Evaluation of Natural Resource Service Losses Related to Oil Field Development in the Concession

It is now well known that tropical rainforests such as those found in the Concession provide a wide variety of "services of nature" not only to local residents, but to entire regions and even to the whole globe (Myers 1997a). Intact rainforests regulate water flows and reduce the intensity of floods. Rain forests also contribute to regulation of the global climate through influencing regional rainfall patterns and providing a sink for excess CO_2 production (Myers et al. 1997a). Rainforests are also reservoirs of biodiversity, supporting large numbers of plant and animal species that have the potential to provide new medicines and food sources (Myers 1997b).

Rainforest ecosystems do not consist only of terrestrial plants and animals. They also include rivers and streams that, like the forests themselves, support abundant and diverse fish communities and provide water and food to local populations. Disturbances such as land clearing and oil-field development have both direct and indirect effects on a rainforest's aquatic resources. In addition to pollution from contaminant discharges, land clearing associated with oil field development promotes erosion, resulting in greatly increased turbidity and deposition of eroded sediments on river bottoms. These sediment deposits make the river bottom unsuitable for natural invertebrate communities and associated fish species. In the case of oil fields, the sediment can also be contaminated with PAHs and other petroleum-related compounds. These compounds are toxic to biota and some can accumulate in food chains, leading to human exposure as well. Contaminated sediment also becomes a secondary source for further contamination as floods resuspend the sediment and move it downstream. For this reason, any assessment of loss of natural resource services caused by development and operation of the Concession must include losses of services provided by both terrestrial and aquatic components of the rainforest habitat.

Determining the extent to which natural resource services in the Concession may have been reduced due to oil field development and operation, and determining the appropriate compensation for those losses, involves three steps:

1. Determine whether hazardous substances were released in quantities sufficient to impair the ability of soil, surface water, groundwater, or biota to provide natural resource services.
2. Determine the spatial extent and degree of impairment of the affected resources.
3. Estimate the monetary value of the resulting loss in resource services.

Data relevant to the first step are available from several published studies, however data and analyses relevant to the second and third steps are available only from the study of Cabrera (2008). For this reason, the present evaluation relies heavily on Cabrera (2008) but notes significant limitations and uncertainties related to this study.

Demonstration of injury to natural resources

Data needed to demonstrate injuries to natural resources are available from environmental audits performed by Fugro-McClelland West (1992) and HBT AGRA (1993), and from the expert report prepared by Cabrera (2008). These studies provide data concerning concentrations of hazardous chemicals associated with oilfield development and operation in the vicinity of oil wells, waste pits, and processing stations. Major sources of hazardous chemicals included oil spills, spreading of oil on roads for dust suppression, disposal of drilling muds and other chemicals used during drilling or operations, and discharge of production water. Collectively, these studies obtained approximately 1500 soil samples and 500 water samples in the vicinity of 82 production wells and 12 processing stations.

The principal substances measured in soil and groundwater samples included total petroleum hydrocarbons (TPH) and various metals. Because production waters are typically highly saline, analysis of surface water samples included major ions (e.g., chloride) that are indicators of potential impacts of salinity on aquatic biota.

To determine whether these substances were discharged in quantities sufficient to impair natural resource services, concentrations of these substances in the sampled media can be compared to national and international environmental quality standards. As noted by Cabrera (2008), Ecuador has enacted environmental quality standards for TPH, cadmium, chromium, nickel, zinc, Benzene, benzopyrene, naphthalene, and polycyclic aromatic hydrocarbons (PAHs) in soil, surface water, and groundwater. Ecuador has not established a standard for chloride in surface water, however, the U.S. Environmental Protection Agency (USEPA) has promulgated a standard for chloride in surface water. In addition, USEPA has developed Soil Screen Levels (SSLs) for many metals intended to protect plants, soil invertebrates, birds, and mammals. The SSLs for birds and mammals account for exposures via direct contact, drinking water ingestion, incidental soil ingestion, and dietary exposure. Concentrations that exceed media-specific standards or screening values have the potential to cause toxicity to exposed biota, therefore impairing natural resource services provided by those biota. The degree of impairment associated with exceedances of these values is somewhat uncertain, because the SSLs and other environmental quality criteria are deliberately established to be conservative. Concentrations lower than these values can be presumed to be safe, however, concentrations higher than these values can be expected to have varying effects, depending on the species actually exposed and on the degree to which the criterion values are exceeded.

