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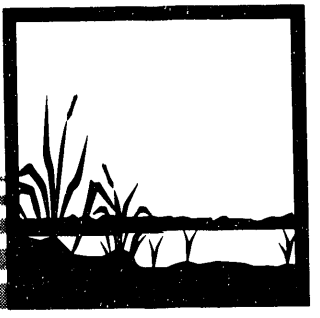
Pattern and Process in Landscape Ecology

Eighth Annual U.S. Landscape Ecology Symposium

Oak Ridge, Tennessee 24-27 March 1993

Program and Abstracts



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Monica G. Turner
Environmental Sciences Division

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8:20 - 8:25	Call to order and introduction - Louis Iverson
8:25 - 8:35	Welcome-Robert I. Van Hook, Director, Environmental Sciences Division
8:35 - 8:40	Local arrangements announcements - Monica Turner
8:40 - 8:45	Introduction of plenary speaker - James Thorne
8:45 - 9:30	Plenary Address - Carol Franklin Ecological design - designing with the patterns and process of place
9:30 - 10:00	Break (Pollard Lobby)
10:00 - 12:00	Concurrent Sessions I and II (Garden Plaza Hotel Salons)
12:00 - 1:15	Lunch (Provided in Pollard Lobby)
12:15 - 1:00	US-IALE Business Meeting (Pollard 249--please get your lunch and bring it with you to the business meeting)
1:15	Plenary Session II (Pollard Auditorium)
1:15 - 1:20	Introduction of plenary speaker - Monica Turner
1:20 - 2:05	Plenary Address - Robert V. O'Neill Landscape ecology over the next decade
2:05 - 2:30	Break (Pollard Lobby)
2:30 - 4:30	Concurrent Sessions III and IV (Garden Plaza Hotel Salons)
4:30 - 7:00	Dinner (on your own)
7:00 - 9:00	Poster Session and Reception (Pollard 240, 242 and Lobby)

WEDNESDAY MORNING, MARCH 24, 1993

Concurrent Session I: **CONSERVATION**
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(Garden Plaza Salon C)

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10:15 am Linehan, John, Jack Ahern, and Meir Gross
Assessing the Impacts of Landscape Fragmentation Upon the Rural New England Landscape

10:30 am Wu, Yegang, Donald L. DeAngelis, Louis J. Gross, and D. Martin Fleming
SIMDEL: A Spatially Explicit Individual-Based Model for White-Tailed Deer on the Everglades Landscape

10:45 am Westervelt, James, Bruce Hannon, Kevin Seel, and Pervaze Ahmed . .
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11:00 am Dunning, John B., Jr., Rene Borgella, Krista Clements, and Gary Meffe
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11:15 am Dewhurst, Stephen M., W.W. Covington, and D.B. Wood
Landscape-Level Habitat Management Using an Integrated Decision Support Approach

11:30 am Keitt, Timothy H. and Alan R. Johnson
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10:15 am — Neilson, Ronald P., C. Daly, J. Lenihan, and J. Chaney
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10:30 am — Lenihan, James M. and Ronald P. Neilson
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10:45 am — Daly, Christopher and Ronald P. Neilson
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11:00 am — Milne, B.T., C.A. Hatfield, and A.R. Johnson
Simulation of Juniper Woodland Landscape Phase Transitions

11:15 am — Tian, Hanqin, Charles A.S. Hall, and Ye Qi
Responses of Biosphere to Changing Global Environments: A Historic Record of Global Biotic Metabolism

11:30 am — Johnston, Carol A., Scott Bridgham, Karen Updegraff, and John Pastor
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11:45 am — Sutherland, Elaine Kennedy and Charles T. Scott
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WEDNESDAY AFTERNOON, MARCH 24, 1993

Concurrent Session III: **BIODIVERSITY**
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3:00 pm — Offerman, Holly, Virginia Dale, Scott Pearson and Robert O'Neill
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THURSDAY, MARCH 25, 1993

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8:25 - 8:30	Introduction of plenary speaker - Susan Glenn
8:30 - 9:15	Plenary Address - H. Ronald Pulliam MAP: Modeling Animal Populations on Changing Landscapes
9:15 - 9:45	Break (Pollard Lobby)
9:45 - 12:00	Concurrent Sessions V and VI (Garden Plaza Hotel Salons)
12:00 - 1:30	Lunch (Provided in Pollard Lobby)
1:30 - 5:30	Field Trips to Walker Branch Watershed and Cumberland Plateau Buses depart from the front of the Garden Plaza Hotel
5:30 - 7:00	R & R
7:00 - 10:00	Banquet (Garden Plaza Hotel Salons A, B, & C) - M.C. Tom Crow Plenary Address - Hal Salwasser Landscapes as the integrating unit of ecosystem management

THURSDAY MORNING, MARCH 25, 1993

Concurrent Session V: **AQUATIC AND WETLAND LANDSCAPES**
Chair, Carolyn Hunsaker
(Garden Plaza Salon C)

9:45 am Robbins, Bradley D. and Susan S. Bell
Marine Landscapes: A New Perspective on Terrestrially Based Conceptualization and Methodology

10:00 am Irlandi, Elizabeth A.
Seagrass Landscapes and Bivalve Fishery Production

10:15 am Fonseca, Mark
Seagrass Landscapes and the Influence of Physical Energy Regimes

10:30 am Strieby, Sandra and Richard Rawlings
Modeling Landscape Patterns Related to Stream Health

10:45 am Tyler, J.A. and K.A. Rose
Individual-based model of fish growth, movement, and survival: fitness-based movement and its effect on population dynamics.

11:00 am Johnson, Lucinda B., Carl Richards, George Host, and John Arthur
Relationship between Stream Community Composition and Landuse Patterns in a 17,000 km² Midwestern Watershed

11:15 am Thorne, Jim, Michael Jennings, Chuck Barscz, and Patricia Weber
The Use of National Wild and Scenic River Designation for Landscape Ecological Planning

11:30 am Lal, Harbans
Modeling Approaches for Wetland Functions at the Landscape Level

11:45 am Richardson, J.R. and J.E. Silveira
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Concurrent Session VI: **FOREST MANAGEMENT**
Chair, Monica Schwalbach
(Garden Plaza Salons A & B)

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10:00 am King, Thaddeus P., Kevin J. Gutzwiller, and Stanley H. Anderson
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10:15 am Gustafson, Eric J. and Thomas R. Crow
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10:30 am Wallin, David O., Barbara Marks, Jane Kertis, and John Cissel
Comparison of Landscape Pattern Dynamics Generated by a Natural Fire Regime and Timber Harvesting in Pacific Northwest Forests

10:45 am Turner, Monica G., William H. Romme, Robert H. Gardner, and William W. Hargrove
Spatial Heterogeneity in Plant Reestablishment Following Large-Scale Fire in Yellowstone National Park, Wyoming

11:00 am Hargrove, William W., Robert H. Gardner, Monica G. Turner, William H. Romme, and Don G. Despain
A Grid-Based Model for Simulating Fire Patterns in Heterogeneous Landscapes

11:15 am Tinker, Daniel B., William H. Romme, and William W. Hargrove
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11:30 am Rudis, Victor A.
Distribution of Forest Fragmentation Among South Central United States Forested Wetland Habitats

FRIDAY, MARCH 26 1993

8:25	Plenary Session IV (Pollard Auditorium)
8:25 - 8:30	Introduction of plenary speaker - Scott Collins
8:30 - 9:15	Plenary Address - Ingrid Burke Regional analysis of landuse in the central Great Plains.
9:15 - 9:45	Break (Pollard Lobby)
9:45 - 12:00	Concurrent Sessions VII and VIII (Garden Plaza Hotel Salons)
12:00 - 1:15	Lunch (Provided in Pollard Lobby)
1:15	Plenary Session V (Pollard Auditorium)
1:15 - 1:20	Introduction of plenary speaker - Ron Neilson
1:20 - 2:05	Plenary Address - Robert G. Lee Human choice and landscape structure: An interdisciplinary approach by U.S. MAB
2:05 - 2:30	Break (Pollard Lobby)
2:30 - 4:30	Concurrent Sessions IX and X (Garden Plaza Hotel Salons)
4:30	Presentations conclude; R & R and dinner on your own

FRIDAY MORNING, MARCH 26, 1993

Concurrent Session VII: **TROPICAL LANDSCAPES**
Chair: Richard Park
(Garden Plaza Salon C)

9:45 am Brown, Sandra, Louis Iverson, Anantha Prasad, and Juan Polit
A Coordinated Research Program on Carbon Fluxes in the Tropics I: Regional Carbon Pools

10:00 am Flint, Elizabeth P. and John F. Richards
A Coordinated Research Program on Carbon Fluxes in the Tropics II: Changes in Land Use from 1880-1980 in South and Southeast Asia

10:15 am Hall, Charles A.S., Margaret Smith, and Myrna H.P. Hall
A Coordinated Research Program on Carbon Fluxes in the Tropics III: A GIS-Based Model of Agricultural Development and Yield

10:30 am Pontius, Jr., R. Gil and Charles A.S. Hall
A Coordinated Research Program on Carbon Fluxes in the Tropics IV: A Geographically Based Model of Carbon Flux Due to Land Use Change in Tropical Africa

10:45 am Everham, Edwin, Charles A.S. Hall, and Marshall Taylor
A Coordinated Research Program on Carbon Fluxes in the Tropics V: The Development of an Integrated Meteorological, Hydrological and Ecological Model for the Luquillo Forest of Puerto Rico

11:00 am Dale, Virginia, Robert O'Neill, and Frank Southworth
Linking Ecologic and Socioeconomic Causes and Effects of Deforestation in the Amazon

11:15 am Frohn, Robert C. and Virginia Dale
Analysis of Land Clearing Practices on Individual Farmer Settlement Lots in Rondonia, Brazil Using Satellite Remote Sensing

11:30 am Chavez, Marta, Nuri Trigo, Jorge Lopez Paniagua, Raphael Acuna
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11:45 am Guevara, Sergio and Javier Laborde
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FRIDAY MORNING, MARCH 26, 1993

Concurrent Session VIII: **SPATIAL ANALYSIS AND LANDSCAPE CHARACTERIZATION**
Chair, Andrew Liebhold
(Garden Plaza Salons A & B)

9:45 am Fortin, Marie-Josée
How to Compare Vegetation and Environmental Maps

10:00 am Qi, Ye
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10:15 am Cancellation

10:30 am Smith, Christopher and Peter August
A Statistical Characterization of Landscape Edges in Rhode Island

10:45 am Rich, Paul M., Fairley J. Barnes, and Kevin P. Price
Spatial Patterns of Canopy Architecture in Pinyon-Juniper Woodlands: Inferences from Stand Allometry and Remote Sensing

11:00 am Henebry, Geoffrey M.
Images of Grasslands: Understanding Spatio-Temporal Variability

11:15 am Rykiel, Edward J., Jr., William C. Forsythe, W. Michael Childress, and Bai-lian Li
Enormous Increases in Numbers of State Transitions with Neighborhood Size

11:30 am Li, Bai-lian
Wavelet Analysis: What is it, and what does it do?

FRIDAY AFTERNOON, MARCH 26, 1993

Concurrent Session IX: **RURAL AND URBAN LANDSCAPES**
Chair, Nuri Trigo
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2:45 pm Swain, Hilary M. and Vickie S. Larson
Optima for the Rural Landscape

3:00 pm Flamm, Richard O., Monica G. Turner, Robin Gottfried, Robert G. Lee, Robert J. Naiman, Nathan Schumaker, and David Wear
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3:15 pm Ahern, Jack
Topologies for Ecological Networks in Rural Areas

3:30 pm Strebel, Donald E., Jingyee Kou, and Paul F. Kazyak
Relationship Between Landuse Patterns Determined by Remote Sensing and Watershed Biotic Indices

3:45 pm Wang, Rusong and Ouyang Zhiyun
An Integration of Space, Time, Quantity and Order into an Urban Eco-Complex Study

4:00 pm Welch, Joan M.
Discriminant Analysis: A Tool to Predict Public Urban Forest Structure

FRIDAY AFTERNOON, MARCH 26, 1993

Concurrent Session X: REGIONAL ANALYSIS AND SCALING
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2:30 pm — Logsdon, Miles G. and E.J. Bell
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2:45 pm — Graham, Robin L. and Mark Downing
Renewable Biomass Energy: Understanding Regional Scale Environmental Impacts

3:00 pm — Clarke, Sharon, Sandra Thiele, Bruce McIntosh, and Jim Sedell
Multi-Scale Regional Analysis of Stream Physical Habitat

3:15 pm — Ribic, Christine A., Lisa Ganio, and Richard Warner
A Preliminary Ecological Assessment Model for Agriculture

3:30 pm — Lynam, Timothy
Predicting Changes in Structure and Outputs of an Agricultural Landscape: A Multiscale Approach

3:45 pm — Pearson, Scott M.
Natural Populations and Habitat Heterogeneity at Multiple Scales

4:00 pm — Johnson, Sherri L. and Alan P. Covich
Spatial and Temporal Patterns of Litter-Input Dynamics in a Prairie Riparian Zone

4:15 pm — Pyle, Charlotte and Jerry F. Franklin
Development of a Research Agenda to Study the Function of the Landscape Matrix in Forested Landscapes

SATURDAY, MARCH 27, 1993

8:00 - 7:00 Field Trip: Landscape Dynamics of East Tennessee

8:00 - 6:00 Field Trip: Great Smoky Mountains National Park

Buses will depart from the front of the Garden Plaza Hotel. Box lunches will be provided.

Walker Branch Watershed Field Trip
Thursday, March 25, 1993
1:30 to 5:30 or later if desired
Leaders: Michael Huston, Paul Hanson, and Pat Mulholland

Walker Branch Watershed has been the site of intensive ecosystem research and monitoring for the past 25 years with funding from the US Department of Energy. The 100 ha site differs from other major watershed research areas in its small size, agricultural land use history, and urban/industrial setting. The forest is still undergoing succession from a variety of subsistence agricultural uses that were abandoned in 1942 when the area was taken over for the Manhattan Project.

The site is only 5 or 6 miles from the city of Oak Ridge, and about 2 miles from Oak Ridge National Laboratory. The tour will start with an overview of the regional geology, local geomorphology, hydrologic dynamics, soils and vegetation using the Walker Branch GIS. We will then visit the weirs where streamflow is continuously monitored and discuss issues of stream hydrology and geochemistry. From the weirs we will hike up the watershed past a variety of forest types and historical land uses. Along the way we will see typical features of karst terrain such as disappearing streams, erosional and depositional features from intensive subsistence agriculture, and the remains of the Walker family's homestead.

At the top of the watershed we will visit the site of the Throughfall Displacement Experiment, a large-scale ecosystem experiment on the response of a deciduous forest ecosystem to altered precipitation input. The site consists of three plots: a dry plot where 30% of incoming precipitation will be intercepted before it hits the forest floor and channelled into pipes that transfer it across the control plot to distribute it on the wet treatment plot. Each of the treatment plots is 80 x 80 m, laid out along a hillslope from ridgetop to valley. We will look at the experimental infrastructure and discuss the various monitoring and experimental methods being used in the experiment.

You should wear clothes and shoes appropriate for hiking off trails. In the event of rain, we will skip the hike and drive to several of the sites that would be seen along the hike. For background information about Walker Branch, see "Analysis of Biogeochemical Cycling Processes in Walker Branch Watershed," edited by D.W. Johnson and R.I. Van Hook, Springer-Verlag, 1989.

Cumberland Plateau Field Trip
Thursday, March 25, 1993
1:30 to 5:00 pm
Leader: Robin L. Graham

We will be driving northeast to the vicinity of Frozen Head State Park. This is a lovely park and at the end of March, the redbuds should be in bloom and some of the wildflowers out. We will visit the park to see what a comparatively undisturbed part of the Cumberlands looks like. We will also visit recent and old strip mine areas nearby the park to better understand the impact of mining activities on the terrestrial and aquatic systems in this region and to contrast old and new rehabilitation efforts. The history of land use and ownership in the Cumberlands and the current socioeconomic problems facing this region will be discussed while driving (and witnessed while looking out the window).

Because of time limitations and limited road access, (the Cumberlands are a "you can't get there from here" sort of a place) the trip will not include much hiking but will be composed of a series of short stops. Bring along an umbrella as we'll get out of the bus even if its raining; but let's hope for a clear day so we can better see the landscape. Do wear shoes and clothing appropriate for walking in the field or scrambling up short muddy slopes. Tennessee clay is red and doesn't come out of clothing easily! Also, the roads in the Cumberlands can be very twisty so if you are inclined to motion sickness, you may experience difficulties.

If you would like a little advance reading on the history of land use in the Cumberlands, you might try "Night Comes to the Cumberlands" by Harry M. Caudill. Your local library is likely to have it. The book was published in the early 1960s and is a "biography of the region" written by a Kentucky lawyer whose family settled the Cumberlands in the 1700s. He has a later book (1976) that deals with the response of the Cumberlands to the War on Poverty in the sixties.

Landscapes of East Tennessee Field Trip

March 27, 1993
8:00 to 7:00 pm
Leaders: Hazel R. Delcourt and Paul A. Delcourt

Hazel R. Delcourt and Paul A. Delcourt
Center for Quaternary Studies, University of Tennessee, Knoxville

This field trip will traverse two physiographic provinces and 20,000 years. At the Sugarlands Visitors Center in the Great Smoky Mountains National Park, we will begin our discussion of the processes that have shaped the development of natural landscape patterns and their transformation into cultural ones. A scenic vista of Mt. LeConte will offer the setting for a description of periglacial environments at high elevations in the southern Appalachian Mountains during the last full-glacial interval. We will proceed to Cades Cove, where we will visit "Lake in the Woods" and discuss the evidence for a warm, wet climatic interval 6000 years ago that may be an analog for future conditions resulting from carbon dioxide-induced global climatic change. Emerging from the Blue Ridge Mountains, we will pause atop an overlook and consider the reasons for the great biological diversity of the Great Smoky Mountains. Then we will compare the landscapes of the Blue Ridge with the Valley and Ridge Province to the north and west. After following the course of the Little Tennessee River, we will stop at Ft. Loudoun and look at the paleoecological and ethnobotanical records of 10,000 years of progressive human impact on the landscapes of this portion of East Tennessee.

The weather is changeable at the end of March. We encourage field trip participants to wear warm, waterproof parkas and field boots or sturdy walking shoes (no high heels or flip-flops, please!). Because of the long travel time from Oak Ridge to the Great Smoky Mountains, be prepared for a full day excursion. Rest Rooms (and souvenirs) will be available at Sugarlands Visitors Center, Cades Cove, and Ft. Loudoun. We will provide a field trip guide and several reprints of relevant research. Binoculars and cameras will be useful for viewing magnificent vistas if the weather is clear.

Great Smokey Mountains National Park Field Trip
Saturday, March 27, 1993
8:30 to 6:00 pm
Leaders: Virginia H. Dale, and Peter White

Logistics:

Departure time: 8:00 AM, Garden Plaza
Return time: 6:00 PM, Garden Plaza
A box lunch and drink will be provided.
Transportation will be by bus. No stops are planned for the 1.25 hour ride between Oak Ridge and the Park.

Be sure to bring:

Hiking boots
rain gear
day pack
Warm coat
Hat and gloves

Optional:

Water bottle or cup (water will be available from a community bottle)
Camera
Binoculars

Trail:

The Ramsey Cascade trail was selected because it traverses a variety of forest types with relatively little elevation gain (1,660 ft.). The trail is considered both short enough for a beginner and rewarding for an experienced hiker. The trail begins from 2,640 ft on gravel Ramsey Prong Road. The trail follows the road and then veers to the left to follow the north bank of Ramsey Prong. Just after it crosses the first foot log at 2.2 miles, there is a large silverbell tree (Halesia carolina), 2.5 ft. in diameter, growing on the left. On the right is the largest sweet birch (Betula lenta) on record, 3.5 ft. in diameter. A little farther on is a grove of tulip poplars (Liriodendron tulipifera) with diameters of 4 to 5 ft. Nearby is a specimen of the rare yellow cucumber tree (Magnolia acuminata), which exhibits its large flowers in May. After the trail crosses the second foot log at 3.6 mile, several large black cherry trees (Prunus serotina), 3 ft. in diameter, can be seen; their fruit falls to the ground in September.

The trail ends at 4 miles at a third foot log at the bottom of 60-foot Ramsey Cascade. This is a large, beautiful falls located in a rich forested glen. By carefully scrambling around the large sandstone boulders at the base of the falls, you may find a suitable lunch spot and photogenic view of the cascade. It is extremely dangerous to climb around or above the cascade itself because the soil and rocks are very slippery. We will return to the trailhead via the same trail.

Weather:

Typical March temperatures average 47.8°F and range from 34.2 to 61.2. However, the March extremes over the past 35 years have been -3 and 85. Therefore we need to be prepared for all types of weather. In the event of an all-day down-pour, our plans to be modified.

LIST OF ABSTRACTS

Andison, David, University of British Columbia, Faculty of Forestry, 2357 Main Mall, MacMillan Bldg., Room 270, Vancouver, BC Canada V6T 1L5. **Measurement and representation of small-scale landscape heterogeneity.**

Landscape ecology faces directly the concern of changing information scales. Considered as non-linear systems, there is growing concern that not including sufficient detail in landscape descriptions will lead to distorted results, because the quality and quantitiy of detailed variability is important. As a result, the emphasis towards detailed data collection, complex aggregation methods, and more efficient data handling is increasing. However, these efforts are hampered by inadequate and inconsistent means of quantifying environmental variables describing heterogeneity, as well as limited understanding of which variables are most important. There are also physical limits as to the amount and extent of information able to be processed mechanically by computers, and intellectually by us. A rational, reasonable balance is sought. This research represents an investigation of methods of simplifying and aggregating ecological variables such that the information lost during aggregation is minimized, and/or limited to information of least consequence. This study is a preliminary step towards a pilot landscape modelling exercise as part of my PhD thesis requirements. (Poster)

Ahern, Jack, Department of Landscape Architecture and Regional Planning, University of Massachusetts, Amherst, MA 01003. **Topologies for ecological networks in rural areas.**

Ecological infrastructure, Greenways, and Ecological Networks are terms used to describe intentionally planned, designed and managed networks of protected lands in intensively used rural landscapes to provide for ecological, aesthetic, cultural and recreational benefits. The discipline of landscape ecology provides emerging principles for describing the structure and function of these networks as interconnected patches and corridors within a base landscape matrix (Forman and Godron, 1986; Harris, 1984, Turner, 1989). There are several premises which structure this proposal. First is that globally, decentralized growth from urban centers and agricultural development will continue to cause fragmentation of rural landscapes with a resulting degradation of ecological functions. The second premise is that structural topologies of open space networks can be described including: network, scattered patch, interdigitated, and checkerboard configurations (Cook, 1991; Forman, 1988). The physical structure of open space networks based on these topologies responds primarily to large scale physiographic features, as well as to land use patterns and property ownership and land use control configurations (Ahern, 1991; Kerkstra and Vrijlandt, 1990). The functions of each of the network topologies vary as a function of many factors including: the configuration of the topology itself, the disturbance regime, and the compatibility of the matrix in which it is located (Kerkstra and Vrijlandt, 1990). The final premise is that open space networks are the appropriate basis for comprehensive, sustainable landscape planning. (Oral, X, 3:15 Friday)

Anjaneyulu, M and Nagulu, V., Osmania University, Hyderabad-500 007, India. **Wetland lake landscapes: natural change and human activity impact at Kolleru**

Kolleru, the largest fresh water lake in India (901 sq. km) is believed to be of recent origin as a lagoon on the Coromandel Coast. Subsequently, excessive siltation from flood waters of flanking rivers Krishua and Godavari have separated it completely from the Sea, However, a connection is retained through a tortuous creek. Byuan San? sailed in, and recorded in his memoirs, vignettes of local culture, custom and history. The major landscape features is a wide unending stretch of water with typical floating vegetation and occasional islands, some populated and others uninhabited. Transport is by typical canoes dug out from palmyrah trunks. The most spectacular feature of the landscape arises seasonally when huge numbers and varieties of migratory birds find their winter home. The natural influence on landscape change is limited compared to changes as a result of human activity. Firstly, the shrinkage of the lake during summer is natural but is aggravated by reduced inflows because of engineering activity in the watershed area for flood mitigation. The exit capacity to the sea has also been enlarged which increases the potential for saline intrusion in case of global sea level rises. Wrong exercise of land-use options has shifted emphasis to lake bed agriculture and pisciculture in artificial ponds to the detriment of capture fisheries. Apart from these, other new elements in the landscape are lakeside industrialization with attendant pollution. Hinterland population pressures and new opportunities along the lake has caused demographic, ecologic and socio-economic changes often not in consonance with the original ethos. Drifting labor, lacking vested interests, indulge in habitat destruction despoiling natural heritage. Floral succession and faunal succession have been vastly altered under human activities. Long term human modification has altered the lake as an entity and the lake's ecological integrity also affecting economic, cultural, recreational and scientific value. Contemporary social scene shows local people being engaged in cottage industry utilizing wood and reed for ornamental art and as thatch to village human habitations. Duck rearing is another cottage industry. Landscape pristinity can still be preserved if change dynamics are contained and jarring elements are curbed, encouraging eco-tourism-sustained development through voluntary action. (Poster)

Bartha, Sandor, Institute of Ecology and Botany of the Hungarian Academy of Sciences, H-2163 Vacratot, Hungary. **Information statistics for detecting multi-species patterns in vegetation dynamics.**

A new methodology based on information statistics (Juhasz-Nagy 1984) is proposed for describing the developing vegetation as diffuse mosaic of interacting patches that change over time in size, shape and distinctiveness. Rather than detecting single species patterns or the common factors derived from single species patterns, these methods reflect the spatial pattern of all realized species combinations. Floral diversity refers to the diversity of species combinations, while associatum is a measure of the total spatial dependence of populations. The calculations are based on series of binary samples collected at different sampling unit sizes. Floral diversity is the joint entropy of an s-dimensional binary contingency table, where s is the number of species considered. Associatum is the corresponding contingency information. Multi-species pattern development was studied in the early stages of primary succession on refuse soil dumps of a strip coal-mine in Hungary. Micromaps of species distributions were made in four vegetation stands of age 1, 2, 7 and 19 years. Square lattice were used for sampling. The plot sizes were 15x22 m and the size of the units was 20x20 cm. Presence/absence data of species were recorded in each unit.

