nd 5g P/m² annually. Results indicate strong nutrient use complementarity among species; *Ledum* was co-limited by N and P, *Kalmia* by P alone, and *Gaylussacia* by N alone. *Chamaedaphne* did not respond to either N or P, and may be limited primarily by light. Thus, species' constraints limit ecosystem response to added nutrients. Laboratory incubations of leaf litter from the dominant dwarf shrubs and of peat soil from the nutrient amended plots assessed nutrient limitation on decomposition. C mineralization of soil showed a slight increase with added N, but decreased by 30% with addition of P. Leaf litter from the 4 dominant species showed no change in C mineralization expressed on a mass basis, but strong species' specific effects on C mineralization became obvious when results were expressed on an areal basis. Thus, our study elucidates the unique and individualistic role that each species plays in determining and constraining ecosystem productivity and decomposition.

JOHNSTON MARSHALL, B.,[1] V. E. BIRDIN[2] and J. BUTLER.[2] [1]Michigan State University, East Lansing, MI 48825 USA; [2]Bellwood School District 88, Bellwood, IL 60104 USA. **The classification of landscape patterns as interpreted by middle school students.**

This study investigated the spatial development stages of middle school students requisite for their subsequent understanding of ecological landscapes. Middle school students were given photographic images representative of an ecological scale of 1000 km². These images were then interpreted and recreated by the students with the use of wooden cubes and balls ranging from cubes and balls ranging from 1/2 to 1-1/2 inches. From the students' interpretive representations, the models' footprints were converted to vector coordinates thus allowing the researchers to employ common graphing software (e.g. Microsoft Excel) to generate x,y scatter plots. The resulting plots were compared using Principle Component Analysis (PCA) and derivations of statistical methods typically associated with insect aggregation and dispersion, particularly, inferences from the mathematical distribution best fitting the sampling data. A classification scheme based on the organization, proximity and combination of landscape elements was created as a result of this analysis. Patterns were further ranked by the frequency with which they represented students' perceptions. From these results we identified a typical middle school student interpretation of the given landscape and generated learning activities designed to mitigate potential learning difficulties and developmental delays associated with visual-spatial abilities and comprehension of landscape ecology. By addressing these fundamental weaknesses early in the science curriculum, students showed increased understanding of ecological patterns and biological systems and were able to recognize and discuss relationships and connections in the context of the ecological landscape.

JONES, J. A.[1] and D. A. POST.[2] [1]Oregon State University, Corvallis, OR 97331 USA; [2]CSIRO Land and Water, Aitkenvale, Qld 4814, Australia. **Hydrologic regimes, disturbance history, and environmental gradients at four forested long-term ecological research sites : Andrews, Coweeta, Hubbard Brook, and Luquillo.**

Hydrologic regimes reflect the operation of key moisture storage reservoirs in the vegetation canopy, snow, and soils; hence they influence key ecosystem properties. These moisture storage reservoirs can be defined by lagged cross-correlations between precipitation and streamflow. They have been determined for four forested sites: Cascade Mountains, Oregon (HJ Andrews LTER); White Mountains, New Hampshire (Hubbard Brook LTER); Smoky Mountains, North Carolina (Coweeta LTER); and Luquillo Mountains, Puerto Rico (Luquillo LTER). Precipitation and streamflow are coherent at multiple time scales, ranging from daily to annual, and the periodicity and strength of these lagged cross-correlations varies among sites according to their forest canopy type, soils, snow and climate. At Hubbard Brook, which has a seasonal snowpack, but small soil moisture storage, and deciduous forest canopy, streamflow is highly correlated with precipitation 4-6 months earlier, reflecting a snowmelt influence. At Coweeta, which also has a deciduous forest canopy, but no seasonal snow, and pronounced spatial heterogeneity of soils, streamflow is highly correlated with precipitation a few days earlier where soils are shallow, but this correlation is much smaller and lasts much longer where soils are deep, indicating a long-term soil moisture reservoir. At Luquillo, which has an evergreen forest canopy, no snow, and a small soil moisture storage, pre-

cipitation and streamflow are most strongly correlated at sca₁, even shorter time intervals. At Andrews, which has seasona precipitation, some snow, large soil storages, and an evergreen canopy, streamflow is significantly correlated with precipitation over time lags ranging from one day to half a year. These storage res₁ ₁rs influence stream ecologic processes and may be diagnostic of ecosystem responses to disturbance.

