United States Environmental Protection Agency | Office of Research & Development | National Health & Environmental Effects Research Laboratory

Corvallis, Oregon | Fall 2011

NHEERL - Western Ecology Division - Research Update

In This Issue:

above: Pollen Confinement Chambers are one of the tools used for gene flow studies at Western Ecology Division (WED)

1) Emerging Technologies

Emerging technologies research addresses EPA's need to understand and predict the ecological effects (direct or indirect) of genetically modified crops, pesticides, nanomaterials, and new technologies on terrestrial ecosystems. These effects must be known so that EPA's Office of Pesticides Programs and Office of Pollution Prevention & Toxic Substances can protect public health and the environment from potential risk of pesticides and toxic chemicals. We are developing new techniques, population models and spatial analysis tools to assess these risks, not only on individual plants and animals, but on the plant-soil communities on which they depend.

The project will develop techniques to assess potential effects of:
a) the transfer of genes from genetically modified plants to compatible weedy, crop, and native plants ("gene flow")
b) nanomaterials on plants and soil organisms
c) herbicide drift on native plants and non-target crops
d) agricultural pesticides on wildlife populations

a) Gene Flow

Methods developed at Western Ecology Division provided the first documentation in the U.S. of long-distance gene flow and establishment of genetically modified (GM) crop/wild hybrids of creeping bentgrass in non-agronomic environments.

New gene flow research focuses on developing methods for measuring and predicting the environmental consequences of gene flow. Molecular markers are being developed that can identify GM crop/wild hybrids and measure changes that occur in wild populations containing GM plants.

A GIS-based framework is being used to quantify the abundance and distribution of GM and wild compatible plant populations, and approaches to assessing the risks of pesticide spray drift on managed and natural ecosystems.

b) Nanomaterials

As of June 2007, there were over 500 products containing engineered nanoparticles already on the market, including clothing, cosmetics, medicines and machines. Yet there is little information on the environmental effects of nanomaterials. Western Ecology Division's research will establish a framework for the EPA to begin assessing the effects of various engineered particles on terrestrial ecosystems.

The research is organized into three linked phases:
—*Phase one:* examines the traditional chemical testing protocols to determine whether such tests are adequate to assess the toxicity of nanoparticles.
—*Phase two:* uses toxicity results to explore the activity of studied nanoparticles.
—*Phase three:* examines the degree to which nanoparticles released into reconstructed ecosystems represent a risk to ecosystem structure or function.

c) Herbicide Drift

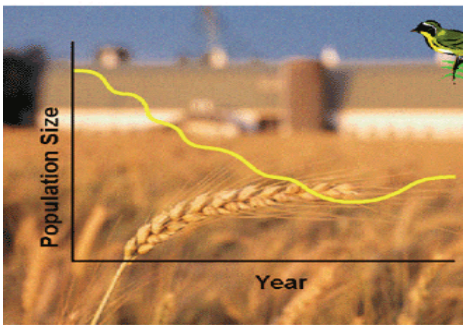
American agriculture depends on chemical herbicides to control "weeds". However, drift of herbicides can cause injury to non-target crops, and native plant communities and their associated wildlife, especially threatened and endangered species.

The goal of WED's herbicide research is to develop ways to determine how chemical herbicides affect non-target plants. Research focuses on the effects of herbicides on plant community structure and function, especially in terms of plant reproduction and subsequent ecological fitness.

Our target system is a reconstructed Willamette Valley prairie. We will also further develop a spatial analysis tool, WED-Pest, as a GIS platform for identifying plant species and other resources at risk from pesticide usage in the U.S.

Studies will help determine effects of herbicide drift on native plants such as Clarkia amoena 'farewell to spring'

d) Wildlife Modeling



The HexSim Model predicts wildlife populations over a landscape with pesticide stress

The EPA needs efficient methods to regulate the thousands of chemicals which may alter the habitats of terrestrial wildlife. The HexSim modeling effort developed at Western Ecology Division will generate tools and databases to assess the effects of these chemicals on wildlife populations.

We are developing an enhanced version of the HexSim wildlife population simulator, with its ability to assess pesticide risk in real or hypothetical agroecosystems through case studies.

