

Binational Conference on Environmental Research and Policy



Final Report

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Attendees: 26 participants from Mexico
96 participants from the U.S./Canada
122 Total (82 academic, 12 community, 18 government, 10 business)

Site: Center for U.S.-Mexican Studies, Institute of the Americas Complex, University of California, San Diego

Date: June 12-13, 2000

Co-Sponsors: The National Institute of Environmental Health Sciences (NIEHS), UC Toxic Substances Research & Teaching Program, City of San Diego Mayor's Office, SANDAG - San Diego Association of Governments, *Dirección de Planeación de Desarrollo Urbano y Ecología, Municipio de Tijuana*, SCERP - Southwest Center for Environmental Research & Policy, and UCSD, including UCSD Superfund Basic Research Program; Health Sciences--School of Medicine; Center for U.S.-Mexican Studies; Urban Studies and Planning; Center for Environmental Research and Training; Division of Social Sciences; UCSD Civic Collaborative; IR/PS - International Relations and Pacific Studies; and the San Diego Supercomputer Center.

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Executive Summary

The NIEHS is strongly supporting the idea of establishing a small number of US-Mexico Binational Centers to foster and enable collaboration in the solution and management of environmental problems relating to human health in the border region. A steering committee was formed in 1998 to move the agenda forward and argued that: "There is a clear need for a binational, university-based center to manage environmental and hazardous-waste information, promote training and education in hazardous-waste management, and establish research ties between U.S. and Mexican investigators in environmental science, health, engineering, and policy." [Robert G. Varady, et al., Udall Center Publications, Working Paper 00-1, Jan. 2000].

While this conference stressed binational issues with an emphasis on the California/Baja California border region, our larger aim is to show how a strategic coalition of academicians, scientists, industry leaders, community-based organizations, and policy-makers in federal and local agencies with binational and border interests could be organized to pursue common problems. This is a huge challenge. As the National Research Council's Board on Sustainable Development argues, we need "significant advances in basic knowledge, in the social capacity and technological capabilities to utilize it, and in the political will to turn this knowledge and know-how into action" (NRC 1999: 7). Toward this end, the conference was also organized with the intent to: (a) establish a border coalition of universities, industrial and civic partners engaged in environmental research and policy, and (b) provide input to the NIEHS as they develop an RFA (Request for Applications) for their prospective Binational Centers Program. The longer-term purpose is to collaboratively build binational capacity for environmental research, education, training and outreach using state-of-the-art information technology and communication systems. The plan is to establish more efficient, interactive, and equitable methods for integrating university-based environmental science with the fast-changing needs of industry, government, and community-based organizations.

The conference included plenary sessions with keynote speakers from the U.S. and Mexico who are involved in the development of environmental policy at the local, state and national levels. Presenters addressed a number of fundamental questions: Can binational collaboration really improve environmental health in the U.S.-Mexico borderlands and beyond? What are the most important scientific, informational, socio-economic, legal-institutional and cultural variables that we should take into account? What are the barriers and bridges to successfully integrating information technology, environmental research and policy in U.S.-Mexico relations? To focus the discussion, the conference included a series of panel presentations and pre-organized breakout sessions. Research scientists at the San Diego Supercomputer Center set the stage for the breakout sessions by providing an overview of cutting-edge enabling technologies available for data collection, integration, and sharing, as well as for modeling and prediction. Day two of the conference allowed for a more in-depth and forward-looking discussion based on the collective results of the breakout sessions.

We structured the conference to examine opportunities for and benefits of applying research results in biomedicine, information technology, environmental science, communications and social science to environmental health and management problems at the US-Mexico border. The work product of the conference, this report, is intended to provide the NIEHS leadership with assistance in developing a strategic plan and criteria for supporting future research on U.S.-Mexico related environmental problems perhaps in association with one or more of the future Binational Centers. To help focus the discussion and results of the Conference we defined seven subject areas as follows:

1. Hazardous waste management (binational priorities and challenges for data collection, integration, and sharing)
2. Industrial ecology and environmental management systems (environmental engineering, regional planning and pollution prevention)
3. Biomedical research (linking exposure with insult at the genomic level); bioremediation
4. Water quality in regional bays, estuaries, and coastal zones (pesticides, heavy metals, and ecotoxicology)

5. Prevention/intervention research with a public health approach geared to U.S.-Mexico cross border and transnational issues (emphasizing occupational health, exposure assessment, infectious disease vectors and environmental epidemiology)
6. Air pollution and global climate change (integrated risk assessment)
7. Enabling multidisciplinary approaches to environmental research, education and training in the U.S.-Mexico transborder context (the culture of binational networking and communication).

The goal, through the efforts of a conference workgroup for each of the subject areas, was to cross-correlate these seven topical subjects with each of the research areas. This cross-correlation proved itself to be a useful method for identifying what should be done, by whom, how and why. The results of these efforts are contained in the section titled, "Research Design and Methods (Breakout Group Reports)."

The importance of multidisciplinary integration, partnerships and collaboration was reinforced at the Conference. During his keynote dinner address, Dr. Samuel H. Wilson provided a holistic vision of environmental health while arguing that the nature of current environmental challenges makes it imperative to think beyond borders and political jurisdictions. Dr. William A. Suk (NIEHS, Director of Program Development) emphasized that the efficacy of a Regional Binational Center Program hinges on the capacity to foster multidisciplinary collaboration. During his opening keynote address, Dr. Suk argued that bringing together one or even two biomedical disciplines is not enough. A narrow disciplinary focus will fail to address enough pieces of the puzzle. Examples of multidisciplinary approaches can be seen in the NIEHS/EPA Superfund Basic Research Program, three of which are focusing on a number of problems within the U.S.-Mexico border region (UCSD, UC Arizona, and Texas A&M). There are other NIEHS-funded programs underway in Mexico City (Berkeley, University of Washington) and others taking place elsewhere in Mexico. With respect to establishing a Binational Center, Dr. Suk emphasized that a critical mass of interactions among researchers and communities will be crucial, and this should be done in the communities where the exposures are taking place.

In writing-up the concluding section of this Report (titled, "Considerations for a Binational Centers Program"), we elected to condense the results of the seven breakout groups into four categories: Environmental Health (biomedical, prevention/intervention), Water Quality, Air Quality, Industrial Ecology and Hazardous Waste. Upon analysis, a set of functions and capabilities emerge as essential to an effective binational center. We suggest that they be organized as follows with a brief description of approximate role of each component:

1. Environmental Health Practice: responsible for Center's activities and collaborations in translating research results into effective public health interventions, policy and protocols.
2. Multidisciplinary Research Division: responsible for the interactive development and synergy of basic biomedical research (e.g., mechanistic-based studies, epidemiology, genetic susceptibility) with non-biomedical research, including both natural and social science-based inquiry (e.g., earth systems, ecological risk assessment, fate and transport, hydrogeology, engineering, remediation, urban and cultural studies, economics, geography), for the purpose of understanding the processes by which environmental health risks emerge and proceed.
3. Education, Outreach and Training Service: responsible for continuing education and training of graduates, professionals and the public-at-large in the issues of environmental health, research methods as well as developing systems for acquiring and sharing public health data from the border community.
4. Information Infrastructure & Integration Division: responsible for computing, data and communications, including the development of a Regional Workbench Program, in a manner that services the mapping and analysis requirements of research collaborations, data acquisition, publication standards and protocols management.

