula lutea*, and *Acer saccharum*, have consistent but variable representation in all stands. The continuous internal compositional variation within the complex indicates that a portion of a regional continuum is well-expressed in the data.

MOLONEY, K.A. Iowa State University, Ames, Iowa, USA

Ecological pattern: a twofold template for understanding plant community dynamics as a spatial process

Ecological pattern—as determined through analysis of remotely sensed images or through on site mapping—can provide a useful template for understanding plant community dynamics as a spatial process during two critical phases of research: (1) the exploratory phase; and (2) the verification phase. Pattern analysis can be used as an exploratory tool for determining the critical scales at which ecological processes are operating to produce ecological pattern. With this information, the list of potential processes responsible for structuring spatial distributions of species and communities can be narrowed down to processes operating at scales consistent with observed patterns. At a more mature stage of research, ecological pattern can provide a means for critically accessing the validity of conceptual models characterizing the nature of ecological interactions in a spatial context. In my talk I will present examples of these approaches taken from a collaborative research program designed to understand the relationship between local ecological dynamics and landscape level pattern formation in a serpentine grassland located at Jasper Ridge, California.

MORENO-CASASOLA, P. & G. VAZQUEZ. Instituto de Ecología, Xalapa, Veracruz, Mexico

Spatial and temporal patterns resulting from disturbance in coastal vegetation

Slack inundation in dune systems is a common disturbance produced by a rise of the groundwater level. Vegetation analysis and its relation to environmental factors were studied in seven slacks in a dune system in Veracruz, Mexico. Spatial analysis showed differences in vegetation structure and composition between and within slacks. The main environmental factors responsible were the depth of the groundwater level, period of inundation, pH and conductivity. Within a slack intense disturbances produced by periods of wet years alters colonization patterns. Slack borders are covered with grasses and shrubs and/or trees. The lower zones are covered by water-tolerant species. Our hypothesis suggests that inundation for prolonged periods of time during several years alters species distribution and succession. This creates unstable habitats, favouring aggressive species and tree establishment along the borders. Drier years promote tree establishment in the lower areas. This analysis is based on a four-year study of the variation in groundwater level which is correlated with precipitation.

MINCHIN, P.R. University of Melbourne, Parkville Victoria, Australia

The role of interspecific competition in determining meso-scale community patterns

There is limited experimental evidence that interspecific competition can modify the responses of species along environmental gradients, but it is still unclear whether this is a general and widespread phenomenon. In Eucalyptus-dominated dry sclerophyll forests northwest of Melbourne, the grasses *Chionochloa pallida*, *Poa sieberiana*, *Themeda triandra*, *Microlaena stipoides* and *Poa labillardieri* form an overlapping replacement series, in the order listed, along the topographic moisture gradient from dry ridges to wet gullies. To test the null hypothesis that this meso-scale pattern results simply from the adaptation of these species to different levels of available soil moisture, the species were grown in both monocultures and additive mixtures along a controlled moisture gradient. Monoculture response curves for the dry weight yield of *Poa sieberiana*, *P. labillardieri* and *Themeda* were monotonic, with maximum yield at the highest moisture level. *Microlaena* had a unimodal response with a maximum towards the wet extreme, while *Chionochloa* had maximum growth in the centre of the gradient. For *P. labillardieri* and *Themeda*, response curves in mixture were similar in form to the monoculture responses. The position of the mode for *Microlaena* was displaced towards the drier extreme, while the mixture response for *P. sieberiana* was bimodal, with maxima at both the dry and wet extremes. *Chionochloa* performed very poorly in all mixtures. While these results indicate that interspecific competition may alter the response curves of some species, the resulting ecological responses do not accord with field distributions. Further research is needed to understand the mechanisms which determine this community pattern.

MIYAWAKI, A. Japanese Center for International Studies in Ecology, Hayama-cho, Japan

Phytosociological vegetation patterns applied to green environmental restoration

There are several methods to recognize vegetation patterns. Each will be effective according to the purpose and the objective, but phytosociology is one of the most precise methods. It is a vegetation-ecological approach which can cope with the modern global green environmental crises. Braun-Blanquet and Tüxen's method, that is the phytosociological pattern recognition by species combinations, can be systematized globally as well as locally. When pattern units of each scale of plant community are shown on a map of actual vegetation, it fulfils a function as a vegetation-ecological diagnosis of the present green environment. A map of potential natural vegetation, on which potential natural vegetation (Tüxen, 1956) patterns are shown spatially, functions as a basic scenario for recovery and restoration of natural vegetation in accordance with the essential potential ability of the land where it has declined to support only substitute vegetation due to various human activities. It is the idea of phytosociological vegetation pattern that makes it possible to grasp vegetation patterns based on species combinations and to extend them to a locality, a region, a country, throughout the world and compare pattern systems of each vegetation.

MYSTER, R.W. & J.R. THOMLINSON. University of Puerto Rico, San Juan, Puerto Rico

Using landscape characteristics to predict the vegetation structural stages of landslide patches in the Puerto Rican rainforest

Although succession occurs in patches on landscapes, the predictive power of landscape characteristics towards the vegetation of these patches has rarely been investigated. Because landslides produce distinctive patches on a landscape, we had the opportunity to explore both the vegetative predictive value of, and correlations among, common landscape characteristics of these patches using three different analyses. First, Maximum-Likelihood Logistic Regression analysis showed that elevation, age and substrate type (volcaniclastic vs. diorite) could significantly predict vegetation. Second, Pearson Product-Moment correlation coefficients showed that landslide aspect was correlated both with elevation and slope, while slope was correlated with area. And third, Principal Components Analysis showed that landslides were differentiated on axes defined primarily by age and aspect, and secondarily by elevation, slope and area.

NAKAGOSHI, N. & M. TANAKA. Hiroshima University, Higashi-Hiroshima, Japan

Trends of community structure of rural pine forest in different sized forest-patches

Human disturbances including forest management must have important roles on community dynamics in rural landscapes. Analyzing soil seed banks and stand populations including seedlings, we discussed how such impacts affect the patches and pine forests. The study pine forests were located in Higashi-Hiroshima, western Japan. Eight plots (10m x 10m in size) were set up in different sized patches. The species composition and population structure of the stand were investigated in these plots. The results indicate the following tendencies: 1) In the smaller patches, buried seeds of weeds were numerous, but they never became established; 2) The densities of tree seedlings were higher in the larger patches; and 3) Human disturbances might accelerate the regeneration of populations among pine forest components.

MUCINA, L. on behalf of the "European Vegetation Survey" Working Group, Universität Wien, Vienna, Austria

European Vegetation Survey: aims, status, perspectives

The European Vegetation Survey is an initiative of the IAVS aimed at (1) promotion of international cooperation in revisions of classification schemes of European vegetation types, (2) know-how transfer from experienced national vegetation survey initiatives to recently established working teams in post-communist countries of Eastern and Southeastern Europe, and (3) assistance by initiation of new national vegetation surveys. The Braun-Blanquet approach (based on floristics) to vegetation classification was adopted as the common methodology. A centralized system of data banks for storage of vegetation relevés and other relevant data, using unified software, and networks of bibliographic databases are being implemented in many European countries. Several publication activities are underway. A Working Group has been established and meets each year in spring in Rome to exchange ideas and screen for progress of the ongoing vegetation-survey initiatives.

MULDAVIN, E.H. & J.A.R. LADYMAN. University of New Mexico, Albuquerque, New Mexico, USA

Spatial distribution of herbaceous plants in a low-disturbance piñon-juniper woodland in the southwest U.S.A.

Mesita de los Ladrones Research Natural Area, a remote, 700 ha mesa top, supports a piñon-juniper woodland that has been excluded from grazing, woodcutting and fire for at least 100 years. Our expectation was that without the impacts of large herbivores or radical changes in stand structure of the woodland, species would be distributed in a fine-grain pattern reflecting high inter-species interactions and finely honed resource allocations. Along two replicate transects, 750 contiguous 25 x 50 cm quadrats were established for spatial-pattern and association analysis of herbaceous species. On a community level, sliding-window analysis revealed relatively sharp boundaries between C4 and C3 grass-dominated communities that are shown to be related somewhat to subtle soil and topographic changes. Within the C4 communities, fine-grain patch size measured by TTLQV ranged from 2.5 to 12 M among the seven species present with the exception of blue grama, the common dominant of disturbed woodlands, which exhibited no fine-scale patch structure between 0.5 and 380 M. In C3-dominated communities large patches between 50 and 100 M were predominant. Spearmans Rank Correlations indicate moderate to strong negative correlations among the major grass dominants of these ecosystems.