According to Cabrera (2008, Annex J, Figures 2 and 3) soil concentrations of TPH exceeded Ecuador's soil quality standard in 36% of samples collected in the 8 oil fields located in the Concession. The standard was exceeded in equal percentages of samples collected within and outside disposal pits located in these oil fields. For the metals barium, copper, chromium, and zinc, Cabrera (2008, Annex J, Figures 4-11) found that 25%-73% of samples had concentrations exceeding one or more of EPA's SSL levels, with similar concentrations being found both inside and outside the disposal pits. These results indicate that oil field soils within the Concession are contaminated sufficiently to impair natural resource services provided by terrestrial biota.

Chloride concentrations measured at production station outfalls by Fugro-McClelland (1992) and HBT AGRA (1993) greatly exceeded EPA's acute and chronic water quality criteria. According to Cabrera (2008, Annex J), average values were approximately 30 times greater than EPA's acute criterion for chloride. Concentrations TPH measured by Fugro-McClelland (1992) exceeded Ecuador's environmental quality standard. Mixing zone chloride concentrations measured a short distance downstream from all but one of the outfalls examined exceeded EPA's chronic criterion (Cabrera 2008, Annex J). Concentrations of TPH exceeding Ecuador's standard occurred as far as 700 meters downstream from the discharge point. These results indicate that surface waters in the immediate vicinity of production stations were, at the time they were sampled by Fugro-McClelland (1992), contaminated sufficiently to impair natural resource services provided by aquatic biota.

Studies summarized by Cabrera (2008) indicate that TPH and metal concentrations from streams and rivers throughout the Concession exceed acute or chronic water quality criteria. Hence, aquatic natural resources throughout the Concession can be considered to be impaired.

Groundwater samples collected in the vicinity of discharge pits was found to be contaminated with TPH in concentrations exceeding Ecuador's environmental quality criterion (Cabrera 2008), therefore, the ability of groundwater to provide natural resource services is also impaired.

Spatial extent and degree of impairment

As can be seen from Figure 3.1 of Cabrera (2008), most sampling of environmental media in the Concession has focused on sites of known contamination in the immediate vicinity of wells, pits, and production stations. A few samples were collected in other parts of the Concession to estimate background concentrations.

Cabrera (2008, Appendix O) estimated the number of hectares of rainforest impaired due oil field wells and stations using information on the area of habitat disturbed or contaminated by oil field-related activities. Sites included in these calculations included oil pits, oil well platforms, spills and other areas of contamination, and production stations. For pits and well platforms, Cabrera (2008, Appendix O) assumed that the area of rainforest lost is equal to area of the pit or platform itself. For stations, Cabrera (2008) assumed that the area of rainforest lost is equal to the total area within the station boundaries. For spills and other areas of contamination around a pit, Cabrera (2008) assumed that rainforest within an area equal to the area of the pit itself. Cabrera (2008) assumed that covered pits provide 25% of the services provided by intact rainforest. Otherwise, all affected areas were assumed to experience 100% reductions in services. Cabrera (2008, Table 1) calculated that, adjusted for partial service reductions, 623 hectares of rainforest services were lost as of 1990. Cabrera (2008) also estimated the number of hectares of rainforest impaired by road-building associated with oil field development, assuming roads are 8 m wide and that a corridor of 15 m on either side of each road is impaired. In 1990, according to these calculations, 4530 hectares of rainforest services were lost due to the roads themselves and 3329 hectares of rainforest services were lost due to disturbance of the adjacent corridors. These values do not include any rainforest habitat that was contaminated by offsite migration of oils, wastes, or production waters, but was not physically disturbed by oil field operations.

It is my understanding that no estimates of the spatial extent of groundwater contamination or the number of stream-miles affected by oil field operations are available. However, it should be noted that in cases where roads were constructed adjacent to rivers and streams, land clearing and construction activities would have led to erosion and subsequent deposition of sediment in stream beds.