The supporting details of this conclusion are contained within the body of the report. There are also a number of appendices providing additional information and documentation of the conference that will be useful in program development for a binational center program.

I. Purpose

The objective of the June 12-13, 2000 Binational Conference was to provide the NIEHS leadership with a strategic agenda and criteria for supporting future research on U.S.-Mexico related environmental problems. The NIEHS is strongly backing the idea of establishing a small number of Binational Centers. A steering committee was formed in 1998 to move the agenda forward. This committee argues that: "There is a clear need for a binational, university-based center to manage environmental and hazardous-waste information, promote training and education in hazardous-waste management, and establish research ties between U.S. and Mexican investigators in environmental science, health, engineering, and policy." [Robert G. Varady, et al., Udall Center Publications, Working Paper 00-1, Jan. 2000].

The June 12-13 Conference at UCSD stressed binational issues with an emphasis on the California/Baja California border region. But our larger aim is to show how a strategic coalition of academicians, scientists, industry leaders, community-based organizations, and policy-makers in federal and local agencies with binational and border interests could be organized to pursue common problems. This is a huge challenge. As the National Research Council's Board on Sustainable Development argues, we need "significant advances in basic knowledge, in the social capacity and technological capabilities to utilize it, and in the political will to turn this knowledge and know-how into action" (NRC 1999: 7). The Conference was organized with the intent to: (a) establish a border coalition of universities, industrial and civic partners engaged in environmental research and policy, and (b) provide input to the NIEHS as they develop an RFA (Request for Applications) for their prospective Binational Centers Program. The longer-term purpose is to collaboratively build binational capacity for environmental research, education, training and outreach using state-of-the-art information technology and communication systems. The plan is to establish more efficient, interactive, and equitable methods for integrating university-based environmental science with the fast-changing needs of industry, government, and community-based organizations.

II. Overall Theme

The conference began with a morning plenary session including keynote speakers from the U.S. and Mexico who are involved in the development of environmental policy at the local, state and national levels (see Appendix). Presenters addressed a number of fundamental questions: Can binational collaboration really improve environmental health in the U.S.-Mexico borderlands and beyond? What are the most important scientific, informational, socio-economic, legal-institutional and cultural variables that we should take into account? What are the barriers and bridges to successfully integrating information technology, environmental research and policy in U.S.-Mexico relations? To focus the discussion, the conference included a series of panel presentations and pre-organized breakout sessions. The breakout sessions focused on seven subject areas:

- Hazardous waste management (binational priorities and challenges for data collection, integration, and sharing)
- Industrial ecology and environmental management systems (environmental engineering, regional planning and pollution prevention)
- Biomedical research (linking exposure with insult at the genomic level); bioremediation
- Water quality in regional bays, estuaries, and coastal zones (pesticides, heavy metals, and ecotoxicology)
- Prevention/intervention research with a public health approach geared to U.S.-Mexico cross border and transnational issues (emphasizing occupational health, exposure assessment, infectious disease vectors and environmental epidemiology)
- Air pollution and global climate change (integrated risk assessment)

- Enabling multidisciplinary approaches to environmental research, education and training in the U.S.-Mexico transborder context (the culture of binational networking and communication).

Research scientists at the San Diego Supercomputer Center set the stage for the breakout sessions by providing an overview of cutting-edge enabling technologies available for data collection, integration, and sharing, as well as for modeling and prediction. Day two of the conference allowed for a more in-depth and forward-looking discussion based on the collective results of the breakout sessions.

III. Background Information

The internationalization of the global economy and the North American Free Trade Agreement (NAFTA) have fueled strong industrial growth along the U.S.-Mexico border. The border region—a 2000-mile-long, 125-mile-wide strip extending from the Pacific Ocean to the Gulf of Mexico—was scarcely inhabited at the beginning of this century. The total population now exceeds 11.5 million, up from only 1 million in 1960. Much of the growth on the Mexican side has been fueled by the rapid expansion of over 1,800 maquiladora manufacturing/assembly operations. Maquiladoras are Mexican manufacturing and assembly plants that are owned by foreign parent companies. Roughly 18 percent of Baja California's total work force is in such plants (San Diego Regional Economic Development Corporation 1997: <http://www.sdcdc.com>). At the end of 1998, Tijuana had 697 maquiladoras, employing 153,876 workers (San Diego Dialog Report, March 1999: 4)..

Of the border region's fourteen binational sister city pairs, the San Diego-Tijuana (SD-TJ) pair is the most populated and rapidly growing. Its combined population is expected to grow from 3.6 million in 1990 to more than 5 million by the year 2000, with the fastest growth occurring in Tijuana. From January 1998 through November 1998, Tijuana added an average of six new maquiladoras and 1,712 more workers each month (San Diego Dialog Report, March 1999: 4). The SD-TJ region provides a gateway to the Pacific; as such it has become a nodal point in the expanding trade among Pacific Rim countries.

The combined effects of urban and industrial growth on both sides of the border have generated a number of increasingly serious environmental problems. Chief among these are the over-exploitation and contamination of transborder ground and surface water resources; the lack of proper disposal or recycling of liquid, solid and hazardous waste; air pollution; and inadequate environmental infrastructure. The severity of these problems--and the mobilization of civil society that has drawn attention to them--helps explain why environmental issues were linked to the negotiation of NAFTA (Ganster and Sanchez 1999). International cooperation on trade and the environment has set the stage for new initiatives and collaborative efforts aimed at preventing pollution and promoting sustainable development (Pezzoli 2000a, 2000b).

Beginning in the early-1990s, the NIEHS began to think seriously about the U.S.-Mexico Border region. The NIEHS has funded a number of conferences and working papers dedicated to the subject (Robert G. Varady, et al., Udall Center Publications, Working Paper 00-1, Jan. 2000). On August 9-11, 1998, the University of Arizona Center for Toxicology, Superfund Basic Research Program, in Tucson, Arizona, hosted one of these binational conferences. One of the outcomes was a recommendation to establish a Regional Binational Center. A Steering Committee composed of conference participants suggested that such a Center might include data management, information dissemination, training and education, and research. They supported this recommendation with reference to the following shortcomings:

- There exists no central repository for environmental data or central responsibility for data dissemination in the region (northern Mexico/southwestern United States).
- Efforts to collect environmental data in northern Mexico remain handicapped by inadequate numbers of trained personnel and limited funds.

- University participation is either missing or inadequate in regional institutions addressing environmental quality, infrastructure, public health, and hazardous-waste issues. (Robert G. Varady, et al., Udall Center Publications, Working Paper 00-1, Jan. 2000).

With respect to defining a strategic action plan, Committee members underscored the importance of enabling US-Mexico collaboration. This theme also emerged loud and clear in our June 12-13, 2000 Binational Conference. During his closing comments on June 13, Dr. William Suk (NIEHS Director of Program Development) emphasized that the prospective Binational Center Program's greatest promise is its potential to engender synergy among NIEHS/NIH researchers, federal agencies (e.g., Border XXI, USGS, DOI), universities, businesses, community-based organizations, agricultural associations, city government and planning departments, state and local environmental departments, and state and local health departments.