Despite the abrupt year-to-year changes of species performance and dominance hierarchy, considerable increase of spatial dependence was detected over time. We have found scale dependent trends. At small sampling unit sizes, heterogeneity increased during succession while it decreased at large sampling unit sizes within the same period. Dominant species built up temporal structures that were disordered during the transformations of dominance hierarchy. The spatial pattern of permanently subordinated species appeared to be more conservative over time. Rare species expressed chaotic behavior at the scales of this study. (Poster)

Binnian, Emily F.[1] and Mark B. Shasby[2], [1]Hughes/STX Corporation, USGS EROS Alaska Field Office, Anchorage, AK 99508 and [2]USGS EROS Alaska Field Office, Anchorage, AK. **Spatial patterns in Alaska's landscape derived from multi-temporal AVHRR NDVI greenness data.**

The U.S. Geological Survey (USGS) Global Change Research Program places high priority on developing of land surface characteristics data to help understand the dynamics of change in ecosystem structure. Therefore, the USGS EROS Alaska Field Office initiated the Arctic Land Processes program, a long-term monitoring activity that focuses on the collecting and integrating of multi-temporal spatial information about the Arctic, SubArctic, and Boreal ecosystems. Twice-monthly advanced very high resolution radiometer (AVHRR) time series composites, including normalized difference vegetation index (NDVI) transformations, have been developed for the 1990-92 vegetation growing seasons. Geographic information system spatial modeling tools are being used to analyze the AVHRR time series data to determine the phenological characteristics of Alaska's vegetation. Distinct patterns were examined in the onset, peak, and duration of Alaska's vegetation greenness and in the relative maximum and net primary productivity across the state's landscape. In addition, the AVHRR data and ancillary data about topography, physiography, soil, geology, permafrost, hydrologic networks, and climate are being integrated to provide a broad scale characterization of Alaska's land. (Poster)

Brown, Sandra[1], Louis Iverson[2], Anantha Prasad[1,2], and Juan Polit[1], [1]Department of Forestry, University of Illinois, W-503 Turner Hall, 1102 S. Goodwin, Urbana, IL 61801 and [2]Illinois Natural History Survey, 607 E. Peabody Dr., Champaign, IL 61820. **A coordinated research program on carbon fluxes in the tropics I: Regional carbon pools.**

Spatial estimates of carbon pools in biomass and soils of forests of tropical Asia (continental and insular) and tropical South America were produced by the use of raster (maps of soil, vegetation, ecological zones), vector (maps of political boundaries, subnational units), point (climate station data, population data), and tabular (soil carbon values, biomass estimates from inventories, etc.) data bases, all converted into digital map layers, and modeling techniques using a GIS. Total potential aboveground biomass of forests (determined from data layers of climate, soils, elevation, slope) in the two regions was similar to each other (about 300-350 Pg), but average biomass density of the forest in Asia was about a third higher than that for tropical American forests (440 vs. 325 Mg/ha). Total biomass of forests on present forest lands was considerably lower than the potential amount due to deforestation and biomass degradation, although the impact was greater on Asian forests than American ones. Carbon pools (to 40 cm) in the soils of these two regions were approximately double that in the forest vegetation. The

distribution of forest biomass and soil carbon pools varies by vegetation classes and ecological zones within a region. (Oral, VII, 9:45 Friday)

Burley, Jon Bryan[1], and Cheryl J. Burley[2], [1]Michigan State University, East Lansing, MI 48824, and [2]Consortium for International Earth Science Information Network, Saginaw MI 48710. **Front range landscape hazards for building sites: risk assessment.**

Risk assessment techniques are being applied within a landscape ecological context for landscape planning and design, as urban development expands into mountainous building environments. The investigation examines the susceptibility of building sites in the Front Range of Colorado/Wyoming to catastrophic disturbance. Four landscape hazards are investigated in the study: flooding, rock fall, fire and avalanche. A hazard rating model is applied to a portion of the Front Range, the Pingree Park vicinity. The investigation revealed that approximately 50% of the landscape contains a high risk rating and the remaining portion contains a moderate risk rating. This means that there is no long-term, safe building site in the area. Providing that the Pingree Park vicinity is a representative sample of the Front Range, the results of the study indicate that the long-term prospects for structures in the mountainous region of Colorado are not particularly promising. The long-term development of extensive urban structures in mountainous regions may not be warranted. (Poster)

Burke, Ingrid. Forest Sciences Department, Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO. **Regional analysis of landuse in the central Great Plains.**

Spatial patterns in ecological phenomena have long provided interesting fodder for generating hypotheses about mechanisms and controls over ecological processes. Observations of patterns at landscape and geographic scales have been important in focusing process-level research at local scales and over short time intervals. There is currently a strong need to develop linkages between human socio-economic processes and ecological processes, particularly as they relate to global scale changes. These linkages are extremely complex, as well as involving cross-disciplinary interactions. I suggest that landuse is an appropriate focal point for such work, and that analysis of spatial patterns of landuse as they relate to both ecological constraints and socio-economic constraints is an important first step for focusing such research. In this paper, I present results of a regional analysis of landuse in the Central Great Plains of the U.S. Data and simulation results suggest that many of the important consequences of global change will be linked directly to decisions about landuse at the regional scale. Historical and current landuse management practices play a significant role in determining regional carbon storage and interactions with the atmosphere. Environmental constraints determine the biological potential for cropping in the grasslands region, however, adequate prediction of landuse in the present and the future will require integration of information from ecological and socio-economic systems. (Plenary, 8:30 Friday)

Burnett, Michael, Peter August, James Brown, and Keith Killingbeck, University of Rhode Island, Kingston, RI 02881. **Using geomorphological variation to predict local biodiversity.**

A fundamental goal of many conservation activities is protection of lands that support high diversity ecological communities. In many circumstances, rapid assessment of the potential biodiversity of an area is required and the luxury of an expensive and sometimes arduous field survey is not possible. The purpose of our research was to determine if variation in the geomorphology of a region can be used to predict biological diversity. Using a geographic information system (GIS), we derived an index to reflect spatial variation in soil solum, soil texture, soil drainage capacity, slope, and aspect for each of 234 2-hectare grids in the research forest at the W. Alton Jones campus of the University of Rhode Island. The study area is a mosaic of upland hardwood forest and riparian wetlands. All grids share a common climatic regime and history of disturbance. The whole region was cleared for farming in the 1700's. In the mid-1800's, agricultural activities ceased and the fields were allowed to revert back to a forested condition. The area has not been disturbed by human activity for at least 70 years. The most recent major natural disturbances have been a hurricane in 1938, a major wildfire in 1942, and defoliation by gypsy moths (Lymontria dispar) in the early 1980's. We used line intercept and point-quarter methods to quantify the diversity of woody vegetation in the 20 grids with the highest geomorphological variation and the 20 grid areas with the least variation in landscape diversity. Preliminary observations show a positive correlation between geomorphological variation and the diversity of woody vegetation. Final results are pending further statistical analysis of the field data. (Oral, III, 4:15 Wednesday)

Chavez, Marta, Nuri Trigo, Raphael Acuna, and Jorge Lopez Paniagua, Universidad Autonoma Metropolitana, Mexico, D.F. **The application of GIS to the management of protected areas.**

The establishment of protected areas is an activity in which our country is a pioneer; however, we can not say the same about their planning, since the latter is a recent activity. For this reason, since 1986, the Area de Ecologia y Planeacion de los Recursos Naturales Renovables proposed, among it's research objectives, to develop planning and management strategies for natural protected areas. In March, 1992 the research team was requested by the Secretaria de Desarrollo Urbano y Ecologia to develop the Management Plan for the National Park Ixta-Popo, with funds from the World bank. For this purpose, the aim of the work was to design the organizational and operational mechanisms for the management of the Park for the next two years. This project meant, for the planning team, the possibility to use Geographical Information System technology. The structure of the proposal had to follow the reference terms from the Government Ministry which included, first of all, a Diagnosis. The Diagnosis was elaborated on the following elements of the Park and its influence area: geology and geomorphology; soils; hydrology; vegetation; climate; wildlife; socioeconomic aspects; and cultural resources. As a complement of the Diagnosis, a geographical data base was obtained by digitizing the maps of most of the above mentioned themes. From this information we processed most of the physical an biological aspects with the ILWIS GIS from ITC in The Netherlands. This allowed us to generate a by-product (the Land Unit Map), which was indispensable for decision making on the stratification and land classification of the Park and its influence area. (Oral, VII, 11:30 Friday)

Chen, Jiquan, and Jerry Franklin, University of Washington, Seattle, WA 98195. **Spatial characteristics of a spruce-fir forest.**

Recently, there has been a great deal of interest in studying the spatial pattern of landscapes, particularly the spatial distributions of ecological variables at relatively large scales. Although the principles and methods of landscape ecology can be applied at finer scales, little has been done at the levels between studying the spatial pattern of individual trees and landscape patches. By applying landscape ecology principles and using geographic information systems (GIS, ARC/INFO), the spatial characteristics of a 2 ha old-growth spruce-fir forest in the Changbai Mountain Biosphere Reserve, northeast China, were investigated. The spatial patterns of canopy gaps, snags, individual species as separated by their size (DBH) class, and canopy projections were analyzed graphically and statistically. Basic landscape indices such as patch shape, patchiness, and continuity were computed to describe these spatial patterns. No variable was found to be distributed randomly across the stand. Extreme aggregations were found for birch (*Betula ermanii*), dominant spruce (*Picea jezoensis*), and canopy gaps. There exists clear relationships between spatial patterns of some variables. Canopies of birch and smaller spruce trees rarely overlap with the canopy of dominant trees (spruce and larch [*Larix olgensis*]), while canopies of smaller fir (*Abies nephrolepis*) and other understory trees (i.e., maples [*Acer* spp.] and mountain-ashes [*Sorbus* spp.]) grew under all canopies. Canopy gaps were found to be rather irregular, non-linear (compared with circles), and highly aggregated. An overall conclusion drawn from this study is that many landscape ecology principles and GIS are useful for exploring ecosystem characteristics and their spatial patterns at this smaller scale. Future efforts will be devoted to examining and comparing the results of this study with other coniferous forest ecosystems. (Poster)

Childress, W. Michael[1], Charles M. Crisafulli[2], and Edward J. Rykiel, Jr.[1], [1]Center for Biosystems Modelling, Texas A&M University, College Station, TX, and [2]Mt. St. Helens National Volcanic Monument, U.S. Forest Service, Amboy, WA. **Disturbance and succession at the landscape level: Some lessons from Mt. St. Helens.**

The eruption of Mt. St. Helens in 1980 created a homogeneous blast zone of 27 square kilometers called the Pumice Plain. Our observations at Mt. St. Helens suggest some generalizations about disturbance and succession at the landscape scale. First, landscape-level disturbances may actually be fairly common in this region and can entail a series of events over an extended period, as well as a single large event. Second, erosion from rainfall and snow melt is rapidly changing the physical environment of the Pumice Plain. Heterogeneity of the physical environment largely determines the amount and arrangement in space of the heterogeneity of biological communities. On the Pumice Plain, many initial communities have been washed away or isolated by waterways cutting through the volcanic rubble. Third, dispersal patterns of plants and animals invading the blast zone are strongly affected by large distances, continuing changes in the physical environment, and by isolation of initial communities. The chance establishment of plant species in different parts of the Plain has resulted in a quilt-pattern of initial communities, including one isolated area in which the only colonizing species to date are the four dominant conifers of the region. The successional sequence in each area should be strongly influenced by the sequence of species arriving, so community development should vary considerably across the blast zone. Apparently, the mosaic of communities observed in typical landscapes develops early in landscape-level succession, even after severe disturbance which leaves a relatively homogeneous

physical environment. If the regional climax Douglas fir/hemlock forest is to eventually develop across the Pumice Plain, the considerable obstacles of continued erosive disturbance, large distances, and spatial heterogeneity of the physical environment and initial communities must be overcome. (Oral, IV, 4:00 Wednesday)

Clarke, Sharon[1], Sandra Thiele[2], Bruce McIntosh[1], and Jim Sedell[3]. [1]Oregon State University, Corvallis, OR 97331, [2]ManTech Environmental Technologies, Corvallis, OR 97333 and [3]PNW Research Station, USDA Forest Service, Corvallis, OR 97331. **Multi-scale regional analysis of stream physical habitat.**

Ecosystem processes and environmental stressors operate at many spatial scales. To improve understanding of natural systems and to develop better management strategies requires an appreciation of inter-scale relationships. A historical database and subsequent resurveys of physical stream habitat throughout the Columbia River Basin are used to assess both temporal and spatial change in habitat. Spatial and temporal change is analyzed at several scales to help understand the processes and stressors which influence stream habitat. The use of ecological regions as an organizational framework facilitated the analysis. The underlying assumption for ecoregions is that potential stream character is influenced at all spatial scales by a combination of climate, topography, geology, soil, and potential natural vegetation. Three scales of ecoregions were used for this project: national (1:7,500,000), state (1:250,000), and basin-level ecoregions (1:100,000). Basin-scale ecoregions were developed to bridge the gap between state-scale ecoregions and reach-level classifications (i.e. constrained vs. unconstrained). The hierarchical nature of these classifications allows site-specific physical stream habitat data to be viewed within the context of a reach type and a basin-level ecoregion. One hypothesis which might be posed in this framework is that the spatial pattern of large pools can be related to ecosystem processes and environmental stressors operating at different spatial scales. (Oral, IX, 3:00 Friday)

Clarke, Sharon[1], Sandra Thiele[2], Bruce McIntosh[1], and Jim Sedell[3], [1]Oregon State University, Corvallis, OR 97331, [2]ManTech Environmental Technologies, Corvallis, OR 97333, and [3]PNW Research Station, USDA Forest Service, Corvallis, OR 97331. **Multi-scale regional analysis of stream physical habitat.**

The US Fish and Wildlife Service surveyed the Grande Ronde River Basin above LaGrande, Oregon in 1941. This survey was part of an intensive inventory of stream habitat conditions for anadromous salmonids throughout the Columbia River Basin. A 1990 resurvey determined how stream habitat conditions had changed. During the resurvey, stream pool and substrate characteristics were recorded with methods and criteria similar to those used in 1941. Pools were classified by size and depth criteria, while substrate was divided into size classes. Over the fifty year period, losses in large pools (>1 meter in depth and >20 m^2 area) ranged from 50-90% throughout the basin. Spatial and temporal changes in pools and substrate were analyzed at several scales to help understand the processes and stressors which influence stream habitat. The use of ecological regions as an organizational framework facilitated the analysis. Three scales of ecoregions were used: national (1:7,500,000), state (1:250,000), and basin-level ecoregions (1:100,000). Basin-scale ecoregions were developed for this project to bridge the gap between state-scale ecoregions and reach-level classifications (i.e. constrained vs. unconstrained). A

regional framework provides a defensible area in which site-specific results may be extrapolated and applied to broad scale resource planning and management. (Poster)

Cornell, Joseph D., State University of N.Y. College of Environmental Science and Forestry, Syracuse, NY 13210. **Spatial scaling and modeling global change: Examples from Central America.**

In order to balance the global carbon budget--an important part of global change research--general circulation models (GCM's) of the atmosphere will increasingly require information about the distribution of carbon exchange due to landuse change in both time and space. Highly detailed spatial information on landuse change can be obtained through primary sources (satellite imagery), secondary sources (ie. maps) and modeling. Unlike the oceans or the atmosphere however, landuse change must be modeled on a much finer scale than that of the current GCM's because of greater heterogeneity in terrestrial systems. GCM's model the Earth using compartments that are between 2 and 5 degrees of lat/long on a side. Landuse change however, can occur at scales that are three orders of magnitude finer (approximately 1 to 5 hectares). Landuse change models therefore, must be detailed enough to accurately reflect changes in biomass and carbon content at regional scales, but must also be capable of aggregating that information for use in models at other scales. Using four countries from Central America as our example we (1) simulate the release of carbon due to landuse change from 1965 to 1988, and (2) demonstrate how this information is integrated into larger models of the global carbon flux. (Poster)

Cosko, Lizette[1], Penelope Morgan[1], and R. Gerald Wright[1], and Carolyn Hunsaker[2]. [1]University of Idaho, Moscow, ID 83843 and [2]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831. **The sensitivity of spatial pattern measures to landscape shape and extent.**

Spatial pattern analysis is an integral part of studying ecological processes. A variety of measures have been developed to quantify different aspects of spatial pattern. Measures of landscape pattern were individually analyzed to determine their degree of sensitivity to extent and geometric shape of landscape boundary. The measures were examined across three different landscape shapes. In addition, we looked at the metric behavior as the landscape extent varied in size from 40 km^2 to 640 km^2. The measures we chose were those that quantified size, shape, boundaries, and distribution of patches. Those measures included dominance, diversity, shape complexity, and number of edge types. The landscapes were based on an actual vegetation data map which came from the GAP analysis database for the state of Idaho. The Idaho vegetation map contains 33 vegetation classes and is mapped at a 1:500,000 map scale ratio. (Poster)

Crisafulli, Charles M., Mount St. Helens National Volcanic Monument, Amboy, WA. **Patterns of avian recolonization following large scale natural disturbance: An example from the 1980 eruptions of Mount St. Helens, WA.**

The 1980 eruptions dramatically altered 500 km^2 of forest, meadow and riparian vegetation and created a complex disturbance gradient. Post-eruption landscape heterogeneity was caused by several factors including: nature of volcanic disturbance, distance from the crater, topography, pre-eruption plant community and site conditions at the time of the eruption. Four structurally distinct disturbance zones have been recognized: pyroclastic flow (total burial and pyrolization), blowdown (leveled trees), scorch (standing dead trees) and ashfall (intact forest receiving up to 30 cm of cool ash). Bird communities were surveyed at sites representative of each disturbance zone in unmanaged (natural recovery) areas and in managed (timber salvaged and reforested) portions of the blowdown and scorch zones. Forty-six bird species were observed at 8 unmanaged sites over an 11 year period since the eruption. Species richness values were inversely related to disturbance intensity; pyroclastic flow = 3 species, blowdown zone = 15 species and ashfall zone = 32 species. The number of foraging guilds increased from pyroclastic flow = 1 to ashfall = 7. The pattern of avian reassembly in the unmanaged landscape was closely tied to the structure and dispersion of surviving and colonizing vegetation and other habitat attributes, such as snags and downed logs. Thirty bird species were observed at 7 managed sites during the 1992 breeding season. Managed sites had greater species richness values, and more complex guild structure than their unmanaged counterparts. Management activities fostered a rapid reassembly of bird communities by accelerating the rate of vegetation development. Observations of avian community reassembly on managed and unmanaged landscapes at Mount St. Helens provides insight into understanding how forest practices influence the distribution of bird species and communities in the Pacific Northwest. (Poster)

Cumming, S. G. and P. J. Burton, Dept. of Forest Sciences, University of British Columbia, 270-2357 Main Mall, Vancouver, B.C., Canada, V6T 1Z4. **Stand distribution patterns in the boreal mixed wood forests of northeastern Alberta, Canada.**

The majority of the forested area of Alberta, Canada, belongs to the "boreal mixed wood" ecoregion, which follows the southern boundary of the true boreal forest across much of Canada. It differs in composition from the more northerly forests, containing substantial areas dominated by *Populus tremuloides* (aspen) and other deciduous species. Most deciduous stands are of fire origin. This poster describes a preliminary exploration of available spatial inventory data. The goals of this effort are to identify structural properties of the region, to detect the existence of climatic gradients, to test some of the standard accounts of the region's ecology, and to determine if the region has a characteristic spatial scale at which it may be said to be in equilibrium.

Forest inventory for Alberta exists as stand maps derived from photo-interpretation. Machine readable summaries were obtained for a contiguous study area of roughly 800,000 km^2 in north eastern Alberta, containing more than 300,000 distinct stands. The area has a north-south extent of 300 km, from the southern boundary of the ecoregion, on the borders of the aspen parkland, almost to the "boreal northlands" ecoregion. The data consist of a list of stand records defining the area, species composition and approximate age of each stand. Stand records are spatially referenced to a 10 km grid. The study area is non-homogenous in mean stand age and species dominance. Older stands are concentrated in the southern portion of the area, which may be a result of fire suppression efforts. There is a weak inverse relation between mean stand age

and aspen dominance. Plots of stand abundance by dominant species, age and area in 5,000 km^2 sub-regions indicate that stand area is log-normally distributed, with a mean strongly dependent on species. The distribution along the age axis is highly variable across the region. (Poster)

Dale, Virginia, Robert O'Neill and Frank Southworth, Oak Ridge National Laboratory, Oak Ridge, TN 37830. **Linking ecologic and socioeconomic causes and effects of deforestation in the Amazon.**

The socioeconomic and ecological aspects of land use change are interrelated, especially in the Brazilian Amazon where immigrants are rapidly cutting the forest to establish farms. A computer simulation model has been developed that projects land use changes, carbon release, and the time a family can remain on a lot as a function of initial soil and vegetation conditions, market and road infrastructure, and decision variables. The model simulates land use practices and typical land cover conditions for central Rondônia, Brazil. Land-use practices are defined based on interviews with farmers conducted in 1991. Model results suggest that farms utilizing a diversity of crops and nontraditional techniques have both social and environmental improvements compared to the other scenarios. These improvements include: subsistence agriculture is sustainable, less carbon is released, and the land maintains a mix of habitat types. Maps projected by the model show that land management scenarios produce unique patterns of forest fragmentation which can affect species movement and survival as well as the spread of disturbance. The model results illustrate that both social and environmental effects of land management practices need to be considered. (Oral, VII, 11:00 Friday)

Daly, Christopher[1], and Ronald P. Neilson[2], [1]Oregon State University, Corvallis, OR 97333 and [2]USDA Forest Service, Corvallis, OR 97333. **Toward a landscape model for predicting vegetation distribution and water balance.**

Efforts to model the influences of climatic variability on terrestrial ecosystems have concentrated on either very small (individual plot) or very large (continental to global) spatial scales. Little work has been done at the landscape scale because of the need to address the complex interactions between landscape components both above and below ground. A hybrid landscape model is now being developed that links a point-based vegetation model with grid-based algorithms that distribute climatic and hydrologic parameters. The vegetation model is MAPSS (Mapped Atmosphere-Plant-Soil System), a steady-state model that has been applied successfully at continental scales to assess potential changes in vegetation given future climatic scenarios. The climatic distribution model is an expanded version of PRISM (Precipitation-elevation Regressions on Independent Slopes Model), which has been effective in distributing precipitation at regional scales over complex terrain. A water routing scheme, developed at the University of Washington, simulates cell-by-cell subsurface drainage and transport; it is being expanded to include surface runoff processes.

A preliminary version of the hybrid landscape model is introduced and results of applications to test data are presented. It is shown that the model is useful in aiding researchers and land managers in assessing the interactions of climate change with land use prescriptions, hydrology, and vegetation at the landscape scale. (Oral, II, 10:45 Wednesday)

Dewhurst, Stephen M., W.W. Covington, and D.B. Wood, School of Forestry, Northern Arizona University, Flagstaff, AZ, 86001, USA. **Landscape-level habitat management using an integrated decision support approach.**

A cooperative research project was undertaken with the U.S. Forest Service to incorporate existing ecological knowledge and recently released habitat management guidelines into the design of a plan for promoting Northern Goshawk (*Accipiter gentilis atricappilus*) habitat on the North Kaibab Ranger District, Arizona. A decision support system which includes GIS, ecological simulation models, automated goal-seeking models (using linear and goal programming techniques), and spreadsheet models was utilized. Spatial analysis was performed using the GIS to delineate the landscape into goshawk habitat management areas, and to assess the current and future implications of alternative treatment scenarios for landscape conditions through ecological simulation. Goshawk home range components consisted of 12 hectare nest areas, 170 hectare post fledgling-family areas, and 2190 hectare foraging areas for a total of 2370 hectares for each home range.

Plans were developed which seek to more nearly approximate presettlement landscape conditions while complying with the goshawk management guidelines, and these plans were evaluated in terms of their multiresource implications on a landscape level, now and in the future. The advantages of managing towards a future landscape condition, as opposed to managing strictly in terms of current conditions, were apparent. A number of other applications of this approach have been identified, and further research is underway with the Navajo Nation and other cooperators. (Oral, I, 11:15 Wednesday)

Dillworth, Mary E, Department of Geography, Western Michigan University, Kalamazoo, MI 49008. **Variations in landscape structure: Bluff vs. floodplain.**

The Mississippi River has created, and continues to shape, a variety of landscapes throughout the central United States: steep loess bluffs; point bar deposits; oxbow lakes and wetlands; and wide, flat floodplains. Through our use of the landscape, humans have modified and subdivided many of these landscapes, altering the structure of such landscapes. This research examines and compares the structure of two distinct types of landscapes (bluff and floodplain) in the Reelfoot Lake area of northwestern Tennessee. Land cover, patch interspersion, patch size and shape, and cover diversity and dominance are calculated and compared for the floodplain and the bluff. Early results reveal structural differences between the floodplain and the bluff in terms of land cover type, patch interspersion, and patch size. An understanding of the quantitative structural differences among geomorphic units should improve our ability to understand and model landscape processes. (Poster)

Dunning, John[1], Rene Borgella[2], Krista Clements[3] and Gary Meffe[4], [1]Institute of Ecology, University of Georgia, Athens, GA USA 30602, [2]Department of Natural Resources, Cornell University, Ithaca, NY USA 14853, [3]Department of Biology, Baylor University, Waco, TX USA 76798, [4]Savannah River Ecology Laboratory, Drawer E, Aiken, SC USA 29802. **The impact of the landscape on avian colonization of isolated patches of habitat.**

The placement of a habitat patch within its local landscape can strongly affect the ability of organisms to find and colonize that patch. A habitat patch that is relatively isolated from potential sources of dispersers may be less likely to support a population than is a similar patch that is close to such sources. We demonstrate that this landscape effect can be seen even with relatively vagile organisms such as birds, which are not generally considered dispersal-limited. We have studied the distribution of Bachman's Sparrow (*Aimophila aestivalis*) in the managed pine woodlands of the Savannah River Ecology Laboratory in the coastal plain of South Carolina. In 1991 and 1992, we followed the sparrow's ability to colonize two "linear landscapes," which were sets of clearcuts that began near a source of dispersing birds, and extended in one direction through a landscape matrix of unsuitable habitat. Thus the clearcuts differed from one another primarily in their isolation from potential sources. Surveys of singing male sparrows during the breeding season showed that densities of the sparrow decreased with increasing distance from potential sources. The effect of patch isolation within the landscape could provide an explanation for this species' population decline during the last 50 years, and may suggest management strategies for halting the sparrow's decline. (Oral, I, 11:00 Wednesday)

Everham, Edwin[1], Charles A.S. Hall[1], and Marshall Taylor[2], [1]State Univ. of NY, College of Environmental Science and Forestry, Syracuse NY. 13210 and [2]Resource Planning Associates, Inc., Cornell Business and Technology Park, Ithaca NY. 14850. **A coordinated research program on carbon fluxes in the tropics V: The development of an integrated meteorological, hydrological and ecological model for the Luquillo forest of Puerto Rico.**

We have developed a geography-based computer model of the Bisley Experimental Watershed ecosystem that simulates basic forest dynamics as a function of meteorological inputs and hydrologic simulation, as influenced by topography, soils, land use, and cover. The model is parameterized based on steady state levels of, and hurricane impacts on, biomass, necromass and rate processes of the Tabonuco forest, and is stable over decades. Over a 60 yr simulation (without hurricanes) leaf biomass remains approximately constant and woody biomass of those regions not having severe sunlight, moisture, or nutrient limitations increases slowly in agreement with observations. Necromass decreases slowly. Small quantities of C leave the ecosystem in stream water, especially during large rain events. When topographically-sensitive hurricane impacts are included, leaf and woody biomass are converted to necromass. In the model the recovery of the watersheds' hydrology, leaf and woody biomass, and necromass are consistent with field observations. We used this model to simulate the C dynamics of the forest over centuries using empirical values and found that this forest acted to pump C from the atmosphere to the ocean at a rate of about 90 kg ha^{1} yr^{1}. (Oral, VII, 10:45 Friday)

Fahl-King, Christine, Jack Ahern, and Judith Eisman, Department of Landscape Architecture and Regional Planning, University of Massachusetts, Amherst, MA 01003, USA. **Encouraging non-compensatory wildlife habitat improvements, restoration or creation in industrial development projects.**

Industrial development projects have large impacts on the landscape. These impacts are especially significant to wildlife habitat and open space values when projects occur on the suburban-rural fringe through effects on wetlands and riparian ecosystems and causing landscape fragmentation. As more communities encourage industrial developments to help increase employment and the tax base, these impacts are having a greater effect on the environment. The planning challenge is to ensure that proposed development projects are ecologically sustainable as well as economically feasible.
Many environmental impacts that development have on the environment, especially wetlands, are required by law to have mitigation done. There are other non-compensatory opportunities to lessen various environmental impacts in industrial developments. These opportunities not only ensure the integration of natural landscape structure and functions in development, but also provide a common ground for the development and the environmental communities to work together towards sustainable development. This project investigates the various techniques of wildlife habitat improvements, restoration or creation available to developers for incorporation into their projects. A questionnaire was used to asses current knowledge and attitudes about incorporating these techniques into industrial development projects of business leaders, developers and environmental leaders. The techniques, case studies of the use of these techniques and the results of the questionnaire are discussed. The research suggests that there is a substantial potential for ecological improvements in industrial development projects. (Poster)

Fairbanks, Dean, Kenneth McGwire, and John Estes, Remote Sensing Research Unit, Department of Geography, University of California, Santa Barbara, CA 93106-4060. **The relationship of changing vegetation community composition in California to GIS-based environmental and remotely sensed gradients.**

The regional ecological characterization group at UCSB is investigating relationships between environment, remotely sensed data and floristic composition and diversity at regional scales. Using the entire state of California as a test site, this effort uses GIS-based data on climate, soils, and topography to determine whether predictable relationships exist between the species composition and diversity of natural vegetation communities and measurable environmental parameters. The effort described here is based on community delta diversity, as discussed by Whittaker (1977). Delta diversity refers to changes in species composition within a community over environmental gradients. In this study we are looking at mapped vegetation communities as defined by Munz (1959) within the state of California. We use Lum's (1975) species database which references 5,902 plants to 94 floristic subregions within the state. Canonical correspondence analysis, an ordination procedure, is used to relate species gradients directly to environmental variables and to passively relate species gradients to normalized difference vegetation index data from the NOAA-AVHRR satellite. In addition to quantitative analysis, the canonical weights for each community ordination are converted into raster canonical trend surface maps (information surfaces), thereby showing the changing community composition in relation to the environmental variables across the state. Remote sensing and GIS based analysis allows landscape ecology to be studied at a scale which is compatible with global climate

modeling efforts. The above effort will allow more effective modeling and monitoring of the effects of climate change on natural vegetation. (Poster)

Ferris, Joseph S., Institute of Ecology, University of Georgia, Athens, GA 30602. **Landscape analysis of a lowland tropical forest through remote sensed multispectral data.**