PAKALNE, M. University of Latvia, Riga, Latvia

The development of rich fen vegetation in the dune slacks of Latvia

Rich fen vegetation is developing in the dune slacks near Engure Lake. The process began after 1842, when the water level in the lake was lowered about 150 cm. During this period of time the present extremely rich fen vegetation has established in the dune slacks. One of the dune slacks was studied more in detail where the characteristic rich fen vegetation with *Schoenus ferrugineus* was described. In the central part of the dune slack separate tussocks with *Schoenus ferrugineus* are found. Also hummocks with *Schoenus ferrugineus* and other vascular and moss species have developed there. Towards the margins of the dune slack a continuous rich fen vegetation has developed. Hummocks of different size and height have established in the dune slack. There are also hummocks with *Sphagnum* species. Mineral islands without *Sphagnum* species are found in the central part, as well as on the margins of the dune slack. The species associations on these islands have common species with forest vegetation. For the vegetation data interpretation the computer program TWINSpan was used.

PALMER, M.W., G.L. WADE & P.R. NEAL. Oklahoma State University, Stillwater,
Oklahoma, USA

Large-scale patterns of vascular-plant species richness

Floras, or lists of vascular plant species occurring within well-defined regions, represent an underutilized source of information for examining large-scale patterns of species richness. In an analysis of over 800 published and unpublished floras from western North America north of Mexico, we find that the number of species is positively and significantly correlated with area, year of study, precipitation, temperature, and range of elevations, and negatively correlated with latitude and elevation. Few clear patterns are observed concerning the proportion of exotic species in a flora. The results of a regression equation can be used to estimate the number of species in an unsampled location, as well as to identify diversity "hot spots" and regions in need of more botanical exploration.

NORTHUP, B. K., S.F. ZITZER, S. ARCHER & T.W. BOUTTON. Texas A&M University, College Station, Texas, USA

Shoot allometry and biomass allocation in a sclerophyllous evergreen shrub

Many landscape elements of savanna parklands in southern Texas are dominated by woody plants with contrasting growth forms. *Berberis trifoliata* (Morc.) is an important understory shrub in wooded ephemeral drainages and upland shrub clusters. Shoot allometry and biomass allocation of this sclerophyllous evergreen was characterized to quantify changes in woody plant biomass and nutrient accumulation during succession. Plant height and canopy and basal stem dimensions were related to aboveground biomass using regression analysis. Plant sizes ($n=21$) encompassed a range of heights (0.4 to 2.4 m), basal diameters (1.4 to 38.5 cm), canopy areas (0.03 to 7.3 m²) and canopy volumes (0.01 to 12.6 m³). Whole shoot biomass (SB, kg) ranged from 0.01 to 22.2 kg/plant and was strongly related to stem basal diameter ($\log SB = -1.89 + 1.89[\log \text{Basal Diam}(\text{cm})]$; $R^2=0.91$), crown volume ($\log SB = 0.41 + 1.02[\log \text{Vol}(\text{m}^3)]$; $R^2=0.93$) and canopy area ($\log SB = 0.92 + 1.26[\log \text{Canopy Area}(\text{m}^2)]$; $R^2=0.90$). Biomass allocation to foliage was greatest (33%) in plants <5 cm in basal diameter and decreased to 12% as plant basal diameters increased to 30 cm. Decreases in biomass allocation to photosynthetic tissue were accompanied by an accumulation of biomass in large (>2 cm diameter) stems. Canonical correlations between plant size variables and biomass distribution among woody and leaf components were high ($r=0.98$; Wilk's $\lambda=0.02$). These relationships will be used in conjunction with landscape surveys of plant distribution to estimate foliar and woody biomass standing crop, and to parameterize biogeochemical models of C and N pool sizes and flux rates for subtropical savannas and woodlands.

OKSANEN, J. University of Tromsø, Tromsø, Norway

Neighbourhood diversity

Diversity is usually assessed from sample plots of vegetation. This may be relevant for a land surface, but hardly for plants. The plant's eye of view of diversity may be assessed by recording the other species that are in contact with the randomly selected reference species. Two published data sets of neighbourhood contacts were analysed for diversity: (1) Vegetation of fixed sand dunes in Finland, and (2) Meadow vegetation in British Columbia. The expected diversity and its confidence intervals assuming random neighbourhood were assessed by bootstrapping. For most species, the neighbourhood diversity was within 95% confidence intervals. On sand dunes, species of sunny slopes had higher neighbourhood diversity than those on the shaded north slopes. This may reflect heterogeneity within the habitat type. In meadows, the general pattern was that the more common the species was, the lower was its neighbourhood diversity relative to the expectation. Low neighbourhood diversity implies that the species is selective to its neighbours and thus important in community organization.

PEDROTTI¹, F. & D. GAFTA². ¹Camerino University, Italy; ²Institute of Forestry Research, Bucharest, Romania

Long-term changes in vegetation of a wetland area (Laghestel) of Italian Alps

Some changes in the distribution of plant associations in a small wetland have been pointed out by its vegetation mapping at two different times, first in 1976 and then in 1994. Dynamic processes in vegetation have occurred spontaneously (secondary succession) or have been induced by man (regression and primary succession). The secondary successions to more mature plant communities are usually accompanied by a "biological drainage", i.e. *Magnocaricion* → *Filipendulion* → *Alnion glutinosae*. The regressions are due to the raising of the watertable, which evoked an opposite dynamic direction, i.e. *Caricion lasiocarpae/Molinion* → *Phragmition*. The primary successions in small stands strewn with gravel caused the appearance of a ruderal plant association (*Artemisio-Tanacetum vulgaris*). A decrease of both plant community types (beta-diversity) and species richness (alpha-diversity) seems to be the main trend in this wetland vegetation dynamic.

PEET, R.K., C.N. NEWELL & R. DUNCAN. University of North Carolina, Chapel Hill, North Carolina, USA

Patterns in species diversity in North Carolina vegetation

Vegetation was sampled over a broad range of forest and woodland habitats within the Carolinas. The standard sampling protocol included estimates of species richness in a nested series of 0.01, 0.1, 1.0, 10, 100 and 1000 m² plots. Soil texture, frequency of fire and soil moisture appear to be the environmental factors most important in determining species richness at small scales (< 1m²). At larger scales (100-1000 m²), species richness is most strongly correlated with soil nutrient content, especially manganese and calcium content. The emergence of soil manganese as the variable most strongly related to species richness over a broad range of separate studies was unexpected and is probably related to the degree of soil weathering.

PARKER, V. T.¹ & S. T. A. PICKETT². ¹San Francisco State University, California, USA;
²Institute for Ecosystem Studies, Millbrook, New York, USA

Formalizing multi-level approaches to vegetation dynamics

We develop an approach to analyzing vegetation dynamics that is not limited to a single level of organization but can apply at different scales. Our generalization requires visualizing vegetation dynamics as an ongoing process of change in a vegetation regardless of the scale investigated. We start from the successional framework developed by Pickett et al. (1987) in a modified form that generalizes the concepts so that they are not scale-limited to a single successional sequence from gap to mature vegetation. By incorporating aspects of hierarchy theory and gradient analysis, we illustrate rules for a stepwise approach. One first delimits the conceptual boundaries of the system investigated using a rate-defined environmental characteristic. Further analyses investigate first the level defined and lower levels subsequently. We compare characteristics of our approach to those of other conceptual systems. Our approach translates earlier analyses of vegetation dynamics into a conceptual approach that can be used empirically to investigate systems. We find that the approach illustrates principles of patch dynamics and incorporates gradient approaches directly. While our approach is consistent with assumptions of hierarchy theory, some fundamental differences also are apparent.