IV. Goals and Objectives

The NIEHS Regional Binational Center Program's fundamental goal is to improve environmental health. Broadly defined, environmental health "comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling and preventing those factors in the environment that can potentially affect adversely the health of present and future generations." This working definition of environmental health (drafted at a World Health Organization consultation in Sofia, Bulgaria, 1993) was used in a recent Binational Center Program presentation in Mexico City ("NIEHS and U.S.-Mexico Border Environmental Health," Liam R. O'Fallon, NIEHS, May 20, 2000). To better understand and improve environmental health, the NIEHS has promoted interdisciplinary and partnership-based approaches. A Binational Center would be expected to do the same. The nine functional goals guiding the NIEHS for the period 2000-2005 provide a good list to guide the development of a Binational Center. They are outlined below.

1. **GOOD SCIENCE FOR GOOD DECISIONS**
Provide a sound, rational scientific foundation to support public environmental health policy.
2. **NEW TECHNOLOGIES**
Develop the new technologies that will provide high-throughput, quick turn-around environmental health data in a way that is relevant and can be extrapolated to the human condition.
3. **ENVIRONMENTAL DATABASES AND REGISTRIES**
Identify the environmental component of human diseases through strengthening existing databases and registries and creating new ones that track and monitor exposures and diseases.
4. **INDIVIDUAL SUSCEPTIBILITY**
Define individual susceptibility to environmental exposures.
5. **ENVIRONMENTAL DISEASE COHORTS**
Define the environmental and genetic components of many human diseases by establishing long-term, prospective studies.
6. **COMMUNITY NEEDS AND EMERGING HEALTH ISSUES**
Ensure that the NIEHS and its research remains responsive to community needs and to newly emerging environmental health problems.
7. **CAREER DEVELOPMENT**
Ensure a well-trained workforce in the environmental health sciences that reflects the diversity of the American people.

8. COMMUNICATION

Enhance the understanding of environmental health sciences and its importance to human health among scientists, policy makers, and the American public.

9. MANAGEMENT

Ensure responsible stewardship of the NIEHS research enterprise. <see <http://www.niehs.nih.gov/external/plan2000/goals.htm>>.

A Binational Center may not be able to put equal emphasis on each of these goals. But one thing is certain. Striving toward any one of the nine goals in a binational context highlights important new challenges. One of the main objectives of a Binational Center will be to enable U.S.-Mexico collaboration in research, outreach, education and training. Such a Center should build on the strengths of established approaches supported by the NIEHS (i.e., the SBRP). The challenge is to foster synergy among basic, applied, and translational research approaches.

V. Multidisciplinary and Binational Approach

To be successful, a Binational Center will have to make information integration and the development of communication systems an integral part of its operation. The importance of multidisciplinary integration, partnerships and collaboration was reiterated again and again at the June 12-13 Binational Conference. UCSD's Senior Vice Chancellor of Academic Affairs, Dr. Marsha Chandler, set the stage early on with her opening comments. Dr. Chandler emphasized three points. First, there is the challenge to make multidisciplinary connections. The study of the environment simply cannot be encompassed by any one discipline. No one discipline has purchase over it. But cross-disciplinary connections don't happen automatically. Dr. Chandler posed the question: How can we actually enable multidisciplinary research and see that the fruits of such work get translated and applied? In medicine this is looked at as moving from bench to bedside. How do you move from science and technology to policy and from policy to the actual application? This is a very important challenge for the prospective Binational Center. The second point Dr. Chandler emphasized was that the university is not an ivory tower. It is a question of seeing the university as more wedded in society and the connection between the university and various institutional groups - cultural, government., industry, K-12. One cannot think about academic research without realizing the real embeddedness of the university. And its not just a question of what good can researchers do for society. The benefits of collaboration - with whatever is the appropriate linkages - also enhances research. The best connections are two-way, mutually-rewarding connections. The third kind of connection Dr. Chandler emphasized concerns globalization. In the case of the environment, an international and local-global perspective couldn't be more important. The nature of environmental challenges today make it imperative to think beyond borders and political jurisdictions. Connections needs to be made and working relationships need to be built--both in framing the problem and the issues as well as considering what kind of problem solving can take place. We should be thinking in the context of building coalitions and leading by example. A Binational Center can be an exemplary learning laboratory where we prototype novel and innovative approaches to doing science, evaluation, and problem solving.

Dr. William Suk (NIEHS, Director of Program Development) also emphasized how the efficacy of a Regional Binational Center Program hinges on the capacity to foster multidisciplinary collaboration. During his opening keynote address, Dr. Suk argued that bringing together one or even two biomedical disciplines is not enough. A narrow disciplinary focus will fail to address enough pieces of the puzzle. Examples of multidisciplinary approaches can be seen in the NIEHS/EPA Superfund Basic Research Program, three of which are focusing on a number of problems within the U.S.-Mexico border region: UCSD, UC Arizona and Texas A&M (Rural School of Public Health). There are other NIEHS-funded programs doing things in Mexico City (Berkeley, University of Washington) and others taking place in Mexico. With respect to establishing a Binational Center, Dr. Suk emphasized that a critical mass of

interactions among researchers and communities will be crucial, and this should be done in the communities where the exposures are taking place.

Dr. Suk also suggested that the Binational Center's approach should emphasize basic research and prevention using state of the art techniques to improve the sensitivity and specifics for detecting adverse effects in humans or in ecological systems. Since effects follow from exposure, a second major emphasis is to understand phenomena that affect transport, fate and toxicity of xenobiotic agents, and to develop approaches to attenuate and investigate exposures through the development of remediation strategies. This means we need to have prevention, and remediation technologies. If you can reduce toxicity before someone is exposed to it, then you are preventing exposure. Dr. Suk concluded his keynote speech by reiterating the importance of achieving genuine binational collaboration. As currently conceptualized, each Binational Center (there may be a total of four) should include a consortium of academic institutions - affiliated Centers of Excellence-- positioned in states along the U.S.-Mexico border. Each Center will be a binational effort involving broad-based local community sectors. The Binational Centers Program (also referred to as the Binational Border Research In Disease and Geospatial Environmental Exposures, BRIDGE Program) will be supported by the NIEHS/NIH and other federal agency partners. The effort will have to be coordinated with the Border XXI Program. Other partnering efforts may take place with the USGS/DOI to provide Exposure and Risk Assessment.

How are we supposed to know if a multidisciplinary and binational approach will pay off? What should be the measures of our success? Dr. Suk noted how Public Health is an interesting field, but there are very few operationally defined measures of success. Once a program is in the field, how do you evaluate its performance, how do you justify the dollars that are being spent to fund academics and technology-driven approaches to environmental problems? Dr. Suk argued that measures of success have to go beyond the number of publications in Cell and Nature, as important as those are. We also need science-based metrics and evaluations of performance. Dr. Suk gave one example based in economics. There is a publication that looked at hospital admissions of children and calculated the number of days lost. Cost/benefit analysis was used as an economic marker, as an indicator of success. One of the challenges for a Binational Center program would be to define measures of success. As Dr. Suk noted, we don't want to say the measure of success is we didn't have 1518 kids with such high blood lead levels there were considered unsafe and they had to be moved. That's not a measure of success. That's measure of failure.