Value of lost resource services

In valuing losses of natural resource services, it is important to account for the duration as well as the magnitude of service reductions. The loss of 100 hectares of rainforest for 30 years entails a much greater cumulative loss of services than does the loss of the same 100 hectares for only a single year. The most commonly-used method for estimating these cumulative losses is termed habitat equivalency analysis (HEA). HEA accounts for the timing and duration of resource losses that occurred in the past, and also for the timing, duration, and effectiveness of future restoration actions or natural recovery. Key consideration in HEA include the magnitude, extent, and timing of historical service losses, the rate of recovery of the injured resources, the relative service value of the restored habitat as compared to the injured habitat, and the number of years required to implement restoration (Penn and Thomasi 2002). As in economics, a discount rate is applied to all past and future service gains or losses to translate them into present-year service values.

Cabrera (2008) used the HEA method to calculate the extent of restoration needed to compensate for losses of rainforest services that have occurred beginning in 1967, including future losses that will occur during a future 60-year restoration/recovery period. This application is similar to HEA applications performed to support Natural Resource Damage Assessments (NRDA) according to U.S. Environmental regulations, except that it includes services losses related to habitat disturbance in addition to losses related to pollutant discharges.

Using a 3% discount rate (commonly used in HEA assessments), Cabrera (2008) calculated that 3,525 hectares of rainforest should be restored to compensate for losses caused by oil wells, oil well platforms, spills, and stations. An additional 26,446 hectares would be required to compensate for losses related to road-building. The reason for these large numbers is that, due to discounting, the cumulative value of service losses that began in the past (in this case, several decades in the past) is much larger than the service loss due to an identical reduction in services occurring in the present. It should be noted that, because of discounting, the estimates of cumulative service losses calculated using HEA are highly sensitive to errors in estimates of the initial magnitude of service reduction. Any errors in these estimates grow exponentially at a rate of 3% per year over the period from the initial service reduction to the present.

Cabrera (2008) used two approaches for assigning the above compensatory restoration requirements: the restoration cost approach and the willingness-to-pay approach. The restoration cost approach involves estimating the cost per hectare of rainforest restoration and then multiplying the cost per hectare by the total number of hectares of restoration required. Cabrera (2008) estimated a per-hectare cost of $US 29,180 for restoring fully functional rainforest similar to the rainforest that existed prior to oil field development. The required compensation calculated using this method is $US 874,553,780, including $102,859,500 for losses due to oil wells and stations and $771,694,280 for losses due to roads.

The above values do not include compensation for losses of groundwater and service water services. Since no data are available concerning the spatial extent, magnitude, or restoration costs for these services, the restoration cost approach cannot be applied to surface water and groundwater resources.

The willingness-to-pay approach relies on surveys that assess the amount of money survey participants state they would be willing to pay for preventing the destruction of rainforest habitat. Cabrera (2008) utilized results of four published studies of willingness-to-pay for rainforest preservation, performed in Brazil (Adams et al. 2007; Holmes et al. 1998), the United States (Kramer and Mercer 1997), and the United Kingdom and Italy (Horton et al. 2003). Adjusting for differences in per-capita income between different countries and for the different years in which the studies were performed, Cabrera et al. (2008) estimated that on average each person participating in the survey was willing to pay $US 0.00000509 per hectare to protect tropical rainforest, based on U.S. per-capita income. To obtain an estimate of the total value per hectare, it is necessary to multiply the per-person value by the total population represented by the survey. Accounting only for countries having a per capita income as high as that of Brazil, Cabrera (2008) estimated a value of $4,735 per hectare. Accounting for all countries in the world (adjusted for relative per-capita income), Cabrera estimated a per-hectare value of $US 7,089. The required compensation using the willingness-to-pay approach ranges from $US 1,420 million to $US 1,965 million, with a mean of $US 1,697 million. Cabrera (2008) noted that this value did not include compensation to indigenous people inhabiting the Ecuadorean rainforest, which could be significant.

The willingness-to-pay approach is controversial among economists and the results produced are subject to a variety of biases and uncertainties that are difficult to quantify. (Diamond and Hausman 1995). However, it is arguably the only approach that can account for service losses related to groundwater and surface water. The reason for this is that the rainforest, as an ecosystem, includes groundwater and surface water as well terrestrial habitats. When people are surveyed concerning their willingness to pay for rainforest preservation they are implicitly valuing the entire ecosystem, not only the trees. Hence, the willingness-to-pay estimates calculated by Cabrera (2008) would include values for losses of groundwater and surface water resources.