PARUELO, J.M.¹, E.G. JOBBAGY², O.E. SALA², W.K. LAUENROTH¹ & I.C. BURKE¹.
¹Colorado State University, Fort Collins, Colorado, USA; ²Universidad de Buenos Aires, Argentina

Regional models in ecology: an evaluation of their predictive power

To what extent is it possible to generalize regional ecological models?. The objective of this paper is to evaluate some regional scale models that describe the climatic controls of the structure and function of grassland and shrubland ecosystems. We evaluated models that describe the regional distribution of functional types (C3 and C4 grasses and shrubs) and aboveground net primary production (ANPP) and its seasonal distribution. Models on plant functional type distribution were derived from relative abundance data for sites with low human impact across central North America. Models on the climatic controls of ANPP and its seasonality were derived from remote sensing data, also for sites with a low degree of human perturbation across North America. To evaluate the predictive power of the models we compared their estimates against observed data. We derived an independent set of data for climatically similar areas of South America. The models predicted satisfactorily the structural and functional attributes of the ecosystem considered. As with any correlative model, those analyzed here do not prove causality, however, they provide a starting point for the analysis of the mechanisms whereby the structure and function of grassland and shrubland ecosystems respond to environmental variables. Our results suggest that climate exerts similar controls on vegetation structure and function of grasslands and shrublands in North and South America.

PIETSCH, W.H.O. Technological University, BTU Cottbus, Germany

Time-dependent succession of the vegetation in the post-mining landscape of the Lusatian Lignite Mining District, Germany

A survey of the time-dependent, spatial succession of vegetation on various dumped substrates is given in the post-mining landscape in the Lusatian lignite mining district in the eastern part of Germany. Sometimes the substrates consist of initial materials which are characterized by an extreme anti-growth behaviour originating from pyrite weathering of tertiary dumped substrates and coal sands. The development of vegetation depends on the physico-chemical condition and the moisture content of the dumped masses. This is described from the spontaneous vegetation of initial stages of plant colonization to the formation of true plant communities and forest stands. The time-dependent succession of vegetation is studied by means of various older mining areas. The comparison of the succession of stages includes dumped areas which are only one year old and others which date back to the end of the last century, i.e. they are approximately 100 years old.

PILLAR, V. DE PATTA, M. CADENAZZI & P. BOGGIANO. Universidade Federal de Rio Grande do Sul, Porto Alegre, Brazil

Probabilistic recognition of homogeneity, edges and patch structure in grassland

We apply a randomization-based probabilistic assessment of community resemblance and group homogeneity to reveal edges and spatial pattern at different scales in grassland. Data come from cover estimates of plant populations in 10 x 10 cm contiguous quadrats placed on a short transect, in a Campos area near Porto Alegre, Brazil. The analysis subjects relevé dissimilarities to a randomization test directed by a random-composition null hypothesis, generating the corresponding 1-alpha probabilities. These measure dissimilarity and, if below a given threshold, indicate indistinguishability in relevé composition. Homogeneous community types are revealed in cluster analysis performed with the probabilities. Edges are detected by neighbor-relevé probabilities that are above the threshold. Community types and edges mapped on the transect indicate patchiness and discontinuity. Quadrat size is increased analytically by combining neighbor units. The results point out the scale dependence in perceiving homogeneity and discontinuity in space and the utility of the approach in optimizing sampling-unit size to study vegetation-environment interactions in a patchy landscape molded by grazing, fire and soil factors.

PFISTER, R.D. University of Montana, Missoula, Montana, USA

Stand structure foundations for forest landscape evaluation

Most knowledge of ecological processes are documented at the community level of vegetation science. Translating that body of knowledge to landscape scales and perspectives is a major challenge and a great opportunity. Innovative approaches to stand structure classification provide a way to abstract appropriate inventory data and knowledge of processes to "stand types". Stand types can provide operational "patch" components to define landscape structure, composition, and pattern. Existing knowledge of stand-level processes can be used to move patches forward in time to create alternative scenarios of future landscape conditions. The aggregation hierarchy approach provides a documented, knowledge-based system for comparison with alternative approaches to study landscape level processes and dynamics. The approach will be illustrated with current landscape analysis projects.

PHILIPPI, T.E. & P.M. DIXON. Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Initial steps toward a method of analyzing vegetation samples including temporal change

Common ordination methods are not appropriate for analyzing vegetation sampled along an environmental gradient and resampled over time. There is no reason to expect that temporal change (e.g., succession or response to climatic changes) should proceed in the same dimensions defined by variation along environmental gradients. Therefore, extracting two or more axes from all plot-by-time samples confounds temporal and spatial variation, and precludes valid assessment of temporal convergence and divergence. Our approach is to extract a first ordination axis as usual, but then define a second axis locally at each point along the first axis, producing a "twisted ribbon" or two-dimensional manifold in the n-dimensional space defined by n species. This approach cannot detect temporal change where all stands shift in the same direction along the first axis. However, our approach has the potential to characterize convergence and divergence of stands through time. This approach is demonstrated using data from bottomland hardwoods and montane meadows.

RAUS, T. Botanischer Garten and Botanisches Museum Berlin-Dahlem, Berlin, Germany

Short-term temporal processes in eastern-Mediterranean therophytic vegetation monitored on permanent plots in Thessaly, Greece

Short-lived Mediterranean therophytic communities are often extremely rich in species. In Attica near Athens (Greece), for example, more than 100 species inhabiting an area of 1 x 1 m have been observed. In eastern Thessaly (east-central Greece), 8 permanent squares of 1 x 1 m have been monitored for about a one-year period (March-November) with respect to floristic composition and phenological symmorphology of their entire, predominantly annual, plant cover. Depending on nutrient availability, between 11 (on silicious soil) and 73 taxa (on calcareous soils) have been found coexisting in a characteristic temporal pattern. On the same spot, groups of species follow each other in their genetically fixed periods of vegetative development, flowering, seed dispersal and decay, thus enabling coexistence by avoiding, or at least reducing, simultaneous competition pressure. Duration of specific, competitively active growing periods varies from about 3 weeks to about 1 year.

REID, E. & S.Y. ROSS. Scottish Natural Heritage, Edinburgh, Scotland, UK

Mapping and quantifying the natural heritage status of semi-natural vegetation in Great Britain

Determination of the occurrence, distribution and abundance of phytosociologically classified vegetation community information remains one of the most elusive goals in remote sensing studies of natural and semi-natural vegetation. Scottish Natural Heritage has tackled the problem of mapping large scale vegetation patterns by utilising satellite imagery in order to characterise the extent and quality of blanket peatland throughout Great Britain. The methodology developed (1) relates classified vegetation variables and surface feature information to spectral classifications, and (2) employs Principal Component Analysis within a Geographical Information System in order to describe the spectral variation of the peatland information throughout the imagery and reduce information from non-peatland classes. Preliminary results show that a relationship between "active" phytosociologically distinct vegetation classes and class patterns can be linked to spectral sample clusters. The spectral properties can then be labelled by utilising quantitative ground data explicit to vegetation ecology.

PODANI, J. Eötvös University, Budapest, Hungary

Space-series analysis of vegetation

Small-scale community studies are associated with different conceptual and real spaces that can be ordered into a logical sequence (for example: topographical space-data space-resemblance space-ordination space). It is emphasized that pattern analyses cannot circumvent the problem of scale dependence in any of these spaces. As the only solution, a sequence of changes has to be defined by the investigator in the space of interest with subsequent evaluation of the series of results. Examples for such sequences are changes in the size, shape, arrangement and number of sample plots, increases in point-to-plant and inter-plot distances, changes of constants in data transformation, diversity or resemblance functions, and logically arranged series of clustering or ordination configurations. Although the importance of certain spatial sequences has long been recognized in many areas of vegetation ecology, and scale problems receive increasing attention in contemporary quantitative studies, the different approaches are isolated and spatial aspects often remain ignored. A general theoretical framework is necessary to summarize past contributions and to explore future possibilities, under the suggested headline "space-series analysis", with a clear reference to a more deeply understood subject, time-series analysis.