Another issue that was raised about the prospective approach of a Binational Center concerns the degree to which it takes on a regional and place-based focus. On this point, Dr. Suk noted that if you're aiming to prevent something and you understand the relevant basic research, you'll have to be able to do population-based, epidemiology-based studies. What kinds of cohorts and biomarkers are appropriate? Dr. Suk suggested that if we're going to try to get an understanding of the linkages between exposure and disease etiology, we need to have a measure that you can look at and assess in some way.

This emphasis on developing place-based studies was echoed in the comments made by Antonio Azuela (Atorney General of Mexico's Environmental Protection Enforcement Agency). Dr. Azuela called for developing our "Geographical" sensitivity. He commented that one of the complicating factors in development models today is the lack of attention paid to spatial structures and how society organizes itself in a given territory. With advances in communication and globalization there is an assumption that spatial barriers are not important anymore. Dr. Azuela argued that we have to reinsert the importance of geography and become more sensitive to how things happen in specific places, where things may be durable and difficult to change. To illustrate his point, Dr. Azuela mentioned the case of a lead-smelting plant in Mexico. The regulations governing this particular industry did not take into account the unintended consequences of contamination over the long term. It took a group of academic researchers to open the eyes of the public to the very serious problem of lead poisoning. The problem had not been perceived by policy, because the policy instruments did not allow us to see it geographically. No one had put the question - who's being exposed and who had been exposed? The lessons learned from this case have changed Mexico's views on how to deal with health issues.

With respect to a developing a binational approach to training, Mariano Cebrián Garcia (Centro de Investigacion y de Estudios Avanzado Del, I.P.N., Dept. of Pharmacology and Environmental Toxicology, Mexico) suggested that we need to build capacity through research and graduate programs in environmental sciences. We need to build these programs in Mexican universities under the umbrella of research centers. An important objective is to have well-trained people able to study and deal with problems in Mexico. Dr. Cebrián laid out the contours of a strategic plan. First stage, select which Mexican Universities we wish to develop to reach critical mass and then enlist the training support of U.S universities. At the same time, develop pathways for cooperative research. Establish a means to collaboratively set research priorities. Have Mexican and American students work on the same set of problems. Dr. Cebrián has had some success doing this already with UCLA by pairing students to jointly study problems. The second stage would advance the infrastructure of health sciences in Mexico, ending a pattern whereby American scientists come and take samples back for evaluation without building capacity in Mexico.

Dr. Octavio Rivero Serrano (Secretario del Consejo de Salubridad General, Mexico) also addressed the conference (on June 12) and offered some observations with respect to human resources and training. Dr. Serano noted that, for Mexico, human resources are an essential element. Although there are 60 universities in Mexico, very few have toxicology programs. Toxicology has been largely neglected in Mexico's universities. Dr. Serano suggested that what we need to do is recognize what is truly available in Mexico in order to stimulate their efforts, foster their groups and have these groups impact the decision-making process. He suggests that Mexico develop an autonomous organizing agency to facilitate this process; the agency should have the support of environmental groups, political organizations, industry and various others in order to be able to promote coordinated efforts among the universities. A Binational Center initiative could prove to be an important catalyst in getting such an agency organized.

VI. Research Design and Methods (Breakout Group Reports)

As noted above the conference included a series of panel presentations and pre-organized breakout sessions. The breakout sessions focused on seven subject areas, including: (1) Hazardous waste management, (2) Industrial ecology, (3) Biomedical research, (4) Water quality, (5) Prevention/intervention research, (6) Air pollution, and (7) Enabling multidisciplinary approaches. Prior to the conference a brief working document was prepared by team leaders responsible for their respective subject area (breakout session). Each of the working documents are listed below along with summary notes that were generated during the June 12th breakout session. Together, the collection of works below is far broader than a single Binational Center could undertake. The range of identified priorities for research and funding suggests that, indeed, there should be more than one Center, and that there should be interactive knowledge networking among those Centers that do get created.

1. Hazardous Waste Management

Authors: Ilya Zaslavsky and Kathy Kopinak with input from Saul Guzman and Jerry Last

A waste is a material that can no longer serve the purpose for which it was originally intended. A waste is considered to be hazardous because of its concentration and quantity of physical or chemical characteristics that may cause or contribute to increased mortality or illness, or pose a present or potential hazard to human health or the environment. Beyond this somewhat simple description, hazardous wastes are defined somewhat differently in the United States and Mexico, with the latter being more inclusive.

North of the border, they are considered to be liquids, solids or sludge which have one or more of the following characteristics: corrosive, reactive, explosive, toxic, and ignitable (CRETI). They can be products of manufacturing processes, or commercial products such as household liquid cleaners and battery acid. In Mexico, biological infectiousness is added as a fifth characteristic to the CRET I list. They

can also be identified by their physical states, such as their chemical composition, or their generic description as one of the following: water, pitch, lubricants, gum, solvents, containers, tailings, sludge, solutions, dirt, etc. Although Mexico's definition of hazardous waste is more extensive than that of the United States, Mexican infrastructure operating to manage hazardous waste is precarious at best. This is due to the fact that Mexico's economic crisis and opening in the eighties was accompanied by the dismantling of earlier legislation for environmental protection. New laws were not re-instituted until 1989.

1.1 Some suggested information sources:

- U. S. Environmental Protection Agency: <http://www.epa.gov/ebtpages/whazardouswaste.html>
- California Department of Toxic Substance Control: www.dtsc.ca.gov
- Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP): <http://www.semarnap.gob.mx/>
- Instituto Nacional de Ecología (INE) -<http://www.ine.gob.mx/>
- Border XXI: www.epa.gov/usmexicoborder/ef.htm
- World Bank. What Improves Environmental Performance. Evidence from Mexican Industry (http://www.worldbank.org/nipr/work_paper/1877/index.htm)

One of the barriers to the use of data from these sources is that information is often incomplete and/or highly aggregated. For example, Mexico's first Pollutant Release and Transfer Report needs to add more detailed information beyond the list of participating companies (<http://www.ine.gob.mx/dggia/retc/ingles/prtring.html>). The dynamism of industrial and population development sometimes makes it difficult to update such information to make it current and accurate. This is especially true in the San Diego/Tijuana region, where industrial growth has been higher than in many other areas in the last decade. In some cases, the generators of hazardous waste may legally report to government agencies, but much of their information remains confidential and not readily available to researchers or students.

Given the broad way in which hazardous wastes are defined, it is difficult to include all of the relevant research in one outline. Most binational concerns relate to hazardous waste generated in, or imported to, the border region. They are often related to rapid urbanization, population growth, industrial agglomeration, and radioactive waste sites. The La Paz agreement called for protection of the U.S.-Mexico border region. Debates about free trade stimulated more concern at the beginning of the nineties, and led to a 1992 consultative mechanism that committed the United States and Mexico to sharing information on hazardous waste sites in the border area. The shortcomings of the 1992 agreement contributed to the fact that "in a lot of ways, 1999 was not a particularly good year for advancing U.S.-Mexico cooperation on environmental issues."