Given the heterogeneous nature of the tropical forest canopy as well as its landscape, application of remote sensed data to ecological questions must go beyond simple vegetation indices and the analysis of its reflective properties. The inclusion of the surface's thermal response with the vegetation's reflective characteristics can provide an alternative means of analysis. Combining these biophysical responses allows one to take into account both the structural and functional properties of a forest canopy. This presentation will focus on new techniques to infer terrestrial processes and patterns from measurements of remote sensed forest canopy parameters. These techniques are useful in delineating various successional stages across a closed canopy landscape, defining the edges and boundaries of these areas, and locating moderate to large canopy gaps. Implications for landscape management and conservation efforts will be discussed. This approach is applied to a lowland tropical forest and elevational gradient in northeastern Costa Rica. (Poster)

Flamm, Richard O.[1], Monica G. Turner[1], Robin Gottfried[2], Robert G. Lee[3], Robert J. Naiman[3], Nathan Schumaker[3], and David Wear[4], [1]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831-6038, [2]Department of Economics, University of the South, Sewanee, TN, 37375, [3]College of Forest Resources, University of Washington, Seattle, WA 98195, and [4]Center for Forest Economic Research, US Forest Service, Research Triangle, NC. **Simulating landscape change in the Southern Appalachians using spatially-explicit socioeconometric data.**

Ecological dynamics in human-influenced landscapes are strongly affected by the socioeconomic factors that influence land-use decisions, but the interactions among these factors are not well known. A model is being developed that considers these socioeconomic factors influencing land use for simulating landscape change in the Little Tennessee River Basin in western North Carolina. This model is spatially explicit, and as such, estimates not only the amount of change that occurs in the landscape and also the spatial expression of this change. We hypothesized that through the introduction of spatially-explicit socioeconomic information, this model can represent the spatial expression of change in this landscape. Information presently being considered in a socioeconometric context include distance-to-the-nearest-paved-road (access costs), distance-to- Franklin (transport costs to cultural center), slope and elevation (landform indicators of land use potential), ownership (land holder characteristics) and land cover. Simulations of landscape change were run using spatially-explicit socioeconometric and land-cover data to evaluate this hypothesis. (Oral, X, 3:00 Friday)

Flather, Curtis H., Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO 80526. **Patterns of avian species-accumulation rates among eastern forested landscapes.**

Regional land use inventories from the U.S. Soil Conservation Service and the U.S. Geological Survey provided the empirical basis for describing land type composition and configuration within forested landscapes over the eastern United States. U.S. Fish and Wildlife Service avian surveys were used to characterize avifaunal assemblages within each landscape. Mean rates of avian species accumulation, which reflect the relative abundances among species and their spatial distribution, were generated under a bootstrap resampling plan and compared to land use descriptors in order to test the general hypothesis that accumulation rates were independent of landscape structure. Species accumulation deviated from a null model that was spatially neutral with respect to the distribution of individuals within landscapes. Evidence in support of two hypotheses (area-per-se and habitat diversity) commonly posited to explain patterns in community structure was lacking or weak. The covariation between landscape structure and avian-accumulation rates was consistent with expectations under an ecosystem stress paradigm. Avian species-accumulation rates were lower and more variable in landscapes with greater proportions of urban and agricultural land and lower dispersion of forest and wetland habitats. These patterns were consistent with predicted degradation of species diversity under land use intensification. Commonality between observed patterns of species-accumulation rates and those predicted for ecosystems under anthropogenic stress notwithstanding, there remained considerable uncertainty in linear regression models that predicted accumulation rate as a function of landscape structure attributes. These results indicated that, at this scale, only general trends in avian species- accumulation rates may be anticipated under an analysis of alternative land policy scenarios. (Oral, III, 3:15 Wednesday)

Flebbe, Patricia A., USDA Forest Service and Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. **Trout abundance patterns among southern Appalachian streams.**

In the southern Appalachian Mountains, native brook trout and introduced rainbow and brown trout are distributed across the landscape in complex patterns that reflect both large-scale factors and site-specific stream habitat characteristics. In part, these patterns are a consequence of past fisheries management practices. About 40 headwater stream basins with similar vegetational characteristics were selected in the southern Appalachian Mountains from central Virginia to northeastern Georgia for study of these patterns. Basin level trout density, biomass, and stream habitat were estimated for these streams (5-15 km total stream length). Factors such as latitude, elevation, aspect, stream order, and geology were addressed in these watershed level studies. Differences in trout abundance estimates among basins in close proximity (<10 km) were as large as among more widely separated basins, up to the scale of the region (500 km). These results have implications for the design of watershed and regional scale landscape studies of trout abundance and production, both in terms of the number of replicate streams required and the role of geographical proximity in stream selection. Furthermore, these results have implications for fisheries management, which has traditionally focussed on short stream segments of a few hundred meters. (Poster)

Flint, Elizabeth P. and John F. Richards, Department of History, Duke University, Durham, NC 27708. **A coordinated research program on carbon fluxes in the tropics II: Changes in land use from 1880-1980 in South and Southeast Asia.**

Patterns of land use were reconstructed for 13 South and Southeast Asian nations (total area 7.9 x 10^8 ha, subdivided into 91 geographical zones) at the dates 1880, 1920, 1950 and 1980. Standardized spreadsheets were used to analyze official census, agricultural, forestry, and revenue statistics in the context of many other sources (e.g. ecological, botanical, agronomic, geographical, anthropological studies; gazetteers and exploration reports; vegetation, land use, and climatic maps; remotely sensed data). From 1880-1980, as the human population increased from 3.4 to 11.4 x 10^8 (+268%), and livestock increased from 2.2 to 5.1 x 10^8 (+130%), the total cropped area expanded by 84% (from 1.3 to 2.3 x 10^8 ha). Combined area of forests and wetlands dropped by 28% (4.8 to 3.5 x 10^8 ha), with areal reductons concentrated disproportionately in closed forest and wetlands rather than discontinuous forest. Timing of deforestation and agricultural conversion was earlier, and the extent of these processes greater, in South as compared to Southeast Asia. For data compiled by nation, quadratic regressions on population density of a) percentage of total area covered by crops, and b) percentage of area covered by (forests+wetlands), were highly significant and opposite in sign: i.e., (a) rose, and (b) fell, with increasing density. Similar patterns hold for data compiled at the zonal scale, although some reduction in goodness of fit is attributable to greater heterogeneity of land use patterns. (Oral, VII, 10:00 Friday)

Fonseca, Mark, National Marine Fisheries Service, NOAA, Beaufort Laboratory, Beaufort, NC 28516. **Seagrass landscapes and the influence of physical energy regimes.**

Under NOAA's Coastal Ocean Program, the relationship of physical energy (wave exposure and tidal currents) to seagrass landscapes is being investigated. This approach will attempt to improve the conceptual basis of seagrass ecosystem structure and function and facilitate seagrass restoration activities. On-site mapping of seagrass cover at thirty, 0.25 ha (50 x 50 m) sections of seagrass beds was conducted biannually for two years. Eighteen sites were located in southern Pamlico Sound, North Carolina and twelve in Tampa Bay, Florida. Mapping resolution was 1 m. Tidal current velocity and a wave exposure index were compiled for each site and were positively correlated with seagrass landscape patchiness. Total edge, vertical relief, coverage turnover and directional migration of patches were positively correlated with physical energy. Sediment organic content, particle size, and contiguity of cover were negatively correlated with physical energy. The pattern of seagrass cover suggests an organizational hierarchy at the 5 m scale. These relationships will be utilized to define sampling strata for functional evaluation of seagrass ecosystems and determine planting strategies in areas of moderate to high physical energy during restoration. (Oral, V, 10:15 Thursday)

Fortin, Marie-Josee, Centre d'etudes nordiques, Universite Laval, Quebec, Canada G1K 7P4. **How to compare vegetation and environmental maps.**

The novelty of geographical information systems (GIS) makes easier the spatial analysis of ecological phenomena (species spatial distribution, spatial variation of topography and soil properties), as well as the investigation of the relationships among the underlying processes and spatial responses of the species. However, such relationships among geographically distributed variables should not be established with classical statistics. In fact, when variables are spatially autocorrelated the correlation between them cannot be assessed using the usual n-2 degree of freedom since these variables violate the assumption of independence required by the significance

test. Thus, the degree of agreement between spatially distributed variables should take into account the spatial autocorrelation structure of the variables by means of significance tests that correct for it. Here, using vegetation data from two data sets, I introduce new ways by which vegetation and environmental maps can be compared: 1) using Clifford et al. (1989) correction for spatially autocorrelated variables; and 2) using restricted permutation tests. (Oral, VIII, 9:45 Friday)

Franklin, Carol, Andropogon Associates, Ltd., 374 Shurs Lane, Philadelphia, PA 19128.
Ecological design - designing with the patterns and process of place

Since its inception in 1975 Andropogon Associates, Ltd. has been committed to effecting fundamental change in our treatment of the landscape by demonstrating ecologically sound alternatives to conventional practices. Andropogon has pioneered the development of an ecological aesthetic where the primary patterns of design are drawn from those of the native landscape in order to sustain the natural processes of each site.

A series of case studies of projects by Andropogon Associates, Ltd. will be used to illustrate the design of regionally appropriate landscapes and show strategies and techniques for innovative stormwater management, planting with native plant communities and habitats and landscape restoration and management. The focus of these projects has been on recognizing and solving environmental problems while expressing - rather than obliterating - the patterns and processes of place. The projects examined range from industrial and institutional sites, office parks and residential development to derelict areas and remnant wildlands, parks, and right-of-way. (Plenary, 8:45 Wednesday)

Freemark, Kathryn, U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR 97333. **Landscape ecology and management of agroecosystems.**

The Midwest Agricultural Surface/Subsurface Transport and Effects Research (MASTER) program is a recent cooperative initiative among the US EPA, US Dept. Agriculture and the US Geological Survey to evaluate the impacts of current and emerging agricultural practices on the quality of environmental resources in Midwestern agroecosystems. The long-term objective of MASTER is to evaluate the effectiveness and viability of alternative management practices and landscape designs in preventing ecological degradation and contributing to ecosystem restoration. As part of the interagency initiative, ERL-Corvallis is evaluating effects on terrestrial biota using a landscape ecology approach. In cooperation with nongovernment scientists, we are currently: (1) investigating the importance of landscape structure to mammals and birds in terms of species richness, abundance, composition and nest predation; (2) evaluating relative impacts of pesticides, other agricultural practices and habitat on birds and plants; (3) developing a predictive multivariate model of how land use patterns and agricultural practices at the county scale and above influence the abundance of game (see Ribic et al., this meeting); and (4) developing a GIS approach for ecological classification of the Midwestern Cornbelt Plains Ecoregion in order to generalize results from specific research sites.

The role of landscape ecology in the management of agroecosystems to benefit wildlife will be discussed by reference to other studies (particularly from the UK and Europe) and to preliminary results from our MASTER projects. Given the large extent of farmland in North

America as elsewhere, there is an urgent need to develop approaches in agrolandscape ecology to improve conservation and restoration efforts. (Oral, III, 4:00 Wednesday

Frohn, Robert C.[1] and Virginia Dale[2], [1]University of California, Santa Barbara, CA 93106 and [2]Oak Ridge National Laboratory, Oak Ridge, TN 37831. **Analysis of land clearing practices on individual farmer settlement lots in Rondonia, Brazil using satellite remote sensing.**

Two decades of colonization and road building in the Brazilian Amazon state of Rondonia have resulted in large scale deforestation. In an effort to reduce the impact of colonization on the forests of Rondonia, the Brazilian government made it unlawful to clear more then 50% of the forests on an occupied lot. Our analysis of Landsat MSS and NOAA AVHRR scenes in Rondonia for several time periods show that this law had been violated as early as 1980. The remote sensing analysis is also being used to evaluate a socioeconomic/ecological model that simulates settlement clearing practices on individual lots under different land management scenarios. (Oral, VII, 11:15 Friday)

Fule, Peter, Margaret M. Moore, and W. Wallace Covington, School of Forestry, Northern Arizona University, P.O. Box 4098, Flagstaff, AZ 86011. **Scaling sample plots to estimate patch characteristics of southwestern ponderosa pine.**

Stem maps of ponderosa pine measured on plots of seven sizes ranging from 25 m^2 to 20,000 m^2 were compared as estimators of forest spatial patterns. The reference for comparison was a complete stem map of a 5 hectare study site in a preserved natural area in northern Arizona. Spatial and conventional statistical methods were applied to this data set to determine: (1) the size, orientation, and variability of old-growth patches; (2) patterns and distances between old-growth patches; (3) size, orientation, and variability of patches of younger trees and grassy openings; and (4) patterns of regeneration, mortality, and downed woody material. Since patterns were observed in a hierarchy of scales, from approximately 25 m^2 to over 1 ha, plots at corresponding scales were repeatedly subsampled from the overall data set and evaluated as estimators of the reference stem-map results. Plots at the smaller end of the range were found to be most suitable for non-spatial estimates of forest parameters such as basal area, trees per hectare, and diameter distributions. Mid-size plots were good estimators of old-growth patch and regeneration patch spatial characteristics and adequate for other characteristics. The largest plots were the best estimators overall and especially for estimating patterns and distances between old-growth patches, mortality, and downed woody material. However, the choice of a sample plot size must balance the desired sampling precision and the inherent scale of each studied landscape component, as well as the cost of measurement. (Poster)

Fulton, Mark R., Hsin-I Wu, and Randal S. Stahl, Center for Biosystems Modelling, Texas A&M University, College Station, TX 77843-3131. **Simulating growth of trees in complex vegetation using a 3-dimensional model of light extinction.**

Simulation of vegetation dynamics in complex landscapes requires the ability to simulate the interactions among plants with variable physiognomic structure. In this study, equations from a state-of-the-art forest simulation model (FORSKA) are being coupled to a 3-dimensional model of light extinction, allowing the realistic simulation of the effect of light conditions in complex vegetation. The combined model will predict growth rates of trees as a function of their map-location in relation to other trees, leaf area distribution, and size. The model will be parameterized for a Post Oak Savanna in East-Central Texas consisting of scattered oak trees in a sparse grassland with red cedars growing up from the understory of the oaks. The light model will be tested against measurements of light attenuation in intact clusters and clusters with the red cedars removed. The ability of the model to account for the patterns of tree growth as a function of location within a cluster will constitute a test of the sufficiency of light as the primary driving environmental variable. (Poster)

Galo, Alisya T., San Francisco State University, San Francisco, CA 94132. **A georeferenced analysis of the plant communities of the Sierra Buttes, CA.**

A vegetation analysis was performed on repeating landscape units found above 6800 ft. on the Sierra Buttes (elevation 8591 ft.), the highest massif in the northern Sierra Nevada, California. The glaciated terrrain and 360 degree exposure provided an excellent natural laboratory for investigation of physiographic and historical determinants of vegetation patterns. Landscape units were identified as topographic features with broad scale differences in vegetation (aerial photos, 1:12,000). Data were collected from 570 random plots distributed across the study area and topographically stratified. Correlations between species composition/abundance and abiotic components, derived from CANOCO analysis, were enhanced using data from a GIS. Coverages include derivations from digital elevation models of slope, aspect, slope position, potential solar radiation, shelter, topographic moisture gradient and drainage patterns as well as independant coverages of snowpack, logging history, roads and soils. This georeferenced vegetation database allowed for multiscale analysis. At a coarse scale of resolution (100 m) vegetation patterns closely follow topographic moisture gradients; for example, hemlock forests were found on sheltered north facing slopes and mountain chaparral on exposed south facing slopes. Small localized patches of unique vegetation could be predicted, if viewed through a landscape perspective, by an analysis of broad scale structure. Quantification of the drainage patterns on the exposed south facing slope predict patches of species that require high soil moisture. Small patches (<15 m) of *Acer glabrum* and *Populus tremuloides* were found in these areas within the chaparral matrix. Distributional patterns of shrubs and herbaceous species were found to be a function of factors associated with a finer scale of resolution, such as the spatial structure of the dominant species, disturbance history, and microtopography. (Poster)

Gardner, Robert H., Anthony W. King, and Virginia H. Dale, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6036. **Forest management, landscape heterogeneity, and species persistence.**

The combined effect of landscape heterogeneity, natural disturbances, and the scale of forest harvesting was simulated for two competing plant species. One species was a generalist able to utilize all habitat types, while the second species was a specialist restricted to a single habitat. Individuals of both species completed their life cycle in a single time step, competed with neighbors for germination sites via a seed lottery, and were distributed on a series of heterogeneous grided landscapes which differed in the scale of habitat fragmentation. Simulated forest harvesting altered habitat types by preventing specialists from germinating. Survival of specialists was highest when habitat was more aggregated at fine scales. Harvesting had a negative effect on survival and abundance of the specialist when the scale of havesting interacted with the landscape patterns to increase habitat fragmentation. Natural disturbance also interacted with harvesting and landscape pattern to dramatically increase the risk of loss of specialists. These results provide a practical basis for considering the complex interactions affecting species survival and to develop positive recommendations for balancing management objectives with the need to preserve biodiversity. (Oral, III, 3:45 Wednesday)

Glenn, Susan M.[1], Ian Butler[2], Brian Chapman[3], Warren Drummond[2], and Rebecca Rudman[2], [1]National Park Service, POB 37127, Stop 490, Washington, D.C. 20013-7127, [2]Oklahoma Biological Survey, University of Oklahoma, Norman, OK 73019-0543, [3]University of Georgia, Athens, GA 30602. **Biogeography of mammals in Rocky Mountain national parks.**

We analyzed 149 mammal species distributions in the U.S. Rocky Mountains to determine which factors were responsible for local extinctions of species in National Parks. Species at the edges of their ranges in the parks were often missing from park species lists. Several species were missing from park lists whose ranges completely overlapped the parks. Lack of adequate inventory may be responsible for many of these omissions. We propose that habitat availability should be analyzed in the parks to determine which species should be inventoried. Analysis of the species-area curve for the region resulted in predictions of how many species may be supported in each park. This information was used to approximate completeness of the existing inventories. Preliminary analyses of shrew species distributions indicated our ability to identify potentially important areas of biodiversity. Shrew species were non-nested in their distribution patterns, therefore several sites should be protected to encompass all shrew species. We propose that this methodology should be used to analyze distributions of all 149 species to make park planning recommendations. (Poster)

Gomez, Sharon, University of Cambridge, Cambridge CB2 3EN, U.K. **The application of remote sensing and GIS technique in the study of Mediterranean ecosystems.**

Ecological surveys provide insights into the functioning of complex ecosystems. In this manner they are a necessary pre-requisite to resource management/conservation practices. In the different ecological surveys in use around the world, bio-physical parameters such as vegetation, soil, and climate have been used in the defining of ecological units. The Mediterranean environment poses an interesting region for a multi-faceted approach to land evaluation as there is a combination of human and physical factors affecting the various vegetation communities. An European Community funded project to study "Threatened Mediterranean Landscapes" is currently underway in the Dept. of Geography, University of Cambridge. An objective of this project is to identify and study the main bio-physical factors that act as influences on the main semi-natural vegetation communities, which occur on the island of Crete. As traditional ecological survey methods (such as field surveys) are time consuming, costly and labour intensive exercises, it was decided that remote sensing techniques used in conjunction with a geographic information system (GIS) would be used to facilitate the study. The application of this methodology to study ecological units on Crete is a novel technique. Initially, a land cover map was developed using SPOT-1, multi-spectral satellite imagery. The classification was used to ascertain the spatial distribution of the semi-natural vegetation communities. The land cover map and data on bio-physical parameters were entered as different layers into a GIS (using the ArcInfo software package). Statistical analysis was performed on the data extracted from the GIS. The statistical analysis and overlay techniques (in the GIS) were used iteratively to assist in the analysis. Results from the research, based on empirical studies, will provide new insights into the inter/intra relationships between bio-physical factors and the semi-natural vegetation communities in a Mediterranean ecosystem. (Poster)

Gottfried, Robert[1], John Chazal[2], and David Wear[3], [1]The University of the South, Sewanee, TN 37375-1000, [2]School of the Environment, Duke University, Durham, NC, and [3]US Forest Service, Research Triangle Park, NC. **Economics, computer simulation, and transition probabilities for landscape simulation.**

This poster briefly describes the economic theory of land use conversion and how this can be embodied in a computer simulation framework to provide transition matrices for landscape simulation. Doing so allows transition probabilities to be based upon a behavioral theory of land use conversion instead of purely historic transition probabilities. The relationship between simulation modeling and regression analysis is discussed, as are the reasons for pursuing a simulation approach. The poster outlines the model used, and the resulting transition probabilities, for the US Man and the Biosphere Temperate Zone Directorate's study on landscape change on the Little Tennessee River of North Carolina. (Poster)

Graham, Robin L. and Mark Downing, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6038. **Renewable biomass energy: Understanding regional scale environmental impacts.**

Biomass from energy crops is becoming an increasingly attractive fuel to electric power companies due to both the Clean Air Act which calls for reductions in SOx emissions and recent federal energy legislation which gives contained biomass power plants (those fueled by biomass grown specifically for the particular power plant) a 1.5 cent kWh tax credit. Biomass burns much cleaner than coal with regards to SOx and NOx emissions. For the same amount of electricity production, a coal-fired power plant will release 26,000 times more SOx and 20 time more NOx than a wood-fired plant even assuming the coal power plant has scrubber sufficient to meet current Clean Air emission standards. If biomass energy is to become a significant component of the U.S. energy sector, millions of hectares of farmland must be converted to energy crops. The environmental implications of this change in land use must be quantitatively evaluated. The changes will be largely driven by economic considerations. Farmers will grow energy crops when it is profitable to do so. Thus, models which purport to predict environmental changes induced by energy crops must take into account those economic features which will control land use change. In this paper we present the results of an analysis of the probable impacts of a land use switch to either herbaceous or woody energy crops on erosion and herbicide and fertilizer use in the Tennessee Valley Authority region - a 276-county, 9.5 million hectare area encompassing all of Tennessee and parts of neighboring states. In the analysis, the price that a utility company might be willing to pay a farmer for energy crop biomass determined both how much and where cropland might be converted to energy crops. In turn, the location and amount of land determined what the probable environmental impacts might be. The analysis expands on a previous facility-scale (42 county) study in East Tennessee which considered only woody energy crops. (Oral, IX, 2:45 Friday)

Guevara, Sergio and Javier Laborde, Instituto de Ecologia, Apartado Postal 63, 91000, Xalapa, Veracruz, Mexico. **Landscape ecology issues in a tropical rain forest in Mexico.**

Original tropical rain forest in the Los Tuxtlas mountain range has and is being replaced by field crops and cattle pastures. Cattle ranching is relatively new in the humid tropics of Mexico and pasture extension has been increasing at an alarming rate in the last twenty years. Today the landscape is a complex mosaic of vegetation where remnant forest fragments are isolated from one another by pastures. These fragments which vary in size are found mainly on hilltops, rocky terrain or land with a tendency towards flooding. Tree-lined riparian corridors and living fences dissect the pastures, which are dotted with isolated trees. At Los Tuxtlas there are two distinct landscape patterns which are directly related to the cultural and economic background of those who use the land. Wealthy non-resident landowners have used modern technology to manage cattle on large tracts of land since cutting down the forest, whereas tenured landholders used smaller patches of the land (ejido) primarily for agriculture until the recent past. The first type of landscape is very open, with cultivated pastures almost bare of trees. Forest fragments are small and scarce. The reduced plant and animal populations are greatly isolated. On the other hand, the ejido landscape has a higher ratio of forest fragments to open areas than the former. These have a high connectivity owing to the presence of arboreal elements within the pastures, which allow for the movement of frugivorous bats and birds. The potential of each type of landscape with respect to preserving original forest species is discussed with emphasis on plants (80% of

native woody species) which depend on frugivorous vertebrates for seed dispersal. (Oral, VII, 11:45 Friday)

Gustafson, Eric J.[1], and Thomas R. Crow[2], [1]North Central Forest Experiment Station, W. Lafayette, IN, and [2]North Central Forest Experiment Station, Rhinelander, WI. **Simulating the effects of forest management on landscape structure.**

A GIS model was developed to allow flexible, but spatially explicit simulation of management activity with varying levels of intensity over extended time periods. The model was developed to evaluate the distribution of management activities resulting from mixed ownership, and the constraints imposed by objectives for the production of commodity and non-commodity outputs. We used the model to allocate clear-cut treatments on a hypothetical forest landscape, using a GIS layer representing forest age classes. The model allows control of the spatial dispersion of the allocations (random, clumped, and even), the size distribution of clear-cuts, the total area of the landscape to be harvested, the rotation length (minimum forest age that can be harvested), and the minimum width of buffers to be left between harvests and non-forest classes. Simulations were conducted to determine the effects of dispersion pattern, mean size, rotation length, and total area of clear-cuts on forest spatial pattern, as measured by mean distance of forest pixels from edge, mean size of forest interior patches, and contagion of forest age classes. Implications for the conservation of neo-tropical migrant birds were evaluated using a GIS model that predicts vulnerability to cowbird parasitism. (Oral, VI, 10:15 Thursday)

Gutzwiller, Kevin J.[1], Heidi A. Marcum[1], and Stanley H. Anderson[2], [1]Baylor University, Waco, TX 76798, and [2]University of Wyoming, Laramie, WY 82071. **Predicting whether human intrusion will perforate subalpine landscapes for birds.**

Intrusion is a form of environmental disturbance that involves the mere presence of people, which is distinct from habitat destruction that often accompanies human activities. Experiments were conducted in Wyoming forests to determine if biological and life-history features of birds could be used to predict whether subalpine forests would be perforated for breeding species as a consequence of repeated human intrusion. Displacement probability was used as an indicator of whether the landscape would be perforated for a given species by the intrusions. If a species was displaced by the intrusions, the landscape in which it was breeding was said to have been perforated because the disturbances generated a gap in resource availability for that species. In 1989, displacement probability was negatively associated with length of the nestling period ($P = 0.004$) and positively related to body mass ($P = 0.028$). No relations were evident in 1990. During 1991, the probability of displacement was negatively related to length of the nestling period ($P = 0.002$) and nest height ($P = 0.001$), and positively associated with length of the incubation period ($P = 0.046$) and clutch size ($P = 0.002$). Life-history traits were not significantly related to displacement probability in 1992. Biological and life-history characteristics have some potential for predicting displacement and hence landscape perforation, but no variables were consistent predictors of displacement for all 4 years. The history of disturbance and avian

responses such as habituation and tolerance may have influenced the utility of the predictors we examined. The ability to predict the effects of human intrusion on habitat integrity and resource availability will be valuable for protecting sensitive species in human-dominated landscapes. (Oral, VI, 9:45 Thursday)

Hall, Charles A.S.[1], Margaret Smith[2], and Myrna H.P. Hall[1], [1]State Univ. of N.Y. College of Environmental Science and Forestry, Syracuse NY. 13210 and [2]Cornell Univ. Ithaca N.Y. 14850. **A coordinated research program on carbon fluxes in the tropics III: A GIS-based model of agricultural development and yield.**

We present a computer model of agricultural development over time that takes available FAO data on total cropland and assigns that land to land quality classes. The model is based on the assumption, commonly observed and articulated by Ricardo centuries ago, that farmers will develop highest quality lands first. It is also based on the assumption that, in general, the highest quality, flattest, most fertile lands will be used first for settlement, then for grains, then for tree crops, and then for pastures. This model is then used to develop mean and total crop productivity as agriculture expands into land of increasingly lower quality. A modified algorithm allows the user to simulate ownership of highest quality lands by ranchers vs. farmers. Where more detailed information on the distribution of crops is available, the model allows the prediction of yields based on crop response to gradients of temperature, sunlight intensity, soil moisture and edaphic factors. These, in turn, can be generated by a subroutine that takes meteorological station data and extrapolates it over a landscape. The model output is compared with data derived from Costa Rica 1940-1990, and the results are displayed in color three dimensional spatial maps that allow the results to be readily interpreted. (Oral, VII, 10:15 Friday)

Hall, Charles A.S., James Uhlig, and Ye Qi, State University of N.Y., College of Environmental Science and Forestry, Syracuse, NY 13210. **The development of a GIS-based predictive model for land use change and its application in peninsular Malaysia.**

We developed a computational procedure for simulating land use change in tropical developing countries as a function of topography and other factors. Our procedure is based on the assumption that land to be cleared is chosen by farmers and other developers based on topographic features, so that initially land near roads and rivers is developed and then development (e.g., deforestation) moves progressively upstream and up slope. We tested this model against two maps of land use in Peninsular Malaysia for 1972 and 1982. We ran the model from 1972 to 1982, and from 1880 to 1972. The model correctly classified land (i.e., as forest versus non-forest) for 90% of all the area in 1982 from initial conditions in 1972. The model correctly classified forest and non-forest land for 74% of all area when run from 1880 to 1972. (Poster)

