every 8 days will explore how well continental gradients of NPP are being represented, and the limits of more regional analysis for discriminating local patterns of productivity.

RUPP, T.,[1] A. M. STARFIELD[2] and F. S. CHAPINIII.[1] [1]University of Alaska, Fairbanks, AK, 99775, USA; [2]University of Minnesota, St. Paul, MN, 55108, USA. **Modeling the response of regional fire regimes to a warming climate in Alaska: Towards an understanding of the affects of vegetation pattern and land use.**

Variations in regional fire regime are highly sensitive to changing climate and vegetation pattern. Simulating the response of terrestrial ecosystems to climatic warming involves complex interactions between climate, disturbance, and recruitment across the landscape. This dynamic linkage is manifest in the Alaskan boreal forest where climate, vegetation composition, and fire regime have all varied considerably in the last 10,000 years. In the boreal forest, successional changes in vegetation strongly influence disturbance probability, and disturbance type and severity largely determine successional trajectory. Historically there have been strong vegetation effects on fire regime, emphasizing the importance of temporal and spatial vegetation pattern across the landscape. We describe a spatially explicit state-and-transition model (ALFRESCO) that simulates the transient response of boreal vegetation to climatic warming in Alaska. We discuss how the model simulates fire ignition and spread, climate-vegetation-fire interactions, and scenarios of vegetation change. We present model simulations of vegetation changes associated with a warming-induced increase in fire probability, and we consider the impacts that landscape pattern and land-use history have on these vegetation changes. We investigate the impacts that different fire control policies would have on these vegetation changes. We discuss the implications of vegetation-induced feedbacks to climate due to changes in albedo and energy partitioning and its importance in understanding future disturbance regimes.

RYEL, R. J. and M. M. CALDWELL. Utah State University, USA. **Hydraulic lift and uptake of water and nutrients.**

Hydraulic lift involves water uptake from relatively moist soil layers, usually at depth, and release of this water from roots in drier soil layers during times when stomatal conductance is very low, such as at night. The following morning most of this released water is apparently taken up and passes into the transpiration stream. This process of temporary storage of water in drier soil layers allows roots in moist layers to absorb water both night and day and to facilitate overall water uptake under conditions of high evaporative demand. Yet, does this process result in a redistribution of water in the soil profile over periods of weeks and months and, if so, what are the implications for both water and nutrient uptake? Furthermore, how are these processes influenced by vertical rooting depth distributions? Recent modeling efforts suggest that a substantial longer-term redistribution of water does occur and it has several implications for both water and nutrient acquisition as the soil profile is depleted of water during drying cycles. Under some circumstances, hydraulic lift may be critical in prevented an extreme desiccation of the upper soil layers. Nutrient uptake in drying soil becomes rapidly diffusion limited and hydraulic lift can theoretically prolong nutrient uptake by several weeks. Root depth distributions and recharge of water at depth may also play important roles in how effectively hydraulic lift redistributes water in the profile.

SABO, J. L. and M. E. POWER. University of California, Berkeley, CA 94720 USA. **Trophic links between rivers and riparian lizards: Indirect effects of aquatic insect subsidies on terrestrial resources.**