A new consultative mechanism signed on December 1, 1999 improves on the earlier one (see text of the agreement at <http://www.epa.gov/usmexicoborder/ef.htm>). It commits both countries to sharing more inclusive information on hazardous waste sites in the border area, and will enable greater citizen participation in waste site permitting decisions. There are still some limitations in the new mechanism, which could be removed via amendment. For example, some readings of the agreement might imply that only radioactive waste needs to be listed, and not naturally occurring radioactive material. Also, due to the different definition of hazardous waste in the two countries, "maquiladora waste that is low enough in toxicity and other hazardous characteristics to escape U.S. hazardous waste definitions, even though it is considered hazardous in Mexico" regularly ends up in commercial solid waste landfill sites in the United States, such as Sunland Park, New Mexico. Commercial facilities that treat or dispose of non-hazardous industrial waste were not included in the new consultative mechanism, and should be.

Another aspect of change has been the implementation of NAFTA, which specifies that hazardous waste imported to Mexico by maquiladora industries no longer has to be exported back to their country of origin. However, in group discussion, one of the participants who works for the EPA said

that the rule requiring the sending of hazardous waste back to the US from Mexico has been indefinitely extended. Mexico does not yet have adequate facilities to properly treat, store, or destroy the hazardous waste. Thus, much of it may continue to be exported to the United States (even if the requirement to do so ends), since that is where the closest facilities are. The new regulation also means that more hazardous waste will probably also be dumped illegally in Mexico. Clearly, more funds need to be made available for the construction of proper treatment, disposal and storage facilities in Mexico. The illegal disposal of hazardous waste into municipal water systems, especially in Mexico, needs to be prevented. This might be facilitated with by more extensive inspections of industrial sites. Industrial discharges need to be pre-treated. Such pre-treatment might be encouraged through the Industria Limpia program.

Although there has been great progress in the development of environmental law at the national and international level in the last decade, more support needs to be given to the implementation of that law. While the environmental side agreement to NAFTA was written to encourage member countries to comply with their own laws, the failure of some industrial violators to do so has raised doubts about the efficacy of that process. One of the worst hazardous waste sites along the U.S.-Mexico border is Metales y Derivados, a car battery recycler and lead smelter located only a few hundred yards from the residential Ejido Chilpancingo in Tijuana, a plant that was closed in 1994 for violating Mexican environmental law. The toxic substances remain on the site to this day. Finally in May, 2000, in response to complaints by a coalition of NGOs, the North American Commission for Environmental Cooperation said it would investigate the site.

Ftnt. 1 Cyrus Reed. 2000. Consultative Mechanism: A Breath of Fresh Air For U.S.-Mexico Environmental Cooperation. Borderlines Updater. April 3.

Fnt. 2 Ibid.

Additional comment by Jerry Last

The combustion of hazardous wastes in the USA to destroy them has been practically eliminated by US EPA policies, which in turn are driven by a very controversial risk assessment for dioxins (as carcinogens). Thus, such wastes are usually disposed of in landfills, with attendant threats to groundwater. It might be timely to revisit the issue of hazardous waste combustion as one of the few possible technologies for destroying toxic organic compounds scheduled for disposal. This is an area of research that requires a fusion of expertise in engineering, toxicology, and public policy to determine optimal strategies for dealing with hazardous wastes that optimize economic benefit while ensuring public health. Similarly, research in optimizing public policy towards dealing with "mining" of wastes, such as the lead deposited on and in the Metales y Derivados site, might suggest strategies of taxation and subsidy that would be of benefit. Such studies would have to be informed by toxicology to be of value. In both of these cases, differences in the regulatory framework on both sides of the border should be seen as an opportunity, not necessarily as a liability.

Notes from the June 12 breakout group

Biomedical Issues

- a. Exposure models tied with qualitative and quantitative risk assessment
- b. Need for different models, for occupational, community, and children exposure
- c. Nutrition as a factor of susceptibility to toxic wastes

Information technology

- d. Negotiating access to data, and developing a mechanism for data sharing is the most important item in the agenda, both research and practical

- e. Cataloguing available databases (in the US: EPA, USGS, CalEPA, SanDAG; in Mexico: INE, INEGI), with consistent database content description/documentation
- f. Consistency checking for existing databases on hazardous waste (following EPA HAZTRAKS vs INE example) – need to be done on the level of individual firms
- g. Database integration based on consistent database descriptions

Education and Outreach

- h. Developing interfaces that allow everyone access to databases
- i. Providing pollution prevention data back to firms
- j. Workshops, “train the trainer” activities
- k. Partnerships between Academia – Government – Industry – NGO (“7 principles”)
- l. Regionalizing education about hazardous waste

Social Science

- m. A survey, on both sides of the border, of common environmental priorities (by regions), determining where toxic waste exposure is in this list of priorities, and building collaboration and education strategies accordingly
- n. Comparative study of hazardous waste perceptions and understanding at different levels (individual – community – municipal – state)

Legislation

- o. Compare definitions of hazardous waste on both sides of the border, communicate the differences and explore the consequences
- p. Compare legal issues in clean-up of abandoned properties (in Mexico, especially, this is a problem)

Specific toxic wastes

- q. Radioactive: low level toxic waste site selection need to be coordinated (siting of Sierra Blanca near Texas border is an example)
- r. Biomedical: it is a hazardous waste in Mexico but not in the U.S.
- s. Used motor oil: need to capture amounts of used oil that is (1) dumped, and (2) sent to certified recycling centers
- t. Agricultural: trans-border transport of pesticides from the Imperial Valley needs to be studied
- u. Household: no data on this topic is available in Mexico
- v. Toxic Waste In Motion: different regulations, and risk assessment models on both sides of the border

Environmental science

- w. Environmental fate of hazardous waste
- x. Degradation of cross-border ecosystems affected by hazardous waste
- y. Integrated approach to ecosystem study, analysis of the circle of haz. materials
- z. Developing rules for locating new sites for storing hazardous waste

2. Industrial Ecology and Environmental Management Systems (EMSs)

Authors: Keith Pezzoli with input from Paul Linden, Antonio Azuela, and Richard Wright

In the introduction to the "NIEHS Strategic Plan 2000," the authors present the following argument: "*The most effective way to prevent disease and disability is to understand the cause of an*

illness and change the conditions that permit it to occur. A key strategy for preventing many diseases or minimizing disease progression is to minimize or eliminate adverse effects of chemicals in the environment and food supply. This preventive strategy underlies the concept of "environmental health." <<http://www.niehs.nih.gov/external/plan2000/intro.htm>>. The North American Agreement for Environmental Cooperation (NAAEC)¹ also emphasizes the importance of prevention. Pollution prevention is advocated as an environmentally and economically effective alternative to pollution control. The Council of the Commission for Environmental Cooperation (CEC), created as a result of the NAAEC, has developed a number of recommendations regarding pollution-prevention techniques and strategies. The CEC defines pollution prevention as "activities that benefit the environment through source reduction of waste and/or emissions; improved efficiency in the use of resources and inputs; and elimination/reduction in the use of environmentally harmful substances or activities." The CEC finds that pollution prevention is becoming the principal environmental paradigm in North America today. The CEC argues: "as a key element in the implementation of sustainable development, pollution prevention requires the involvement of all types of business and non-business activity, and must become the dominant strategy for addressing non-point, as well as point sources of pollution" (CEC 1996). A Binational Center can help make this happen.