These studies will capture effects of actual patterns of habitat structure, human activity, and other stressors on wildlife population size and distribution, and also will provide an analysis of habitat attributes that are key drivers in wildlife population performance.

--Emerging Technologies--

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Global Climate Change Research at WED

WED has been conducting climate change research for two decades. Past research has resulted in major contributions to our understanding of how global climate change may affect agriculture and forests, and the role forests play in carbon sequestration.

Current research addresses the potential effects on water quality, ecosystem services, and estuarine ecosystems. Contributing to the development of greenhouse gas mitigation strategies, research is evaluating the environmental consequences of carbon offset forestry.

Current projects include: Streamflow Vulnerability Analysis (**Dr. Jim Wigington**); Vulnerability of Pacific Coast estuarine ecosystems and population viability of key Pacific Coast estuarine species to global climate change (**Dr. Henry Lee II**); Ecological implications of carbon offset forestry: water quality and ecosystem services (**Dr. Paul Rygiewicz**); and Northwest Climate Change Collaboration, a regional forum that focuses the efforts of the Federal community in addressing climate change in the Pacific Northwest (**Dr. Peter Beedlow).**

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2) Estuarine Ecosystem Services

The ecologic, economic, and cultural values of estuarine ecosystems are not well understood by the public. However, tidal wetland habitats are critically important due to their high biodiversity, productivity, importance to threatened or endangered species, and other contributions to human well-being.

Estuarine Ecosystem Services research is developing the tools for estimating the effects of habitat alteration on estuarine ecosystem services associated with tidal wetlands of the Pacific Northwest.

Human activities within an estuary (shipping, recreation, aquaculture), or nearby (urbanization, agriculture, logging), may alter estuarine habitats either directly, or indirectly through such problems as excessive nutrients or introduction of invasive, non-native species. Global climate change may also bring many changes to coastal systems. As tidal wetland habitats are altered by human actions, so will the sum of the ecosystem services provided by these systems.

The primary products of the research will be GIS-based tools capable of estimating the value of ecosystem services provided by different combinations of habitat types, habitat conditions, and habitat area coverage in PNW estuaries, at scales from single system to the entire Pacific coast.

Research will focus on highly valued services such as healthy fish, shellfish, and wildlife populations, and will evaluate the likely changes in terms of these and other ecosystems services resulting from impacts of current and future alterations of tidal wetland habitats.

left: satellite map has overlays showing density of fish, crab and shrimp populations in Yaquina Bay, Newport, Oregon

3) Non-Navigable Streams & Wetlands

In 2006, the US Supreme Court addressed jurisdiction of non-navigable waters and adjacent wetlands (NSW) under the Clean Water Act (CWA). The *Rapanos* decision resulted in two criteria for determining CWA jurisdiction of NSWs: their hydrological permanence and whether they have a "significant nexus" (contribute to the functional integrity of navigable waters).

In 2008, scientists from EPA's Western Ecology Division (WED) and colleagues published a paper proposing an approach for examining some of the scientific issues raised by the *Rapanos* decision. WED's NSW Project is using this approach to develop information and methods that could help assess hydrologic permanence and significant nexus.

The research includes:

- Field testing of the Oregon Streamflow Duration Assessment Method, which assesses over 20 environmental factors in the field to distinguish between ephemeral, intermittent and perennial streams. In partnership with EPA's Region 10, the NSW Project is conducting a two-year study to test and improve the method at over 170 sites across Oregon.
- Development of a map of Hydrologic Landscape Regions (HLRs) for Oregon that will help classify the effects of NSWs on navigable waters. A classification system will provide context for considering the aggregate function of NSWs.
- Other components of the Project examine the connectivity, or "significant nexus," of NSWs with respect to fish habitat, nitrogen removal, and water source.

Such information should help EPA staff identify waters subject to CWA regulatory jurisdiction in light of the *Rapanos* decision, and could inform future policies and legislation.

above: Project member Joe Ebersole investigates NSW contributions to critical cold water habitats for native fish in Oregon's Upper Grande Ronde River.