Hargrove, William W.[1], Robert H. Gardner[1], Monica G. Turner[1], William H. Romme[2], and Don G. Despain[3], [1]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831-6038, [2]Biology Department, Fort Lewis College, Durango, CO, 81301, and [3]National Park Service, Yellowstone National Park, WY, 82190. **A grid-based model for simulating fire patterns in heterogeneous landscapes.**

A spatially-explicit stochastic forest fire model simulates the patterns produced by large fires burning through a heterogeneous landscape by specifying the probabilities of fire spread from site to site. Five factors influence fire spread: fuel class, fuel moisture, wind speed and direction, and firebrands. Spatial resolution of each site, or cell, is 50 m. We have chosen parameters to represent the central subalpine plateau of Yellowstone National Park, WY, U.S.A. Implementation of the model for Yellowstone considers five fuel classes patterned after types of lodgepole pine climax communities. Fire is modelled with 2 mechanisms for spread: 1) adjacent spread from one cell to a neighbor, and 2) firebrands, or spotting, to remote downwind sites. For local spread, the 8 adjacent neighbors of each burning cell are sequentially considered; thus, fire can move in any of 8 directions. The probability of a particular potential local propagation is specified by the fuel class in which the fire is burning, the fuel class of the potentially-igniting adjacent cell, and the fuel moisture. An anisotropic, directional probability "bias" simulates wind speed and direction. A bias value is estimated for each of the 8 directions relative to the direction the wind is blowing. The position of the potentially-ignited cell relative to the burning cell and the wind direction determines the bias factor that will be used. Probability of adjacent fire spread is adjusted under each of three 1000 hr. fuel moisture regimes: very dry (<12%), dry (12-16%), and nominal (>16%). Each site generates a fixed number of firebrands according to the fuel class present at that site. Firebrands are distributed in random directions if there is no wind. If wind is present, the downwind direction of firebrand travel describes a 3 degree normal random deviate around the wind direction to simulate turbulence. The distance each firebrand moves is a function of wind speed class, and is generated by a negative exponential function. The model is easily parameterized, efficient to run, and shows interactions between pattern and process. (Oral, VI, 11:00 Thursday)

Hatfield, C.A. and A.R. Johnson, University of New Mexico, Albuquerque, New Mexico 87131. **The effect of topography and geology on riparian species abundance.**

Riparian vegetation communities are influenced by many factors including the biotic and abiotic environment. This study examines the influence of two abiotic factors, stream size and substrate type and their effect on riparian species abundance. A series of drainage basins were selected in the Sangre De Cristo mountains in northern New Mexico where there is a transition from granitic to sedimentary substrate. Stream networks in granitic and sedimentary basins were selected and first, second and third order streams were sampled. Elevation was approximately the same for each stream order and ranged from 3700 meters for the first order streams to 2900 meters for the third order streams. Species abundance was recorded for the stream-side woody plant community for each order in each substrate type. Canonical discriminant analysis was performed to summarize the differences in species composition of riparian vegetation as a

function of stream order and substrate type. Results show that species abundance is most influenced by stream order with the effect of substrate type becoming more apparent with increase in stream size. Bootstrap analysis was used to evaluate the robustness of the canonical discriminant analysis. This study illustrates the interplay of topography and geology which forms the template for riparian communities in the landscape. (Poster)

Henebry, Geoffrey M., Kansas State University, Manhattan, KS 66506. **Images of grasslands: understanding spatio-temporal variability.**

The primary forces shaping grassland productivity -- fire, water, herbivory -- operate across multiple spatial and temporal scales. Environmental monitoring of grasslands thus requires a strategy that is sensitive to change amidst spatio-temporal variability. Remote sensing offers a way to integrate this variability at the landscape level. Satellite-derived NDVI (Normalized Difference Vegetation Index) images provide an "ecophysiological snapshot" that reveal dominant species responses to topoedaphic gradients associated with drainage and depositional networks, antecedent meteorological conditions, and disturbance regimes. But how can we link image patterns to ecological processes? Landscape dynamics can be reconstructed as trajectories in a 3-space described by measures of spectral reflectance, spatial dependence, and spatial heterogeneity. Trajectories are scale-dependent but are robust to different measures. The 3-space approach provides a framework with which to predict disturbance effects and to develop nested dynamical scene models. Satellite imagery of Konza Prairie Research Natural Area, the humid grassland site in the LTER network, provides examples of the effects of fire and drought on growing season and inter-seasonal trajectories. (Oral, VIII, 11:00 Friday)

Hess, George R., North Carolina State University, 1509 Varsity Drive, Raleigh, NC 27606 USA. **Analyzing landscape structure in North Carolina's Neuse-Tar Basin: Findings and frustrations.**

The Environmental Monitoring and Assessment Program (EMAP), a United States Environmental Protection Agency initiative, is an effort to monitor and assess the status of the nation's ecological resources at regular intervals, on a continuing basis. The Environmental Protection Agency is developing EMAP in cooperation with many other federal agencies, universities, and private environmental organizations. The EMAP Agroecosystem Resource Group is developing measurable indicators in order to monitor the condition of agroecosystems and the surrounding landscapes. Among these indicators are measures of landscape structure which are intended to reflect the landscape's potential to support a diverse biota and to moderate soil erosion, sedimentation, and nutrient runoff. The measures include landscape heterogeneity; patch size, shape, and distribution; the degree of fragmentation of landscape elements; and the amount of cropland-water edge. They are calculated using geographic information system coverages of land cover, derived from Thematic Mapper data and aerial photography. The findings of a pilot study, as well as the difficulties and uncertainties encountered along the way, will be reviewed. (Poster)

Hoeting, Gregory J. and Kimberly E. Medley, Department of Geography, Miami University, Oxford, OH 45056. **Temporal trends in bird species populations and land use in an eastern Cincinnati suburban landscape.**

Urbanization and the conversion of agricultural and forested lands have greatly influenced habitat structure and available resources for resident bird populations. The objectives of this study were to determine what patterns of local change in bird populations correspond with change from an agricultural to suburban landscape. We used 1950 and 1988 aerial photos and 1947-1990 Christmas Bird Count data in order to document trends in land use proportions and abundances (#/observer) of ten resident bird species for a ~458 km^2 circle near Mt. Carmel, a suburb of Cincinnati. Urban-residential developments increase (+30%), reducing forests on steep slopes (-7%), cropland (-12%), fields (-11%) and orchards (-2%). Five bird species show a decline, three increase, and two show no significant change. Certain relationships with land use appear direct such as the horned lark's decline with a loss of agricultural habitat, an increase in the European starling with urban-residential developments, an increase in the pileated woodpecker with maturation of forests protected in the suburban matrix, and stability in the belted-kingfisher present along permanent waterways. What remains unclear, however, is the relative importance of habitat area versus competitive exclusion by exotic species in the long-term protection of native bird diversity. (Poster)

Host, George, E.[1], David J. Mladenoff[1], Philip Polzer[1], Mark A. White[1], and Thomas R. Crow[2], [1]Natural Resources Research Institute, University of Minnesota, Duluth, MN 55811 and [2]USDA Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, Rhinelander, WI. **A climatic and physiographic classification of regional landscape ecosystems in northwestern Wisconsin.**

Hierarchically-structured multifactor classifications provide an important framework for quantifying both landscape structural features and ecosystem-level processes. The increased availability and access to digital data sources coupled with the spatial analysis capabilities of geographic information systems (GIS) greatly facilitates the identification and mapping of ecological land units at multiple spatial scales. In the present study, climatic, physiographic, and edaphic databases were integrated to produce a classification of regional landscape ecosystems over two 1:250,000 quadrangle areas in northwestern Wisconsin. Climatic regions were identified based on a high resolution climatic database consisting of 30 year mean temperature and precipitation values interpolated over a 1 km^2 grid across the study area. Principal component analysis coupled with an isodata clustering algorithm was used to identify regions of similar seasonal climatic trends. Maps of Pleistocene geology and major soil morphosequences were used to identify the major physiographic and soil regions within the landscape. Digital elevation models over the two quadrangles were used to verify the landform units derived from geology and soils. Climatic and physiographic coverages were integrated to identify regional landscape ecosystems which differ in terms of characteristic late-successional forest composition, successional dynamics, potential productivity, and other ecosystem-level processes. The classification provides

a basis to assess the influence of natural and anthropogenic disturbance on existing landscape patterns. (Poster)

Hunsaker, Carolyn[1], Sidey Timmins[2], Barbara Jackson[1], Jerry Griffith[3], and Robert O'Neill[1], [1]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, [2]Analysas Corp., Oak Ridge, TN, and [3]ECO, Inc., Boston, MA. **Landscape pattern analysis for ecoregions.**

One of the central tenets of landscape ecology is that landscape pattern relates to ecosystem processes, and ecologists believe that ecosystem processes operate at several geographic scales. Only recently have standardized digital data of vegetation become available for large geographic regions and continents thus allowing the exploration of landscape patterns for these regions at several data resolutions. This study examines the distribution of landscape pattern metrics for Omernik ecoregions and aggregated ecoregions using Advanced Very High Resolution Radiometry (AVHRR), Thematic Mapper (TM), and U.S. Geological Survey Land Use/Land Cover (LUDA) data for the United States. AVHRR data are analyzed for the entire United States while higher resolution data (TM and LUDA) are only analyzed for ecoregions in Florida. The AVHRR and TM imagery are evaluated for separate vegetation habitat classifications and for Anderson land use/land cover classifications while the LUDA is only evaluated for the latter classifications. The following landscape metrics are calculated on raster images: dominance, contagion, shape complexity, patch size classes, percent land cover, and number of types of land cover edges. The distribution of values for these metrics are compared among the two ecoregion classifications and the different data resolutions and to results from previous work on landscape units of 1 x 2 degrees latitude/longitude. The results of this study will help identify the usefulness of landscape pattern metrics for regional monitoring of change and assessments of ecological condition with respect to vegetation biodiversity and wildlife habitat. (Poster)

Irlandi, Elizabeth A., University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, NC 28557. **Seagrass landscapes and bivalve fishery production.**

Management of terrestrial parks, preserves, and forestry systems has long been concerned with the issues of habitat shape, size, and configuration. In marine systems we have just recently begun to take active measures to restore and preserve estuarine habitats, such as seagrass beds, that are vital to commercial fishery production. Managers have very little empirical information, however, with which to make informed management decisions concerning the appropriate size and/or spatial arrangement of preserved or restored habitats. Seagrass landscapes vary from extensive, continuously vegetated sea floors, to mosaics of seagrass patches with interspersed sand channels. Hard clams (*Mercenaria mercenaria*) are commercially harvested bivalves that live in both vegetated and unvegetated sediments, and often incur higher rates of survivorship within seagrass beds. Mark-recapture studies were done to examine the effect of seagrass habitat patch size and overall seagrass landscape, or percent cover of seagrass, on survivorship of the hard clam. Clam survivorship in large seagrass patches (>4-5 m across) was twice that from small patches

(1-2 m across; 18% and 9%, respectively), and almost 20 times that from unvegetated sediments (18% and 1%, respectively). Clam survivorship in different seagrass landscapes (including both vegetated and unvegetated components of the habitat) was highest (49%) in continuously vegetated seagrass habitat (100% cover), intermediate (40%) in habitats with 70% cover, and lowest (23%) in habitats with only 23% cover. When considering only the vegetated bottom as the habitat, clams survived at higher rates with 100% cover (76%) than with 70% or 23% cover (56% and 52% recovered live, respectively). From these results, managers can predict how transplant patches in restoration projects will change in function as they increase in size and eventually coalesce. These results also may be useful in determining selection of preservation sites. (Oral, V, 10:00 Thursday)

Johnson, Alan R., and Pablo A. Marquet, Department of Biology, University of New Mexico, Albuquerque, NM 87131. **A cellular automata model of 2-species metapopulation dynamics.**

A probabilistic, 2-dimensional cellular automata (CA) model is presented which simulates metapopulation dynamics (local colonization and extinction) of two species on a landscape consisting of patches arrayed as a square lattice. The model is constructed so that its expected dynamics in the absence of spatial constraints would correspond to the ordinary differential equation (ODE) model proposed in 1983 by Hanski. However, since patch dynamics in the CA model are constrained by being a function of nearest-neighbor patches, its behavior often diverges from that of the ODE model. A systematic search of the parameter space reveals that the CA model often converges to a fixed point attractor (i.e., an unchanging pattern), or to a cyclic attractor of period 2. Convergence to the attractor can be very rapid (<10 iterations) or very slow ($>10{,}000$ iterations). In several cases, no attractor was reached during the simulation. Several types of stable or long-lived transient spatial patterns are catalogued as a function of parameter values. Relative advantages and disadvantages of CA and ODE approaches to modeling metapopulation dynamics are discussed. (Poster)

Johnson, Lucinda B.[1], Carl Richards[1], George Host[1], and John Arthur[2], [1]Natural Resources Research Institute, University of Minnesota, Duluth, MN 55811 and [2]Environmental Research Laboratory, U.S. Environmental Protection Agency, Duluth, MN 55804. **Relationship between stream community composition and landuse patterns in a 17,000 km^2 midwestern watershed.**

We are conducting an investigation of the effects of landuse and landuse patterns on the structure of stream macroinvertebrate communities in several subwatersheds of the Saginaw River Basin. Land cover/use was mapped for the Michigan Resource Inventory Program by the Center for Remote Sensing at Michigan State University using aerial photographs at a scale of 1:15,840 and 1:24,000. A modification of the Anderson (1976) classification scheme was used; this differentiated landuse classes to three levels of detail. Land cover/use characteristics were summarized for: 1) the entire watershed, 2) a 250m buffer and 3) a 100m buffer using Level I

and Level II classifications. Several methods of gradient analysis (e.g., principal components analysis, canonical correspondence analysis) were used to describe the relationships between total species abundance, richness and species diversity and land cover/use patterns. Preliminary data suggest that landscape factors influence physical habitat structure, which in turn strongly moderates macroinvertebrate community structure. (Oral, V, 11:00 Thursday)

Johnson, Sherri L. and Alan P. Covich, Department of Zoology, University of Oklahoma, Norman OK. **Spatial and temporal patterns of litter-input dynamics in a prairie riparian zone.**

We use several scales of observation to examine the patterns and patch dynamics of riparian zone vegetation in a prairie watershed. Riparian zones are important ecotones between aquatic and terrestrial environments. Vegetation along a stream provides detrital inputs of leaves and woody debris. Gaps in the riparian canopy influence the amount of primary production in the stream. The Little Washita River originates in deeply dissected sandstone baserock; the headwater streams have narrow, incised channels. Inputs are primarily from deciduous trees and junipers. The downstream riparian corridor, impacted by historic and present-day land use, has an irregular distribution of trees. For large-scale analysis, stream corridors are first extracted from Landsat TM imagery of the watershed and then vegetation patterns are analysed along the longitudinal gradient of the river. Historic and recent air photos are compared to identify changes in the boundries and fragmentation of the riparian corridor over time. At a finer scale using field observations, percent cover of overhanging vegetation along the stream channel is compared at multiple sites to measure variations that contribute to the food-web structure. Characterization of these riparian dynamics is critical for comparisons or models of organic inputs and their effects on stream ecosystems. (Oral, IX, 4:00 Friday)

Johnston, Carol A., Brian Allen, Jim Sals, Paul Meysembourg and John Bonde, University of Minnesota, Duluth, MN 55811. **Effects of past disturbance on present-day forests at Voyageurs National Park.**

Forests are subjected to a variety of natural disturbances that have long-term effects on species composition. GIS analysis was used to determine how past fires, logging, and browsing by beavers have altered present-day upland forests on the Kabetogama Peninsula of Voyageurs National Park. Aspen/birch and aspen/conifer stands were the predominant covertypes under all disturbance types, but the importance of other covertypes varied with disturbance. Fires that burned 60% of the peninsula in 1923 and 1936 increased the percent cover of jack pine from 4% in unburned areas to 24% in burned areas, and increased the area of red oak from 5 to 10%. Areas that were logged in the 1950s and 1960s currently have 3x as much spruce/fir cover as those that were not, and only 1/4 as much pine cover. Beaver browsing increased spruce/fir cover from 5 to 17% at the expense of aspen, their preferred woody forage. These disturbance patches have different sizes, shapes, and locations, which are reflected in the resulting forest mosaic. (Poster).

Johnston, Carol A., Scott Bridgham, Karen Updegraff, and John Pastor, University of Minnesota, Duluth, MN. **Influence of beaver and bogs on trace gas fluxes from boreal landscapes.**

The potential for increased methane emission from boreal regions is of key concern to scientists and policy makers because the boreal biome is global in extent, stores large amounts of carbon, is a strong source of trace gases, and is projected to become significantly warmer over the next 30 years. Field measurements of methane (CH_4) and carbon dioxide (CO_2) emissions from beaver ponds, sedge meadows, and peat bogs were made at Voyageurs National Park in northern Minnesota. Methane flux was essentially zero until the water table approached the surface. Net ecosystem respiration (CO_2) was significantly correlated with soil temperature but showed little relationship with water depth. Integrated annual flux rates from different landscape types were used with a GIS land cover database to estimate the change in methane flux caused by beaver ponds built between 1940 and 1988. (Oral), II, 11:30 Wednesday

Jordan, Dean N.[1,2], Fairley J. Barnes[2], and James E. Bossert[2], [1]University of Wyoming, Laramie, WY 82071-3165 and [2]Los Alamos National Laboratory, Los Alamos, NM 87545. **Influence of surface spatial scale on regional atmospheric fluxes.**

A mesoscale atmospheric model was applied to vegetation, soil, and topographic data from a 400 km x 400 km grid in North-central Oklahoma and South-central Kansas. The region was selected to encompass the recently established Southern Great Plains Cloud And Radiation Test Bed (SGP/CART site) recently established under the Department of Energy Atmospheric Radiation Monitoring (DOE ARM) program. Advanced Very High Resolution Radiometric (AVHRR) satellite data was used to assign vegetation types (i.e., Crop/mixed farming, tall grass, mixed woodland, etc... from the eighteen types used in the Biosphere Atmosphere Transfer Scheme [BATS] model) to 1 km2 areas across the region. This fine-scale data was resampled to coarser resolutions of 16 km2 and 256 km2 to determine the effect of spatial resolution on the model results. Scaling, data management and visualization were performed using ARC/INFO. Areas within the large, coarse-scale grid were supplied with data nested at higher resolutions not computationally practical for the entire grid dimensions. Various methods of increasing pixel size result in different pictures of the landscape at coarser resolutions. The model results from these different landscape patterns were compared. The atmospheric flux model utilized permits local features (vegetation type, soil characteristics, topography) to influence predicted atmospheric variables on a sub-GCM (General Circulation Model) grid scale. These variables influence the lowest level of a multilayered atmospheric model, and therefore indirectly influence the upper atmospheric layers. Model boundary conditions were imposed based on typical surface conditions of the region, while variable lower boundary conditions were imposed for each model scale and grid vegetation type. Such modelling studies may help to identify the lower limit of spatial resolution of surface data required to achieve the desired level of spatial resolution in a hierarchical or nested general circulation model. (Poster)

Keane, Robert E.[1] and Penelope Morgan[2], [1]USDA Forest Service, 1Intermountain Fire Sciences Laboratory, Missoula, MT 59807, and [2]College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, ID 83843. **Landscape evaluation of the status of whitebark pine (*Pinus albicaulis*) in the Bob Marshall Wilderness, Montana, USA.**

Whitebark pine (*Pinus albicaulis*) provides important food for wildlife, especially the endangered grizzly bear (*Ursus arctos horribilis*), and important cover for snow retention and watershed protection. However, whitebark pine populations in the northern Rocky Mountains are being reduced at alarming rates by combined or individual effects of blister rust (*Cronatium ribicola*), mountain pine beetle (*Dendroctonous ponderosae*), and advancing succession resulting from fire suppression. This study evaluates the extent and severity of the reduction in whitebark pine on the Bob Marshall Wilderness Complex landscape in Montana, USA. An extensive field survey of various whitebark pine successional communties was mapped on a spatial level using Geographic Information Systems (GIS) to evaluate current whitebark pine population levels and their health. Results indicate that whitebark population levels are significantly declining as a result of blister rust infection. This decline is most extensive in the northern and western portions of the Bob Marshall study area. (Poster)

Keitt, Timothy H. and Alan R. Johnson, The University of New Mexico, Department of Biology, Albuquerque NM 87131. **Spatial heterogeneity and anomalous kinetics: emergent patterns in diffusion-limited predator-prey interactions.**

The Lotka-Volterra model of predator-prey interaction is based on the assumption of mass action, a concept borrowed from the traditional theory of chemical kinetics in which reactants are assumed to be homogeneously mixed. In spatially heterogeneous landscapes, constraints on local immigration and emigration can lead to aggregated spatial distributions and violation of the assumption of mass action. In order to explore the effect of spatial heterogeneity on predator-prey dynamics, we constructed a lattice based reaction-diffusion model corresponding to the Lotka-Volterra equations. Spatial heterogeneity was imposed on the system by making certain cells unavailable according to a binary mask. Percolation maps, gradient-percolation maps, and fractional-Brownian surfaces were used as masks in different simulation runs. Simulated predator and prey individuals randomly diffuse among available cells, with movement, reproduction, and mortality determined by a probabilistic rule set. The observed dynamics were considered to be anomalous if the order of the simulated system differed from the second-order Lotka-Volterra model. The 'reaction order' was estimated by fitting the slope of the log-log plot of population growth versus population density for both predator and prey. In all simulations where diffusion distances were short, anomalously low reaction orders and aggregated spatial patterns were observed. In general, the estimated order decreased with increasing degrees of spatial heterogeneity. For simulations using percolation maps with p-values varying between 1.0 (all cells available) to 0.5 (50% available), order estimates varied from 1.27 to 0.47. Gradient percolation maps and fractional-Brownian surfaces also resulted in anomalously low reaction orders. Increasing diffusion distances resulted in reaction order estimates approaching the expected value of two. We conclude that localized diffusion-limited interactions are an important

consideration in modeling population dynamics and can lead to significant deviations from traditional differential equation approaches which model population responses according to global state variables. (Oral, I, 11:30 Wednesday)

Keller, Jeffrey K., Habitat by Design, 611 Pennbrook Avenue, Lansdale PA 19446. **Explaining the occurrence and richness of avian guilds: a spatial analysis of landscape mosaics using GIS.**

The species composition and richness of 19 guilds of birds were studied for five years on 23 plots representing variously aged successional stages. Habitat size, insularity, and measurements of the degree to which habitat distribution was clumped were derived from aerial photographic analysis of the 23 study plots using a proprietary raster-based Geographic Information System (GIS) technique for quantifying edge and the spatial arrangement of habitat. Additional information was gathered on the quantity and vertical distribution of foliage and the density of snags. Fifteen of the 19 guilds had their highest correlations with measures of the size and shape of specific habitat subsets (patches) of the plant communities in which they occurred. Independent evidence for the influence of patch size came from 9 guilds where the smallest species (by weight) in the guild was the species most likely to occur when only one guild member was present, or where larger guild members occurred only in larger patches. The average classification accuracy of jackknifed Stepwise Discriminant Function Analysis (SDFA) models for guild species richness was 82.8%. Multiple regressions of guild species richness on the habitat variables averaged R2 = 721. The results suggest that new guilds appear in a landscape when the patch appropriate to the guild reaches a threshold size with the appropriate shape, optimally a circle, such that the minimum critical habitat requirements for the first (often the smallest) member of the guild are met. Additional guild members are most frequently added as patch size and/or productivity (leaf area or # of prey per unit volume of vegetation) increase. (Oral, III, 3:30 Wednesday)

Kesavan, Ramadevi, Department of Computer Science, Florida Institute of Technology, 150 West University Blvd., Melbourne, FL 32901. **Fractal applications in landscape ecology.**

Protection of habitats in Florida is a key issue for the conservation of natural communities and species that rely upon them. Habitat loss in Florida has been extensive since European colonization. Millions of hectares of wetland marshes have been converted to developed areas. It was found that only 43.6% of the acreage remains in natural or semi-natural communities. These remaining areas are highly fragmented with the vast majority in the 5 ha size range. This is of critical concern as this region supports a large number of threatened and endangered species and is recognized to be of high conservation value. In order to identify clearly, key areas for conservation action, more accurate measures of the spatial distribution of these natural communities are needed. Factors that are important for conservation planning are the size of remaining natural areas, the shape of remaining natural areas, their context, juxtaposition and their distribution. Fractal geometry, a newly evolved area of Mathematics, quantifies landscape

patterns and topology, and many other natural phenomena. The shape complexity of any irregular shape is determined by finding the fractal dimension of its boundary. This presentation would focus on the applications of fractal geometry in determining the degree of habitat fragmentation in the watershed of Indian River Lagoon, East Central Florida. The degree of fragmentation will be determined based on area, perimeter and fractal dimension of the natural community patches remaining at present. Scale dependent nature of landscape patches will be studied using fractal measurement techniques. The results will be presented using a GIS. GIS principles pertaining to this paper would also be discussed. (Poster)

Kienast, Felix and Bogdan Brzeziecki, Swiss Federal Institute for Forest, Snow and Landscape Research, CH-8903 Birmensdorf, Switzerland. **Temporal and spatial simulation models for ecological risk assessment studies.**

Two modeling approaches were developed and applied to assess the risks and possible impacts of an anticipated climate change on the structure of forest communities and the fate of major tree species in Swiss Alps.

The dynamic, mechanistic approach was used to identify the successional patterns of forest communities and to determine the competitive ability of tree species under a changing climate. A model experiment with a climate change scenario that assumes a linear warming of 3-5° C and quadrupling of the CO_2 concentration in the next 300 yrs showed an invasion of deciduous trees in today's montane and subalpine belt. Most conifers were outcompeted and migrated into today's subalpine (and possibly alpine) belt. In intra-alpine, dry regions, where pines and oaks are already at its ecological limits, the probability of steppification appeared to be very high.

The simple probabilistic "vegetation-site" model was developed, to simulate geographical distribution of forest community types. The model was interfaced with a geographic information system (GIS) and used to generate a numerical vegetation map, on the basis of digital maps of environmental variables. The model was used to extrapolate the findings of the dynamic modeling and to delineate the risk zones of changed ecological potential of sites and altered structure of forest communities. (Poster)

King, Thaddeus P.[1], Kevin J. Gutzwiller[1], and Stanley H. Anderson[2], [1]Baylor University, Waco, TX 76798, and [2]University of Wyoming, Laramie, WY 82071. **Does human intrusion generate influence fields in avian distributions?**

Influence fields are areas under the control of, or affected by, a particular disturbance. Human intrusion, which involves just the presence of people in the environment, can create such disturbances. Influence fields have been documented for gamma-ray emission and dispersing pollutants, but not with respect to human intrusion and vertebrate distributions. We tested experimentally whether low levels of human intrusion created influence fields for breeding birds in Wyoming subalpine forests from 1989-1992. A researcher disturbed 1-ha plots once, twice, or five times per week (frequency) by walking through 25 or 100 percent of a plot (scale) for one hour. No disturbances were administered to control plots. As a consequence of the treatments, some

species' abundances were reduced in the disturbed plots (1 ha) and out to approximately 100 m surrounding the disturbed plots (7.1 ha total). The statistically significant differences between control and treated plots were associated with 18 to 67% declines. Because sensitive individuals were displaced, essential resources within the influence field, although still intact, were no longer available. Reduced use of available forest matrix may lower fitness for individuals sensitive to this type of environmental perturbation. Influence fields may be expressed beyond the perimeters of the site of disturbance. Therefore, effects of intrusion may be greater than what one might predict based only on the area of disturbance alone. (Oral, VI, 10:00 Thursday)

LaGro, James, Jr., Department of Landscape Architecture, University of Wisconsin, Madison, WI 53706. **Forest patterns in an urbanizing landscape.**

Land use/land cover data for an urbanizing landscape in New York State were interpreted and mapped from aerial photographs taken in 1985. These 1:36,000-scale maps were digitized and the data were integrated with ancillary physiographic and socioeconomic data in a raster geographic information system (GIS). Spatial analysis of the digital land use/land cover image quantified the juxtaposition of the forest patches with the other seven classes represented within the landscape. Spatial filtering of the binary, digital forest class image was employed to quantify the contiguity of the pixels comprising the patches within the forest class. Statistical analyses were designed to determine: 1) if soil and topographic conditions, or socioeconomic factors can account for forest patch size and shape variation; and 2) if forest patch size and shape variation can be accounted for by the juxtaposition of the forest class patches with any of the other land use/land cover classes. The results show that larger, more contiguous forest patches were located on relatively inaccessible higher elevations, on steep slopes, and on soils poorly suited for both urban and agricultural uses. Conversely, the forest class was most fragmented at lower elevations, on level to moderate slopes, and on soils where the conversion of land to agricultural and urban uses has been extensive. (Oral, IV, 3:00 Wednesday)

Lal, Harbans, ManTech Environmental Technology, Inc., USEPA Environmental Research Laboratory, 200 SW 35th St, Corvallis, OR. **Modeling approaches for wetland functions at the landscape level.**

The Landscape Function Project of the USEPA-Wetland Research Program is examining the role, functions, and values of wetlands in a region at the landscape level. Research objectives include: 1) evaluation of the role of the aggregate of wetlands in water quality improvement, wildlife habitat support, and hydrologic control functions at a landscape scale; and 2) quantification of the effects of environmental stressors and landscape factors on these functions. This presentation outlines principal approaches for achieving these objectives which include: 1) development and refinement of conceptual models and best professional judgement hypotheses regarding the role of wetlands in landscape functions and the influence of landscape processes on wetlands; 2) performing empirical analyses for testing these hypotheses; 3) development and evaluation of low-cost landscape assessment methods; and 4) development and calibration of

spatial models for evaluating management options for wetlands protection and management. Advantages and limitations of these approaches in handling ecological processes are discussed. The presentation also elaborates on the current and planned activities within the project. (Oral, V, 11:30 Thursday)

Lee, Robert. College of Forest Resources, University of Washington, Seattle, Washington 98195.
Human choice and landscape structure: An interdisciplinary approach by U.S. MAB

Landscape ecologists, land use planners, and natural resource managers face a fundamental dilemma. Landscapes are generally studies as alrge-scale ecological processes when they are in fact joint products of independent and cumulative human land use choices and biological processes. Consideration of the human element is essential for predicting landscape structure and influencing decisions affecting it.