There is now a growing number of pollution prevention programs underway throughout Mexico, the United States, and in the U.S.-Mexico border region. The main types of approaches include technical assistance, training, public and private sector programs in pollution prevention awareness, assessment of pollution prevention opportunities, policy development and institutional support, and technology development and investment activities. The range of entities engaged in these activities covers the full spectrum. At the broadest level, one finds international and federal government agencies as well as national and transnational trade associations and non-governmental organizations. At the meso level, one finds public, private, and non-profit organizations active at state, regional, and local levels. And at the micro end of the spectrum, there are noteworthy "best practices" and award-winning cases at the firm and industrial plant level (Pezzoli 2000).

Manufacturers in the U.S. currently spend around \$50 billion annually in pollution abatement and control; the figure for the U.S. as a whole is over \$120 billion (PCSD 1996: 38). The global market for environmental technology (ET), goods and services is large and expanding. ET is one of the fastest growing industry sectors worldwide. The global market for ET--currently estimated at about \$400 billion and expected to reach \$600 billion by the year 2010.² The United States is the largest, single market for ET in the world. The US accounted for 41 percent of the total global market (\$408 billion) for ET in 1995. By comparison, Latin America (including Mexico) accounted for only 1.6 percent of the total global market (EBI 1995: 16). California is a leader in environmental technologies, especially for applications that improve air quality, water quality, and pesticide management, and that provide energy from sources other than fossil fuel. Today, more than 180,000 Californians are employed by companies producing \$20 billion worth of waste treatment and minimization, pollution control and prevention, and related environmental technologies and services" (California Environmental Technology Certification Program 1996). ET is one of the export oriented growth clusters in the San Diego region (SANDAG 1998). Regional support infrastructure for this cluster includes the headquarters of the California Institute for Environmental Technologies at Scripps Institute of Oceanography, the UCSD Connect Program, and the Border Environmental Commerce Alliance (BECA).

The Mexican market for ET is one of the leading export opportunities for U.S. companies.³ The Mexican government's pressure on industry to become self-sufficient in solid waste management and wastewater treatment, as well as existing and proposed requirements in the areas of air pollution and

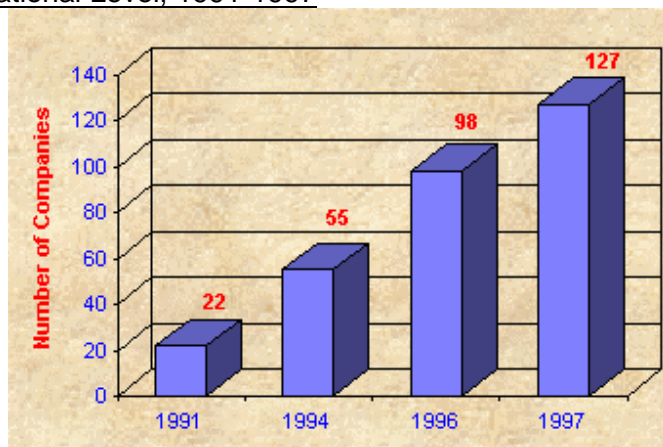
¹The NAAEC creates a North American framework whereby goals related to trade and the environment can be pursued in an open and cooperative way (see <http://www.cec.org>).

² Figures cited on the website of the US government's Office of Environmental Technologies Exports (<http://www.ita.doc.gov/envirotech/etindus.html>).

³ US government's Office of Environmental Technologies Exports (<http://www.ita.doc.gov/envirotech/etindus.html>)

hazardous waste management, will help drive demand.⁴ The number of companies in Mexico conducting the business of hazardous waste disposal rose from 22 in 1991 to 127 in 1997 (see Figure 1). Yet, the rate of hazardous waste generation, which rose from a national total of 5.7 million tons in 1990 to 12.7 tons in 1997, may outstrip Mexico's capacity to properly deal with it (see Figure 2).⁵ In 1997 the EPA reported that the U.S. border states produced 20 million tons of hazardous wastes (EPA 1999).

Figure 1. Hazardous Waste Disposal Infrastructure, Mexico, National Level, 1991-1997

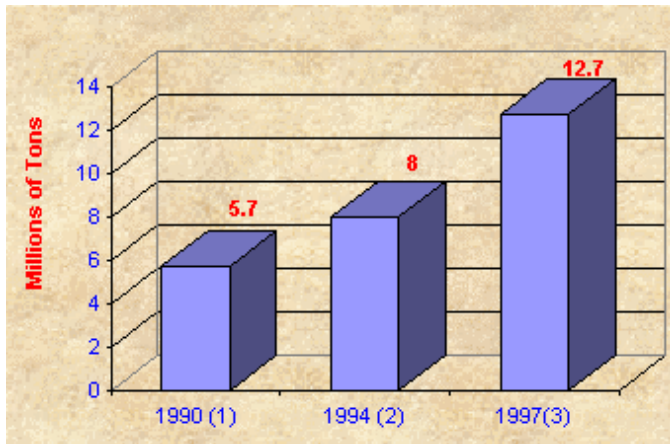


Source: Dr. Octavio Rivero Serrano, Secretario del Consejo de Salubridad General, Data supplied for the June 12-13, 2000 Binational Conference (UC San Diego).

Figure 2. Hazardous Waste Generation, Mexico, National Level, 1990-1997

⁴ The environmental technologies market in Mexico was valued at \$2.3 billion for 1996, up from \$2.1 billion in 1995. U.S. environmental technology exports accounted for over 60% of this market -- \$1.4 billion. During 1996, U.S. market share was greatest in the field of hazardous waste handling and cleanup (85%), followed by service sector pollution abatement (84%), and petroleum and petrochemical pollution abatement and remediation (82%). Environmental engineering services (\$1 billion) and the petroleum and petrochemicals pollution abatement (\$842 million) constitute the largest overall markets in Mexico (U.S. Department of Commerce, Office of Environmental Technologies Exports, 1997; <http://www.ita.doc.gov/envirotech/mexmktsm.html>).

⁵ See "Hazardous Waste Management in the United States--Mexico Border States: More Questions than Answers," prepared by published by the Red Mexicana de Acción Frente al Libre Comercio (Mexico City), La Neta--Proyecto Emisiones: Espacio Virtual, (Mexico City), and the Texas Center for Policy Studies (Austin Texas), March 2000. Copies of this report (in English and Spanish) can be downloaded from: <http://www.texascenter.org/btep/index.htm>.



Source: Dr. Octavio Rivero Serrano, Secretario del Consejo de Salubridad General, Data supplied for the June 12-13, 2000 Binational Conference (UC San Diego).