Conclusions

The available data, much of it collected during environmental audits performed in the 1990s, show that concentrations of TPH and metals in soil, groundwater, and surface water have exceeded levels considered to be toxic to terrestrial and aquatic biota. Concentrations of chloride in production water discharges were high enough to be toxic to aquatic biota for at least several hundred meters downstream from the discharge points.

Estimates of the number of hectares of rainforest disturbed by well, waste pit, station, and road building operations can be fairly precisely estimated. However, service reductions related to contaminant exposures are highly uncertain. In Cabrera's analysis he did not take into account data concerning the spatial extent of groundwater contamination or the number of stream-miles that may have been affected by spills or production water discharges. To the extent there was such data showing such contamination, the estimates of hectares of rainforest and associated aquatic resources affected by oil field development and related activities such as road construction are lower-bound estimates of the service reductions related to development of the Concession.

Estimates of the economic value of these service reductions, accumulated over all of the years since the Concession was first opened to oil field development, are the most uncertain of all. Direct economic valuation of flood protection, climate regulation, and other services provided by rainforests is clearly impossible. The two approaches used by Cabrera (2008) are both surrogate methods that have been used in the United States to calculate compensatory restoration requirements. The restoration cost is probably the more reliable of the two approaches used by Cabrera (2008), because restoration costs can be objectively evaluated and supported, if necessary, by additional studies. The restoration cost approach as applied by Cabrera (2008) does not include costs for restoration of groundwater or surface water resources. The nature (and hence value) of any services provided by groundwater is unclear, however, rivers within the Concessions provide both ecological and human-use services that are not captured in values derived using the restoration cost approach. Estimates obtained using the willingness-to-pay approach can, in principle, account for values of all services provided by rainforest ecosystems, including groundwater and surface water. However, estimates obtained using this approach are highly subjective and difficult to interpret.

With further studies it would probably be possible to develop more refined estimates of service losses and values, however, it is not clear that the range of plausible values would be different from the range calculated by Cabrera (2008).

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Education

Ph.D., Biology, University of Chicago, Chicago, Illinois, 1976
A.B., Biology, Kenyon College, Gambier, Ohio, 1968

Work History

1976-1995: Research Staff Member, Environmental Sciences Division, Oak Ridge National Laboratory
1995-1998: Principal Scientist, McLaren-Hart, Inc.
1998: - President and Principal Scientist, LWB Environmental Services, Inc.

Experience Summary

Dr. Barnthouse is the President and Principal Scientist of LWB Environmental Services, Inc. His consulting activities include 316(b) demonstrations for nuclear and non-nuclear power plants, Superfund ecological risk assessments, Natural Resource Damage Assessments, risk-based environmental restoration planning, and a variety of other projects involving close interactions with regulatory and resource management agencies. He formerly spent 19 years as a research staff member and Group Leader at Oak Ridge National Laboratory, where he was involved in dozens of environmental research and assessment projects involving development of new methods for predicting and measuring environmental risks of energy technologies. After leaving Oak Ridge National Laboratory in 1995, he spent two and a half years with McLaren-Hart, Inc. prior to establishing LWB Environmental Services.

Dr. Barnthouse has authored or co-authored more than 90 publications relating to ecological risk assessment. He is a Fellow of the American Association for the Advancement of Science, Hazard/Risk Assessment Editor of the journal *Environmental Toxicology and Chemistry*, and Founding Editorial Board Member of the new journal *Integrated Environmental Assessment and Management*. He frequently serves on committees of the National Academy of Sciences and on peer review panels for major federal agency projects.

Current Activities

- **Technical expert on NRDA, Portland Harbor Superfund site.** Engaged to evaluate the contribution of the client's site to alleged natural resource injuries in the Willamette River, Oregon.

- **Technical expert on NRDA, Tar Creek Superfund site.** Engaged to evaluate natural resource injuries related to mining activities in northeastern Oklahoma.

- **Technical expert on ecological risk assessment and NRDA for General Electric Co. operations in New York and Massachusetts**. The project involves support of ongoing CERCLA risk assessment and Natural Resource Damage Assessment activities relating to historic discharges of PCBs to the Hudson and Housatonic Rivers.