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RAMSEIER, D. Harvard University, Cambridge, Massachusetts, USA

Influence of nutrient levels on the establishment of sown species and volunteers in "wandering fallows" in Switzerland

The sowing of seeds of endangered species is becoming more and more important in conservation biology. However, there is limited information how to establish a species-rich plant community from seeds. The aim of my work was to develop a seed mixture to promote plant diversity in "wandering fallows" in Switzerland. A wandering fallow ('Wanderbrache') is a strip of arable field that remains fallow and is relocated by half of its width each year. This system has the goal of preserving rare plant and animal species, promoting beneficial arthropods, and improving soil quality. Twenty-nine species were selected for the seed mixture on the basis of their behavior in preliminary trials. Seed mixtures were tested and adjusted over 3 years. The resulting mixtures were then sown in fall and spring at 5 experimental sites with 4 replicates each. More of the sown species established on the nutrient-poorest site than on the nutrient-richest site (21 vs. 16 per subplot in the first year and 25 vs. 23 in the second year). On the nutrient-poor site, 3 times more volunteer species established than on the nutrient-rich site (21.6 vs. 7.4 in the first year, 15.3 vs. 5.6 in the second year). However, the total number of species on the nutrient-poor site was only twice that on the nutrient-rich site. This is because patches dominated by single species were larger in high-nutrient sites. Sites with intermediate nutrient levels showed intermediate behavior in all respects.

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Temporal patterns of first-year post-fire recuperation of ground-layer species in a cerrado near Brasilia

Above-ground biomass and cover of the ground-layer species in a hectare of cerrado vegetation of natural shrub-savanna physiognomy were investigated during the first year of regrowth (Sept. 1986-Sept. 1987) after a wildfire (Aug. 1986) had completely consumed this layer. Nine 1x1 m systematically spaced quadrats were clipped at ground level each month and separated into species. Six temporal patterns of biomass and cover could be distinguished: 1) immediate increase after the fire with a peak at the beginning of the rainy season (Sept.-Nov.); 2) a peak in the middle of the rainy season (Dec.-Jan.); 3) a peak during the second half of the rainy season and the beginning of the dry season (Feb. - June); 4) a continuous increase from immediately after the fire to a peak at the end of the dry season after a year's growth (Sept.); 5) two peaks, one at the beginning of the rainy season and the other at the end of the rainy season; 6) two peaks, one at the beginning of the rainy season and the other at the end of the dry season. In patterns 2-6 plants were present in all months.

SCHELL, L.D., T.J. STOHLGREN, M.B. FALKNER & G.W. CHONG. Colorado State University, Fort Collins, Colorado, USA

Estimating plant species composition and cover from subplots: improving multi-scale sampling designs

Many vegetation sampling techniques involve subsampling for understory cover in a small area in the center of a larger plot. The implicit assumption is that the subsampling provides a representative and unbiased estimate of plant cover in the larger plot. Species composition and cover data were tested using two multi-scale plot designs in various vegetation types in Colorado (n = 12 sites) and South Dakota (n = 19 sites). We found that the mean plant cover values for the five dominant species were not significantly different using the two plot designs. However, we showed that the center-only subplot design (Whittaker design) was significantly affected by spatial autocorrelation. We found also that the perimeter-subplot (Modified-Whittaker) design returned significantly greater ($p < 0.05$) number of species in the 1 m² subplots (26.4 ± 1.9 S.F. species compared to only 17.6 ± 1.6 species for the Whittaker design). And, the Modified-Whittaker plot reported significantly more low-cover (< 1% cover) species in the 1 m² subplots (16.9 ± 1.3 compared to 10.2 ± 1.0 , respectively). Particularly in species rich areas or when vegetation is clumped in distribution (which is often the case), vegetation plot designs that subsample plant composition and cover in a small area in the center of a much larger plot may not produce representative, unbiased estimates of plant composition and cover.

ROBERTS, D.W. Utah State University, Logan, Utah, USA

Species vital attributes, environmental heterogeneity, and the pattern of vegetation

Species vital attributes are the minimal set of autecological characteristics sufficient to explain the abundance and dynamics of species in vegetation subject to recurrent disturbance, and to explain the distribution of species across a range of environmental variability. Vital attributes were estimated for 10 species of trees in Bryce Canyon National Park, Utah, USA. Existing vegetation and potential natural vegetation were mapped throughout the Park and entered into a GIS as a basis for analysis of vegetation distribution and dynamics. Fire history studies and forest structure analyses of the forests in Bryce Canyon demonstrate that historical fire return intervals ranged from less than 20 years in xeric communities to greater than 100 years in more mesic communities. Vegetation structure analyses and historic photograph relocation studies document the dramatic shift in vegetation composition and distribution within the Park as a consequence of fire suppression. An analysis of vegetation distribution and dynamics in Bryce Canyon National Park with the vital attributes-based VAFS/LANDSIM landscape simulation model shows that the trends of temporal abundance and spatial distribution of species, community complexity, and landscape gamma diversity are all strongly affected by characteristics of the disturbance regime, which in turn is affected by the environmental heterogeneity. Simulated changes in the disturbance regime result in unique maps of predicted vegetation distribution, indicating potential management activities designed to maximize Park vegetation diversity, to restore vegetation characteristic of a particular point in time, or to achieve other specific community and landscape-level characteristics.

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ROMERO F.J. & A. VELAZQUEZ. Departamento El Hombre y su Ambiente, Villa Coapa, Mexico; Universidad Nacional Autónoma de México, Mexico

Spatial and temporal variation of montane temperate Neotropical communities: a small-scale spatial scenario

Description of plant communities is important to carry out quick evaluations on potential use of natural areas. Structure and composition, however, vary along environmental gradients and time. The present research aims at describing montane temperate Neotropical communities at three times of the year (dry, rainy and most productive seasons). The study area lies within the central part of the Transversal Neovolcanic Belt in Mexico. Data from 86 sampling units were used to describe three communities characterised by *Pinus* spp., *Muhlenbergia macroura* and *Furcraea bedinghausii*. Floristic composition, cover and height of all species were recorded, as well as the cover by strata. Additionally, 19 environmental variables were measured. Multivariate exploratory statistical analysis (classification and ordination) were used to analyse the data. The results show that two types of change in composition and structure took place, namely: intra- and inter-community. Further experimental research is recommended to determine the factors that govern these processes.

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ROSA, C.M.M. & G. EITEN. Universidade de Brasília, Brasília, Brazil

SILANDER, J.A., Jr., J.G. MICKELSON, Jr., D.L. CIVCO¹ & C.D. CANHAM². ¹University of Connecticut, Storrs, Connecticut, USA; ²Institute of Ecosystems Studies, Millbrook, New York, USA

The structure and dynamics of forest communities in northeastern North America: scaling from the individual to the landscape

Using spring, summer and fall Landsat 5 TM images for 2000+ km² of NE Connecticut, we have been able to resolve and classify approximately 15 forest cover types. The 18 reflectance band composite (3 dates by 6 bands) was classified using existing algorithms within ERDAS Imagine 8.1 software. The classification and the accuracy assessment were based on 300 stratified, GPS ground control points. For each point we collected species inventory information, plus a suite of environmental data. This information was then combined in a GIS data base with other spatial data (digitized soils maps, DEM, hydrography, etc.). We performed CCA ordinations and classifications on: (1) the vegetation by reflectance matrices, and (2) the vegetation by environmental attributes matrices. The results reveal a surprising ability to discriminate among forest types at a fine spatial scale and provide some insight into environmental control of species distribution patterns at the landscape level. The findings from this study are then compared with predictions of forest tree species distribution patterns made at small to intermediate spatial scales using SORTIE, an individual based, spatially explicit model of forest structure and dynamics. Using the above approach we discuss how it is possible to examine and accurately predict forest community structure and dynamics from the scale of the individual to that of the landscape.

SLIVA, J. Technische Universität München, Freising-Weihenstephan, Germany

Investigation of safe sites within tussocks of *Eriophorum vaginatum* and their role in the secondary succession processes in milled bog areas

After the peat milling of raised bog areas in southern Bavaria the rewetting milled fields are recolonised by *Eriophorum vaginatum* as a euryvalent pioneer species. The effect was observed that the tussocks of *Eriophorum* form sites for the establishment of many mosses, ferns and phanerogams. Between-tussock ground surface of the peat fields stayed without plant cover. The study investigated which site conditions (microclimate, nutrient enrichment) define these safe sites within and beneath the tussocks and which ecological groups of species prefer these safe sites for establishment. The results show the significant differences of some site parameters between tussock zones as well as between tussocks and the surrounding vegetationless peat surface. The results are discussed considering the importance of safe sites formed by tussocks of *Eriophorum* for the secondary succession processes on the disturbed peat areas.