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4) Monitoring For Aquatic Resource Assessment

The Methods for Aquatic Resource Assessment (MARA) project consists of three main activities in assessing the conditions of the nation's waters:

1) MARA will provide scientific support for EPA Office of Water and the enforcement of the Clean Water Act. EPA will utilize some of the tools developed at the Western Ecology Division as they seek to improve the availability and usefulness of water quality monitoring information. The monitoring program will include lakes, rivers, streams, coastal areas and wetlands.
2) MARA will develop models for predicting the conditions of rivers and streams at unsampled locations. "Spatially explicit estimation" uses verifiable data to develop models that can then be applied to areas where no sampling has occurred.

WED has already developed a simple model of this type to predict the probability of high phosphorus concentrations in Western streams.

below: team carries equipment into otherwise inaccessible areas to collect samples of macroinvertebrates, bacteria and chlorophyll. Samples will be transported back to civilization in coolers.

3) The services we receive from ecosystems include clean air, clean water, productive soils, and food sources, and MARA will develop indicators of these *ecosystem services*, the next generation of assessment endpoints.

There is a need to identify, quantify and understand ecosystem services so that environmental decisionmakers can evaluate the trade-offs to sustainability and human health with their use. MARA will focus on developing ways to assess the ability of ecosystems to continue providing these services.

This research will produce new ways to assess the condition of the nation's aquatic resources in compliance with the Clean Water Act, and will inform decisionmakers in weighing the benefits provided by ecosystem services.

5) Willamette Ecosystem Services Project

Lack of a standard method to evaluate ecosystem services has prevented full recognition of their contribution to human well-being, and has rendered their protection more difficult. The Willamette Ecosystems Services Project (WESP) seeks to quantify and understand the effects of anthropogenic (human-caused) stresses on ecosystems services. Many factors make up the web of ecosystem processes that provide beneficial services to humans.

Example: Restoration of riparian systems to provide fish habitat would also enhance other ecosystems services such as nitrogen control, carbon sequestration, flood protection, and habitat provisioning. Sequestering carbon not only removes greenhouse gas from the atmosphere, but it also reduces nutrient loss and improves erosion control.

Think of these multiple, linked ecosystem services as "bundled services". What value can be placed on the benefits provided by interlocked or bundled services?

left: Ecosystems can provide a valuable service by sequestering and neutralizing pollutants entering the air and water. Once ecosystems are disturbed or damaged, they may no longer function in this capacity.

To answer this question WED scientists will evaluate land use, forest productivity, wildlife, agricultural practices, riparian wetland, and aquatic biota. The responses of various ecological services (or bundles of services) to change are the basis for developing future projections of landscapes and the services that they provide.

Future projections can be calculated for use in economic and political analyses; bundles of services can also form the basis for trading.

The results will help EPA and others evaluate the implications of regulatory actions with regard to ecosystems services over large spatial areas.

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--Willamette Ecosystem Services Project--
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6) COFFEE

CARBON OFFSET FORESTRY: FORECASTING ECOSYSTEM EFFECTS

Amid rising concern about increasing levels of carbon dioxide (CO2) and other greenhouse gases known to accelerate climate change, the U.S. may be able to limit the buildup of these gases using Carbon Offset Forestry (COF) practices to sequester some of the CO2. Atmospheric CO2 is absorbed by plants, and sequestered in leaves, stems, branches, roots and soils. Forest and agricultural lands currently store large amounts of carbon. Programs such as "cap and trade" may allow a portion of the CO2 emissions cap to be offset by CO2 sequestration achieved elsewhere by someone other than the emitters. The U.S. does not have a mandatory cap and trade program, but should one arise, assessing the environmental benefits and consequences will be vital.

The focus of the Carbon Offset Foresty: Forecasting Ecosystem Effects (COFFEE) project is to assess potential environmental effects of COF practices on a large scale. COF practices would likely affect all ecological processes, thereby altering the delivery of many ecosystem services (ESs), which are the resources and processes supplied by ecosystems that benefit humans. EPA will evaluate effects of COF practices and climate change on ESs.