- **Senior ecologist, restoration of the southeastern Tennessee Copper Basin.** The project involves development and implementation of an adaptive management-based watershed restoration plan for the North Potato Creek Watershed, Tennessee, which was seriously degraded by historic mining and smelting activities. This project was recently cited by the National Academy of Sciences as an example that should be followed at other large, complex sites.

- **Technical expert on effects of cooling water withdrawals on Hudson River fish populations**. Performing analysis of impacts of cooling water withdrawals on Hudson River fish populations and communities in support of ongoing permitting proceedings for the Indian Point Generating Station. Testified as an expert witness at permit hearings for the Danskammer Generating Station, November-December 2005.

- **Technical expert on impacts of power plants on Long Island Sound fish populations**. Engaged as expert witness by owners of two New England nuclear power plants to testify concerning impacts of their plants on winter flounder and American shad populations.

- **Technical expert on impacts of power plants on Cape Cod Bay fish populations**. Engaged by owners of a Massachusetts nuclear power plant to perform technical analyses and testify concerning impacts of their plant on winter flounder and other susceptible fish populations.

Significant Previous Projects

<u>LWB Environmental Services</u>

- **Technical expert on fisheries impacts at the proposed Calypso LNG terminal.** Engaged by company preparing Environmental Impact Statement to provide oversight on the fisheries impact component of the EIS.

- **Technical expert on ecological risk assessment and NRDA for pulp mill in eastern North Carolina.** Provided confidential comments to facility owner concerning validity of ecological risk assessments performed by consultants to the owner and by the U.S. Environmental Protection Agency; advised the owner concerning the types and magnitudes of potential natural resource damage liabilities due to contamination of sediment by dioxins and mercury.

- **Technical advisor, remediation of contaminated sediment at Langley AFB, Virginia.** Provided advice to remediation team concerning (1) establishment of cleanup goals in lead-contaminated sediment, and (2) development of a post-remediation monitoring program involving measurement of lead concentrations in fish and mussels. Assisted team in obtaining EPA approval of cleanup goal.

- **Development of biologically-based methods for compliance with EPA's 316(b) Phase II Rule.** Funded by the Electric Power Research Institute (1) to develop and demonstrate methods for quantifying biological benefits of reducing entrainment and impingement losses at existing facilities, and (2) to review biological issues affecting the feasibility of using habitat restoration as a compliance approach.

- **Technical expert on entrainment impact assessment for Gulf of Mexico LNG terminals.** Provided advice to two major corporations concerning the validity of data and methods used to predict impacts of proposed offshore LNG terminals on Gulf of Mexico fishery resources, and on the design of baseline monitoring programs for these facilities.

- **Technical Team Leader, 316(b) assessment for the Salem Generating Station.** Responsible for developing methods for quantitative assessment of impacts of entrainment and impingement on estuarine fish species; directed the analysis of data relating to entrainment and impingement impacts to support the facility owner's 1999 and 2006 permit renewal applications.

- **Member, National Academy of Sciences Committee on Superfund Site Assessment and Remediation of the Coeur d'Alene River Basin.** This committee independently evaluated the U.S. Environmental Protection Agency's scientific and technical practices in Superfund site characterization, human and ecological risk assessment, remedial planning, and decisionmaking with regard to the Coeur d'Alene Basin Superfund site. The committee's report was released in July, 2005.

- **Expert witness, NPDES Permit action in western Pennsylvania.** Engaged by corporate client to evaluate claims that discharges from the client's steel mills have caused ecological degradation of the Allegheny and Kiskiminetas Rivers. Led technical team performing quantitative ecological risk assessment. Testified at trial, February, 2001. Prepared supplemental report following successful appeal of initial decision by client; case was settled out-of-court in November, 2004.

- **Expert witness, NPDES Permit action in Ohio.** Engaged by corporate client to evaluate allegations by federal and state agencies that discharges from the client's metal plating plant caused fish kills in the Ohio River. Charges against the client were withdrawn prior to trial.

- **Technical expert on 316(a) and 316(b) issues at the Diablo Canyon Power Plant.** Reviewed historical predictive and retrospective thermal effects assessment studies; provided expert review of draft 316(b) Demonstration. Represented client at regional water board hearing, March 2001.