The U.S. Man and the Biosphere, Temperate Ecosystem Directorate, is nearing completion of an interdisciplinary project focused on the linkages between human land use choices, landscape structure, and sustainability of both biological functions and human sustenance activities. Much has been learned about building a successful interdisciplinary team, integrating diverse sciences (sociology, economics, ecology, plant physiology, botany watershed managment, modeling)., linking diverse data sets, and constructing a synthetic modeling approach. Most significant for successful synthesis has been two integrating elements: (1) a transition probability matrix used to predict land use changes for small parcels, and (2) landscape modeling to project spatially explicit ecological processes and strucutures resulting from land use changes. The products of this research will be of considerable interest to landscape ecologists, regulatory agencies, and public and private landowners. (Plenary, 1:20 Friday)

Lenihan, James M.[1], and Ronald P. Neilson[2], [1]Oregon State University and [2]USFS-PNW, Corvallis, Oregon 97331. **Projecting the vegetation response to climatic change in the North American Central Grasslands Region.**

Anticipated changes in global climate may seriously impact the North American Central Grasslands Region in complicated ways. The U.S. National Park Service has land units within this region for which projections of change are needed to make management policies. To provide a basis for such projections, a coordinated modelling effort is underway in which high-resolution climatic change projections generated by the Regional Atmospheric Modeling System (RAMS) will be used to drive the Mapped Atmosphere-Plant-Soil System (MAPSS) to simulate regional changes in vegetation. MAPSS calculates a complete site water balance and predicts the potential leaf area supported within the constraints of the abiotic climate and seasonal soil moisture patterns. Mixtures of grasses and woody life forms are obtained through light and water competition. Initial estimates of the potential impact of climatic change on the Central Grasslands region, using coarse-scale output from GCM doubled-CO_2 experiments and a coarse resolution of life forms in MAPSS, include significant changes in grass leaf-area throughout the region. But the magnitude and even the sign of the change varies with the climatic scenario and

with assumptions concerning wind speed and plant water-use efficiency. Future enhancements of MAPSS for research in the Central Grassland Region will include a higher resolution of life-forms and communities, more specific calibration of stomatal response functions for incorporation of the direct effects of CO_2, provisions for the influence of the interannual variability of weather, incorporation of soil data and fire/grazing rules, and an integration of MAPSS with RAMS to explore two-way biosphere-atmosphere interactions. Funded by the NPS, EPA, and USFS. (Oral, II, 10:30 Wednesday)

Li, Bai-lian, Center for Biosystems Modelling, Texas A&M University, College Station, TX 77843-3131. **Wavelet analysis: what is it, and what does it do?**

Wavelet analysis is a new mathematical theory and calculation method for separating and sorting different structures on different time scales at different times, and different spatial scales at different locations. It is attracting increasing interest among landscape ecologists due to characteristics of localization and multiresolution. Although wavelet analysis applications in landscape ecology are just beginning, its potential looks very promising. Basic theory and method of wavelet analysis with landscape ecology applications will be introduced with an emphasis on using orthonormal wavelet bases. Several applications include identification of spatial heterogeneity in subsurfaces, avian patch size detection in desert shrublands, and coherent turbulence structure in the atmosphere-forest interface. The relationships among wavelets, fractals, and geostatistics will be discussed. Common mistakes and inappropriate usage of wavelet analysis in landscape ecology will also be addressed with an example from the current literature. (Oral, VIII, 11:45 Friday)

Li, Bai-lian, William C. Forsythe, and Edward J. Rykiel, Jr., Center for Biosystems Modelling, Texas A&M University, College Station, TX 77843-3131. **Weighted mean cluster size as an index for identifying landscape response to disturbances.**

To measure landscape response to disturbances, we developed an index called weighted mean cluster size based on percolation theory. We used the index to analyze a cellular automata model of a multispecies clonal plant growth system under different disturbances. The results showed that the index is very sensitive to disturbances and has a strong relationship with intensity, scale, and frequency. The index provided a good measure for spatio-temporal characteristics of model landscape response. We also analyzed the dynamics of woody plant clusters in a south Texas savannah under 20 year wet and dry periods. Our results suggest that weighted mean cluster size can be sensitive indicator of landscape change. Possible disturbance effects on landscapes are addressed based on comparison with time series values of the index and associated disturbance agents. (Poster)

Li, Bai-lian, William C. Forsythe, and Edward J. Rykiel, Jr., Center for Biosystems Modelling, Texas A&M University, College Station, TX 77843-3131. **Fractal analysis of cluster-phase dynamics in southern Texas savanna.**

To determine the long-term patterns and dynamics of vegetation cluster to cluster interactions we defined different fractals and fractal relationships to describe (a) cluster growth relationships; (b) changes in the size and shape of clusters; (c) degree of coalescence or fragmentation; and (d) spatial pattern shifts of different types of vegetation clusters during succession in southern Texas subtropical savanna. These fractals and their relationships included: fractal kinetics of aggregation processes (Li, et al., 1992), area-perimeter fractals, cluster-size distribution fractals, self-affine fractals, correlation fractals, and information fractals (Li, 1992). Our method looks very favorable and is straightforward for understanding and identifying cluster-phase processes and successional mechanisms in vegetation systems. An application of the methodology to south Texas vegetation will be described. (Poster)

Liebhold, Andrew[1], Michael Hohn[2], Guofa Zhou[1], Linda Gribko[2], and Richard Rossi[3], [1]USDA Forest Service, 180 Canfield St., Morgantown, WV 26505, [2]West Virginia Geologic & Economic Survey, Morgantown, WV 26506, and [3]FSS International, Redwood City, CA 94063. **Geostatistical models that predict defoliation caused by the gypsy moth.**

Every year the gypsy moth, Lymantria dispar, damages vast portions of the Northeastern United States and about 1 million acres are sprayed every year to prevent defoliation. Unfortunately, gypsy moth populations behave erraticly and outbreaks are consequently very difficult to predict at any location in space. We have applied geostatistical models, specifically 3-dimensional Kriging, to forecast where outbreaks will be in the future. This technique quantifies spatial and temporal dependence in historical defoliation patterns to extrapolate future defoliation maps. We have found that incorporation of gypsy moth census data, such as spatially stratified counts of over-wintering egg masses, substantially increases the precision of defoliation predictions. We illustrate and compare the incorporation of census data using the co-kriging, gausian simulation, and logistic model procedures. These procedures provide estimates of the univariate and joint probability distribution of various defoliation events that are useful to decision-making processes. (Poster)

Linehan, John, Jack Ahern and Meir Gross, University of Massachusetts, Amherst, MA 01060.
Assessing the impacts of landscape fragmentation upon the rural New England landscape.

Greenway planning has steadily grown in popularity in the planning and design fields as an efficient and attractive approach to the design of regional open space systems. Whereas landscape assessment techniques have been generally successful in generating multiple use plans, the ability to assess ecocentric parameters and to evaluate alternatives quantitatively for decision making purposes has yet to adequately evolve. The purpose of this presentation is to introduce methods for assessing the latter through the use of graph theory. Graph theory is a highly appropriate approach since it fits well within the planning and design paradigms, can respond to underlying ecological and anthropocentric objective functions, and can quickly and easily be used to assess networks for connectivity and efficiency based on an assortment of landscape parameters and objectives.

The purpose of this study is to provide a method for assessing, delineating, and evaluating network alternatives as it applies to protecting significant habitats and linkages for fragmentation-sensitive species in Central New England. It will also demonstrate the utility of the approach on a case study involving fishers and otters in Central Massachusetts. The methodological framework includes the following aspects that allow the planner to generate more appropriate, ecocentric alternatives: 1) selection of indicator species that successfully include a wide species set via cluster analysis based on habitat needs; 2) determination of habitat suitability for the indicator species; 3) determination of important habitats and links based on the juxtaposition of functional habitat areas; 4) development, assessment, and evaluation of network alternatives; and 5) development of an implementation plan based on habitat and linkage significance and projected landscape change. (Oral, I, 10:15 Wednesday)

Logsdon, Miles, and E. J. Bell, University of Washington, Seattle, WA. 98195. **Effects of regional land use planning policy on landscape pattern.**

Broad scale landscape patterns in vegetation cover for the urbanized region of Puget Sound are compared to patterns created by the implementation of the finer grained land use planning policy of varied minimum lot sizes. Landscape patterns were compared using indices measuring, evenness (E), dominance (D), contagion (C), contrast (LC), and heterogeneity (LH) to illustrate the scaled relationship between planning policy and regional landscape ecology. A minimum lot size land use policy is shown to decrease measures of evenness and dominance and increase measures of contrast and heterogeneity at finer scales, yet broad scale regional patterns exhibit an increase in evenness and contagion and decrease in heterogeneity. Thus, characterizing the relationship of spatial scale and land use policy may make it possible to better evaluate alternatives in order to achieve broad scale regional planning goals. (Oral, IX, 2:30 Friday)

Lucas, Michael F., John D. Peles, and Gary W. Barrett, Miami University, Oxford, OH, 45056. **Experimental landscape corridors: barriers to or conduits for small mammal and arthropod dispersal.**

The importance of landscape corridors on small mammal or arthropod dispersal merits increased attention. Corridors may function as agents for dispersal or barriers to movement, or both. The Miami University Ecology Research Center (ERC) has been the site of various studies addressing the effects of natural (e.g., successional vegetation) and human (e.g., split-rail fencing) corridors on the population dynamics and dispersal behavior of small mammals and arthropods. In experiments involving small mammals, *Mus musculus* exhibited a strong propensity for human-made corridors, especially during late summer and autumn. Vegetative corridors were used by *Mus* only to a limited extent. Adult males dispersed more readily than adult females. *Microtus pennsylvanicus*, however, readily dispersed through vegetative corridors, whereas human corridors (e.g., roads, mowed areas) have been reported to act as dispersal barriers. *Microtus* populations, especially adult males, used natural corridors to expand home ranges.

Natural (successional vegetation) and human (simulated grassy roadsides, tall sorghum) corridors introduced into soybean agroecosystems often have contrasting effects on arthropod populations. Whereas successional corridors enhanced populations of defoliating coleopterans (e.g., *Epilachna varivestis*), tall sorghum corridors acted as barriers to dispersal of *Popillia japonica*. Corridors of successional vegetation increased populations of lepidopteran pests (e.g., *Plathypena scabra*). Lepidopteran populations remained unaffected by grassy corridors; however increased occurrence of fungal parasites (e.g., *Nomuraea rileyi*) was found. The presence of grassy corridors in soybean plots acted as barriers to leaf and stem sucking guild members (e.g., *Empoasca fabae*) and populations were reduced. Abundance of arthropod predators (e.g., *Orius insidiosus*) was greatly increased in successional corridors. Replicated field studies of this design are needed if we are to encompass landscape elements into management practices such as integrated pest management. Landscape corridors also must become a critical component of programs designed to foster sustainable agriculture. (Poster)

Lucas, William C., University of Pennsylvania, Philadelphia, PA 19104. **Landscape ecological planning for water resource management.**

Landscape Ecology presents a fertile opportunity to integrate recent research in the fields of hydrology, limnology, pedology, ecology and agronomy. Studies in these fields demonstrate that agricultural practices and urban development patterns have significant deleterious effects on surface and groundwater resources. Many of these studies indicate that an integrated landscape approach is the most effective method for water resources management. Complementing agricultural source control practices such as conservation tillage, the landscape approach includes treatment measures such as Vegetative Filter Strips, Riparian Forest Buffers , Extended Detention Basins, and Artificial Wetlands. With the inclusion of Infiltration Practices, these treatment measures are likewise applicable to development. Source control strategies such as Clustered Developments and Urban Growth Management (UGM) policies can also be effective.

Pollutant loading models such as AGNPS, ANSWERS, and CREAMS can approximate the relative impacts of a variety of different land uses and treatment measures. With the file manipulation capabilities of GIS to rapidly update relevant input parameters, the effects of alternative scenarios can be rapidly determined to obtain the optimal "suite" of land use allocations and treatment strategies. This presentation explores the water resource implications of applying an integrated landscape approach to a small watershed in the piedmont region of Pennsylvania. Conventional agriculture and development without treatment measures is contrasted with the landscape approach. While not quantified, there are substantial benefits of water resource measures for other dimensions of landscape ecology. At the site level, treatment measures and Cluster Design can be incorporated into a more effective configuration of patches and corridors. On the regional scale, UGM policies constrain the extension of suburban development into the agricultural matrix. (Poster)

Luque, Sandra S., Richard G. Lathrop, and John A. Bognar, Department of Natural Resources, Rutgers University, New Brunswick, NJ 08903. **Temporal and spatial changes in the New Jersey Pine Barrens landscape.**

Housing developments, introduction of species and active wildfire control are changing landscape patterns in the New Jersey Pinelands National Reserve. The purpose of this study is to devise a methodology to characterize and monitor the Pinelands landscape and to evaluate the trends in the fragmentation process. More precisely, the objectives of this study are twofold: (1) to characterize changes in the landscape pattern in a study area of the New Jersey Pinelands at two points in time (1972 and 1988) based on data obtained from multispectral satellite remote sensing imagery, and (2) to compare trends of the fragmentation process occurring within versus outside the Pinelands Reserve. Land-cover patterns were quantified by mean, number, and size of patches; and by amount of edges between land cover types. Indices of landscape patterns were calculated and a map of changes was produced. Spatial patterns of land cover in the Pinelands study area have changed during the past sixteen years. Fractal dimension, diversity, and contagion generally decreased while dominance, disturbance and edges increased, indicating a trend to a more dissected and disturbed landscape, with more human influence. There was an increase in the number of forest patches and a dramatic decrease in the average size of forest patches. In contrast, the patch size for the non-forest category has increased as a result of a coalescence of patches. The landscape fragmentation is shown by a downward shift in the distribution of forest patches by size class. Overall, the Pinelands landscape has become more fragmented during the past sixteen years. These changes have implications for many ecological processes and resources. Management practices need to consider landscape fragmentation in the Pinelands National Reserve in order to preserve the essential character of the Pine Barrens Landscape. (Oral, IV, 2:45 Wednesday)

Lynam, Timothy, J.P. WWF Multispecies Animal Production Systems Project, P.O. Box 8437, Causeway, Harare, Zimbabwe. **Predicting changes in structure and outputs of an agricultural landscape: A multiscale approach.**

In an attempt to answer the question: "What is the likelihood of this agroecosystem continuously satisfying the needs of local inhabitants?", a hierarchically structured, systems approach was developed and tested on an agricultural landscape (agroecosystem) in a semi-arid area of northern Zimbabwe. This paper describes the approach. Important characteristics of the approach are: 1) analyses are conducted at several scales; 2) conceptual models, simulation models, data collection methods and analytical methods were selected and used so as to be consistent with the scale of each level of the analysis; 3) results of coarse scale evaluations (broad extent, coarse grain) focus finer scale evaluations (narrow extent, fine grain); and 4) results of finer scale evaluations are integrated into new iterations of coarse level evaluations.

The approach was developed due to the necessity of resolving three major problems: Firstly, the agroecosystem was extremely complex. Agroecosystem inputs (rainfall, crop types, crop varieties, labour and management), agroecosystem structure (soil physical and chemical properties, household numbers, household resource holdings and household characteristics) and agroecosystem outputs (crop yields, erosion and runoff) varied considerably in space, time and at different scales of analysis. The interactions among these components were also spatially and temporally variable, assumed different weightings at different scales and, for at least some of them, were thought to be non-linear. The second major problem was that agroecosystem

structure changes continuously. Increases in household numbers (9-15% per annum), changes in soil structure (reduced stability, increased erosivity), changes in crop production technologies and spatial and temporal patterns of cultivation, for example, could lead to spatially and temporally unstable variances in agroecosystem outputs. The third major problem was the dearth of data on important properties of, as well as changes in, the inputs, outputs and structure of the agroecosystem. (Oral, IX, 3:30 Friday)

Mazzotti, Frank J., Wiley M. Kitchens, Laura A. Brandt, and Leonard C. Pearlstine, University of Florida, Gainesville, FL 32611. **Evaluating the regional effects of new citrus development on the ecological integrity of southwest Florida.**

State-of-the-art methods in landscape ecology, impact assessment and environmental planning were applied to evaluate the regional effects of new citrus development on the ecological integrity of southwest Florida. The 600,000 ha study area borders environmental sensitive Everglades and Big Cypress areas and is prime habitat for the endangered Florida panther. Citrus development radically alters existing landscape conditions and there is concern that the scale of the proposed citrus development could significantly effect regional ecological resources. Evaluation of the effects of new citrus development focused on listed species, vulnerable habitats, and regional biological diversity. A multi-tiered approach integrated species/habitat matrices, field sampling, and habitat modeling for Sandhill Cranes, Florida panthers and wading birds, with geographic information system analytical capabilities. Landcover maps were produced for 1900, 1973, 1989 and three levels of intensity of citrus development. Pine flatwoods and freshwater marshes have been and continue to be the most vulnerable and species rich habitats in the region. Although habitats for cranes, panthers and wading birds have been lost due to changes in land use (primarily deforestation and drainage for agricultural activities), considerable habitat for these species remains. The foundation for the conservation of fish and wildlife resources with continued citrus development will be a regional landscape that is a mosaic of different intensity land uses. This mosaic will be the result of protection and maintenance of natural and low intensity use areas, and ecologically sensitive grove design. The ratio and spatial arrangement of different land uses will be of critical importance. Creating the necessary landscape conditions to meet the goals of regional fish and wildlife conservation will require a combination of land acquisition, attractive economic and recreational incentives for private landowners to maintain natural and low intensity use areas, and regulation. (Oral, I, 10:00 Wednesday)

McFadden, Bryan A.[1], Jeffrey W. Fitzgerald[1], John R. Giardino[1], and Robert N. Coulson[2]
[1]Department of Geography, Texas A&M University, College Station, TX 77840 and
[2]Department of Entomology, Texas A&M University, College Station, Texas 77840.
Predicting forest insect outbreaks: The role of landscape structure in the epidemiology of the southern pine beetle.

Insect outbreaks are autogenic disturbances that directly and measurably influence forest landscape structure, function and rate of change. Outbreaks of forest insects are episodic phenomena. They are normally observed at the landscape scale as levels of herbivory above an average or expected amount. This presentation deals with forecasting insect outbreaks in forest landscapes. In particular, we consider the role of landscape structure for it (i) influences movement of insect species within and among landscape elements and (ii) it is the template for the dispersion pattern of food resources and habitat conditions available to the insect. The population system for the southern pine beetle, Dendroctonus frontalis Zimm. (Coleoptera: Scolytidae), was examined as this insect has been studied in considerable detail. We constructed a GIS database of the Davy Crockett National Forest in East Texas from aerial photographs and thematic maps. This landscape was characterized using statistical procedures developed to measure heterogeneity and connectivity. We produced epidemiological maps that integrate information on forest stand structure, disturbance centers (lightning strikes), and location of existing infestation. (Poster)

McNulty, S.G., J.M. Vose, and W.T. Swank, Coweeta Hydrologic Laboratory, 999 Coweeta Lab Road, Otto, NC 28763. **Modelling forest hydrology and productivity at the ecosystem and regional level: Comparisons of scale.**

Three forest hydrology and productivity models are being developed which increase in spatial and temporal resolution from the regional to ecosystem to stand level, respectively. Each of the models is run independently of the others. This paper examines the development and output of the ecosystem level models and discusses how these values relate with the coarser regional level model. Using mensurational and soils data collected from approximately 20 sites across the southern U.S. in conjunction with climate data, ecosystem level hydrologic and productivity models have been run on selected sites. Mensurational data included annual basal area growth, height, diameter at 1.5 m above ground level, and Leaf Area Index (LAI). Soils data include depth of each horizon and moisture release curves for each soil layer. Climate data bases were obtained from screened monthly values of precipitation, average temperature, windspeed, relative humidity, solar radiation provided by the National Climatic Data Center. These input databases were entered into a Hydrologic model (PROSPER) and a productivity model (developed at Coweeta), to produce monthly outputs at the ecosystem level. While the hydrology and productivity models are run separately, output from one model serves as an input to the other. For example, output from the productivity model (e.g. July LAI) would be entered into the hydrology model as an input during the ensuing month (e.g. August). The output from ecosystems having a range of conditions (e.g. soils, climate and vegetative state will be discussed). (Poster)

Medley, Kimberly E. and Samuel Fitton, Department of Geography, Miami University, Oxford, OH 45056. **Spatial analysis of intra-forest establishment by *Lonicera Mackii* in the Kramer Woods Natural Area.**

Conservation efforts have encouraged the protection of small forest patches in agricultural-urban matrices. While the area of these forest fragments remains essentially stable, more subtle human influences are degrading their ecology. Of profound importance are changes attributable to the competitive establishment of exotics. We investigated the spatial patterns of invasion by *Lonicera Mackii* in a 5.2 ha, ~80-year deciduous forest protected by Miami University. The objectives were to measure the intra-patch abundances of the shrub and quantify relationships with three hypothesized models of plant invasion: (1) a gradient from the forest edge; (2) a gradient from the southwest corner; and (3) a dispersed pattern determined by canopy openings and a hiking trail. *L. Mackii* and trees greater than 10 cm dbh were measured in 60, 24 m^2 and 108 m^2 nested plots, respectively, which were located at 20 m intervals along 7 transects. Vegetation data compiled from this fine-network of plots were analyzed, using GIS to map abundances, quantify distances, and identify spatial relationships. Density and coverage of *L. Mackii* show a gradient from the edge, most evident by the absence of the plant in the forest-patch interior. Correlations were positive and significant with distance from the forest edge and the southwest corner, whereas correlations with canopy cover and distance from the trail were nonsignificant and opposite to those predicted. The study documents the intra-forest patterns of *L. Mackii* in one forest and presents an approach applicable to further research on the spatial patterns of exotics currently influencing the diversity of forest fragments in this region. (Poster)

Milne, B.T, C.A. Hatfield, and A.R. Johnson, University of New Mexico, Albuquerque, NM 87131. **Simulation of juniper woodland landscape phase transitions.**

The responses of juniper woodland ecotones to climate fluctuation may exhibit properties of spatial phase transitions, in which case the formalism of percolation theory is appropriate and predictive. Our study combines image analyses of retrospective aerial photographs (1930s - 1980s), GIS, and simulation modeling to test the appropriateness of phase transition theory for landscapes. A major goal of the work is to identify locations that are particularly sensitive to climate change. Percolation theory predicts that maps containing gradients in tree density, as do the woodland maps, may contain a large woodland cluster that spans the map. Theoretically, the outer edge of the spanning cluster occurs where environmental conditions control the transition from grassland to woodland. We used Dean Urban's model Zelig to simulate *Juniperus monosperma* density as functions of elevation, slope, and aspect. By mapping the model results to the land surface we investigated the relation between the appearance of the outer edge of the spanning cluster and the corresponding model parameters. Thus, simulation modeling provided a means of validating the ecological interpretation of our empirical studies of woodland transitions. (Oral, II, 11:00 Wednesday)

Mitasova Helena[1], Eric Lambert[2], Franz Mora[2], and Louis Iverson[2,3], [1]U.S.Army Construction Engineering Research Laboratory, Environmental Division, P.O.Box 9005, Champaign, IL 61826-9005, [2]Illinois Natural History Survey, 607 E.Peabody Dr., Champaign, IL 61820, and [3]USDA Forest Service, NEFES, Delaware, OH 43015. **Modeling of (selected) spatial dynamic processes in complex terrain using GIS.**

A system for modeling the spatial dynamics of the average soil moisture, erosion/deposition, temperature, precipitation, snowpack, solar radiation evapotranspiration with influence of vegetation and human activity is presented. The model is designed to incorporate the important role of terrain in the control of water and energy (solar) fluxes through high resolution DEM with comprehensive topographic analysis. The processes are modelled on cell by cell basis with the resolution of 10m (necessary for movement of water) under raster-vector GIS in 3d space. The generic dynamic model was formulated and tested for a single cell using STELLA software for modeling of dynamic systems. To incorporate the spatial variability and fluxes, the model has been transformed to GIS and connected to a spatial database. GRASS GIS was used at various levels in this project - as a programing environment for C-programs for interpolation, topographic analysis, and erosion/deposition modeling, and as a database for model inputs and graphical outputs. The model was applied to the area on the eastern side of Cascade mountains in the vicinity of Yakima, Washington. (Poster)

Mladenoff, David J.[1], George E. Host[1], Joel Boeder[1] , and Thomas R. Crow[2], [1]Natural Resources Research Institute, University of Minnesota, Duluth, MN 55811, and [2]USDA Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, Rhinelander, WI. **Modeling forest succession and landscape change at multiple scales with LANDIS.**

We have developed a computer simulation model of forest landscape disturbance and succession (LANDIS). This object-oriented model is written in C++, is pixel-based, and has a graphical user interface and analytical capability. File input and output is in ERDAS GIS format. LANDIS is derived very generally from some aspects of LANDSIM (D. Roberts 1989) a polygon-based fire and succession model for the central Rocky mts. that operates on principles of fuzzy set theory and species vital attributes. It is also philosophically related to forest gap models of the JABOWA/FORET type, and attempts to retain the biological aspects of gap models with the capability to spatially model larger areas. The model is driven by a series of tree species life history and silvical parameters coupled with probability functions such as disturbance initiation and spread, and species dispersal and establishment. The model operates on a ten-year time step and simulates forest succession semi-quantitatively based on the presence of species age classes. Disturbance, management, dispersal, growth and death subroutines are contained in the model. Initial vegetation and landscape site characteristics are exist as separate GIS data coverages. The model code and parameters are structured to allow simulation at various scales of resolution depending on landscape extent and purpose, and relevant temporal scale. For example, a landscape could be simulated at 30 m pixel resolution to examine species dispersal and patch spread on a relatively small (1000s ha) landscape, or 200 m or 1 km resolution to examine

regional, long-term forest succession and landscape structural change. We have applied the model in analyzing a forest landscape in northern Wisconsin. (Poster)

Moore, Margaret M., W. Wallace Covington, and Peter Fule, School of Forestry, Northern Arizona University, Flagstaff, AZ 86011. **Changes in spatial patterns of presettlement and postsettlement ponderosa pine structure.**

Heavy livestock grazing and fire suppression associated with Euro-American settlement have brought about substantial changes in forest structure of southwestern ponderosa pine ecosystems. Extensive sampling in this vegetation type has shown that tree density has increased substantially since Euro-American settlement. The data indicate that on basaltic sites, where fine textured soils favor a bunchgrass understory and surface fires were frequent, average tree densities have increased from 56 trees/ha in presettlement times to 700-2100 trees/ha in relatively undisturbed stands today. Other structural characteristics such as tree patchiness, crown closure, and bunchgrass openings have changed as well. To better understand the dynamics of this pine/bunchgrass type, we compared the structure and pattern of presettlement and postsettlement ponderosa pine using conventional and geostatistical techniques. Patterns were identified among individual trees and tree groups on two 1-ha stem-mapped plots. Distinct patchiness was observed for both presettlement and contemporary pine forests, although the underlying causes for this patchiness over time are quite different. The results indicate that detection of pattern depends on past versus present ecosystem disturbances, scale of observation, and choice of analytical technique. (Oral, IV, 2:30 Wednesday)

Mora, Franz, Department of Forestry, University of Illinois, Champaign IL 61820. **Ecological landscape classification of Mexico: Pattern identification based on the stratification of dynamic landscape processes.**

As an intent to stratify the landscape heterogeneity resulting from dynamic processes that are iteratively related at regional scales, and also occurring at both spatial and temporal recurrent patterns, a classification scheme was obtained using a GIS cartographic model derived from multitemporal datasets (remotely sensed and cartographic resources) and applying multivariate exploratory data analysis (principal component analysis and discriminatory analysis) over functional landscape attributes.