COFFEE will account for where and how carbon is sequestered in forest ecosystems because of the implementation of COF practices, and also will develop ways to determine quantified trade-offs among changes in the production of several ESs. COFFEE will collaborate with another Western Ecology Division project, the Willamette Ecosystem Services Project (WESP), to test a new decision tool for policymakers that takes into account simultaneous effects of multiple environmental and policy factors on ESs. The decision tool will be capable of providing outcomes for suites of alternative COF practices and future climate scenarios.

Having such a tool is crucial to the future interests of EPA national programs and regional offices, and external stakeholders.

below: Oregon's Willamette Valley, with its forest resources, major river, agriculture, and dense human population, provides an ideal location for COFFEE

--Carbon Offset Forestry: Forecasting Ecosytem Effects: --
Contact: **Dr. Paul Rygiewicz** (541- 754-4702)

RECENT PUBLICATIONS

Andersen, C.P., W. Ritter, J. Gregg, R. Matyssek, and T.E.E. Grams. Below-ground carbon allocation in mature beech and spruce trees following long-term, experimentally enhanced O_3 exposure in Southern Germany. *Environmental Pollution* doi:10.1016/ J.envpol.2010.05/2008 WED-10-029

Bautista, N.S., C.L. Sagers, E.H. Lee, and L.S. Watrud. Flowering times in genetically modified Brassica hybrids in the absence of selection. *Can. J. Plant Sci.* 90:185-187 (2010)

Brooks, J.R., H.R. Barnard, R. Coulombe and J.J. McDonnell. Ecohydrologic separation of water between trees and streams in a Mediterranean climate. *Nature Geoscience* 3:100-104 (2010)

Bryce, S.A., G.A. Lomnicky, and P.R. Kaufmann. Protecting sediment-sensitive aquatic species in mountain streams through the application of biological based streambed sediment criteria. *Journal of North American Benthological Society* 29 (2):657-672 (2010)

D'Andrea, A. F. and T. H. DeWitt. Geochemical ecosystem engineering by the mud shrimp *Upogebia pugettensis* (Crustacea: Thalassinidae) in Yaquina Bay, Oregon: Density-dependent effects on organic matter remineralization and nutrient cycling. *Limnology and Oceanography* 54:1911–1932 (2009)

Das, M., Reichman, J.R., Haberer, G., Welzl, G., Aceituno, F.F., Mader, M.T., Watrud, L.S., Pfleeger, T.G., Gutiérrez, R.A., Schäffner, A.R., Olszyk, D.O. A composite transcriptional signature differentiates responses towards closely related herbicides in *Arabidopsis thaliana* and *Brassica napus*. Plant Molecular Biology, 72: 545-556 (2010)

Ebersole, J. L., M. E. Colvin, P. J. Wigington, S. G. Leibowitz, J. P. Baker, M. R. Church, J. E. Compton, and M. A. Cairns. Hierarchical modeling of late-summer weight and summer abundance of juvenile coho salmon across a stream network. *Transactions of the American Fisheries Society138*(5): 1138-1156 (2009)

Eldridge, P.M. and D.L. Roelke. Origins and scales of hypoxia on the Louisiana shelf: Importance of seasonal plankton dynamics and river nutrients and discharge. *Ecological Modelling* doi: 10.1016/j.ecolmodel.04.054 (2009)

Floyd, W.C., S.H. Schoenholtz, S.M. Griffith, P.J. Wigington, Jr., and J.J. Steiner. Nitrate-Nitrogen, LandUse/Land Cover, and Soil Drainage Associations at Multiple Spatial Scales. *Journal of Environmental Quality* 38:1473-1482 (2009)

Hall, R.K., R.L. Watkins, D.T. Heggem, K.B. Jones, P.R. Kaufmann, S.B. Moore and S.J. Gregory. Quantifying structural physical habitat attributes using LIDAR and hyperspectral imagery. *Environmental Monitoring* Assessment 159-63-83 (2009)

Herlihy, A.T., J. Sifneos, C. Bason, A. Jacobs, M.E. Kentula and M.S. Fennessy. An Approach for Evaluating the Repeatability of Rapid Wetland Assessment Methods: The Effects of Training and Experience. *Environmental Management* 44:369-377 (2009)