SHARITZ, R.R., E.F. PAULEY & B.P. ALLEN. Savannah River Ecology Laboratory, Aiken, South Carolina, USA

Spatial patterns of disturbance and recovery from hurricane winds in an old-growth floodplain forest

The tree canopy in an 8988 hectare tract of old-growth bottomland hardwood and swamp forest in the southeastern USA was affected by hurricane winds in 1989. Effects on forest structure, species composition, and spatial patterns were examined in ten 1.0 ha plots. Trees and large saplings were tagged, measured, mapped, and described as to the nature and extent of the damage. Effects of the hurricane were greater in bottomland hardwood forest communities (37% of trees heavily damaged) than in swamps (10%) but varied considerably among plots. Types of damage differed among floodplain species and among size classes within a species. In the more heavily damaged areas, post-hurricane mortality changed the spatial distributions of some canopy species. Regeneration in canopy gaps was dominated by early-successional species in the hardwood forest but not in the swamp. Thus, effects of this hurricane are likely to have longer-term, larger-scale consequences on the structure of bottomland hardwood forests than on the swamp forests.

SHARITZ, R.R. & W.D. MARSHALL. Savannah River Ecology Laboratory, Aiken, South Carolina; S. Carolina Department of Natural Resources, Columbia, South Carolina, USA

Vegetation classification as a framework for environmental management

Vegetation classification and mapping can provide a framework for characterizing and evaluating natural resources and for establishing management goals. For example, classification serves as a means for identifying areas that are most in need of protection or preservation. For many land managers, vegetation classification also provides a valuable tool for land inventory and assessment of change. The pattern and distribution of vegetation cover types, especially when integrated with other ecological and geographic data, can be a base for making sound environmental and economic decisions. An ecological characterization of the Edisto River Basin in the coastal plain of South Carolina, USA, serves as an example. This is a research and demonstration project focused on developing a geographic information system (GIS) and a public policy process aimed at improving the way environmental management decisions are made. The purpose of the project is to evaluate the natural resources of the 8080km² Edisto Basin, categorize them according to their significance, identify opportunities to enhance resource conservation objectives and local economic development, and recommend how to achieve these objectives. Data incorporated into the GIS include land use and land cover type, National Wetlands Inventory, SCS soil surveys, USGS digital line graphs, USFS forest survey data, agricultural data and other spatial information. Fifteen expert committees evaluated various resources (such as wetlands, forestry, hydrology and water quality, wildlife habitat), classified the resources by relative value, and used the GIS to identify and map areas valuable to single resource uses and areas with multiple (compatible and conflicting) resource uses.

SPIES, T.A. & W.B. COHEN. USDA Forest Service, Pacific Northwest Research Station, Corvallis, Oregon, USA

Mapping forest structure and dynamics in the Pacific Northwest using remote sensing

Forest stand and landscape structural diversity and patch dynamics are extremely important drivers of ecosystem processes and biological diversity in the Pacific Northwest. Therefore, regional and landscape planning, conservation, and research efforts have focused on identification of forest canopy structure/seral stage conditions, specifically old-growth stands, rather than vegetation composition. Structural differences observed on the ground among stand age-classes typically appear as canopy textural or spectral differences in remote sensing imagery from sensors with different scales of resolution (e.g. 1 m, 10 m, and 30 m). We have developed several classification models for mountainous areas in the region that are moderately successful at discriminating 5 to 10 land cover/stand structural classes. Classifications with more than 8-12 classes have low overall accuracy. We have used these models to examine landscape patterns and dynamics among ownerships and as input into carbon storage and biological diversity models. Analyses reveal that fire history and recent anthropogenic disturbances have created complex and highly contrasting forest stand/patch patterns. Future research will focus on integrating plot data and GIS layers with remote sensing imagery to increase information content within the relatively broad mapped cover classes.

STADLER J., & R. BRANDL. Centre for Environmental Research Leipzig-Halle Ltd., Bad Lauchstädt, Germany

Early succession in abandoned fields: germination strategy and vegetation development

We investigated the vegetation development on abandoned fields and posed three questions: 1. Do early successional stages of abandoned fields show marked differences in their floral composition when laid out at different times? 2. Which factors trigger seedling establishment? 3. Is competition an important factor during the very early phases of succession? Although the floral components of all treatments showed a general similarity with the surrounding vegetation, species composition differed considerably between autumn treatment on the one hand and spring and summer treatment on the other. The observed variances of species richness across plots of each treatment are higher than expected from a Monte Carlo simulation, thus niche limitation is not detectable within our plots. Seedling establishment showed a clear seasonal pattern with a minimum during summer. In the experimental plots where all seedlings were removed during the vegetation period, the number of seedlings which appear from one sampling date to the other was about tenfold higher than on plots with an undisturbed development of the vegetation. Despite the large number of emerged seedlings mortality of plants was very low and showed no density-dependent pattern. From these results we conclude that seedling establishment is triggered by the germination strategy of the species and that the development of the vegetation cover suppresses further germination. Niche limitation and direct competition between already established plants seems to be unimportant within the early phase of succession in abandoned fields.

STANDOVAR, T. Eötvös University, Budapest, Hungary

SNYDER, J. R. National Biological Service, Ochopee, Florida, USA

Fire ecology of South Florida rockland pine forests

Pinus elliottii var. *densa* replaces *P. palustris* in southern peninsular Florida and shows many similar adaptations to fire. In extreme southeastern Florida and a few of the lower Florida Keys, *P. elliottii* var. *densa* grows on exposed oolitic limestone. These rockland pine forests are characterized by a diverse woody understory, including numerous tropical hardwoods and a few species of palms, and an herbaceous flora with several endemic taxa. Less than 10%, or about 7,000 ha, of the pine forest that existed at the turn of the century still remains in a more or less natural state. In south Florida, lightning-caused fires burn the greatest area from May to August, but fires, including those caused by humans, occur throughout the year. Pines have relatively long lifespans and a wide tolerance of burning regimes so that forest structure is probably a crude means to evaluate different fire management practices. Experimental studies of the effect of different seasons of burning on understory vegetation suggest that in many cases the effect of fire intensity overrides the effect of season. In order to maintain the biological diversity of these rockland pine forests it appears prudent to maintain a variety of burning regimes.

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SOLOMESHCH, A.I. Bashkirian Research Center, Russian Academy of Sciences, Ufa, Russia

Parallel variation in plant communities

The principle of homological series has been applied for an analysis of small-scale variation of plant communities. According to this principle, vegetation diversity can be reduced to several community types with the parallel changes of their floristic composition. The parallel variation has been observed for oligomesotrophic bogs between the associations *Sphagno-Rhynchosporium*, *Caricetum limosae* and *Caricetum lasiocarpae* (order Scheuchzerietalia), as well as for associations of the mesophytic broad-leaved forests (order Fagetalia) and for weed communities (order Secalietalia). Ecologically and floristically similar communities have more complete parallel variation series than the floristically remote communities. Ecological prediction on this basis is possible. If a complete variation series has been revealed in one group of community types, the homological series may be expected in the similar groups and an existence of new community types may be predicted. Homological variation criteria for an estimation of difference between community types and combinatorial principle for vegetation classification are proposed.

Relationship between spatial and temporal scales in natural forest dynamics

To explain the dynamics of temperate forests in Europe, at least three different models are applied. Their spatial scales range from 0.01 ha to tens of hectares, but the temporal scales are not clearly defined. Comparisons with empirical data on distribution patterns and growth rates of forest regeneration suggest that each of those models performs well only within certain time limits. Single gap model gives reasonable short-time predictions; for longer periods multiple-gap model performs better. Forest dynamics spanning several tree generations can be most accurately described using the developmental phase approach; however, that model is of little use for explaining local phenomena. Essential mechanisms of forest dynamics, like competition among trees or seedling demography, can be followed in small plots. But long-term forest dynamics are also influenced by events and processes—like large-scale disturbances or species dispersal—which can be neither studied nor simulated at local scale. Thus none of discussed models can be applied to all temporal scales: a set of hierarchically organized submodels could provide a more reliable picture of forest dynamics.