JORDAN, M. J.,[1] W. A. PATTERSON III[2] and A. WINDISCH.[3] [1]The Nature Conservancy, Cold Spring Harbor, NY 11724 USA; [2]University of Massachusetts, Amherst, MA 01003 USA; [3]Department of Environmental Protection, Trenton, NJ 08625 USA. **Conceptual fire ecology model for the Long Island, NY pine barrens.**

A conceptual model summarizes effects of fire on pine barrens species and ecological communities, and will provide ecological guidance for future prescribed burning. Aerial photographs from 1938, 1961 and 1996 were used to produce vegetation maps, from which transition matrices and trajectories of change for community types were derived. Detailed GIS analysis including 1986 aerials, a fire history study, and post-wildfire research provided additional information. In 1938 90% of the 12,000 acre study area was dominated by pitch pine-scrub oak woodland (*Pinus rigida*, *Quercus ilicifolia*), scrub oak shrubland and limited coppice tree-oak shrubland; only 10% was closed-canopy forest (> 60% tree cover). Woodland and shrubland communities had been created by large (100–2,000+ acres) intense or severe duff-consuming fires that top-killed most trees. Between 1938–1994 fires were smaller (2–500 acres) and ~73% of the study area did not burn, or was burned by low severity surface fires. As a result ~5,000 acres of shrubland and woodland succeeded or matured into pine-oak forest by 1994, creating a mosaic of shrubland + woodland (44%) and forest (56%). In 1995 an unusually severe summer wildfire converted 2,000 acres of woodland and forest back into scrub oak shrubland. The LI Pine Barrens Commission, governmental agencies and The Nature Conservancy are drafting a prescribed fire management plan for maintaining pine barrens and reducing the likelihood of future catastrophic wildfires.

JUDGE, M. L.[1] and N. J. O'CONNOR.[2] [1]Manhattan College Riverdale NY 10471 USA; [2]University of Massachusetts Dartmouth No. Dartmouth MA 02747 USA. **Stimulatory cues for molting of fiddler crab megalopae are specific to salt marshes.**

Natural estuarine marsh sediments and seawater overlying marshes have been shown to stimulate *in situ* metamorphosis (molting) of fiddler crab (*Uca pugnax*) megalopae. We sought to extend our earlier work by testing whether this response is (1) restricted to intertidal salt marshes and (2) observed in another fiddler crab species inhabiting low-salinity marshes. We exposed naïve, lab-reared *Uca minax* megalopae enclosed in plastic mesh cages to both a marsh and a river site separated by 15 m. In both habitats, megalopae were exposed to local waterborne cues without sediments. Additional marsh habitat treatments included sediment additions (freshly collected or combusted to remove organic fraction) or no marsh cues (jars of filtered seawater). Examining the megalopae after nearly three days of deployment (ca. 28 h submerged), all those exposed to natural seawater in the marsh had high rates of molting regardless of sediment type. However, megalopae in the river molted at very low rates similar to those enclosed in jars. Results indicate stimulatory waterborne cues for metamorphosis are specific to the salt marsh environment.

JULIANO, S. A.,[1] L. LOUNIBOS[2] and G. F. O'MEARA.[2] [1]Illinois State University, Normal, IL 61790 USA; [2]University of Florida, Vero Beach, FL USA. **Invasion biology of Asian tiger mosquito, *Aedes albopictus*: Competitive effects on a resident species at multiple sites in Florida.**

Introduction and spread of the container dwelling mosquito *Aedes albopictus* in Florida have been accompanied by declines in resident *Aedes aegypti* at some sites. Prior experiments show that when larvae compete, *A. albopictus* is the superior competitor. In this experiment, we test the hypothesis that competition among larvae is important at ambient densities at sites where *A. aegypti* has gone extinct and at sites where it survives. Vases were placed at 3 cemeteries in south Florida where *A. aegypti* went extinct after invasion by *A. albopictus*, and at 3 cemeteries where *A. aegypti*