GIS and multivariate analysis are used iteratively at two levels: a) to build a geographic database for a cartographic model definition of landscape ecological units, and b) to evaluate the significance of landscape attributes in order to define a set of "rules" for the landscape classification of Mexico.

The geographic dataset consists of phenological attributes of global vegetation derived from multitemporal global vegetation index (GVI) images, climatic attributes obtained from meteorological stations, and physiographic attributes derived from cartographic sources and digital elevation models.

Preliminary results suggest that individual spectral signatures of photosynthetic activity for the different ecosystems can be obtained from the analysis of GVI temporal and spatial variations. In such terms, land units (at mesoscale or landscape level) can be characterized on the basis of gross primary productivity; minimum, maximum and mean levels of photosynthetic activity at the beginning and during the growing seasons; and using seasonality measures of both natural and non-natural vegetation.

Since PCA maximizes the differences in GVI temporal variation, the geographic distribution patterns of individual classes obtained with discriminant analysis are mainly associated with seasonal variations of climatic variables. Physiographic variables act as physical barriers creating discontinuities and regionalizing the distribution of classes. Phenological attributes are more important to differentiate classes where vegetation share similarities in structural attributes such as lifeforms. (Poster)

Naveh, Z., Faculty of Agricultural Engineering Technion, Haifa, 32 000 Israel. **Red books for threatened landscapes: an innovative tool for holistic landscape conservation.**

In view of the alarming threats to our Planet Earth and its natural and cultural diversity, there is urgent need to broaden the conservation efforts from species and ecosystems to landscape levels, and from biological diversity ("Bio-diversity)" to ecological landscape diversity ("Eco-diversity"), incorporating endangered biological, cultural and socio-economic patterns and processes of landscape heterogeneity.

"Red Books", prepared for specific, highly valuable, threatened landscapes could serve as powerful tools for this purpose. Their object should be to create greater public awareness and apprehension to these threats, to change the attitudes of politicians and decision-makers, and to provide practical guidance for holistic, sustainable and multi-beneficial land use planning and management. This could be achieved by presenting, in clear non-technical terms with ample maps and illustrations, not only recent, adverse changes endangering both natural and cultural assets and scenic and economic values, but also suggesting alternative, sustainable land-use strategies based on holistic landscape planning and dynamic conservation management. In this way, "semantic" scientific information, collected by integrated field surveys and remote sensing, dynamic GIS and advanced landscape ecological methods will be transformed into "pragmatic" information, becoming meaningful through its feedback on the receiver and its actions.

A joint Working Group of IALE and IUCN - Commission on Environmental Strategies and Planning - is preparing for the 1993 General Assembly of IUCN a comprehensive proposal for the compilation of world-wide Red Lists of endangered landscapes and a "Blueprint" of such Red Books, presenting the first case study, carried out in Crete by a multinational and multidisciplinary team, and examples of threatened landscapes in industrialized and developing countries for which such Red Books could be of immediate, practical value. (Oral, I, 11:45 Wednesday)

Neilson, Ronald P.[1], C. Daly[2], J. Lenihan[2], and J. Chaney[2], [1]U.S.D.A. Forest Service, PNW Research Station, Corvallis, OR 97331, and [2]Oregon State University, Corvallis OR 97331. **Vegetation modeling from landscapes to global scales for global climatic change.**

A model for predicting the distribution and water-balance of vegetation has been developed and applied at three spatial extents and resolutions. At the extent of landscapes (10s of km) MAPSS (Mapped Atmosphere-Plant-Soil System) has been applied at a 30m Digital Elevation Model (DEM) resolution and is linked to a 3-D, gridded hydrology model. MAPSS has been implemented at the continental extent at a resolution of 10km and at the global extent at a resolution of 0.5°. The implementation of a single model at several different spatial resolutions allows the testing of several hypotheses pertaining to spatial and temporal scaling within ecosystem modeling. For example, at the resolution of 30m, a mosaic of forested and grassy slopes, commonly observed within the intermountain West, can be easily resolved. However, at the resolution of 10km, the average climate of the mosaic produces a savanna. Since the vegetation characteristics, such as lifeform mixture, leaf area, and rooting depth are deterministically linked to site water balance, some landscape processes can be directly simulated. An example question could be: is a vegetation mosaic functionally the same as a savanna in terms of whole watershed energy and water balance? While energy and water flux patterns and processes might be similar between a mosaic and a savanna, one would hypothesize that habitat-wildlife interactions would be different. Examples of model output will be presented at the different scales and discussed in the context of global warming. (Oral, II, 10:15 Wednesday)

Nekola, Jeffrey C. and Susan K. Wiser, Curriculum in Ecology and Biology Department, University of North Carolina, Chapel Hill, NC 27599. **Influences on habitat saturation in plant species of isolated habitats.**

The level of isolation experienced by a species is a function of its dispersal abilities, the amount of habitat present in the landscape, and its biogeographic history. It is reasonable to expect that the percent of potential habitats occupied by a species in a landscape will be inversely related to the isolation experienced by that species. To investigate how landscape factors affect rates of niche saturation, we have studied species distribution patterns from two naturally isolated habitats: fens in Iowa and high elevation rock outcrops in the Southern Appalachians. We have estimated the niche space of each species by defining 95% Gaussian bivariate ellipses from sites of occurrence along the two main axes in a multidimensional scaling environmental ordination. Saturation rates were estimated by calculating the ratio of sites of species occurrence to the total number of sites within the ellipse. From these data the relationship between 1) species dispersal strategies (wind vs. other), 2) ability of a species to live in the surrounding matrix (leading to a lesser level of isolation), and 3) biogeographic history (i.e., origin of species populations via vicariance or long-range dispersal) and the estimated rates of niche saturation will be discussed. (Oral, III, 2:30 Wednesday)

Offerman, Holly, Virginia Dale, Scott Pearson and Robert O'Neill, Oak Ridge National Laboratory, Oak Ridge, TN 37830. **Effects of forest fragmentation on biodiversity of neotropical migrant birds.**

Land use activities change patterns of vegetation and indirectly affect movement and survival of species. For example, arboreal animals, like sloths and primates, require trees close together for their movement, but winged animals can fly between widely dispersed trees. Forest fragmentation may instigate a cascade of extinctions when one integral component of the fauna disappears. The goal of this project is to develop and test techniques for relating fragmentation caused by land use to changes in biodiversity. Resource utilization rules are used to evaluate the effects of forest fragmentation on birds migrating between North and South America. These rules are developed from data on species home range sizes and movement between suitable habitats. For the South American part of the study, data on species survival and movement in Brazil in the aftermath of forest fragmentation are used to develop appropriate resource utilization rules. These rules are used to quantify biodiversity impacts from forest fragmentation over a 50 year period (using forest maps produced using a land use model which predicts spatially-explicit patterns of deforestation based on human development scenarios). For the North American part of the study, we identify species of neotropical migrant birds that are currently declining by examining Breeding Bird Census data. For selected species, we determine habitat fragmentation in southeastern Tennessee. By evaluating the spatial distribution of habitat and its degree of fragmentation, we identify concentrations of habitat important for conserving breeding habitat for these birds. The results demonstrate how land use pattern can affect species persistence over multiple spatial scales. (Oral, III, 3:00 Wednesday)

Okey, Brian, Department of Geography, Miami University, Oxford, OH 45056. **Agricultural intensification and landscape pattern in the Upper Four Mile Creek Watershed, Preble County, Ohio.**

Farm technology, economics, and government policy caused a transformation in midwestern U.S. agriculture from mixed farming to intensive cash grain production during the post-WWII era. In Ohio, production has become concentrated on fewer, larger farms, and simultaneous increases in harvested cropland and forest land are documented. I examined the effects of these trends on landscape pattern at a local scale in the Upper Four Mile Creek Watershed, Preble County, Ohio. County agricultural land-use data were compiled from census statistics (1935, 1954, 1982), and wood and brush landscape element data for the 260 km^2 watershed were collected from aerial photographs (1935, 1956, 1984).

Crop and land-use diversity steadily declined in Preble County as corn and soybeans dominated the agricultural landscape mosaic. Forest and less dense woodland patches increased in number by 10% between 1935 and 1956. After 1956 these patches decreased in number by approximately 50%, and the mean area of forest patches increased from 6.5 ha to 16.7 ha. Analysis of patch distribution indicates a concentration of agriculture in the more level headwater areas, and forest patch coalescence in stream gullies and state park land in the lower watershed. Hence, agricultural intensification initially resulted in a more fragmented landscape. Ultimately,

however, coincident increases in forest and cropland polarized the landscape into two distinct homogeneous areas. (Oral, X, 2:30 Friday)

O'Neill, R. V. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37830. **Landscape ecology over the next decade.**

Landscape ecology has developed extremely rapidly in the U.S. over the last decade. What can we predict about the next ten years? We can expect increasing resistance unless theoretical constructs are subjected to rigorous field tests. We can expect increasing demands to rush research findings into applications. Hopefully, colleagues will see the applicability of our paradigms to ecological systems at smaller scales. Hopefully, we will have the wisdom to incorporate more socio-economic theory. Hopefully, the federal agencies will mobilize the resources needed to continue development of landscape ecology. (Plenary 1:20 Wednesday)

Park, Richard A.[1], Jae K. Lee[1], David W. Crumpacker[2], and Michael J. Duever[3], [1]School of Public & Environmental Affairs, Indiana University, Bloomington, IN 47405, [2]University of Colorado, Boulder, CO 80309, and [3]National Audubon Society, Naples, FL. **Potential impacts of sea level rise on South Florida natural areas.**

Simulation of the effects of sea level rise due to global warming, using Landsat data and digitized elevational data, indicates that southern Florida could lose twenty percent of its wetlands with a one-meter rise in the next century. In peninsular Florida mangroves and saltmarshes would expand initially at the expense of wet prairies and of lowland tracts that have been drained for development, then the coastal wetlands would decline in area. Some freshwater wetlands would in turn migrate to higher elevations as the water table is raised adjacent to the coast. The Florida Keys initially would experience a shift from roughly equal areas of saltmarsh and mangroves to greater dominance by mangroves, followed by a decline in all wetlands with depletion of adjacent lowlands suitable for colonization. Dire consequences are predicted for the many protected natural areas in the region. Large areas of the Everglades and Biscayne National Parks could be lost; the Crocodile Lake, Great White Heron, and Key West National Wildlife Refuges and the National Key Deer Refuge could be severely affected; and some State parks, recreational areas, and preserves could be lost entirely. (Poster)

Pearson, Audrey F., College of Forest Resources AR-10, University of Washington, Seattle WA 98195. **Are intact primary watersheds functional conservation units in coastal temperate rain forests?**

Inherent in the non-equilibrium view of natural systems is the recognition that conservation decisions must accomodate ecosystems dynamics to be successful. Since ecosystem processes are difficult to quantify, pattern is considered a surrogate for process. The task of conservation is thus to protect a complete set of patterns, thereby ensuring a complete set of

processes. However, no one knows what constitutes a complete set of patterns. I hypothesize that primary watersheds (those with their terminus in salt water) contain a complete set of patterns in coastal temperate rain forests and are therefore functional conservation units. The concept of gradient analysis offers two areas of support for this hypothesis. First, primary watersheds contain the interfaces between saltwater, freshwater, and terrestrial systems, which define the environmental gradient of coastal temperate rain forests. Second, by virtue of its elevational range, a primary watershed potentially contains the possible variation in fundamental factors that influence the forest (nutrients, moisture, light, temperature and mechanical forces). A primary watershed, therefore potentially contains the complete range of possible environmental gradients which organize environmental heterogeneity and are the underlying organizers of pattern. Knowledge of the ecological function of primary watersheds is especially crucial to the conservation debate in coastal temperate rain forests, since they are increasingly rare features. On Vancouver Island, British Columbia, only 6 of 89 watersheds greater than 5000ha are still pristine, three of which occur in Clayoquot Sound. A preliminary pattern analysis of the intact primary watersheds in Clayoquot Sound using the GIS data base and means of testing this hypothesis using gradient analysis are presented. (Poster)

Pearson, Scott M., Environmental Sciences Division, Oak Ridge National Laboratory, P.O. Box 2008, MS: 6038, Oak Ridge, TN 37831-6038. **Natural populations and habitat heterogeneity at multiple scales.**

Heterogeneity in habitats and resources is hierarchical in nature. Patterns occur at multiple scales from continents down to local resource patches. Natural populations are influenced by these nested scales of heterogeneity. At the finest scale, the density of organisms is influenced by the abundance of required resources and community-level interactions such as competition and predation. However, spatial patterns at broader scales may constrain the size of a population and its distribution among habitat patches. For example, for birds wintering in the southeastern U.S., the vegetation in a habitat patch provides some amount of food and protective cover, determining the suitability of that patch for different species. In addition, the size and spatial arrangement of habitat patches in the broader landscape can affect the occupancy of individual patches. The occupancy of a patch depends on both the resources of that patch and the type and spatial arrangement of habitats in the surrounding landscape. Moreover, these landscape-level effects depend on the natural history of the species involved and characteristics of the spatial pattern in the landscape. Spatial pattern can affect landscape characteristics like connectivity. For example, habitat loss when occurring in a fine-scaled pattern fragments the landscape more quickly than when occurring in a more coarse-scaled pattern. Thus, local, fine scale processes do not operate independently of the larger landscape. (Oral, IX, 3:45 Friday)

Pontius, R. Gil, Jr., and Charles A.S. Hall, SUNY College of Environmental Science and Forestry, Syracuse NY. **A coordinated research program on carbon fluxes in the tropics IV: A geographically based model of carbon flux due to land use change in tropical Africa.**

We use digital maps, tabular data, and a novel FORTRAN program to extrapolate past and future land use change in tropical Africa. The maps we use describe present and historical land use, vegetation, soil, elevation, and political boundaries. Our model GEOMOD extrapolates the rasterized land use maps forwards and backwards in time as a function of topography, proximity to previous development, and other parameters. On a grid cell level, we calculate the amount of carbon flux due to land use change based on our carbon storage and land use change estimates. In Africa, carbon flux due to land use change is responsible for 70% of the anthropogenic emissions of the greenhouse gas, carbon dioxide. (Oral, VII, 10:30 Friday)

Prasad, Anantha M.G.[1,2], Louis Iverson[2,3], Sandra Brown[1] and Helena Mitasova[2,4], [1]Department of Forestry, University of Illinois, Urbana-Champaign, IL 61820, [2]Illinois Natural History Survey, Champaign, IL 61820, [3]USDA Forest Service, Delaware, OH 43015, and [4]U.S. Army Construction Engineering Research Laboratory, Environmental Division, P.O. Box 9005, Champaign, IL 61826. **Using climatic index and GVI data to capture the dynamics of tropical south american vegetation.**

The amount of woody biomass present on the ground varies depending mainly on the climatic and geomorphologic/edaphic factors. The climatic component can be captured at a continental scale by using an index that was originally derived by Dr. Weck. Weck's climatic index gives an indication of the biomass accumulating capacity on the ground. However it needs, along with average monthly precipitation and temperature, the average maximum and minimum temperatures, mean hours of daylight during the growing season and average annual humidity. Since getting all these parameters for a large number of tropical stations is difficult, a modified climatic index was derived using only monthly precipitation and temperature data. Annual precipitation was multiplied by the number of growing months and divided by the average maximum temperature of the warmest month of the growing season. This index has very high correlation with the original Weck's index. The index was calculated for 435 stations in tropical South America and interpolated into a raster map using regularized thin plate spline with tension. The map of climatic index was compared with an overall integrated global vegetation index (GVI) map (the average monthly GVI from January to December). All regions that showed significantly lower GVI for high values of the index were hypothesized to have undergone deforestation and degradation. Also the first principal component of 12 monthly GVI has been known to be correlated with the aseasonal characteristic of vegetation and the second principal component with the seasonal characteristic. These were compared to the climatic index and seasonality map and statistics derived to test the validity of the hypothesis. (Poster)

H. Ronald Pulliam, Institute of Ecology, University of Georgia, Athens, Georgia 30602. **MAP: Modeling animal populations on changing landscapes.**

Most animal populations live in changing landscapes. An individual may itself move through a mosiac of habitat types and a landscape may change around an individual during the course of a single lifetime. Furthermore, birth and death rates differ between habitats and the dynamics of an animal species depends critically on characteristics of the landscape. Although these points may seem obvious, it has been only in the past 5-10 years that animal ecologists have begun to incorporate landscape change into models of animal population dynamics.

MAP models, or models of Mobile Animal Populations, represent one recent attempt to deal with the complexities of animal population dynamics in changing landscapes. Current MAP models simulate long-term land use change, population trends and patterns of biological diversity on landscapes of up to 10^4 ha. MAP models can incorporate information about past land-use patterns and management practices and can project future patterns based on management plans. I shall illustrate this approach with an example of how implementation of a Forest Service Management Plan at the Savannah River Site in South Carolina might influence population trends of the Bachman's Sparrow (Aimophila aestivalis), a species of management concern.

MAP models can also incorporate economic variables and be used to illustrate the potential tradeoffs between biodiversity and economic goals. By incorporating tree growth and yield, timber harvest and economic variables, MAP models have been used to predict the net income, net present value and land expectation value associated with a forest management plan. In the future, MAP models may provide land managers an important new tool for seeing the consequences of management decisions and, thereby, contribute to more holistic landscape management. (Plenary, 8:30 Thursday)

Pye, John[1], Karen Lee[1] and Ray Sheffield[2], [1]Southeastern Forest Experiment Station, Research Triangle Park, NC 27709, and [2]Southeastern Forest Experiment Station, Asheville, NC 28802. **Effects of population on within-forest patch size in landscapes of the Southeastern US.**

This study investigates processes underlying changes in the scale of patches (stands) within the highly modified forests of the Southeastern US. Because stand borders reflect the finer-scaled afforestation and disturbance processes by which forests are created and altered, they should be more directly related to processes driving fragmentation and better describe its effects on species with particularly narrow habitat requirements. The study tests the hypothesis that the impact of rising human population on the spatial structure of forests can be adequately described by simple removal of the patches (stands) of which forests are comprised. If stands are removed in their entirety and removed (or created) without bias to their size then forests would be comprised of stands of similar size regardless of forested cover or population. Stand size data from approximately 25,000 forested locations across the Southeastern US and from two points in time (approx. 1980 and 1987) were compared with stand characteristics and ownership and county-level measures of land use, physiographic region and population. The analyses do not support the hypothesis. Higher populations and lower forest cover are associated with smaller stand sizes,

indicating that 1) larger stands are preferentially lost to deforestation, 2) stands themselves are fragmented, or 3) new stands are smaller than existing ones. While urbanization is associated with smaller stand sizes, so too is farming. Farmer-owned stands were the smallest of the five ownership groups. These data suggest that continuing population increases in the region should result in forests comprised of finer grained patches than in the past. However, shifts of land from farming to industrial forestry would likely produce opposite results. (Poster)

Pyle, Charlotte, and Jerry F. Franklin, University of Washington, Seattle, WA 98195.
Development of a research agenda to study the function of the landscape matrix in forested landscapes.

Using landscape ecology theory, we address the questions of where (spatially) and when (temporally) the long-term functioning of landscapes with many seral stages of forest is most significantly affected by matrix-mediated processes. We outline methods for acquiring broad scale and fine scale experimental field data and the expected time frames for various types of results. Through a large areal extent or through juxtaposition with many landscape elements, the matrix may control the movement of energy, materials, and biota across the landscape by functioning as a connector/barrier or as a source/sink. Identifying the patch type which constitutes the matrix is the first step in understanding matrix function in the landscape. As with the delineation of patches and pattern in the landscape, the delineation of the landscape matrix is contingent upon the focus of the investigator. The outcome of matrix-mediated processes includes both broad scale effects (dictated by the position of a homogeneous matrix in the overall landscape pattern) and the sum of fine scale effects (i.e., the consequences of various boundary interactions of the matrix and adjacent patches). Underlying and preliminary to our development of a research agenda for study of matrix function was the recognition of both the ambiguity inherent in identifying the landscape matrix and the existence of multiple scales in landscape functioning. (Oral, IX, 4:15 Friday)

Qi, Ye, State University of N.Y. College of Environmental Science and Forestry, Syracuse, NY 13210. **Effect of spatial scaling and partitioning on spatial autocorrelation analysis.**

Spatial autocorrelation analysis is important to the study of landscape ecology because it is commonly found in landscapes. The existence of autocorrelation can lead to significant errors and misleading conclusions when it is not well considered in conventional statistical analyses. Several approaches have been developed for analyzing spatial autocorrelation. However, the effect of spatial partitioning and scaling has not been well discussed in the literature of spatial statistics. As more and more scientists become interested in using satellite data, the problem of spatial partitioning and scaling will become more evident. Satellite images are captured in different scales and can be processed in different partitioning methods, which may affect the analysis of the spatial autocorrelation. In this study, I analyzed Moran Coefficient (MC), Gear Ratio (GR), and Jacobian Term using different spatial statistics models and the vegetation data of Peninsular Malaysia. I aggregated the data to obtain some levels of scaling and ways of partitioning. I

compared the results and found that some indices such as MC and GR are sensitive to spatial scaling and partitioning, while others are not. (Oral, VIII, 10:00 Friday)

Ravenscroft, W.D. and Charles A.S. Hall, State University of N.Y. College of Environmental Science and Forestry, Syracuse, NY 13210. **The use of models to incorporate spatial and non-spatial data to simulate global land-use change.**

The world is awash in digital data which is of great importance for increasing our understanding of the conditions of our planet, but much of this data is scattered and hard to access and use. There has been little systematic synthesis and cross disciplinary analysis of many social, geographic, satellite and model-derived data. Yet combining land use, demographic and social data can be used for the purposes of assessing and understanding the human motivations that lead to changes in land use, population growth, resource depletion, soil erosion, etc., and all of these issues interact with issues related to potential climate change. Our models also allow us to project trends both backwards and forwards in time to recreate possible historic patterns and to look at possible future scenarios. In our modeling process we are using our evolving computer models to synthesize and display both spatial and non-spatial data such as: 1. physical data sets, derived with colleagues, such as satellite imagery, historical land use, and tropical forest biomass inventories; 2. digital maps of elevation, slope, aspect, vegetation cover, forest type, climate, etc.; 3. currently available digital agricultural, economic, energy, and demographic data sets. Results from our model using maps and data of Costa Rica show that large and differing data sets can be combined in a way that even nonprofessionals can readily understand. (Poster)

Remillard, Marguerite[1], James Saveland[2], and Roy Welch[1], [1] Center for Remote Sensing and Mapping Science, University of Georgia, Athens, GA 30602 and [2]U.S. Forest Service, Southern Forest Laboratory, Dry Branch, GA 31020. **Landscape analysis of fuel hazard for Yellowstone National Park.**

The Center for Remote Sensing and Mapping Science (CRMS) at the University of Georgia and the U.S. Forest Service (USFS) Southern Forest Laboratory have utilized remote sensing and geographic information system (GIS) technologies to assess landscape structure related to fuel conditions within a portion of Yellowstone National Park. Selected data layers (e.g., land use, vegetation cover, hydrography, topography, transportation and park boundaries) from the National Park Service GIS database of Yellowstone were input to ARC/INFO and GIS analyses performed to rank areas of relative fuel hazard before and after 1988 fires. These fuel hazard data sets were then transferred to the Desktop Mapping System (DMS) software package and draped over digital elevation models (DEMs) of Yellowstone to create 3-D perspective views. Such views permitted assessments of fuel conditions in relation to topography, cultural features and transportation routes. A combination of ARC/INFO-DMS analysis procedures and customized computer programming also were employed to calculate landscape indices such as contrast, porosity, grain size, mesh size, patch shape and network connectivity for pre- and

post-fire conditions. This information is being used by the USFS to investigate the impact of fire disturbance and fuel treatment on landscape structure. (Poster)

Renwick, William H, Miami University, Oxford, OH. **Diversity of temporal behavior patterns within geomorphic landscapes.**

Geomorphic landscapes consist of landforms interconnected through process-regulating elements such as slope steepness, and exchanges of sediment and water. Landforms in a 38 km^2 area in southwestern Ohio were analyzed with respect to the degree to which they are controlled by past events or present environmental conditions. The study area landscape has been heavily disturbed by 19th-century forest clearance, agriculturally-accelerated erosion, and subsequent reforestation. Among the more significant features of this landscape today are: 1) meso-scale topography and drainage networks that reflect local geologic and hydrologic conditions; 2) relict erosional and vegetation features, most of which were created between 200 and 50 years ago; and 3) modern gully systems that appear to behave in an inherently unstable fashion not directly related to either past or present environmental controls. These three examples are characterized as equilibrium, disequilibrium, and nonequilibrium landforms, respectively. Landscapes are viewed as mosaics of interacting landforms with different temporal behavior patterns, including equilibrium, disequilibrium, and nonequilibrium behaviors. Temporal variability of process and form in the landscape has complex origins that confound historical interpretation and prediction of future conditions. (Oral, IV, 3:15 Wednesday)

Ribic, Christine[1], Lisa Ganio[2], and Richard Warner[3], [1]U.S. EPA Environmental Research Laboratory, Corvallis, OR 97333, [2]ManTech Environmental Technology Incorporated, Corvallis, OR 97333, and [3]Illinois Natural History Survey, Champaign, IL 61820. **A preliminary ecological assessment model for agriculture.**

The effects of changing agricultural practices on terrestrial wildlife are difficult to predict on a landscape scale. We are developing an index, the Ecological Assessment Model for Agriculture (EAMA), to investigate the effects of farming practices on upland wildlife for large spatial scales. The EAMA has 3 components: Wildlife Resources, Soil Resources, and Farm Disturbances. Each component is comprised of county level variables derived from agricultural censuses and other widely available sources of information. For example, the Farm Disturbances component, standardized for land area in each county, includes the amounts of fertilizer, herbicides, and insecticides applied, and livestock (cattle and hogs) produced. Results of the EAMA are presented for Illinois and Iowa for 1964 and 1987. These results include: (1) inter-relationships of various components and sub-components that comprise the EAMA index; (2) temporal and regional patterns in the index; and (3) comparisons of the EAMA index with trends in upland wildlife abundance and habitat quality documented by long-term studies in Illinois. (Oral, IX, 3:15 Friday)

Rich, Paul M.[1], Fairley J. Barnes[2], and Kevin P. Price[1], [1]University of Kansas, Lawrence, KS 66045 and [2]Los Alamos National Laboratory, Los Alamos, NM 87545. **Spatial patterns of canopy architecture in pinyon-juniper woodlands: inferences from stand allometry and remote sensing.**

Pinyon-juniper (PJ) woodlands tend to display heterogeneous spatial patterns, with clumps of shrubs and small trees surrounded by openings. Canopy architecture, in this case referring to the three-dimensional arrangement of aboveground vegetation elements, was reconstructed in a GIS modelling environment (ARC/INFO and GRID) from stand allometry (relations between stem diameter, height, and crown dimensions) for a mapped PJ site at the Los Alamos National Environmental Research Park in New Mexico. Results of this three-dimensional reconstruction were compared to measurements from ortho- and stereoimagery produced from low altitude overflights. Spatial patterns for the mapped plot were also compared to patterns in other stands along an elevational gradient. Finally, the GIS-based solar radiation flux model SOLARFLUX was used to examine shadow patterns based on the canopy surface topography. Estimates of clump and individual crown dimensions based on allometry generally agreed with measurements from aerial imagery. With increasing elevation, clump size and height tended to increase, space between clumps decreased, and species mix shifted from dominance by junipers to dominance by pinyons. Canopy architecture could be predicted from the distribution and size of shadows at spatial scales comparable to the dimensions of individual crowns, given knowledge of the solar angle. One important implication of this finding is that three-dimensional geometry of plant canopies may be inferred from shadow patterns in remote sensing imagery if analyzed at appropriate spatial scales. (Oral, VIII, 10:45 Friday)

Richardson, J.R. and J.E. Silveira, Dept. of Wildlife and Range Sciences, University of Florida, Gainesville, FL 32611. **Spatial complexity and energetics in the northern Everglades.**

The vegetation communities in the northern Everglades (at the Arthur R. Marshall Loxahatchee National Wildlife Refuge) are a spatially complex mix of tree islands, sawgrass ridges, wet prairies, sloughs and invading species (cattail). The patterns found in the Everglades appear to follow flows of water through the system. Other forces influencing patterns are fires and long period catastrophic events. SPOT satellite data transformed to 10 meter resolution was classified to generate a vegetation map. This map was analyzed using GIS techniques to interpret spatial hierarchies and organization of the complex landscape. Nearest neighbor analysis provided information on vegetation spatial relationships. Size classes were determined for various vegetation communities at a 10 meter and 40 meter pixel size. In a system with energy inflows that are constant over space, the size classes of some of the vegetation communities may be related to the "EMERGY" of the individual objects. (Oral, V, 11:45 Thursday)