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THOMSON, J.D., G. WEIBLEN, B.A. THOMSON & S. ALFARO. State University of New York, Stony Brook, New York, USA

Gopher-driven patchiness and source-sink effects in a subalpine lily: rock-refuge effects

We examined spatial patterns of glacier lily (*Erythronium grandiflorum*) seedlings, vegetative plants, and flowering plants in a square grid of 256 contiguous 2 x 2 m quadrats in subalpine meadow in western Colorado. We also measured soil moisture, pocket gopher activity, and soil rockiness. All six variables showed significant patchiness at similar scales. Flowering was positively correlated with rockiness, negatively correlated with moisture and gopher activity. Although limited seed dispersal suggests that seedlings should be found associated with flowering plants, there was no correlation, and examination of the bivariate scatterplot suggests a negative association in the sense that seedlings are abundant only in quadrats where flowering is low. We hypothesize that seeds usually desiccate in the rocky areas where most of them fall; that seed germination is higher in non-rocky areas of deeper, moister soil; that gophers kill most seedlings in the deep-soil patches; that gophers are excluded from the rocky patches; and that therefore the rocky patches comprise source areas from which some seeds disperse outward into surrounding sink areas where they eventually perish. This ecological situation should weaken natural selection on characters enhancing dispersal distance. We discuss two general statistical problems exemplified in our data: assessing the significance of correlations between spatially patchy variables and describing ecologically informative relationships in bivariate scattergrams not well described by correlation/regression.

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TUOMISTO, H. University of Turku, Finland

Within-community vegetation patterns in relation to habitat factors in a sessile oak stand

Within-community vegetation patterns were studied at two spatial scales in a 90-year-old stand of 5.5 ha situated in Northern Hungary. Classificatory analyses of ground vegetation resulted in four groups of relevés. They were distinguished by detecting floristic differences (presence-absence data, 148 species, 354 12.5x12.5 m quadrats). To get a finer description, data collected from 290 3.14 m² circular plots were analysed in a similar way. The floristic types obtained were assessed by using ecological indicator values of the species. Habitat patches with different soil moisture regime and acidity were indicated by herbaceous species. Patches, where measured moisture content and moisture storing capacity of the top soil were different, were indicated by the vegetation agreeably. Plexus graphs based on interspecific association calculations, were constructed to show basic community structures.

STANISCI, A., A. ACOSTA, P. DI MARZIO, G. DOWGIALLO & C. BLASI. Università degli Studi "La Sapienza", Roma, Italy

Plant communities in relation to soil and water persistence in subcoastal ponds (Central Italy)

We analyse plant communities of the interdunal wet depressions (ponds) in relation to soil features. In these ponds soils are rich in clay, allowing water stagnation in autumn and spring. These particular soil conditions determine the presence of plant coenoses with *Quercus robur* L. and *Fraxinus oxycarpa* Bieb. and hygrophilous understory species. Each pond was sampled for four seasons recording plant cover in transects of continuous quadrats, starting from the centre of the pond. Along the transects, soil samples were taken in order to analyse edaphic variables such as sand, clay, lime, organic matter, pH, etc. Data were analysed using ordination techniques and canonical correlation analysis. There is a clear floristic and structural gradient ranging from the core to the external border of the ponds. The central band, rich in clay and organic matter, is occupied by spring annual communities. The intermediate band is characterized by perennial hygrophilous herbs and the external band, more rich in sand, by woody species of *Quercus cerris* L. forest, the dominant formation on these pleistocenic dunes.

SZWAGRZYK J. Agricultural University, Krakow, Poland

VAN DER MAAREL, E.¹ & M.T. SYKES². ¹Uppsala University, Uppsala, Sweden; ²Global Systems Group, Lund University, Lund, Sweden

Small-scale processes in semi-natural grasslands

In earlier work we launched the carousel model to describe patterns and processes occurring in plant communities. Seemingly stable and homogeneous plant communities are in fact constantly mobile at small scales. This large small-scale mobility was for the first time demonstrated for limestone grassland suffering from regular summer droughts, but it appears to occur in other grassland types and species-rich forest floors as well. We now examine more precisely some of the possible processes involved in this mobility. We use data from a 10-year project in a semi-natural limestone grassland on the island of land in the Baltic Sea. The grasslands are extremely species-rich, particularly at small scales with up to more than 20 species/100 cm². Soils are thin and nutrient-poor, severe droughts occur at fairly regular intervals in the growing season. Mobility is approached on the basis of appearances and disappearances of species in 100 cm² subplots. In our approach we consider three possible models of mobility which species in this grassland community may exhibit: (1) the null or random model (after J. B. Wilson), (2) the minimal mobility model and (3) the maximum mobility model. We measure turn-around mobility using frequency accumulation through time and the concept of cumulative frequency for each species. We apply the null model idea based on the random allocation of species occurrences to calculate random accumulations over time. The minimum mobility model assumes that occurrences are always in subplots where the species was found earlier unless there is an increase in frequency. The maximum mobility model locates species always into new subplots. We compare model results with our field data.

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VAN KLEY, J.E., R.L. TURNER & M. CLENDENIN. Stephen F. Austin State University, Nacogdoches, Texas, USA

An ecological classification system for the Western Gulf coastal plain: preliminary results

Natural vegetation and its relationships with soils and topography is being described as part of the development of a multifactor ecological classification system for the National Forests of Texas and Louisiana. 98 forest stands were sampled from a variety of soil and topographic types in the Kisatchie, Angelina, and Davy Crockett National forests during 1994. Measurements of ground flora and overstory from stands older than 60 years were subject to TWINSpan classification, DCA ordination, and canonical ordination. Preliminary results indicate relationships between soil texture, soil nutrients, landscape position and vegetation. These and other relationships identified during this on-going study will form the basis for a regional ecological land classification system which will provide baseline ecological information for researchers, naturalists, and forest land managers.

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Amazonian rain forests: how studies at different scales help understand a complex whole

The Amazonian tropical rain forests seem at first glance remarkably uniform at large spatial scales. Paradoxically, at small spatial scales there is a bewildering diversity of species. A plot of 1 ha may contain more than 1000 species of vascular plants, including more than 300 species of trees, and share less than half of these with a neighbouring plot. Given that it takes several years of work just to get those 300 species collected and identified, it is no wonder that it has been difficult to see the forest for the trees. Only a few vegetation types have been recognized in Amazonia, and none of them has been defined on the basis of its floristic composition. The spatial and temporal scales involved in tree sampling are obviously unpractical for vegetation ecological studies. There are two ways in getting around this problem: looking at smaller scales, and looking at larger scales. Smaller scales can be addressed by studying smaller plants, such as ferns, which are rather abundant in any tropical forest. In a plot of 1 ha, 30 species and 5000 individuals may be encountered, and therefore firm conclusions about the floristic differences within and among sites can be drawn. Comparisons of the similarities among fern communities at different rain forest sites with those of corresponding tree communities show that there is a high correlation, both plant groups being also correlated with edaphic conditions. Larger scales can be addressed by using satellite images, which reveal quite an array of different vegetation formations in lowland Amazonia. Such large-scale information enables estimations to be made about the spatial representativeness of the point data obtained from the field. It also invites linking the distribution of the vegetation types to the distribution of geological formations, at which stage long-term temporal processes become relevant.

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UDVARDY, M.D.F. California State University, Sacramento, California, USA

The world system of biogeographical provinces of IUCN based on the largest scale of vegetation patterns

The system, in use for 25 years but now under revision, serves both zoo- and phytogeographical classification of spatial units of land. Its basis, wherever adequate data are available, is the pattern of potential vegetation.

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WALKER, R., F.W. DAVIS¹ & J.W. VAN WAGTENDONK². ¹University of California, Santa Barbara, California; ²National Biological Service, Yosemite Field Station, California, USA

Remote sensing and geographic information system integration for monitoring dynamics of natural vegetation in California

With projected climatic warming, coniferous forests at the lower elevations of California's Sierra Nevada mountains may become more susceptible to insect infestations and disease, due to increased moisture stress. This in turn could lead to a general decline in ecosystem health. For the past 3 years, we have been developing a vegetation baseline for Yosemite National Park for resource and habitat inventory, and from which to begin to monitor changes. For species composition information we have used detailed vegetation maps, digitized into a geographic information system (GIS), and for site-specific information on canopy structure we are employing Thematic Mapper satellite data. Concurrently, we are designing and implementing a GIS-based dynamic vegetation sampling system, of which a remote sensing subsystem (based on Thematic Mapper data) is an integral part. The overall objective of the system is to track, quantitatively over timescales of years to decades, systemic changes taking place in the Yosemite ecosystems. A side benefit of such ecological monitoring will be a detailed and comprehensive record of landscape-altering processes with their frequencies and magnitudes, from which a more thorough understanding of Sierra Nevada vegetation dynamics could emerge.