Resource flow between rivers and surrounding watershed habitats can have direct and indirect effects on recipient food webs. We document strong links between riverine insects, riparian lizards, *Sceloporus occidentalis*, and terrestrial invertebrates. We used 2 m high "subsidy shields" to experimentally reduce aquatic insect flux at the river-land interface in two separate experiments. First, we used lizard enclosures with either reduced or ambient subsidy levels to evaluate the effects of riverine subsidies on lizard growth rates. Second, we employed experimental plots open to lizard movement with or without subsidy shields to measure the numerical response of lizards to riverine subsidies. We also measured the abundance of ground dwelling terrestrial invertebrates in both experiments to assess the direction of indirect effects on in situ prey. Lizards grew up to seven times faster in ambient vs. reduced subsidy enclosures ($P < 0.05$). Moreover, lizards emigrated at significantly higher rates from reduced subsidy plots open to lizard movement, leading to two-fold decreases in density in shielded plots ($P < 0.05$). Average density of lizards ($0.034\ l^*m^2$) in ambient open plots was nearly identical to that used in the enclosure experiment. Fixed densities of lizards in enclosures had stronger effects on terrestrial invertebrates in reduced vs. ambient subsidy enclosures ($P < 0.05$). This suggests that if lizard densities are held constant, subsidies may release terrestrial resources from predation pressure by lizards and that seasonal declines in subsidy availability may result in pronounced negative effects as a result of lizard diet shifts to in situ resources. In contrast, we observed no significant difference in terrestrial invertebrate prey abundance between ambient and reduced subsidy plots open to lizard movement. We hypothesize that numerical tracking of aquatic resources by lizards may compensate for strong negative effects brought on as a result of diet shifts by lizards to terrestrial resources. These experiments demonstrate that riverine subsidies can enhance the performance and local density of riparian consumers, and that subsidies can exert either positive or negative indirect effects on terrestrial prey depending on the temporal and spatial scales of resource availability.

SANCHEZ PINERO, F. University of California at Davis, Davis, CA 95616 USA. **Subsidies make strange partners: The effects of seabirds on terrestrial detritivores.**

Organisms moving in a landscape link different habitats as prey, predators or transporters of nutrients and energy from one habitat into another. The impact of such organisms on the dynamics of the recipient habitat is influenced by differences in productivity between the habitats. On island ecosystems in the Gulf of California, where an unproductive desert juxtaposes to a highly productive ocean, seabirds are a major conduit bringing marine productivity to land in the form of guano and carrion. Seabirds directly and indirectly affect the abundance of a dominant group of detritivores, tenebrionid beetles. Tenebrionid densities vary by three orders of magnitude among islands; they are more abundant on islands where seabirds roost and nest than on other islands and on mainland sites. In addition, within nesting islands beetles are most abundant in areas influenced by seabirds, and tenebrionids are more dense inside versus outside colonies. Seabirds have direct and indirect effects on the abundance of these detritivorous beetles. On roosting islands, effects are mainly indirect via guano, which enhances primary productivity and increases availability of plant detritus, a food resource for tenebrionids. In contrast, on nesting islands, effects are primarily direct via seabird carrion, which tenebrionids scavenge, whereas indirect effects via guano are less important on these islands. Increases in these primary consumers indirectly facilitate high densities of many predators. By providing energy and nutrients to fuel a diverse array of consumer populations, seabirds are central to the dynamics of these island ecosystems. Because consumers cannot influence the renewal rate of their allochthonous resources, the dynamics of these consumers and their food webs are largely donor-controlled.

SANZONE, D. M.,[1] J. L. MEYER,[1] J. L. TANK,[2] P. J. MULHOLLAND,[3] N. B. GRIMM,[4] S. V. GREGORY,[5] W. H. MCDOWELL,[6] W. B. BOWDEN[7] and W. K. DODDS.[8] [1]University of Georgia, Athens, GA, 30602 USA; [2]University of Illinois, Urbana, IL, 61801 USA; [3]Oak Ridge National Lab, Oak Ridge, TN, 37831 USA; [4]Arizona State University, Tempe, AZ 85287 USA; [4]Oregon State University, Corvallis, OR 97331 USA; [4]University of New Hampshire, Durham, NH 03824 USA; [4]Landcare Research, Lincoln 8152, New Zealand; [4]Kansas State University, Manhattan, KS 66506 USA. **Nitrogen transfer from stream to riparian foodwebs: Results from eight ^{15}N tracer experiments.**