The CEC (1996) reports that “the US experience suggests that pollution prevention faces two unique obstacles, both of which limit implementation and help explain why information, financial resources, and promotion are still not enough: the first is the inadequacy of current perceptions and budgeting for pollution prevention, which thus inhibits its implementation; the second is the inadequacy of integration of pollution prevention into the business issues, relationships, and organizations that influence business decision-making.” Likewise in Mexico, a World Bank study found that in order for pollution prevention efforts to be effective they “need to be incorporated into the overall business strategies of companies as part of a general cultural change process linked to continual learning, improvement and innovation” (Ahmed, Martin and Davis 1999). A Binational Center could play an important role in bringing about such a cultural change. A conceptual framework for doing this can be found in “industrial ecology.”

2.1 Industrial Ecology

Preventing pollution is obviously crucial. But closing the loop on the economy's throughput of material and energy resources, while addressing challenges posed by urban growth, eco-system interdependencies and carrying capacity, presents an equally daunting task. Such concerns lie at the heart of industrial ecology (IE). IE looks for ways to incorporate pollution prevention into activities that already influence business decision-making. Rather than attempting to “sell” a concept like pollution prevention, IE aims to make pollution prevention a part of what is already credible and needed by businesses. IE expands the scope of environmental decision-making beyond plant managers to also include design engineers, process engineers, marketing personnel and accountants, as well as other stakeholders outside the firm (e.g., community groups).

IE is a promising new multidisciplinary field that encompasses a broad range of concepts, methods and applications for improving the environmental performance of industry and related systems. A growing number of educators, environmental managers, engineers, consultants, researchers and policy analysts are promoting IE. In their landmark book titled Industrial Ecology, Graedel and Allenby (1995) define IE as “the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural, and technological evolution. It is a systems’ view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, to ultimate disposal” (p. 11). Along similar lines, Wernik et al. (1996: 171) define IE as “the study of the totality of the relationships between different industrial activities, their products, and the environment. It is intended to identify ways to optimize the network of all industrial processes as they interact and live off each other, in the sense of a direct use of each other's material and energy wastes and products as well as economic synergism.” This analytic merger of industrial development with an ecological metaphor (first done by Ayres 1989) marks an important conceptual step forward. IE is ecological in that it “(1) places human activity—industry in the

very broadest sense—in the larger context of the biophysical environment from which we obtain resources and into which we place our wastes, and (2) looks to the natural world for models of highly efficient use of resources, energy and byproducts. By selectively applying these models, the environmental performance of industry can be improved" (Allen, Ehrenfeld, and Lifset 1997).

In the U.S., research on industrial ecology has begun to get support from the National Science Foundation (NSF), the Department of Energy (DOE), government laboratories, and university-based research centers (Eisenberger 1996, Wernick and Ausubel 1997). During May 1995, the US-EPA, the Research Triangle Institute, and the UC San Diego CONNECT program convened the first ever **"Industrial Ecology for Border Area Economic Development Workshop."** The objective of the workshop was to explore applications of IE and environmental technology to economic development in the U.S.-Mexico border area.⁶ In Mexico, SEMARNAP (Secretariat of the Environment, Natural Resources and Fisheries), SECOFI (the Ministry of Commerce and Industrial Development), and the nation's main industrial organization, CONCAMIN (the Confederation of Industrial Chambers), entered into an agreement to jointly undertake a "Program in Environmental Protection and Industrial Competitiveness." Embracing some of the principles of IE, this program includes activities aimed at regulatory simplification, industrial self-regulation, promotion of competitiveness, information systems development, and training. Julia Carabias Lillo, the Secretary of SEMARNAP, characterized her government's signing of the CONCAMIN accord as a major step forward. She pointed out that over 5.3 million tons per year of toxic wastes are produced in Mexico from the combined sources of eight major industries: the chemical, petrochemical, pharmaceutical, mining, metallurgical, machining, food and textile industries. The Secretary expressed optimism that the agreement would enable government-industry cooperative efforts to analyze production processes in these industries in an effort to reduce the heavy volumes of toxic wastes generated (Robillard 1995: 7).

The shift from pollution control to pollution prevention is well underway. The shift from pollution prevention to the more holistic systems approach of IE is barely beginning. The momentum for such a shift depends, in part, on the speed at which Environmental Management Systems (EMS) are developed and implemented by both public and private sector organizations. Solid science needs to drive EMSs and related policy development. Here again is a role for a Binational Center.

2.2 Environmental Management Systems (EMSs)

An organization with an Environmental Management System (EMS) in place is distinguished from a traditional organization most of all by how it incorporates pollution prevention and resource conservation into its ongoing business decisions and activities. Traditional organizations typically do not have such an integrated approach to environmental considerations; rather they have a reactive approach designed to comply with narrowly defined, and often fragmented, government regulations. The California Environmental Protection Agency (Cal/EPA) defines an EMS as "a process by which an organization's management identifies regulated and unregulated environmental aspects and impacts of its operations, assesses current performance, and develops targets and plans to achieve significant environmental improvements."⁷ California Governor Gray Davis recently established the Cal/EPA EMS Innovation Initiative, the purpose of which is to find more effective and innovative ways to achieve superior environmental protection. The Governor's initiative targets the inefficiencies of environmental policy built on principles of "command-and-control."

⁶ Cosponsors of the workshop included the California Environmental Technology Center, UCSD's Institute of the Americas, the National Association of Industrial and Office Properties, the President's Council on Sustainable Development, the Southwestern College Small Business Development and International Trade Center, the Urban Land Institute, the U.S.-Mexico Border Progress Foundation, and the IOA's U.S.-Mexico Environmental Business Committee.

1. CALIFORNIA EPA, ENVIRONMENTAL MANAGEMENT SYSTEM INNOVATION INITIATIVE, FIRST QUARTERLY REPORT TO THE LEGISLATURE 2, Submitted Dec. 31, 1999 [hereinafter FIRST QUARTERLY REPORT].

The potential benefits of EMSs go beyond individual firms or organizations. Benefits can be also achieved at the level of supply-chains, whole industrial clusters, sectors, regions, and even transnational networks. Other positive outcomes may include improved industry-community relations and industry-government relations. The Environmental Protection Agencies of Mexico, Canada and the U.S. are currently collaborating to promote the widespread adoption of EMSs. A research and policy-based collaborative called the Multistate Working Group (MSWG) recently hosted a major conference in San Diego (June 5-6, 2000) on EMSs and regulatory innovation <<http://www.dep.state.pa.us/dep/deputate/pollprev/mswg/2000/presentation.htm>>. At this conference, there was a session focusing on "**North American Cross-Border EMS Initiatives.**" The session described and explained the new Commission for Environmental Cooperation EMS Guide, including initiatives being developed for implementation in the United States, Mexico and Canada. To facilitate this in the U.S.-Mexico border region will require novel measures and methods. One method for enabling such networking can be found in a project already underway called the Regional Workbench.