WALKER, S., A.F. MARK & J.B. WILSON. Otago University, Dunedin, New Zealand

Seasonal changes in semi-arid vegetation of New Zealand

The three seasonal vegetation surveys of permanent quadrats allowed consideration of questions regarding the nature of seasonal change in the vegetation of semi-arid Central Otago, New Zealand. Thirty-one percent of the species recorded showed significant changes in seasonal abundance over a growing season. Only 4% of the species were most abundant in the autumn, and 34% and 62% reached maximum abundance in the spring and summer respectively. Species distributions are least predictable in the spring, when soil moisture is briefly available, and most predictable in the autumn, when moisture deficit is at a maximum. However: (a) there was no indication that different communities tend to occur in different seasons; (b) the ordination positions of sites were highly correlated between seasons; (c) there was considerable agreement between separate seasonal classifications; (d) seasonal differences in community structure were non-significant. Thus, although there was significant seasonal niche differentiation, and this was correlated with the geographical origin of the species, seasonal changes within the study period are small in comparison to the spatial variation in the reserve.

VELAZQUEZ, A. & G. ISLEBE. Universidad Nacional Autónoma de México, Mexico;
University of Amsterdam, The Netherlands

Spatial and temporal community patterns of high mountains in Megamexico

Megamexico, as a phytogeographic unit, shows strong vegetation affinities among areas from southern USA down to the Depression of Nicaragua. Detailed information at community and landscape level is still scanty to document (dis)similarities among most environments within this area. Recent phytoecological surveys conducted at four high mountain ranges (Sierra Chichinautzin and Sierra Nevada, Mexico; Sierra de Los Cuchumatanes and Cadena Volcánica, Guatemala) allowed us to test, at community level, the degree of affinity. Altitudinal zonation of upper montane and alpine communities is as follows: alpine bunch grassland (Mex.: 4000-4500 m; Gua.: 3800-4200 m), *Pinus hartwegii* community (Mex.: 2900-4000 m; Gua.: 3000-3900 m), *Abies religiosa* community (Mex.: 2400-3600 m), *Abies guatemalensis* community (2800-3400 m), mixed forest community (Mex.: 3000-3500 m; Gua.: 2800-3300 m). These vegetation types follow the same successional pattern in which the youngest (disturbed) vegetation types are dominated by broad-leaved trees, whereas the last stages (well-conserved) by needle-leaved ones. Soil humidity and elevation were detected as the ecological variables which explain better the overall distribution pattern. Ecological conditions, however, seem substantially different, the Mexican vegetation types being cooler and drier than the Guatemalan ones. Mexican high mountain landscapes comprise relatively more coniferous-dominated communities than the Guatemalan ones. Human interference plays an important role in explaining this landscape pattern. To conclude, historic events seem to explain the strong affinity at generic level, hence the common temporal pattern.

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WALKER, M.D. University of Colorado, Boulder, Colorado, USA

Biodiversity of arctic ecosystems: patterns within and among communities and landscapes

The Arctic is a region of low biodiversity and both extreme and highly variable physical conditions. It contains within a strong and consistent gradient of floristic diversity: if one begins at some arbitrary point in the southern Arctic, there will be a gradient of decreasing diversity to the north, with species being lost and only a few new truly arctic species gained, and a gradient of increasing total diversity to the east or west. There is also a pattern of decreasing geographic variation from south to north—southern areas have about 60% of their species in common, which increases to 90% in the northernmost partially vegetated areas. These natural gradients of diversity represent ideal conditions on which to develop hypotheses regarding controls on diversity. In this talk I present patterns of diversity at a series of spatial scales, from mesoscale toposequences to large landscapes with different glacial histories, and discuss the major factors controlling those patterns. Thermal energy is shown to be a common element controlling diversity at all spatial scales, and therefore changes in growing season temperature are likely to have dramatic impacts on biodiversity.

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WILSON, J.B. University of Otago, Dunedin, New Zealand

Theories of community structure: a reductionist approach

General theories of plant community structure are not abundant. Two recurring questions are whether communities are deterministic or stochastic, and whether they are discrete or continuous (usually, none of these terms are well defined). This gives four possible combinations, which can be identified in the literature. The CSR theory of plant 'strategies' has implications for communities, which could be tested. These are top-down approaches. The alternative, reductionist, approach is to start at the lowest level. There is little evidence from real plant communities of overall limitations to species coexistence. However, evidence does exist for coexistence limitations based on guilds, at least in some communities. The scale at which this evidence can be found, and correlation with plant morphology, suggests local canopy interactions may be important. There is little evidence for community structure in terms of abundance. Either species-specific processes dominate, or we have not yet found which aspects of abundance to measure. Larger-scale structure, when not dominated by the underlying environment, is probably attributed to the effects of the species on their environment by switches and grain coarsening.

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WINKLER, E., S. KLOTZ & C. WISSEL. Centre for Environmental Research, Leipzig, Germany

Long-term control of species abundances in a dry grassland community—a lesson from small-scale mathematical modeling

Following small-scale records over 15 years on the fate of individuals in a low-productivity dry grassland community in Central Germany, the temporal and spatial dynamics of the community was investigated by spatially explicit individual-based and by population dynamic modeling. The main results on regulation of species abundances are: 1) The basic matrix of *Festuca cinerea* tussocks is regulated by the reduction of the seedling establishment rate when its cover increases. Regulation of cover exhibits a strong density vagueness even without environmental fluctuations. 2) "Sparse species" (tussock grasses and perennial herbs) are largely uncoupled in their dynamics from the basic matrix. Because of their strong dependence on climatic conditions they need heterogeneous habitats and/or amass storage for persistence. 3) The degree of interspecific interactions in the community is low and unspecific; the struggle with harsh environmental conditions is predominant.

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WIEGAND, T. & S.J. MILTON. Centre for Environmental Research, Leipzig/Halle, Germany; University of Cape Town, Rondebosch, South Africa

A simulation model on shrubland ecosystem dynamics in the semi-arid Karoo, South Africa

Using an individual-based spatially explicit simulation model that is based on detailed life-history data including information on life histories, competitive ability and densities for the five dominant Karoo shrubland species *Brownanthus ciliatus*, *Rushia spinosa*, *Galenia fruticosa*, *Pteronia pallens* and *Osteospermum sinuatum* and on monthly long-term rainfall data for this region we investigate the effect of seed production on long-term persistence and coexistence of component spp. We show that the temporal dynamics of the ungrazed shrub community are typified by episodic and discontinuous changes in species composition with intervening quasi-phases lasting some decades. If seed production of one species permanently remains below a critical value (e.g. due to selective grazing) the dynamical state of the system changes to more oscillatory behaviour. In case of heavy grazing the dynamics of the system switches to a degraded state where plant densities become low and the abundance of the unpalatable degradation indicator *B. ciliatus*, which colonizes large gaps in open vegetation, increases. We show that the time-scale for changes of the dynamical state of the system are long compared with human lifespans. Memory effects and dynamical inertia veil (or conceal) changes in the dynamic state of the systems for long periods, so that the consequences of environmental changes or differences in management are only manifested long after they have begun.

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Regional gradients in lichen communities in eastern USA forests

Macrolichens on standing woody substrates are used as indicators of ecosystem health in the Forest Health Monitoring (FHM) Program (USEPA and USDA Forest Service). 184 lichen species were found in 203 plots surveyed in 1992 and 1993 in southeastern USA. Multivariate analysis of plot data identified two major gradients in lichen community composition: a macroclimate gradient from the coast to the Piedmont to the Appalachian Mountains, and a gradient in air quality from pollution tolerant species and lower species richness to pollution sensitive species and higher species richness. Plots are assigned scores on each of the gradients; comparison of gradient scores in plot resurveys will provide regional indicators for changes in forest ecosystem health. 1994 surveys were extended to the northeastern and mid-Atlantic USA regions. Preliminary comparisons with SE USA data suggest equivalent gradients will be identified in these regions, with region-wide poor air quality in the mid-Atlantic and southern New England areas clearly delimited.