Movement of nutrients and organic matter between aquatic and terrestrial habitats may have a greater impact on assemblage structure and community dynamics than within-habitat inputs. In this study, we document the effect of aquatic prey subsidies on surrounding terrestrial predators in eight riparian zones using a stable isotopic ^{15}N tracer experiment to quantify the flow of nitrogen from aquatic to terrestrial food webs via emerging aquatic insects. We continuously dripped ^{15}N-NH_4Cl for six weeks into four tem-

perate forested streams (North Carolina, Tennessee, New Hampshire and Oregon), one tropical forest stream (Puerto Rico), a desert stream (Arizona), a grassland stream (Kansas), and one arctic stream (Iceland), and traced the flow of ^{15}N from the streams into spiders living in the riparian zone. After correcting for background ^{15}N values, we used simple mixing models to calculate proportion of ^{15}N tracer from emerging aquatic insects incorporated into spider biomass. In addition, we documented spider abundance, biomass and diversity along a transitional gradient at various distances from the stream bank (0–50m). Ground-dwelling spider abundance was highest within the first 10m of the stream bank in six of the eight streams, three of which had relatively high emergence production (desert, arctic and temperate rainforest streams). Spider $\delta^{15}N$ values were elevated above background levels and tracked that of emerging aquatic insects at these three sites, indicating a reliance on aquatic resources.

SAUER, J. R. and W. A. LINK. USGS Patuxent Wildlife Research Center, Laurel, MD 20708 USA. **Quantifying bias in estimates from wildlife surveys.**

Most wildlife surveys are based on counts, rather than censuses, of animals. These counts represent an unknown proportion of animals present at sample sites. Counts complicate analysis by introducing irrelevant variation; this variation often introduces patterns in counts that do not reflect patterns in the underlying populations. Although the potential for bias in estimation from counts is well known, controversy exists regarding appropriate approaches for mitigating the effects of the bias in estimation. Some investigators ignore the potential for bias, while others require estimation of the proportion of animals missed during counting. Occasionally, bias in estimation can be mitigated in analyses by using covariates that control for the effects of changes in the proportion of animals counted. We discuss several classes of covariates that can be used to accommodate differences in detection of animals in wildlife surveys, and describe generalized linear models that can be used for estimation of population change from count data. Example applications of these models include estimation of population change and spatial patterns of relative abundance from the North American Breeding Bird Survey when quality of observers varies over space and time, and estimation of population change in Christmas Bird Counts when counting effort varies. Unfortunately, many factors that influence proportion of animals counted cannot be accommodated through use of covariates; hence, care must be used in design of surveys to minimize the limitations of count data.

SCHADE, J. D., J. R. WELTER, N. B. GRIMM and S. G. FISHER. Arizona State University, Tempe, AZ 85287 USA. **Movement of organic matter and nutrients from stream to riparian zone: A reversal of fortune.**

In the classic model of stream ecosystems, materials move from the surrounding watershed to the stream. This classic model derives from mesic streams, characterized by a closed canopy, high leaf litter inputs and low instream productivity. Furthermore, rain infiltrates upland soils in mesic watersheds and groundwater tends to move from uplands through riparian soils to the stream. Arid land hydrology leads to a different direction and strength of aquatic-terrestrial material exchanges. Rain in the desert does not infiltrate upland soils, rather it flows overland into stream channels, generating flash floods. These spates prevent plants from establishing in the channel, thus the streams channels are wide and well lit. Floodwaters also infiltrate coarse channel sediments, and thence move from the stream out into the riparian zone. Because of the open canopy, leaf litter inputs are low, and algal production is high. Algal biomass increases during post-flood succession but as the stream contracts, stranded algae are exported laterally to the terrestrial system. High production rates also lead to high insect emergence, of which 3% is permanently exported. In Sycamore Creek, Arizona, lateral export of organic matter from the stream is on the same order of magnitude as leaf litter input, and there is a net export of dissolved nutrients as water moves subsurface from stream to riparian zone. In the desert, the stream in many ways rules the valley.