- **Peer Review Coordinator, Columbia Basin PATH Project.** Organized and chaired an external review committee for a multi-stakeholder project that developed and tested models of the impacts of hydropower operations, harvesting, hatcheries, habitat quality, and oceanic conditions on endangered Snake River Basin salmonid populations. Organized an expert briefing on salmon issues for senior executives of the Bonneville Power Administration.

McLaren-Hart, Inc.

- **Senior Technical Advisor for an assessment of ecological risks of chlorinated solvents, heavy metals, mercury, and PCBs at a chemical manufacturing facility in southwest Louisiana.** Responsible for selection of risk assessment methodologies used by team of risk assessors evaluating on-site and off-site risks to fish, wildlife, and sediment-dwelling biota. Developed a strategy for negotiating major elements of the project work plan with EPA Region VI. Responsible for defining strategy for integrating results of ecological risk assessment into corrective measures planning and potential NRDA defense activities.

Environmental Sciences Division, Oak Ridge National Laboratory

- **Co-principal investigator, 5-year EPA/DOE research program on ecological risk assessment methods.** This was the first federally funded research project explicitly identified as an "ecological risk assessment" project. Methods for uncertainty analysis of ecological models developed for this project were the forerunners of Monte Carlo food-chain exposure models that are widely used today. Much of the ecological risk assessment terminology now used by EPA and other agencies (e.g., "assessment endpoints" and "measurement endpoints") originated with this project. The final publication from this research was named the best scientific paper published at Oak Ridge National Laboratory in 1990.

- **Project manager for a basic research program on biological mechanisms underlying density-dependent population growth in fish.** The project pioneered the development and application of "individual-based population models" that are now widely used in biological research and in management of endangered species.

- **Technical advisor and expert witness for EPA Region II in NPDES permit hearings related to impacts of fossil and nuclear power plants on fish populations in the Hudson River.** Assisted EPA lawyers in preparation of case, performed independent data evaluations and model-based analyses, testified in administrative law hearings. Represented EPA on a technical team that assisted EPA, the State of New York, and the Consolidated Edison Co. in the negotiation of a widely publicized settlement agreement. Became senior editor for an American Fisheries Society monograph presenting scientific results from 10 years of monitoring and research on the Hudson. Assessment methods developed for the "Hudson River Power Case" are now used by utility companies and regulatory agencies throughout the United States.

- **Group leader for ecological risk assessment team performing CERCLA baseline ecological risk assessments for U.S. Department of Energy facilities in Oak Ridge, Tennessee, Portsmouth, Ohio, and Paducah, Kentucky (EPA Regions IV and V).** Major assessments included a five-year investigation and baseline risk assessment for the Clinch River, Tennessee; reservation-wide assessments for the Portsmouth Gaseous Diffusion Plant and the Oak Ridge National Laboratory; and operational-unit-level assessments for numerous burial grounds and waste ponds.

- **Expert advisor on ecological risk assessment for the DOE Office of Air, Water, and Radiation**. Surveyed ecological risk assessment capabilities at all major DOE facilities, initiated development of standard ecological screening benchmarks for all DOE sites, reviewed EPA draft Ecological Risk Assessment Guidance for Superfund for DOE; developed training course on Natural Resource Damage Assessment for DOE site managers, led NRDA case study project at the Savannah River Site, prepared white paper on the application of the EPA Data Quality Objectives Process at DOE sites.

Professional Society Activities

Member, Ecological Society of America, Society for Environmental Toxicology and Chemistry, Society for Risk Analysis

Hazard/Risk Assessment Editor, *Environmental Toxicology and Chemistry*, 1992 - 2010

Founding Editorial Board Member and Associate Editor, *Integrated Environmental Assessment and Management*, 2004-present

Chair, SETAC Global Internet Committee, 2007-present

Chair, SETAC/ESA Workshop on Sustainable Environmental Management, Pellston, Michigan, August 1993.

Chair, SETAC Workshop on Population-Level Ecological Risk Assessment, Roskilde, Denmark, August, 2003.