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A land cover analysis of Texas National Guard training areas

In a move toward ecological management of military lands, current land cover was analyzed for eight Texas National Guard Training Areas using color infrared (CIR) aerial photography, thematic mapping (TM) satellite imagery, a global positioning system (GPS), and a Geographical Information System (ERDAS and ARC/INFO). The delineation of current land cover was preceded by terrestrial biological surveys for rare plant and animal species, significant natural features, and natural plant communities. Analysis of current land cover was performed by delineating recognizable community types on the CIR aerial photos and by applying principal component analysis (PCA) to recently acquired TM imagery. Using the Nature Conservancy's national community classification system, a total of twenty-two plant communities were recognized for the eight training areas. Eight rare or threatened species were located on three areas. Information from the surveys and the land cover analysis will be used to develop ecologically-based management plans for each training area.

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Impact of trees on subordinate layer structure in pine forest of South Karelia

Each tree in the forest imposes some influence on subordinate layer composition. An interference of these influences together with a heterogeneity of tree distribution in space creates very complex spatial pattern of environmental conditions under the tree layer. Such a pattern has been studied in dry pine forest of South Karelia. An analysis of the subordinate layer on more than 60000 microscopic plots (8x8 cm) located on transects between trunks of trees of various sizes permitted distinction of two additive components of tree influence. The first component represents shading, the second one has been interpreted as trunk influence. The composition of the subordinate layer depends on the combination of both factors. The set of possible combinations that may be realized under forest canopy is broader than the set of combinations that are feasible under influence of one tree. This is because deep shade produced by one tree is always accompanied by substantial trunk influence. It is not the case when there are many trees, and 60% of the sites in the forest experience only shading. Such sites are dominated by *Pleurozium schreberi* and *Vaccinium vitis-idaea*, the most widespread species in Karelian pine forests. So, the forest cannot be regarded as composed of trees with their own suites in the subordinate layer. Rather, ground vegetation responds to the whole tree canopy.

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Relevance of the "Peninsular Effect" Hypothesis for floristic diversity in Baja California

The "peninsular effect" hypothesis predicts (1) lower species richness on peninsulas than on "nonpeninsular areas in the same latitude and of similar topographic relief"; and (2) a regular decrease in richness from the base of the peninsula to the tip. Such equilibrium hypotheses applied to Baja California rest on several key assumptions: (1) the principal, or only, colonization source lies at the base of the peninsula; (2) environmental gradients along the peninsula are insufficient to disrupt the pattern; (3) biotic communities are in equilibrium, and no major vegetational shifts have occurred within the last 30,000 years; and (4) the diversity of mainland habitats is directly comparable to adjacent peninsular areas. The physical geography and environmental history of Baja California violate these fundamental assumptions. First, two additional colonization routes exist: (i) to the Cape Region of Baja California and northward, and (ii) across the midriff islands to mid-peninsula. Second, the latitudinal gradient and the southward gradient of increasing precipitation may promote increased floristic diversity toward the Cape. Third, the peninsula's origin on the tropical mainland of Mexico combined with the spread of warmer and drier climates since the Pleistocene may have promoted northward extension of southern species, and retreat northward of northern taxa. Fourth, differences in topography, landform, and climate may confound direct comparison of floristic diversity for adjacent peninsular and mainland sites across the Sea of Cortéz. Finally, both field surveys by the author and comparison of previously published results suggest maximum peninsular floristic richness in the cape region. Thus, the peninsular effect hypothesis appears to be of little utility in predicting, or explaining, large-scale patterns of floristic diversity in Baja California.

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Some ecological implications of phytogeographical distribution patterns in Switzerland

Previous biogeographic regionalisation of Switzerland included only few species all showing typical distribution patterns. Thus, exact limits are exclusively defined for large geographical regions. In addition there exists no review of published chorological maps. For the present study distribution data of 2600 species, based on a systematic inventory of the pteridophytes and phanerogames of Switzerland during the sixties and seventies, have been used. The species lists of all 600 mapping areas were used as entities to be grouped in floristic regions using different resemblance analysis (correlation, Jaccard coefficient) and clustering methods (complete linkage, minimal variance clustering). The floristically defined geographical regions were then related to the environmental envelope of the mapping area (e.g. range of altitude, rock type, yearly mean temperature etc.). The most important discriminating factors are the range of altitude and the substrate. A superimposed rather meso-scaled gradient with east-west direction was detected, that can most likely be attributed to plant immigration during the postglacial period. The phytogeographical regionalisation and its ecological interpretation is a useful tool for revised stratified classification of the forest communities in Switzerland.

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Effect of illumination and fertilization on seasonal changes in canopy structure of a species-rich grassland

We established an experiment in a species-rich permanently mown wooded meadow to seek evidence for the relative role of root and shoot competition as diversity determinants. It is known that fertilization, as well as cessation of mowing, cause rapid decrease of richness in this community. If competition for light were responsible for such decrease, additional illumination would be expected to slow down the decrease of diversity. The experiment has factorial design with three treatments applied—1) mowing, 2) fertilization and 3) additional illumination with the help of mirrors. The permanent plots were sampled by point quadrat method (using laser beam instead of the usual pins) in 50 points, at angles of 60°, 90° and 120°. Such a sampling method allows one to obtain data also on canopy architecture. Fertilization significantly increased the degree of spatial aggregation of biomass in the canopy during the first season of the experiment. In fertilized plots there was also a significant decrease in evenness of abundance of species. The main effect of illumination on canopy structure was not significant. However, illumination compensated the effect of fertilization in plots where both treatments were applied.

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Climatically sensitive modeling tools to predict vegetation patterns at the landscape level

Two modeling approaches are described that were successfully combined to evaluate spatio-temporal vegetation patterns on a landscape level. The first approach (gap model) aims at generating successional patterns on a few scattered geographical locations using a succession model of the FORET family, whereas for the second attempt (spatially explicit model) the relationship between vegetation and site is formalized in order to extrapolate the findings to larger geographic areas, i.e. the entire Swiss territory. The models are based on the following data: (1) experimental results concerning the responses of plants to site conditions and site dynamics, (2) proxy data on past vegetation changes, (3) empirical phytocoenological data relating the occurrence of vegetation types and plant species to site conditions, (4) a country-wide landscape ecological database on a 250 m and, recently on a 50 m grid. Both model approaches (spatial and temporal) have been combined to perform ecological risk assessments of potential species changes as a result of climate change. The paper gives some examples of such risk assessment exercises.

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Temporal variation in seedling growth among contrasting growthforms: a mechanism for succession from hardwood savanna to evergreen woodland?

Succession of post oak (*Quercus stellata*) savannas to juniper woodlands begins when eastern redcedar (*Juniperus virginiana*) establishes beneath post oak canopies. Field observations suggest redcedar eventually over-tops post oak plants in the absence of fire. However, our past controlled environment experiments on growth of post oak and redcedar seedlings under varying levels of light, nitrogen and water indicate post oak seedlings should out-compete redcedar seedlings in under-canopy environments. We therefore tested the hypothesis that redcedar recruitment beneath hardwoods occurs because of growth of these evergreen plants during periods when deciduous oak seedlings are dormant, light attenuation is minimal and soil moisture is optimal. Although maximum net photosynthesis (P_{net}) of redcedar seedlings was low ($8.1 \mu\text{moles CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ at 35°C) and declined with decreasing temperature (by 19%, 38% and 42% at 25, 15 and 10°C respectively), plants could maintain a positive carbon balance during a substantial number of autumn, winter and spring days. During the first 84 days of the hardwood dormant season, field-grown redcedar seedlings increased 4% in height, 12% in diameter and 25% in branch number. Thus, during the mild winters of east central Texas, redcedar is capable of significant growth, suggesting a possible mechanism for achieving greater annual growth than post oak seedlings. In addition, evergreen seedlings may experience lower levels of seedling predation than hardwood seedlings. This hypothesis is currently being tested.

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