SCHLESINGER, W. H. Duke University, Durham, NC 27708 USA. **Pressing questions for ecosystem science to 2100 A.D.**

With demographic momentum destined to carry the Earth's human population beyond 10 billion individuals, and with the recognition that each individual is likely to place self-interest ahead of nature in the face of life's critical decisions, we must be realistic about how much "nature" will remain at the end of the 21st century. I predict that "natural" ecosystems, as we have traditionally recognized them, will be very rare-equivalent to the great works of art that hang in the world's museums. The Earth's surface, both land and sea, will be dominated by human activities, and ecosystem science must focus on the critical questions facing human-dominated ecosystems-in both urban and agricultural areas. Can humans and human society persist in the absence of nature's services and with only a small fraction of the Earth's current biodiversity? Will we be able to feed our population? Can we manage the effluents and wastes from our society? Will we succumb to pandemic diseases as a result of high density of our numbers and frequent contact between our subpopulations? How will we survive the effects of nuclear radiation emitted as our rising population density leads to crowding and conflict? We must meld the expertise of ecosystem science and environmental engineering to ensure an optimistic future for humans in the impoverished biosphere that they will dominate before this century's end.

SCHMITT, J.[1] and M. A. GEBER.[2] [1]Brown University, Providence, RI 02912-9127 USA; [2]Cornell University, Ithaca, NY 14853-0001 USA. **Microevolution of physiological traits in natural populations.**

For physiological traits to evolve, they must be genetically variable and they must affect fitness. We will focus on the dual themes of genetic variation and fitness consequences of physiological and developmental traits in natural populations. There is increasing evidence that physiological and developmental traits, such as gas exchange physiology, photomorphogenesis, and development rate, are under selection in the wild. The fitness consequences of these traits are often manifested through intermediate fitness components, such as resource allocation, plant size and flowering time. Their expression and effects are also environment-dependent. There is also evidence that these traits are genetically variable within populations, providing the substrate for natural selection to act on, and differ among populations with different histories of selection. However, response to selection may be constrained by genetic trade-offs among traits and among environments. An exciting prospect for the future is identifying the loci underlying variable phenotypes and detecting selection directly on these loci.

SCHULTZ, C. B.,[1] E. E. CRONE[2] and K. D. HOLL.[3] [1]University of California, Santa Barbara, CA USA; [2]University of Calgary, Calgary, Alberta Canada; [3]University of California, Santa Cruz, CA USA. **The influence of landscape processes on an endangered butterfly population: deciding where to restore habitat for the Fender's blue.**

In the Willamette Valley in Oregon, persistence of several native species depends on adequate restoration of the prairie habitats. In upland prairies, the primary goal of restoration activities is to enhance population viability of an endangered butterfly, the Fender's blue (*Icaricia icarioides fenderi*) and its threatened larval hostplant, the Kincaid's lupine (*Lupinus sulphureous kincaidii*). Methods for restoration and management are becoming better understood from recent experimental studies, but managers must decide which of several potentially available sites to restore. We develop an approach to predict the relative likelihood of success of restoration efforts based on the location of potential sites for restoration relative to intact prairie habitat and relative to large patches of invasive weeds. In our analyses we consider butterfly population dynamics and plant community dynamics, both of which depend on site-specific and landscape-level factors. Based on these analyses, we rank sites for acquisition. In addition, we ask how much the relative ranks of different options depend on site-specific vs. landscape-level differences among the sites.

SHAFER, S. L.,[1] P. J. BARTLEIN[1] and R. S. THOMPSON.[2] [1]Dept. of Geography, Univ. of Oregon, Eugene, OR 97403, USA; [2]Earth Surface Processes Team, U.S. Geological Survey, Denver, CO 80225, USA. **Potential changes in the distributions of tree and shrub taxa in western North America under future climate scenarios.**

In order to characterize the ways in which vegetation will respond to future climate change, this study uses response surfaces to simulate the distributions of individual tree and shrub taxa in western North America under