Short Course Instructor, Annual SETAC meeting

- Ecological Risk Assessment (1992, 1994)
- Product Life Cycle Assessment (1996, 1997)
- Applications of Population Biology in Ecological Risk Assessment (2008, 2010)

Chair, Applied Ecology Section, Ecological Society of America, 1995-1997

Ecological Risk Assessment Specialty Group Chair, Society for Risk Analysis, 1991-1993

Member, Advisory Panel, Society for Risk Analysis, 1996-1998

Other Professional Activities

Member, Kalamazoo River Ecological Risk Studies Peer Review Panel, 2008-

Member, Atlantic States Marine Fisheries Commission Power Plant Panel, 2001-

Member, External Laboratory Review Panel, EPA Midwest Ecology Division, Duluth, MN, February, 2002.

Peer reviewer, EPA Drake Chemical Site Incinerator Risk Assessment, 1998.

Member, Ecological Committee on FIFRA Risk Assessment Methodologies (ECOFRAM), 1997-2000

Reviewer and issue paper author, EPA Risk Assessment Forum Ecological Risk Assessment Guidelines Program, 1991-present

- Member of Peer Review Panel for EPA Framework for Ecological Risk Assessment
- Author of issue paper on Conceptual Model Development
- Member of Peer Review Panel for EPA Ecological Risk Assessment Guidelines
- Member of Peer Review Panel for EPA Generic Endpoints for Ecological Risk Assessment

Chair, National Research Council Workshop on Ecological Risk Assessment, Warrenton, Virginia, February 1991.

Member, National Research Council Committee on Environmental Remediation at Naval Facilities, 1997-1998.

Member, National Research Council Committee to Review the DOI's Biomonitoring of Environmental Status and Trends Program, 1994

Member, National Research Council Committee on Risk Assessment Methodology (Chair, Ecological Risk Assessment Topic Group), 1989-1993

Member, National Research Council Board on Environmental Studies and Toxicology, 1989-1992

Member, National Research Council Committee on Pesticides and Ecological Risk Assessment, 1986-1987

International Activities:

Workshop on Population-Level Ecological Risk Assessment, 12th SETAC Europe Congress, Vienna, Austria, 2002

Ninth SETAC Europe Congress, Leipzig, Germany, 1999

XIIIth International Plant Protection Congress, The Hague, The Netherlands, 1995

Fifth SETAC Europe Congress, Copenhagen, Denmark, 1995

IPPC Special Workshop on Article 2 of the U.N. Framework Convention on Climate Change, Fortaleza, Brazil, 1994

SGOMSEC Workshop on Methods to Assess the Effects of Chemicals on Ecosystems, Montpellier, France, 1994

IAEA Validation of Assessment Models Project, Vienna, Austria, 1992

International Biospheric Model Validation Project, Vienna, Austria, 1992

Seventh International Congress of Pesticide Chemistry, Hamburg, Germany, 1990

Workshop on Ecological Risk Assessment for Chemicals, Schmallenburg, West Germany, 1987

NATO Conference on Safety Assurance for Environmental Introductions of Genetically-Engineered Organisms, Rome, 1987

Awards and Honors

- Martin Marietta Energy Systems Technical Achievement Award, 1991
- Martin Marietta Energy Systems Author of the Year, 1991
- Martin Marietta Energy Systems Technical Achievement Award, 1994
- Fellow, American Association for the Advancement of Science, 1994

Publications

Books and Monographs

Barnthouse, L. W., W. R. Munns, and M. T. Sorensen (eds.). 2007. *Population-Level Ecological Risk Assessment.* Taylor & Francis, Boca Raton, Florida, U.S.A.

Barnthouse, L. W., G. R. Biddinger, W. E. Cooper, J. A. Fava, J. H. Gillett, M. M. Holland, and T. F. Yosie (eds.) 1998. *Sustainable Environmental Management.* SETAC Press, Pensacola, Florida, U.S.A.

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Journal articles and book chapters

Barnthouse, L. W., D. Glaser, and L. DeSantis. 2009. Polychlorinated biphenyls and Hudson River whiter perch: Implications for population-level risk assessment and risk management. *Integrated Environmental Assessment and Management* 5:435-444.

Barnthouse, L. W. 2008. The strengths of the ecological risk assessment process: Linking science to decision making. *Integrated Environmental Assessment and Management* 4:299-305.

Gustavson, K. E., **L. W. Barnthouse**, C. L. Brierly, E. H. Clark, II, and C. H. Ward. 2007. Superfund and mining megasites. *Environmental Science and Technology* **41**:2667-2672.

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