Hosack, G.R., P.M. Eldridge. Do microbial processes regulate the stability of a coral atoll's enclosed pelagic ecosystem? *Ecological Modeling* 220:2665-2682 (2009)

Hughes, R.M., A.T. Herlihy, and P.R. Kaufmann. An Evaluation of Qualitative Indexes of Physical Habitat Applied To Agricultural Streams in Ten U.S. States. *Journal of the American Water Resources Association* 1-15. DOI: 10.1111/j.1752-1688 (2010). WED-09-123

Jacobs, A.D., M.E. Kentula, and A.T. Herlihy. Developing an index of wetland condition from ecological data: An example using HGM functional variables from the Nanticoke watershed, USA. *Ecological Indicators* 10:703-712 (2010)

Johnson, S.L., J.H. Power, D.R. Wilson and J. Ray. A Comparison of the Survival and Migratory Behavior of Hatchery-Reared and Naturally-Reared Steelhead Smolts in the Alsea River and Estuary, Oregon, using Acoustic Telemetry. *North American Journal of Fisheries Management* 30:55-71 (2010)

Kausch, A.P., J. Hague, M. Oliver, Y Li, H. Daniel, P. Mascia, L.S. Watrud and C.N. Stewart Jr. Transgenic perennial biofuel feedstocks and strategies for bioconfinement. *Biofuels* 1(1):163-176 (2010)

Kausch, A.P., J. Hague, M. Oliver, L.S. Watrud, C. Mallory-Smith, V. Meier, A. Snow, and C.N. Stewart Jr. Gene flow in genetically engineered perennial grasses: Lessons for modification of dedicated bioenergy crops IN Plant Biotechnology for Sustainable Production of Energy and co-products, *Biotechnology in Agriculture and Forestry*, Vol 66, Peter N. Mascia, Jurgen Scheffran, Jack M. Widholm, editors; Springer-Verlag Berlin Heidelberg (2010). WED-10-FCO-105

Keiluweit, M., P.S. Nico, M.G. Johnson, and M. Kleber. Dynamic Moecular Structure of Plant Biomass-Derived Black Carbon (Biochar). *Environmental Science & Technology* 44:1247-1253 (2010)

Kleber, M. and M.G. Johnson. Advances in Understanding the Molecular Structure of Soil Organic Matter: Implications for Interactions in the Environment. *Advances in Agronomy* 106:77-142 (2010)

Lackey, R.T. "Challenges to sustaining diadromous fishes through 2100: lessons learned from western North America." In *Challenges for Diadromous Fishes in a Dynamic Global Environment* edited by Haro, A., K.L. Smith, R.A. Rulifson, C.M. MOffitt, R.J. Klauda, M.J. Dadswell, R.A. Cunjak, J.E. Cooper, K.L. Beal, and T.S. Avery. American Fisheries Society, Bethesda, MD (2009) 609-617

Landers, D.H., S.M. Simonich, D. Jaffe, L. Geiser, D.H. Campbell, A. Schwindt, C. Schreck, M. Kent, W. Hafner, H.E. Taylor, K. Hageman, S. Usenko, L. Ackerman, J. Schrlau, N. Rose, T. Blett and M. Morrison Erway. The Western Airborne Contaminant Assessment Project (WACAP): An Interdisciplinary Evaluation of the Impacts of Airborne Contaminants in Western U.S. National Parks. *Environmental Science and Technology* 44(3):855-859. (2010)

Lee, E.H., D.T. Tingey, R.S. Waschmann; D.L. Phillips, D.M. Olszyk, MG. Johnson and W.E. Hogsett. Seasonal and long-term effects of CO2 and O3 on water loss in ponderosa pine and their interaction with climate and soil moisture. *Tree Physiology* doi: 10.1093/triiphys/tpp071 (2009)

