changes resulting from global climate change. For ecology and ecologists to contribute to the solutions of the societal problems we must address three challenges: 1. How can we use managed lands and waters as experiments to help us understand what human uses of land and water are compatible with the sustenance of species and ecological systems? 2. How can society and ecosystems adapt to the consequences of climate change and land use? 3. How can we change the research, training and other scientific institutions so that ecologists know how to inform societal decisions?.

JO, H. Kangwon National University, Chuncheon 200-701, Korea. **Carbon flows and the role of greenspace in urban ecosystem for Chuncheon, Korea.**

Carbon dioxide is a major greenhouse gas causing climate change. This study estimated carbon uptake by urban greenspace and carbon emissions from fossil fuel use, and quantified the role of urban greenspace in atmospheric carbon reduction for Chuncheon, Korea. Carbon storage by woody plants averaged 26.0 t (metric tons)/ha for wild lands and 4.7 t/ha for urban lands (all land uses except wild and agricultural lands). Annual direct carbon uptake (uptake through photosynthesis) by woody plants averaged 1.7 t/ha/yr for wild lands and 0.6 t/ha/yr for urban lands. Annual indirect carbon uptake (emissions avoided through building energy savings) by trees in urban lands was 1.4 t/ha/yr, which is approximately 2.5 times greater than the direct uptake. Annual carbon release from tree maintenance in urban lands accounted for 5.5% of the direct and indirect uptake. Annual carbon release from grass maintenance was about 1.2 times greater than annual direct uptake by grass. Carbon storage in soils averaged 31.6 t/ha for wild lands and 24.8 t/ha for urban lands. Annual carbon input by litterfall into and carbon output by decomposition from soils in wild lands were estimated at 3.2 t/ha/yr and 1.9 t/ha/yr, respectively. Annual per capita carbon emissions from fossil fuel consumption were 1.3 t/yr. Urban greenspace (woody plants, grass, and soils) played a significant role through offsetting total carbon release from vegetation maintenance, soil decomposition, and fossil fuel use by 6% annually in the study city.

JOHNSON, S. L., L. R. ASHKENAS and S. V. GREGORY. Oregon State University, Corvallis, OR 97331 USA. **Terrestrial-aquatic linkages in a Pacific Northwest old-growth forest: Results from an aquatic ^{15}N tracer study.**

Many studies in lotic ecology have focused on the influences of riparian forests on stream structure and function. However, few have examined stream influences on riparian forests and terrestrial vertebrates. We added ^{15}N -NH_4 for 6 weeks to Mack Creek, a third-order stream in the H.J. Andrews Experimental Forest, Oregon. At the end of this release, we sampled leaves, roots and stems of 4 perennial riparian species from four sites along a 200 m longitudinal gradient. We observed significant enrichment of all 4 species. However, the pattern of enrichment varied substantially among species: leaves, stems and roots of oxalis (*Oxalis oregana*) had similar levels of enrichment ($\delta^{15}N$ ~28‰), while the leaves of lady fern (*Athyrium filix-femina*) were only slighlty enriched ($\delta^{15}N$=2‰) compared to their roots ($\delta^{15}N$=53‰). Leaves from an additional 15 species, sampled at one site, exhibited similar variation. Our results suggest that these riparian species have high hydraulic connectivity with stream water, but differ in their partitioning of N. A stream-foraging bird, the dipper (*Cinclus mexicanus*), and 3 species of small riparian mammals also showed slight ^{15}N enrichment. Stream N budgets usually do not account for terrestrial uptake of N but our calculations suggest that it may in fact be important.

JOHNSON, W. South Dakota State University, Brookings, SD 57707-0001 USA. **Cattle and trees at home on the range: The Mortenson Ranch (South Dakota) story.**

The Mortenson family has worked over fifty years on their western South Dakota ranch to restore woodland and grassland despoiled by homesteading in the early 1900's. Native woodland has returned to draws and streams because of changes in grazing practices, construction of sediment storage dams, and the return of beaver. The sheltering effect of the new woodland on spring calves has increased overall ranch profitability. This case study demonstrates cooperative efforts of ecologists and ranchers in restoring ecosystems.

JONES, C. G. Institute of Ecosystem Studies, Millbrook, NY 12545 USA. **Plant resource heterogeneity: When is it signal and when is it noise?**

Plant chemistry affects the performance of consumers, and plant chemistry varies markedly at virtually all temporal and spatial scales. Consequently, many have postulated that chemical heterogeneity is an important factor determining patterns of variation in consumer distribution and abundance. And yet good evidence that chemical heterogeneity affects consumer population dynamics, community structure and dynamics, or ecosystem-level producer/consumer relationships is scanty at best. Why is this so? Does it mean that, although chemical variation may be important to individual performance, at higher levels of organization other factors are always more important determinants of consumer distribution and abundance? Or is it a reflection of inadequate testing of the general hypothesis arising from the lack of a clear framework for when, how and why we should expect chemical heterogeneity to make a difference to consumers at different scales? Evidence from many other systems (e.g., the role of lignin in decomposition, atmospheric impacts of plant volatiles) as well as a number of "success stories" in plant-consumer interactions (e.g., host plant demic adaptation, evolutionary patterns of host specialization) suggests that there are circumstances in which causal chemical signals can be seen at higher levels of organization, and other situations where lower level chemical resource heterogeneity is just noise. I will analyze these examples and present a framework for integrating scales of resource heterogeneity with scales of variation in consumer distribution and abundance.

JORDAN, N. Agronomy & Plant Genetics Department, University of Minnesota. **Agroecology of mutualisms between plants and mycorrhizal fungi.**

A fundamental feature of plant biology is complex mutualism between plants and soil biota that associate with their roots. This mutualism is arguably of fundamental importance to sustainable agroecosystems, as one of the major engines by which biological diversity provides agroecological services. I will survey the agroecological significance of a particularly important instance of this mutualism, that between plants and arbuscular mycorrhizal fungi (AMF). These relationships can affect many aspects of agroecological functioning, including plant productivity and tolerance of biotic and abiotic stresses, the biological provision of soil fertility and quality, and population dynamics of non-domesticated species in agroecosystems, including both organisms that are viewed as beneficials and those viewed as pests. Management of the plant-AMF relationship may offer important opportunities to improve these and other aspects of agroecosystem functioning. However, this management must be guided by understanding of the ecological and evolutionary dynamics of the relationship. Several notable features and outcomes of these dynamics include potential for rapid change in the quality of the mutualism and its impacts on agroecological function, and the potential for formation of diffuse mutualisms among multiple plant species and associated AMF. These latter relationships may be important mechanisms by which agroecosystems develop resilient and regenerative properties important to sustainability.

KARBAN, R.,[1] J. S. THALER[2] and A. A. AGRAWAL.[2] [1]University of California, Davis, CA 95616 USA; [2]University of Toronto, Toronto, Ontario M5S3B2 CANADA. **Testing the moving target model of plant resistance.**

Induced resistance may involve either a consistent, directional change in the mean level of resistance or an increase in variance in resistance with no necessary change in the mean. An increase in variance of traits that provide resistance makes plants seem like moving targets to their herbivores; plants change after attack but not in a predictable manner. Although such a moving target strategy has been hypothesized to provide effective defense, few experiments have considered whether plants in fact become more variable following damage. This property can be tested easily by comparing the variance in resistance associated with damage to the variance associated with no damage. We illustrate this simple test with our own data and find that resistance in cucumber plants becomes more variable following feeding by spider mites. Other similar examples from the published literature are also presented. Increased variance may protect plants by making it difficult for herbivores to induce appropriate metabolic enzymes to

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