Robbins, Bradley D. and Susan S. Bell, University of South Florida, Department of Biology, Tampa, FL 33620-5150. **Marine landscapes: a new perspective on terrestrially based conceptualization and methodology.**

Extensive marine landscapes are formed intertidally and subtidally by patches of vegetation within a mosaic of soft sediment or hard bottoms. While the application of techniques for landscape quantification has been widely utilized in terrestrial systems, applying these methodologies in marine systems is problematic. Unlike their terrestrial counterparts, marine systems are greatly influenced by the fluid medium in which they exist. For example, the temporal scale of response to a disturbance event in a marine landscape may be markedly slower then that of a terrestrial landscape due to the buffering capabilities of the water. However, the water may also act as a mechanism of disturbance. Marine landscapes are typically much smaller spatially due to depth and tidal flux. These constraints also influence the landscape's interior (e.g. patch size, shape, and arrangement). Nutrient availability, reproductive cycles, and dispersal capabilities can be closely linked to the movement of water. Landscape measurements are logistically restricted by tidal flux, water clarity, depth, and other constraints. Using an example from the shallow subtidal seagrass meadows of Florida's Gulf Coast, we present information that size and arrangment of patches as well as the percolation of disturbance events through beds of the seagrass *Halodule wrightii* vary with hydrodynamic energy regime of a given site. Faunal responses to landscape features also appear to vary with energy regime. These findings suggest that new approaches beyond those emerging from terrestrially-based studies may be required in vegetated habitats within marine subtidal landscapes. (Oral, V, 9:45 Thursday)

Rudis, Victor A., USDA Forest Service, Southern Forest Experiment Station, Starkville, MS 39759. **Distribution of forest fragmentation among South Central United States forested wetland habitats.**

Historically, there has been a large-scale decline in Southern U.S. forested wetlands that has slowed in recent years. How has this affected the distribution of remaining forest community types? Data from a broad-scale survey of forested wetlands in the South Central United States (Alabama, Arkansas, Louisiana, Mississippi, east Oklahoma, Tennessee, and east Texas) are used to assess patterns in vegetation and land use along a continuum of forest tract sizes. A comparison of interior canopy forest tree species indicates the more fragmented tracts have significantly fewer baldcypress (*Taxodium sp.*), overcup oak (*Quercus lyrata*), and other species typical of bottomland habitats with prolonged inundation. Winged elm (*Ulmus alata*), water oak (*Quercus nigra*) and other species typical of drier bottomland habitats are more frequent in stands with smaller tract sizes. Two alternate hypotheses reflected by the data are: (1) drier bottomlands are more prone to fragmentation than wetter bottomlands, and (2) wetter bottomlands become drier when fragmented. Stands part of larger tracts are older and contain a higher stocking of growing-stock trees, on average, than those associated with smaller tracts. Stands part of smaller tracts are greater among individual owners, rather than public, forest industry, and other corporate owners. Increasing fragmentation is associated with increased frequency of livestock use, fences, human access, and trash dumping. Increasing fragmentation also is associated with

reduced frequency of Spanish moss (*Tillandsia sp.*), black bear (*Ursus americanus*) habitat potential, and opportunities for primitive-oriented recreation. Regional differences across the Interior Highlands, Coastal Plain, and Mississippi Valley note recent changes in area and relative vulnerability to increasing fragmentation. Results indicate priorities for investigating ecological processes and management practices that retain multiple values for remaining stands. (Oral, VI, 11:30 Thursday)

Rykiel, Edward J., Jr., William C. Forsythe, W. Michael Childress, and Bai-lian Li, Texas A&M University, College Station, TX 77843. **Enormous increases in numbers of state transitions with neighborhood size.**

We examined the consequences of including neighborhood interactions in a Markov model of cluster phase vegetation dynamics in south Texas. This model specifies the transition probabilities for seven vegetation states under two moisture regimes by observing the state transitions of 20m x 20m cells in aerial photography. State transitions in a Markov model do not depend on the local neighborhood and may be considered a zero'th order model in that sense. Based on a cellular automata approach, we determined the state transitions for two second order (i.e., 2-dimensional) systems, a five cell von Neuman neighborhood and a nine cell Moore neighborhood. When neighborhood configuration is considered, the number of transition possibilities increases from 49 (1 cell) to 117,649 (5 cell) to over 282 million (9 cell). Most of the transitions are not observed in the data set. This power function effect has profound implications for data collection, sampling, modelling, and interpretation of landscape patterns. (Oral, VIII, 11:15 Friday)

Salwasser, Hal, School of Forestry, The University of Montana, Missoula, MT 59812-1063. **Landscapes as the integrating unit of ecosystem management.**

Ecosystem management has evolved during the past decade to provide a more holistic context for traditional approaches to forestry, wildlife, recreation, rangeland, fisheries, and water resources. It strives to bring a better balance to the constant challenge of producing the things human cultures need with sustaining diverse, resilient, and productive land, what might be commonly thought of as healthy land.

The task of blending people's needs with long-term land health cannot be performed on every site at all times. Some sites must be dedicated to a subset of overall goals at any point in time. For example a forest patch cannot simultaneously be habitat for all 200 vertebrate species that could potentially occupy it over the course of 200 years of successional development. Nor can a forest site yield high volumes of wood at the same time it serves people as a spiritual retreat. A geographic scale larger than patches is needed so that overall economic, social, and environmental goals can be met with reasonable tradeoffs among them. This larger scale is what we call watersheds or landscapes.

At landscape scales, human communities and their economies and lifestyles are integral parts of ecosystems. Therefore, ecosystem management forces an integration of biological,

physical, social, and economic sciences that has heretofore not been required of foresters or wildlife managers. Managing landscape ecoystems to restore, sustain, or enhance desired conditions of our communities, economies, and the land is key to the notion of sustainable development. It will lead to the emergence of synthesis disciplines that address complexity, uncertainty, and risk at multiple spatial and temporal scales as the context for application of traditional disciplines that have focused on single resources. Landscapes are the fundamental unit of ecosystem management much as patches have been the fundamental unit to forestry and wildlife habitat management and as industries and communities have been the unit for economics and sociology. (Banquet Address, 7:00 Thursday)

Savisky, Timothy, University of Georgia, Athens, GA 30605. **An analysis of landscape change in the Georgia Piedmont, USA.**

Land use of a 22,000 hectare portion of Madison County, a typical rural piedmont county in Georgia, was digitized using black and white aerial photos from 1955 and 1988. Other landscape features, such as soil, topography, and roads, were digitized as well. Land use changes, and the relationship between landscape features and land use change, were analyzed using a GIS and the statistical procedure logistic regression. Several computer simulations that used a one hectare grid size were developed and compared that modeled the pattern in land use change, including: a) random simulation; b) nearest neighbor simualtion; and c) landscape feature simulation. In addition, land owners in the county were surveyed using a questionnaire, so that factors influencing their future use of the land could be discerned. This information was statistically analyzed and used to develop a simulation model that used the size of actual land parcels as the basic unit, instead of the one hectare size of the previous models. (Poster)

Schulz, Terri T. and Linda A. Joyce, USFS, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO 80526, USA. **Landscape patterns and environmental variables in the Black Hills National Forest.**

The relationship between landscape patterns and environmental variables within the Norbeck Wildlife Preserve and the Black Elk Wilderness Area was compared to surrounding intensively managed areas of the Black Hills National Forest, South Dakota. The Preserve has been managed for wildlife habitat with disturbances mainly fire. The surrounding forest has been intensively managed with disturbances mainly timber harvesting (shelterwood method) and a few fires. The entire area has been subjected to extensive fire suppression efforts. Data used in this study included Black Hills National Forest vegetation patch information, the Soil Conservation Service soil classifications, and USGS elevation. Landscape characteristics of vegetation patch size, perimeter and shape were correlated separately with environmental variables and vegetation types using a decision tree analysis. Approximately 20 percent of the variability in patch size, perimeter and shape was explained by these analyses. The most important environmental variable in most decision trees was the standard deviation of elevation within a patch. The decision trees created

for the surrounding managed lands tended to be more highly branched than the trees created for the Norbeck Wildlife Preserve. Elevation variability was more influential within the Norbeck Wildlife Preserve than on the surrounding forest landscape. Vegetation type and age class were also classified within these two areas using environmental variables and landscape patterns in a decision tree analyses. The decision trees created for the Norbeck Wildlife Preserve contained only environmental variables, while landscape parameters as well as environmental variables were components of the decision trees for the surrounding managed lands. (Poster)

Schwalbach, Monica[1], Tom Crow[2], Eric Gustafson[3], and Ted Marine[1], [1]Wayne-Hoosier National Forest, Bedford, IN, [2]North Central Forest Experiment Station, Rhinelander, WI, [3]North Central Forest Experiment Station, Purdue Univ., IN. **Landscape pattern-implications for management of neotropical migrant birds and forest openings, Hoosier National Forest, Indiana.**

Management of openings on public lands is receiving increased scrutiny as concerns about forest fragmentation and conservation of biological diversity escalate. Of particular interest is the effect of openings on habitat integrity for area or edge sensitive neotropical migrant birds. Traditional National Forest management emphasized local diversity by maintaining openings throughout a management unit. Such openings were generally located opportunistically; careful consideration of landscape pattern and resource needs of the range of plant and animal species was often lacking. Access to satellite imagery data and spatial analysis tools provide the ability to integrate knowledge of landscape pattern into openings management designs. Combined with knowledge of landscape-level habitat relationships of forest birds, we can make more informed decisions on openings management strategies. We compare landscapes resulting from the traditional vs. designed approaches for a management unit on Hoosier National Forest. Implications of these two approaches are discussed. (Poster).

Schwartz, Mark W., Illinois Natural History Survey. Champaign, IL 61820. **Modelling the effects of habitat fragmentation on the ability of trees to respond to climatic warming.**

The ability of trees to migrate in response to climatic warming was simulated under various conditions of habitat availability. The model uses Holocene tree migration rates to approximate maximum migration rates in a forested landscape. Habitat availability and local population size was varied systematically under two dispersal and colonization models. These dispersal models varied in the likelihood of long-distance dispersal events. The first model used a negative exponential function that severely limited the probability of long-distance dispersal. The results of this model indicate that migration rate could decline an order of magnitude where the habitat availability is reduced from 80 to 20 percent of the landscape. The second model, using an inverse power function, carried a higher probability of long-distance dispersal events. The results from this model predict relatively small declines in migration rates when habitat availability is reduced to 50% of the simulation matrix. Below 50% habitat availability, mean migration rate was similar to the negative exponential model. These results predict a failure of many trees to respond

to future climatic change through range expansion. A further implication of this model is that future migrations are likely to be channeled through regions where habitat availability remains high on the modern landscape. (Oral, II, 10:00 Wednesday)

Sessa, Andrea and Jeff Lakey, Colorado State University, Fort Collins, CO 80523. **Interpretation of similarities between Aboriginal and Euro-American settlement patterns in Central Oregon.**

Human life is enriched when people are given an opportunity to understand the universal nature of human and landscape interactions across cultures. Natural systems and processes create landscape settings that may result in recurring settlement patterns and processes between occupations of the same landscape by very different cultures through time. Recurrent themes in the use of the landscape have been detected between aboriginal and Euro-American occupations in Central Oregon, and in the case of this project, demonstrated for public appreciation through an urban landscape design project in Bend, Oregon.

A landscape design project is ordinarily demanded by public needs beyond scientific hypothesis. In this case, the needs pertained to: providing better physical accessibility to amenity qualities of the Deschutes River; providing a more spiritually uplifting yet culturally well-rooted and uniquely identifiable focal setting for urban enterprise and festivities; and providing restoration of degraded plant and animal habitats adjacent to the river. However, the hypothesis served as a vehicle to unify the spatial and spiritual qualities of the design of a new urban site in downtown Bend.

The actual project includes restoration of native riverbank and upland vegetation typical of the Deschutes River ecosystems. Restoration is accomplished with installation of landscape tiles (sods) imported from local donor sites of appropriate physiography, species composition, and species diversity for the installation site intended. Cultural interpretation is accomplished with a native tribal council ring, a settler's cabin restored as an information center, a ceremonial garden of native plants important to aboriginals, sculptures of coyotes as tribal mythical figures, and a native tribal family in a summer camp. Wholeness and integration is achieved through the arrangement of major patterns of native vegetation including ponderosa pine, cottonwood, hydric and xeric grasses, and flowering plants. Lastly, a trail along the river mimics those of earlier times that provided access to water and regional trading routes for the aboriginals and Euro-Americans alike. (Poster)

Shao, Guofan[1], Hank Shugart[1], John Porter[1], and Don Young[2], [1]Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903 and [2]Department of Biology, Virginia Commonwealth University, Richmond, VA 23284. **Distribution patterns and water relations for shrub thickets on Hog Barrier Island of Virginia.**

Shrub thickets represent a major vegetation type on barrier islands. The dominant species is often Myrica cerifera. Interpretations of aerial photographs from 1949, 1962, 1974, and 1989 indicated that the shrub thicket on Hog Island has been rapidly spreading toward the oceanside.

But most of shrub thickets are restricted to the lowlying swales among sand dunes, forming many ring-like distribution patterns. The preference for the relatively mesic swales may be related to a sensitivity to moisture stress.

In order to evaluate the effects of moisture stress on the distribution of M. cerifera, a water relation model, MCHOG, was developed. The model consists of three sub-models: transpiration (Penman-monteith equation), root zone water balance, and water table dynamics (Darcy's law). The environmental data from one year records of precipitation, relative humidity, wind speed, solar radiation, and air temperature, collected on Hog Island in 1991, were used with an hourly time step to simulate thicket response on a cross island transect.

We defined the transpiration pattern under sufficient soil moisture as the optimum transpiration pattern. Moisture stress was then expressed numerically as the number of growing-season days on which the ratio of daily transpiration to the optimum transpiration rate was less than a critical value (1/5). Simulations were conducted for shrub thickets at relative elevations of 60, 70, and 90 cm. Although the difference in elevation between these sites was less than 30 cm, the simulated transpiration pattern differed considerably. The water deficits were 0, 24, and 34 days, respectively from the lowest to the highest site. Comparing the dynamic processes of soil water content and water table height between the lowest and highest site, the difference in soil water content was greater than that in water table height. Thus, elevationally related capillary rise from groundwater must play an important role in determining shrub distribution patterns. Further, competition may exist for ground water resources among individuals of shrub thickets and between shrubs and associated grasses. (Poster)

Sherman, Benjamin H., University of Wisconsin-Madison, Land Resources Management Program, 322 Birge Hall, Campus Mail, UW-Madison, 53706. **Theory and method for landscape ecological assessment monitoring and management of multijurisdictional regions.**

Presented is an intellectual framework which integrates contemporary theories in ecology, economics, history, geography, and regional planning thereby making them functionally compatible. Stressed are the complexities involved in creating a management regime for natural and cultural resources which are defined by continuing interaction between humans, their managed lands, and environmental constraints. A framework has been created to inventory, assess, and monitor managed systems by applying transdisciplinary methods to a common and distinct spatial region. Such regions transcend the traditional jurisdictional boundaries of management units. Characteristic homogeneity and heterogeneity within these regional systems is established by correlating filtered remote sensing, ecotones, and amalgamated ecoregions. Management methods are assessed using multivariate data reduction employing neural networks. Comparative analysis of methods prioritizes management in defferrence to weighting of environmental constraints and provides flexible region-specific formula for management which considers multivalue committments. Management structure and administration are reconceptualized in terms of regional process and function. Monitoring and assessment protocols are developed to measure variability and change within these distinct regions. It is hoped that resource managers will be able to use this theoretical framework to broaden their definition of structure and function to better understand and predict change. (Poster)

Skage, Olav, Karin Hall-Konyves, and Berggren-Barring, Ann-Margreth, Swedish University of Agricultural Sciences, Dept. of Landscape Planning, Box 58, 230 53 Alnarp, Sweden. **Remotely sensed data for analyses of patterns and processes in Swedish landscapes.**

The landscape transformation during the last decades, and consequential loss of biodiversity and visual qualities, has been controversial. Future change is likely to be equally drastic and controversial owing to parliamentary resolutions and decreased production subsidies. Swedish farmers will reduce their agriculture production. Extensive structural changes are thus in progress in the agricultural landscape. Methods are therefore acutely needed to follow the landscape transformation, thus providing the necessary information for landscape planning in order to maintain biodiversity and recreational values. Current landscape and conservation planning has taken little account of landscape geometry and island theory. These factors are intimately connected to the possibility of biota to grow, feed, spread and migrate as well as affecting the risk of random extinction. The aim of this study is to evaluate the potential of remotely sensed data for analyses of patterns and processes in Swedish landscapes. A parallel aim is to derive parameters to be used in ecological assessments on different planning levels. As some of the more specific information needed is unlikely to be provided directly by remote sensing data the prospective usefulness of the derived parameters as proxy data is of interest. Landsat TM-data, SPOT-data and aerial photography has been used to measure "mean view length", "shape complexity","area to perimeter ratio", "fractal area dimensions" and patchiness at different scales. The parameters derived from remotely sensed data show greater potential for landscape ecological studies than common landscape statistics (land use mapping etc). (Poster)

Smith, Christopher[1] and Peter August[2], [1]Computer Sciences Corporation, EPA Environmental Research Lab, Narragansett, RI 02882 and [2]University of Rhode Island, Kingston, RI 02881. **A statistical characterization of landscape edges in Rhode Island.**

The boundaries between adjacent landscapes are of interest to conservation biologists and land managers because of their influence on biotic diversity and habitat fragmentation. Edge characteristics such as length and sinuosity play an important role in determining the level of "edge effect" associated with a habitat. However, few studies have treated landscape edges as discrete entities and quantitatively examined them for spatial characteristics. The purpose of our study is to characterize edge habitats on the Rhode Island landscape. We are particularly interested in the relationship between edge orientation and sinuosity in human disturbed and natural landscapes. Our baseline data set for the study is a land cover database derived from 1988 aerial photography of the state (276,230 hectares). The data set consists of 9,600 polygons among 37 land use categories (Anderson level III detail) mapped at a spatial resolution of 0.2 ha. The Rhode Island landscape is a complex mosaic of relatively natural land covers (forests, wetlands, old fields; 60% of RI), developed lands (urban, residential, commercial/industrial; 25% of RI) and farms (7% of the state). From this data set we randomly selected 30 study sites, each 3 square km in area. The edges occurring within these areas were examined for structural characteristics such as length, shape, and orientation. Preliminary results suggest human disturbed landscapes have small patch sizes and short, rectilinear edges. Natural landscapes tend to occur in larger patches

and have elongated, complex edges. Boundaries between disturbed and natural lands tend to have edges of intermediate complexity. (Oral, VIII, 10:30 Friday)

Strebel, Donald E., Jingyee Kou, and Paul F. Kazyak, Versar, Inc., 9200 Rumsey Rd., Columbia, MD 21045. **Relationship between landuse patterns determined by remote sensing and watershed biotic indices.**

Landsat imagery was used to derive a quantitative measure of landuse patterns in a watershed undergoing restoration. This information was combined with digitized watershed boundary information and biotic index scores to evaluate the relation of stream community structure to increases in impervious surface area associated with development in the Gwynns Falls, MD watershed. This watershed system ranges in quality from reaches supportive of trout reproduction to reaches severely impacted by urbanization. A focal point of the restoration effort is identifying factors impacting the watershed biota, such as the altered hydrological conditions that result from the introduction of impervious surfaces (roads, parking lots, etc.) into the landscape.

Fishery and benthic macroinvertebrate biotic index scores for 21 stations were statistically compared with percentages of impervious surface area and other landuse classifications derived from a Landsat-based Normalized Difference Vegetation Index (NDVI) for the drainage above each sampling station. A significant correlation between fish IBI (Index of Biotic Integrity) scores and the percentage of impervious surface was observed, indicating that altered runoff patterns and nonpoint source pollutants associated with impervious surface are important factors in shaping stream fish community structure. The analysis also suggests that factors beyond imperviousness are important factors impacting fishery resources and that combining fish IBI and benthic biotic index scores improves assessment accuracy.

These results indicate that remote sensing can play an important role in identifying quantitative links between landscape patterns and ecological community structure on a watershed scale. These links can provide the basis for improved monitoring and modeling of such systems and better informed and more effective restoration efforts. (Oral, X, 3:30 Friday)

Strieby, Sandra and Richard Rawlings, Mail Stop JO-34, University of Washington, Seattle, WA 98195. **Modeling landscape patterns related to stream health.**

Liberty Bay, located off the Kitsap Peninsula in Puget Sound, has for years housed a productive shellfishery, but was closed to shellfish harvest in 1988 because of high fecal coliform levels in the waters of the bay. Dogfish Creek drains into the bay and supports populations of anadromous fish. We are modeling the health of Dogfish Creek in order to form a basis for land use and development guidelines that will result in reduced pathogen levels in water reaching the bay, stable flow rates in the stream, and improved habitat quality in the stream corridor. The Dogfish Creek sub-basin is primarily rural; parts are urbanized, and development pressure is increasing as the Seattle metropolitan area grows. Runoff from livestock operations, stormwater runoff from urbanized areas, and failing septic systems have been identified as the main sources of

fecal coliform in the sub-basin. Changes in landscape patterns within the sub-basin are resulting in increased levels of sediments and other pollutants and degradation of structural components of habitat. We are modelling the relationship between existing ecological patterns within the Dogfish Creek sub-basin and water resource quality, defined as the sub-basin's ability to deliver a stable supply of pure water to the bay and to provide in-stream habitat support. Using aerial photographs, we will quantify those patterns over time and correlate them with changes in pollutant levels to develop thresholds beyond which change seems to cause degradation. We will also examine patterns over time to identify areas suitable for restoration and areas where changes in landscape patterns are likely to result in further damage to the health of the stream system. (Oral, V, 10:30 Thursday)

Strittholt, J.R., and Ralph E.J. Boerner, The Ohio State University, Columbus, OH 43210. **The use of large scale conservation gap analysis in nature reserve design.**

Conservation gap analysis has been promoted as a method of identifying deficiencies in current nature reserve systems using geographic information systems (GIS). By using the power of computer mapping technologies, gap analysis has been developed with promising results, particularly in the western U.S., where relatively small spatial scale are used. However, small-scale map analysis may be more useful in areas like the eastern U.S. landscapes. This paper examines the use of gap analysis at a 1:24,000 scale as part of a nature reserve design study for The Nature Conservancy (TNC) in an area called the Edge of Appalachia found in south-central Ohio. The Edge of Appalachia is noted for its unique assemblage of biological elements including numerous rare and endangered species. By combining Landsat TM imagery with elevation, slope, aspect, soil bedrock geology, and proximity to streams, a rule-based technique was developed to differentiate plant community types present in the 146 square mile study area. Once these community types were successfully mapped, an attempt was made to apply the technique to help predict the historical makeup for the same region before serious human disturbance. Once these two maps were completed, the information contained in each one was compared to the 10,000 acre preserve network currently owned and managed by TNC. The resulting comparisons identified important preservation deficiencies, or gaps, in the current preserve system. (Poster)

Sutherland, Elaine Kennedy, and Charles T. Scott, USDA Forest Service, Forestry Sciences Laboratory, 359 Main Road, Delaware, OH 43015. **A conceptual model for the U.S. Forest Service's Northern Global Change Program.**

The U.S. Forest Service's Northern Global Change Program (NGCP) is responsible for global change-related research in the Northeast and North Central states. The NGCP is charged with producing information for policy makers about potential forest change in the northern region of the US. This topic is broad and research is being performed by many individuals at several scales. Information expected from research efforts includes future environmental scenarios and expected changes in land use, species composition, forest productivity, and health. The conceptual model for the NGCP is designed to facilitate the exchange of information between

experimentalists and modelers. This model will also provide guidance to program management and individual researchers, and to the quality assurance/quality control and data management groups so that information needs are known and can be considered in the research and model design process. The conceptual model is structured as a series of interacting process models, with sets of state variables, processes, and outputs shown at five scales that increase space and time. These scales are: Organ/Tissue, Individual Plant, Community/Ecosystem, Landscape/Biome, and Globe. Atmospheric Processes and Land Use/Management are overall drivers to these models, acting on several scales simultaneously. Components of individual models are limited to the critical variables and processes that are necessary to fulfill program needs. Presently, specific variables and their units are being described so variables can be passed between scales, and so models at different scales can interface. (Oral, II, 11:45 Wednesday)

Swain, Hilary M.[1] and Vickie S. Larson[2], [1]Department of Biological Sciences, Florida Institute of Technology, 150 West Univ. Blvd., Melbourne, FL 32901 and [2]Bionetics Corporation, Mail Code BIO-2, Kennedy Space Center, FL 32899. **Optima for the rural landscape.**

There is growing acceptance that in order to assure the long-term continuance of many of our natural communities and the species that rely upon them we have to address protection of the rural landscape. The rural landscape is the matrix of natural communities, disturbed areas, and agricultural/silvicultural operations that exist outside the network of parks and protected areas. But what proportion of the rural landscape is potentially valuable for conservation? What is the spatial distribution of the components of the rural landscape? How do we determine goals and prioritiies for conservation action in the rural landscape? This paper presents a geographical information system (GIS) analysis of a rapidly developing landscape within the watershed of the Indian River Lagoon, East Central Florida. We characterize the rural landscape in terms of land covers that range from extraordinarily high value for conservation to very limited value for conservation. We investigate the trade-off, in terms of conservation value, between the increasing costs of protecting a greater proportion of the landscape versus the increasing benefits of larger fragment sizes and greater connectivity. The paper explores optima for the landscape (points representing the best possible compromise between costs and benefits) in relation to the conservation value of landscape components, their spatial distribution and degree of fragmentation, and the distribution of existing protected areas. These optima will be used to help define priorities for landscape conservation. (Oral, X, 2:45 Friday)

Thiele, Sandra[1], Philip Kaufmann[2], and Colleen Burch Johnson[1], [1]ManTech Environmental Technologies, Corvallis, OR 97333 and [2]Oregon State University, Corvallis, OR 97333. **Associations of lake biological assemblages to varying catchment disturbances.**

The Surface Waters component of the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP) is designed to use biological assemblages as indicators of the condition of lakes and streams. During the summer of 1991, EMAP-Surface Waters conducted a field pilot, part of which sampled 19 hand-selected lakes in New England for a collection of

aquatic and riparian indicators. One objective of the pilot was to examine the relationship between various biological assemblages and disturbances within the catchment. Landscape characterization was a prerequisite to the selection of reference and impaired lakes and to the identification of major human impacts. The lakes were selected along disturbance gradients representing residential, agricultural, timber harvest and fish stocking practices. In the analysis of the lake biological data from the pilot survey, landscape data at various scales, e.g., landuse/landcover, road density, and human population density, were used to explore associations between potential stressors and biological indicators. To date, we have found strong associations between riparian bird and fish assemblages and the gradient in shoreline and catchment disturbances. (Poster)

Thorne, Jim[1], Michael Jennings[2], Chuck Barscz[3] and Patricia Weber[3], [1]University of Pennsylvania, Philadelphia, PA 19104-6311, [2]U.S. Fish and Wildlife Service, Pocatello, ID 83209, and [3]The National Park Service, Philadelphia, PA 19003. **The use of National Wild and Scenic River Designation for landscape ecological planning.**

The designation of Wild and Scenic Rivers has taken place primarily in the western United States to protect half-mile wide river corridors which have been predominantly on federal land. The application of the National Wild and Scenic Rivers designation process to eastern US rivers faces an entirely different land ownership configuration; land is mostly privately held by a large number of owners. Since designation requires the approval of any relevant local governmental entities, the prospects for designation are much less favorable. To designate a reach of a river therefore, requires an extensive public participation process and incentives for consensus. Watershed areas have been targeted where political consensus can be achieved and where the resource base merits consideration under the Act. One such area is the White Clay Creek Watershed in southeastern Pennsylvania. Enabling legislation for this particular designation process was written so that not only would designation include the half-mile strip along the stream, but also any area of use within the watershed which would affect the integrity of the half-mile strip. In effect, this provision allows for comprehensive landscape ecological planning under the provisions of the Federal Wild and Scenic Rivers Act for the first time.