Leibowitz, S. G. and D. White. "Modeling the effect of stream network characteristics and juvenile movement on coho salmon." In *Pacific salmon environmental and life history models: advancing science for sustainable salmon in the future* edited by E. E. Knudsen and J. H. Michael, Jr. American Fisheries Society, Symposium 71, Bethesda, Maryland. (2009) pp 203-224

Magee, T.K., P.L. Ringold, M.A. Bollman and T.L. Ernst. Index of Alien Impact: A Method for Evaluating Potential Ecological Impact of Alien Plant Species. *Environmental Management* doi: 10.1007/s00267-010-9426-1 (2010)

Nikolova, P.S. C.P. Andersen, H. Blaschke, R. Matyssek, and K-H. Häberle. Belowground effects of enhanced tropospheric ozone and drought in a beech/spruce forest (*Fagus sylvatica* L./*Picea abies* [L.] Karst). *Environmental Pollution* 158:1071-1078 (2010)

Olszyk, D., T. Pfleeger, E.H. Lee, and M. Plocher. Pea (Pisum sativum) Seed Production as an Assay for Reproductive Effects Due to Herbicides. *Environmental Toxicology and Chemistry* 28(9):1920-1929 (2009)

Olszyk, D., T. Pfleeger, E.H. Lee and M. Plocher. Potato (Solanum tuberosum) Greenhouse Tuber Production as an Assay for Asexual Reproduction Effects from Herbicides. *Environmental Toxicology* 29(1) 111-121. (2010)

Painter, M.L., C.L. Chambers, M. Siders, R.R. Doucett, J.O. Whitaker, Jr., and D.L. Phillips. Diet of spotted bats (*Euderma maculatum*) in Arizona as indicated by fecal analysis and stable isotopes. *Can J. Zool*. 87:865-875 (2009)

Peterson, SA, NVC Ralston, PD Whanger, JE Oldfield, WD Mosher. Selenium and mercury interactions with emphasis on fish tissue. *Environmental Bioindicators* 4(4):318-334 (2009)

Phillips, C.L., N. Nickerson, D. Risk, Z.E. Kayler, C. Andersen, A. Mix and B.J. Bond. Soil moisture effects on the carbon isotope composition of soil respiration. *Rapid Communications in Mass Spectrometry* 24:127-1280 (2010)

Roper, B.B., J.M. Buffington, S. Bennett, S.H. Lanigan, E. Archer, S.T. Downe, J. Faustini, T.W. Hillman, S. Hubler, K. Jones, C. Jordan, P.R. Kaufmann, G. Merritt, and C. Moyer. A Comparison of the Performance and Compatibility of Protocols Used by Seven Monitoring Groups to Measure Stream Habitat in the Pacific Northwest. *North American Journal of Fisheries Management* 30:565-587 (2010).

Rygiewicz, P.T., V.J. Monleon, E.R. Ingham, K.J. Martin, and M.G. Johnson. Soil life in reconstructed ecosystems: Intial soil food web responses after rebuilding a forest soil profile for a climate change experiment. *Applied Soil Ecology* 45:26-38 (2010)

Roelke, D.L. and P.M. Eldridge. Losers in the 'Rock-Paper-Scissors' game: The role of non-hierarchical competition and chaos as biodiversity sustaining agents in aquatic systems. *Ecological Modeling* doi: 10.1016/j.ecolmodel.2009.02.005 (2009)

Stierhoff, K.L., T.E. Targett, and J.H. Power. Hypoxia-induced growth limitation of juvenile fishes in an estuarine nursery: assessment of small-scale temporal dynamics using RNA:DNA. *Can. J. Fish. Aquat. Sci.* 66:1033-1047 (2009)

Usenko, S., S.L. Massey Simonich, K.J. Hageman, J.E. Schrlau, L. Geiser, D.H. Campbell, P.G. Appleby and D.H. Landers. Sources and Deposition of Polycyclic Aromatic Hydrocarbons to Western U.S. National Parks. *Environ. Sci. Technol.* 44:4512-4518 (2010).

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The information in this document has been funded wholly or in part by the U. S. Environmental Protection Agency. It has been subjected to review by the National Health and Environmental Effects Research Laboratory and approved for publication. Approval does not signify that the contents reflect the views of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.