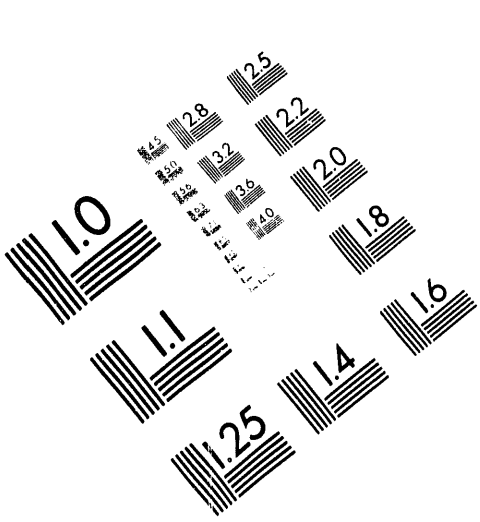
Based on resource inventories conducted in Fall 1992, we will identify critical landscape configuration needs for the conservation of breeding trout populations (the only ones in the metropolitan Philadelphia area), area-sensitive meadow birds, area-sensitive forest birds and the endangered bog turtle. In addition, we will show conflicts and concurrences between the need for wildlife habitat conservation and needs for aesthetic resource conservation. Zoning and incentive program mechanisms for conserving in-stream water quality as well as wildlife and aesthetic resources will also be presented. (Oral, V, 11:15 Thursday)

Tian, Hanqin, Charles A.S. Hall, and Ye Qi, State University of New York, Syracuse, NY 13210.
Responses of biosphere to changing global environments: A historic record of global biotic metabolism.

Some models of the global carbon cycle include fertilization effects that sequester carbon in terrestrial vegetation and so solve the "missing carbon" problem. In these models, increased atmospheric CO_2 stimulates photosynthesis, the so-called "Beta effect". To date, sufficient evidence does not exist to validate this hypothesis. Recently, the observed increase in the amplitude of the winter-summer difference in atmospheric CO_2 concentrations has been used to infer that the terrestrial biota is reacting to CO_2 enrichment. However, previous studies of this phenomenon did not consider seasonal variations in fossil fuel use, oceanic exchange and landuse change. Therefore, observed increases in amplitude are not necessarily due to increased biotic activity. On the other hand, it is difficult to infer biospheric respiration from atmospheric CO_2 data. In this paper, we derive a normalized CO_2 curve for yearly global biotic metabolism corrected for these additional factors. We also developed a model based on biotic metabolism to simulate ecosystem response to increased CO_2. By analyzing CO_2 data from several stations, we generated a historic record of global biotic metabolism over the recent past. After correcting for the additional factors, we found that both photosynthesis and respiration have increased since the early 1980's. This effect varies over time and space. Even though photosynthesis and respiration have changed, the ratio of photosynthesis to respiration has not changed significantly. We deduce therefore, that the Beta effect does exist, but it is being balanced by a "negative" Beta effect that the respiration of biosphere increases as the deterioration of global environment. This increase in global respiration itself might be caused also by increased CO_2. In any case, it seems that this "negative" Beta effect has been important for maintaining the stability of the biosphere in a changing global environment. (Oral, II, 11:15 Wednesday)

Tinker, Daniel B.[1], William H. Romme[1], and William W. Hargrove[2], [1]Fort Lewis College, Durango, CO 81301, and [2]Oak Ridge National Laboratory, Oak Ridge, TN 37831.
Landscape-scale heterogeneity in lodgepole pine serotiny.

A study of serotiny in lodgepole pine (*Pinus contorta* var. *latifolia*) was undertaken in 1992 in Yellowstone National Park. We asked two questions: (i) are there morphological characteristics that can be used to estimate the pre-fire percentage of serotinous trees in forests that burned in 1988; and (ii) at what spatial scale does the percentage of serotinous trees vary across the landscape? We first sampled cone characteristics in serotinous and non-serotinous trees along four 3-km transects in unburned forests. Results indicated that asymmetrical cones and an acute angle of cone attachment to the branch were reliable predictors of serotiny. We then sampled 9 patches of lodgepole forest which burned in 1988, and varied in size from 1-3600 hectares. We sampled serotiny at regular intervals along two perpendicular transects that crossed in the center of each patch. At each sample point, the 12 nearest trees were classified as serotinous or non-serotinous. The percentage of serotinous trees was found to be relatively homogeneous within each patch, but varied substantially among patches, with mean percentage of serotinous trees ranging from 0-73.5. We concluded that serotiny varies in a coarse-grained



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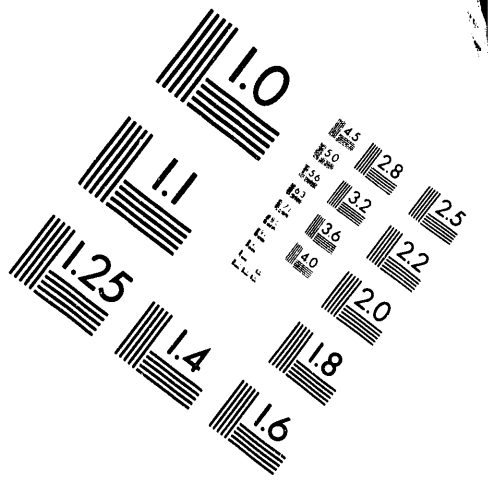

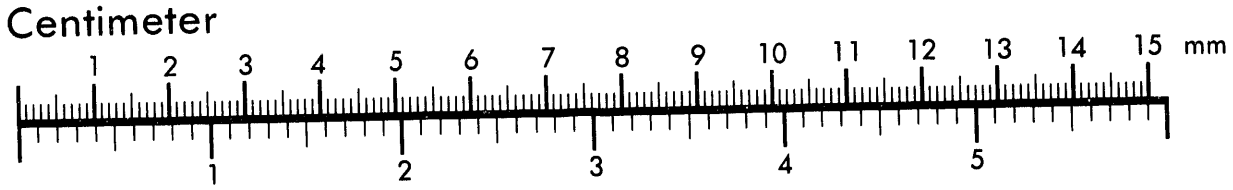

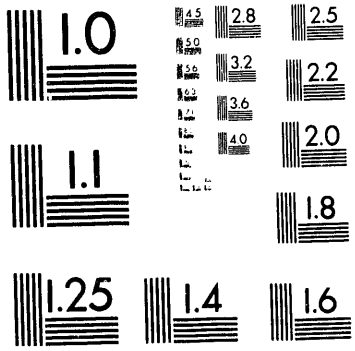

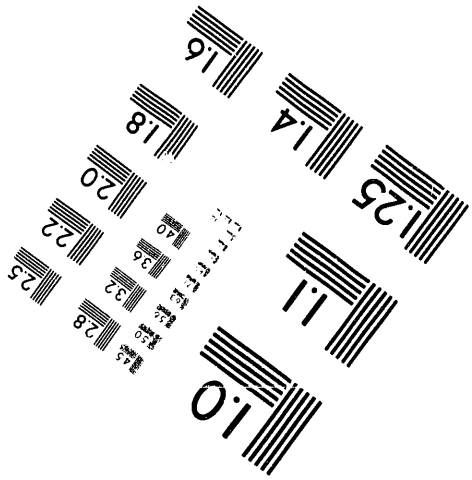

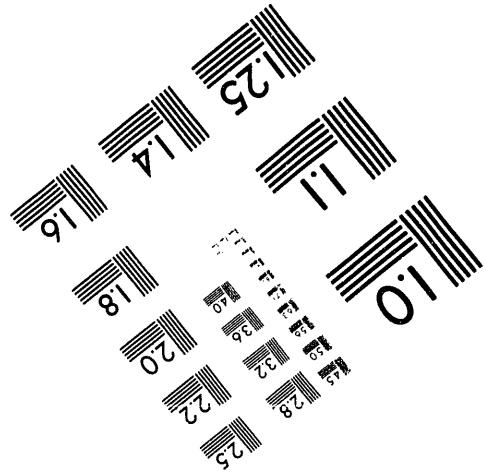

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pattern across the Yellowstone landscape, with more-or-less homogeneous patches extending over areas of square kilometers. This finding has important implications for landscape-level patterns in post-fire regeneration of lodgepole pine. (Oral, VI, 11:15 Thursday)

Turner, Monica G.[1], William H. Romme[2], Robert H. Gardner[1], and William W. Hargrove[1], [1]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6038 and [2]Biology Department, Fort Lewis College, Durango, CO 81301. **Spatial heterogeneity in plant reestablishment following large-scale fire in Yellowstone National Park, Wyoming.**

Spatial variation in the behavior and severity of the 1988 fires in Yellowstone National Park created a very heterogeneous landscape. We initiated studies in 1989 to explore how the post-fire heterogeneity generated by varying burn severities influenced plant reestablishment. At three sites, we sampled 100 points distributed regularly in a 1-km x 1-km grid. Information was recorded on fire severity (severity class, depth of ash, depth to which soil was charred, and percent mineral soil exposed); pre-fire forest structure (forest successional stage; tree density; tree species; tree size, measured by diameter at breast height; and evidence of pre-fire disturbance by mountain pine beetle and mistletoe); percent cover of graminoids, forbs, and low shrubs; dominant species; number of seedlings of lodgepole pine (*Pinus contorta* var. *latifolia*); number of individual resprouts and seedlings of dominant herbaceous species and shrubs; and general site characteristics (slope and aspect). Fire severity was not influenced by slope, aspect, or tree density. Fire severity was influenced by stand age, with older stands more likely to have burned, and by tree size, with larger trees being associated with more severe burns. Pre-fire bark beetle and mistletoe damage also influenced fire severity. Plant recovery varied with burn severity. In lightly burned areas, the percent cover of graminoids, forbs and shrubs returned to unburned levels by 1991. In severely burned areas, the percent cover of graminoids and forbs increased dramatically each year, but shrub cover increased very slowly. Total percent cover four years post-fire at the most severely burned areas was about half that of unburned sites. Recruitment of lodgepole pine seedlings was greatest during 1990 and in areas in or near a moderately severe burn. The number of forb seedlings (e.g., *Epilobium angustifolium*) was greatest in the most severely burned sites, whereas the number of resprouting individuals was greatest in lightly or moderately burned sites. Seedling recruitment also varied through time, e.g., there was a six-fold increase in seedling abundance between 1990 and 1991. The spatial and temporal heterogeneity of plant reestablishment in response to fire severity suggests that the long-term spatial dynamics of the vegetation in Yellowstone become established soon after fire. (Oral, VI, 10:45 Thursday)

Tyler, J.A. and K.A. Rose, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37830. **Individual-based model of fish growth, movement, and survival: fitness-based movement and its effect on population dynamics.**

Individuals move in a heterogeneous environment to maximize their fitness. Individual-based models (IBMs) that explicitly depict the spatial location of individuals have not

included movement rules that depend upon individuals' fitness. Here we developed an IBM for juvenile, planktivorous fish living in an environment with heterogeneously distributed fish predators and prey (zooplankton). The model includes size-dependent rules for individual mortality, foraging, and growth of the fish and follows individuals through a growing season. We depict the environment as a 10 x 10 grid with each cell measuring 100 m x 100 m with a 1 m depth. Individual fish depart a cell based on their ability to maximize their fitness in that cell. Individuals use one of three different currencies for measuring fitness: maximization of growth rate (g), minimization of mortality risk (f), and minimization of the mortality risk to foraging rate ratio (f/g). When moving to a new cell, fish randomly move to a neighboring cell. Results show that the fitness currency which individuals use, the amount and renewal rate of prey, and the degree of spatial correlation of predators and prey affect fish survival to the end of the growing season. When prey and predators are highly correlated, the minimize f/g departure rule results in the highest survival rate. The maximize g rule results in only a slightly lower survival rate. The minimize f rule results in a much lower survival rate than do the other two rules. When predators and prey are randomly distributed, survivorship is between four and seven times greater than when predator and prey distributions are correlated, except under the most extreme case of prey depletion. Under conditions of random predator-prey distribution, the fitness currency that provided fish with the greatest survivorship depends upon the equilibrium density of food and the rate of prey renewal. Under most scenarios, the fitness currency that produced the highest survivorship was either minimize f or minimize f/g. Selection of an appropriate movement rule can greatly affect the predictions of fish population dynamics in heterogeneous environments. (Oral, V, 10:45 Thursday)

Van Pelt, Robert, University of Washington, College of Forest Resources, AR-10, Seattle, WA 98195. **Assessment of landscape reconstruction methods: limitations of historical data.**

Presented are several techniques used in a reconstruction of presettlement vegetation in the Puget Sound area of Washington state. Techniques were then compared to those of current remote imagery sources - aerial photos, AVHRR and TM. The historical data focuses on changes based on composition and edaphic characters, while remote techniques pick up small variations in texture and reflectivity. The reconstructed presettlement vegetation is the result of many sources of information, varying widely in quality and quantity. Records from the Land Survey Office and 19th century soil surveys provide baseline information. The relatively recent introduction of Europeans into the Puget Sound region (significant numbers arriving only after 1850) and high quality land survey techniques already perfected from decades of use in the East, allow for detailed spatial mapping of many vegetation features (particularly prairies and wetlands). Variations in forest composition, however are poorly assessed using these techniques. Witness tree accounts have been extensively used in other areas to assess changes in forest composition. These data are only partially useful in this region due to the extensive distribution of native dominants such as Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). Their overwhelming dominance at low elevations masks more subtle changes in forest composition. Remote imagery has its strength in the detection of variations in texture which can be related to forest age, density, or heterogeneity, while being less

sensitive to compositional changes. Available historic information, while occasionally very spatially detailed, is variable in coverage and often inconsistent with data collected through modern surveying techniques such as remote imagery. While not a problem in itself, this limits the ability to make quantitative temporal comparisons. (Oral, IV, 3:30 Wednesday)

Wallin, David[1], Barbara Marks[1], Jane Kertis[2] and John Cissel[3], [1]Dept. of Forest Science, Oregon State University, Corvallis, OR 97331; [2]USDA Forest Service, Siuslaw National Forest, Corvallis, OR 97331; and [3]USDA Forest Service, Blue River Ranger District, Willamette National Forest, Blue River, OR 97413. **Comparison of landscape pattern dynamics generated by a natural fire regime and timber harvesting in Pacific Northwest forests.**

Timber harvesting in forests of the Pacific Northwest has resulted in fundamental changes in landscape pattern. These changes may have important consequences for a wide range of ecosystem processes and this is the focus of much current research. Most of this research concentrates on the analysis of static landscape patterns and fails to consider variation in landscape pattern over long periods of time. In this study, we analyze temporal variation in landscape pattern in a 7600ha watershed in the central Oregon Cascade Mountain Range. The study is based upon a comparison of data from a 500 year reconstruction of fire events in the watershed, observed timber harvest patterns during the past 40 years and 500 years of timber harvest patterns generated with a simulation model. The model runs involved two sets of simulations using either a dispersed or an aggregated distribution of cuts. The dispersed cutting pattern generated by the model was intended to mimic the cutting system currently used on national forest service land. Landscape patterns generated by the natural fire regime were markedly different from the patterns observed over the last 40 years and from the pattern simulated using the dispersed distribution of cuts. The patterns simulated using an aggregated distribution of cuts was more similar to the natural fire regime but not as variable through time. The results of this work provides insights into how cutting practices might be altered to more closely mimic natural disturbance regimes. (Oral, VI, 10:30 Thursday)

Wang, Rusong and Ouyang Zhiyun, Department of Systems Ecology,Research Center for Environmental Science, Chinese Academy of Sciences, Zhongguancun, Beijing 100080, China. **An integration of space, time, quantity and order into an urban eco-complex study.**

A city is a special kind of heterogeneous ecotone dominated by anthropocentric impacts. This deals with this ecotone by considering its space, time, quantity and order and incorporating into it the ancient Chinese philosophy of man and nature should be in one. Cities are usually in the edge of different ecosystems such as in the mount of rivers, coastal areas, etc.. There are varies slow and fast ecological process interact upon each other ranged from geological, hydrological to economical. The material and energy flow and biological migration consist of its quantity variation. And different production, consumption and maintenance agents formulate its complex ecological order such as that of competition, symbiosis and self-organization. The

methodology is developed by trying to integrate these four categories together through a decision support system, in which the mapping, data, knowledge and modeling base are combined.

A case study of Tianjin, the third largest city in China is given to show the techniques of identification, simulation and regulation of these four categories from the interaction of the water, land and people. The emphases are given to the eco-chain, eco-network and eco-potential analyses from different scale of space and time. An index of ecological sustainability is provided which includes the efficiency, harmony and vitality. Some integrative strategies and a decision support system were developed for helping local decision makers to understand the relationship between time, space, quantity and order of their own system. (Oral, X, 3:45 Friday)

Welch, Joan M., West Chester University, Department of Geography, West Chester, PA 19383.

Discriminant analysis: a tool to predict public urban forest structure.

Urbanization as a process acting over space and time creates new patterns of biota. The research presented herein focuses on an evaluation of human processes acting on urban biota, and specifically on discriminant analysis as a tool to predict urban forest structure with socioeconomic histories. The study site is two neighborhoods in Boston, Massachusetts, Roxbury and North Dorchester. Information used in this study includes socioeconomic data for the decades 1950 through 1980, and forest structure data from an inventory of street and park trees carried out in 1988-89. Socioeconomic characteristics by census tract include eight variables chosen to describe and measure quality of housing, residential stability, and performance of the political system. Based on the values of seven urban forest structure variables, the 45 census tracts in the study area are classified into one of four forest structure categories: good quantity and quality, good quantity and poor quality, poor quantity and good quality, and poor quantity and quality. The categories serve to represent urban forest structure with only one variable. There are two discriminant analysis methods employed in the study. The first interprets the difference between urban forest structure categories, and how well forest structure variables discriminate between the four categories of urban forest structure. Results show that only 4 of the 45 census tracts are reclassified into a different category than the one determined by the method devised for the study. The second method classifies census tracts into urban forest structure categories according to socioeconomic characteristics of the census tract. Results show that socioeconomic data over four decades successfully discriminates between forest structure categories as only two census tracts out of 45 are reclassified. The findings suggest that historical socioeconomic characteristics of a census tract effectively predict public urban forest structure. (Oral, X, 4:00 Friday)

Westervelt, James[1], Bruce Hannon[2], Kevin Seel[1], and Pervaze Ahmed[2], [1]U.S. Army Corps of Engineers Research Lab (USACERL), Champaign, IL, 61826 and [2]University of Illinois, Urbana-Champaign, IL, 61801. **The dynamic modelling of a threatened sage grouse ecosystem (*Centrocercus urophansianus*) at the Army's Yakima Training Centre, Yakima, Washington.**

This paper discusses the application of the dynamic modelling program STELLA II for the Macintosh computer to the conceptualization and simulation of a sage grouse (*Centrocercus urophansian 's*) ecosystem located on the training range of the Army's Yakima centre. The model was produced as a multidisciplinary class project for a new experimental course in advanced ecologicl modelling at the University of Illinois, Urbana-Champaign, and sponsored by the U.S Army Corps of Engineers Research Lab (USACERL).

Specifically, several aspects of sage grouse population, age and habitat selection were modelled in relation to changes in vegetation cover and composition, soils, climate and human interaction throughout an annual cycle. Using a CM-5 supercomputer and the Geographic Information System (GIS) GRASS 4.1, the model was then applied to a comprehensive spatial database in order to display sage grouse migrational responses and patterns over a critical area of the training range. The resulting temporal and spatial models comprised a computer-based decision support system provided to the base. It is expected that such a management tool will greatly enhance the ecological sensitivity of long term planning of Army training activities. (Oral, I, 10:45 Wednesday)

White, Mark A.[1], David J. Mladenoff[1], George E. Host[1], Peter Wolter[1], and Thomas R. Crow[2], [1]Natural Resources Research Institute, University of Minnesota, Duluth, MN 55811 and [2]USDA Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, Rhinelander, WI. **Analyzing regional forest landscape structure across ownership categories and ecological land units.**

We are conducting an analysis of the structure of a large regional landscape through multi-temporal analysis at several scales. In this portion of the study our objective is to assess current differences in landscape pattern between various ownerships, consisting of national, state, county and private industrial forest. We used LANDSAT TM and MSS imagery to classify forests and other land cover categories on a large (>1000 km2) landscape of northwestern Wisconsin centered on the Chequamegon National Forest. We developed techniques using multiple, seasonal images and tree species phenology to derive a fine-level classification of forest types. We created a regional ecological landscape classification using climate, physiography and general soils types, to separate the effects of landscape features from forest management on the different ownerships. We found that forest land ownerships are not randomly distributed across different ecoregions. The locations of various forest ownerships are in part artifacts of historical land use. National forests tend to be located on poor sandy soil regions, with county forests on the better and more productive mesic soils. Private industrial lands are widely distributed, with extensive pine plantations on sands, and aspen and other hardwoods on better soils. Landscape patterns are influenced by clearcuts, which are larger on private and county forests than national forests.

Conversely, road density was greater on federal forest lands. These patterns have consequences for forest ecosystem management and for meeting other goals, such as biodiversity, on different ownerships. (Poster)

White, P.S.[1], J. Nekola[2], and S. Wiser[1], [1]Department of Biology, University of North Carolina at Chapel Hill, CB# 3280, Chapel Hill, NC 27599, and [2]Curriculum in Ecology, University of North Carolina at Chapel Hill, CB# 3280, Chapel Hill, NC 27599. **Scale, biological diversity, and the distance decay of similarity.**

The distance decay paradigm, sometimes called the first law of geography, states the simple expectation that the similarity between two observations will decrease or decay with the distance between them. We apply this paradigm to the distribution of biological diversity and infer that the processes that contribute to distance decay vary with the scale (grain and extent) of the sample. While conservation biology has often focused on issues of grain (preserve size) relative to ecological integrity, low costs of management, and viable population sizes, there is essentially a species-extent relation that shows that preserves must be spatially dispersed in a manner set by the rate of distance decay. The rate of distance decay varies with spatial configuration and history. Some landscapes are more resistant to organism and gene movement that others. The rate of distance decay of similarity for vascular plants across boreal Canada is lower than for vascular plants in patchily distributed Appalachian forests. The rate is also higher for the aquatic organisms of lakes (which are island like in a terrestrial environment) across boreal Canada than for vascular plants of forests in the same region. Regardless of cause, the rate of distance decay can be used as a descriptor of one aspect of the distribution of biological diversity. The SLOSS (single large or several small) debate misses the point that we need to consider both components of scale--grain and extent--in conservation strategy. All else being equal, species may generally accumulate faster with extent than with grain, but that does not eliminate the need for large grain size for other reasons. (Oral, III, 2:45 Wednesday)

Wilson, Bert and Celeste Wilson, Las Pilitas, California Native Plants, Las Pilitas Road, Santa Margarita, CA 93453. **Matching landscape conditions to the growth of mycorrhizal California native plants.**

We are growing and planting out mycorrhizal California native plants. If we design the site so the plants grown are from the site's plant community, match the site's soil (clay lovers to clay, sand lovers to sand), and grown so they are mycorrhizal, we do not have to water more than once to achieve at least a 50% success. It appears that if we match the mycorrhizal community it will support our plants. On most sites with water we found we could not water after the 3rd watering without drowning the plants. (The second watering will generally bring the success up to 95-98%). It appears that if plants are mycorrhizal, native in that plant community, and are grown to match the site's mycorrhizal, planting anywhere, anytime may only need one to three waterings. To date, we have done this in the Shadscale Scrub, Oak Woodland, Coastal Prairie, Closed-cone Pine Forest and Chaparral plant communities of California. The Shadscale Scrub site has less

rainfall per year and has temperatures as high as the desert. The plants were planted in Oct. with 2 waterings and a 95% success rate. The Coastal Prairie was planted in Oct. had no water and a 99% success rate. In the Closed-cone Pine forest and Chaparral the problem was overwatering. They were watered 3 times and the plants were drowning, with a 90% success rate. It is interesting to note, that on the Coastal Prairie site 100 non-mycorrhizal plants from 2 other sources were planted, and only 8 lived. We believe it will work anywhere there is an intact mycorrhizal and plant community or was one in the recent past. The closer we get to the site's mycorrhizal match the better our success. A 50% success with no irrigation is still more cost-effective than a 95% success with an irrigation system, if maintenance, water, and labor are included. (Poster)

Wolter, Peter[1], David J. Mladenoff[1], Philip Polzer[1], George E. Host[1], and Thomas R. Crow[2], [1]Natural Resources Research Institute, University of Minnesota, Duluth, MN 55811 and [2]USDA Forest Service, North Central Forest Experiment Station, Forestry Sciences Laboratory, Rhinelander, WI. **Forest landscape classification using multi-season LANDSAT imagery and trees species phenology.**

Forest classification using single date LANDSAT TM data has been moderately successful in separating forest covertypes in the Lake States region. Increased spatial, spectral and radiometric resolution afforded by the availability of TM over MSS data in 1984 brought digital imagery to a more useful level for landscape management and planning applications. Although overall classification accuracy has increased from approximately 75 percent using MSS data to approximately 85 percent using TM data, forest cover accuracies have not increased as dramatically. For example, classifications at the Anderson Level III or US Forest Service level covertypes have been difficult to obtain. By using imagery from several different dates, a more specific forest cover classification was developed for a regional landscape centered on the Chequamegon National Forest in northwestern Wisconsin. In this classification, TM data from late spring were used in conjunction with MSS data from late summer, mid-fall and mid- winter. These dates were selected to capture specific phenological phenomena of major forest species. The combined classification produced more forest classes than otherwise obtainable with a single TM or MSS data set. This approach may also be useful for broad-scale forest cover monitoring in many areas, particularly where ancillary data layers other than LANDSAT, such as National Wetlands Inventory and digital elevation models, are not available. (Poster)

Wu, Jianguo[1,2] and Simon A. Levin[1], [1]Princeton University, Princeton, NJ 08544 and [2]Cornell University, Ithaca, NY 14853. **A spatially explicit patch dynamic model of a grassland landscape.**

A landscape may be viewed as a hierarchical mosaic system of patches that are different in their age, size, shape, content and other aspects. The spatial change of the patch mosaic results in the landscape pattern, whereas the phase change of individual patches at the local scale and temporal change in patch mosaics at larger scales give rise to the landscape dynamics. This view holds for many, if not most, terrestrial ecosystems simply because disturbances at different spatial and temporal scales are general phenomena which significantly structure a variety of biological communities. The system of concern in this study is the Jasper Ridge serpentine grassland in which as high as over 20% of the area is disturbed by gopher activity. In particular, we conceptualize the annual grassland landscape as a patch mosaic of gopher mounds of different size, (successional) age and species composition, and construct a spatially explicit patch dynamic model to relate the landscape pattern to the underlying process at the individual patch scale.

The model has two basic submodels: a spatially-explicit, age-/size-structured patch demographic model and a multi-specific plant population dynamic model of a non-equilibrium island biogeographic type. We use this simulation model to examine the spatio-temporal patterns of the disturbance patches and population abundance and to address the following questions: How do the mean size, total number and total area of patches change in time with different disturbance rate functions? Given a spatial patch pattern generated by a known process (e.g., random, clustering or regular), how does the disturbance scale up? How is vegetation pattern at the landscape level related to local patch dynamics? How is a particular functional relationship (e.g., plant weight-seed production or population density-biomass relation) at the local scale manifested at the landscape scale? The modeling philosophy and preliminary simulation results and analysis are presented. (Oral, IV, 3:45 Wednesday)

Wu, Yegang[1,2], Donald L. DeAngelis[1,2], Louis J. Gross[2], and D. Martin Fleming[3], [1]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, [2]Department of Mathematics, University of Tennessee, Knoxville, TN 37996, and [3]Everglades National Park, Homestead, FL 33030. **SIMDEL: A spatially explicit individual-based model for white-tailed deer on the Everglades landscapes.**

SIMDEL simulates individual white-tailed deer (*Odocoileus virginianus seminolus*) foraging in changing heterogeneous landscapes. SIMDEL is designed to: 1) simulate the life cycles of each individual deer on the landscape as well as interactions between individuals, 2) assess potential impacts of human activities and climate change on deer population dynamics, and 3) allow model comparisons of alternative water management strategies on deer population in the Everglades. SIMDEL simulates the interactions of hydrology, vegetation, Florida panther (*Felis concolor corvi*), and deer on multiple spatial and temporal scales. It provides a visualization in real-time of the spatial and temporal dynamics of the simulation. Estimation of various individual behavioral and physiological parameters is done using published data as well as knowledge from wildlife biologists familiar with the local populations of deer and panther. Each individual

white-tailed deer is simulated in the Everglades landscape on a daily basis. For deer reproduction, we considered: 1) pregnancy and fawning and 2) the effects of age, population density, water level, nutrition, and habitat. Deer mortality factors included are: predation, hunting, vehicular deaths, parasitic infections, disease, poor nutrition, and old age. Foraging rates and caloric intake for each animal in a day are dependant on the biomass in each pixel as well as the individual's home range. Home range may change in magnitude and shift in spatial location due to the influence of available biomass or changes in water level. The induced daily energetic balance and body weight changes are key factors driving the population-scale results derived from the model. (Oral, I, 10:30 Wednesday)

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