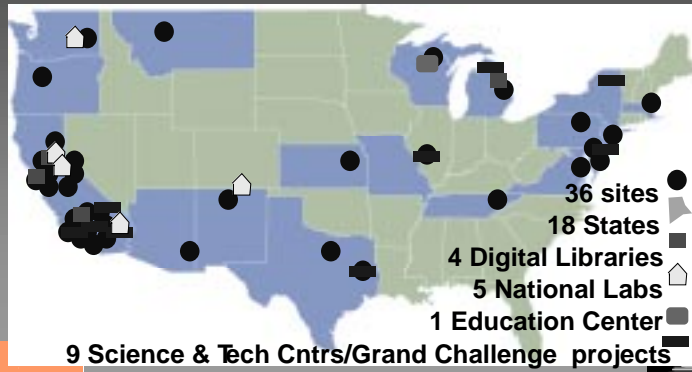
2.3 The Regional Workbench

The Regional Workbench <<http://regionalworkbench.org>>, now under construction at UCSD, is a partnership-driven research network and method (for outreach, education and training) that can enable the kind of information integration necessary to promote high quality, scientifically-based environmental management. The Regional Workbench is a web-based initiative that has four broad objectives: (1) Provide mode of communication among University, Industry, Government, and Community-based Organizations, (2) Integrate research & technology development with regional planning and policy, (3) Create an environment for high quality undergraduate/graduate research, service learning, and workforce development, and (4) Link research to action for social learning and sustainable development. The National Research Council's Board on Sustainable Development has dubbed this kind of an initiative a "knowledge action collaboratives.". Each one of the Workbench objectives require new capacities for "knowledge networking," a process the NSF defines as "attaining new levels of knowledge integration, information flow, and interactivity among people, organizations and communities" <see <http://www.nsf.gov/kdi>>.

The Regional Workbench draws some of its inspiration from a recent report titled, Our Common Journey: A Transition Toward Sustainability. The report was published by of the National Research Council's Board on Sustainable Development. Chaired by Professor Edward A. Frieman of UCSD, the Board on Sustainable Development argues that we need "significant advances in basic knowledge, in the social capacity and technological capabilities to utilize it, and in the political will to turn this knowledge and know-how into action" (NRC 1999: 7). A workbench approach is the most appropriate way to provide a gateway to well-organized information, as well as scenarios of how these resources can be used. The Regional Workbench is being developed in the spirit of several discipline-specific researcher interfaces such as the Biology Workbench (developed at NCSA by Shankar Subramanian - now with UCSD), the Sociology Workbench (developed at SDSU by Ilya Zaslavsky - now with SDSC), the Environment Workbench from NASA, Scientist's Workbench from Cornell, etc. From a technical standpoint, building the Regional Workbench at UCSD benefits from the fact that the San Diego Supercomputer Center serves as headquarters for the National Partnership for Advanced Computational Infrastructure (NPACI), funded by the NSF. Figure 3 shows the constituent parts of the NPACI partnership; it is obvious that California is especially endowed.

Figure 3: The National Partnership for Advanced Computational Infrastructure

*The National Partnership for Advanced
Computational Infrastructure
(NPACI): Funded by NSF*



Binational Conference on Environmental Research and Policy, San Diego, June 12-13, 2000



Source: Powerpoint slide shown by Ilya Zaslavsky, SDSC, at the June 12-13 Binational Conference for Environmental Research and Policy, UCSD.

The diagram shown in Figure 4 charts the multiple benefits one may expect to derive from the Regional Workbench Program.

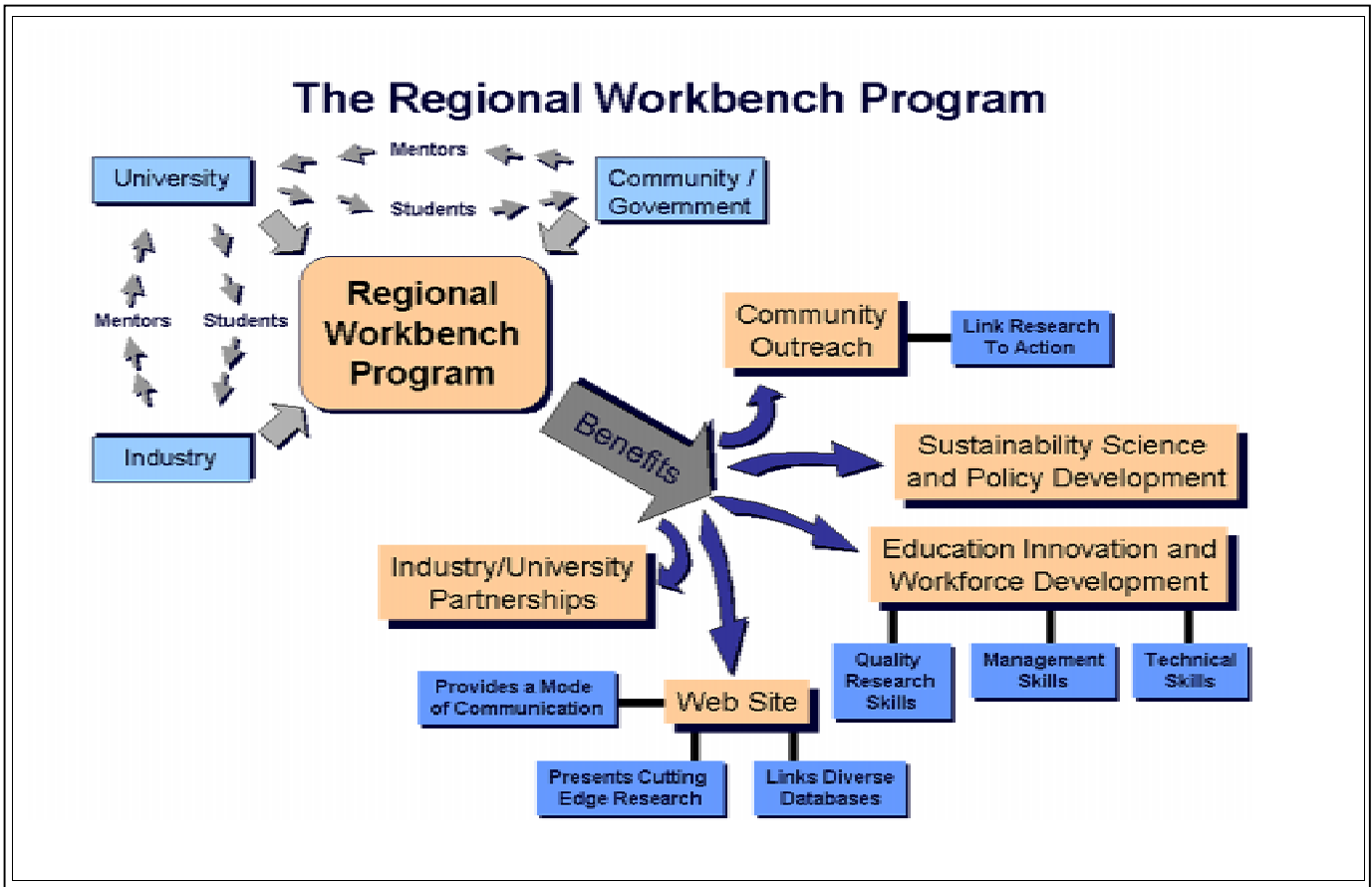


Figure 4: Organizational Structure of the Regional Workbench Program

A strong rationale for investing in the development of high-quality regional information systems (and in capacity-building for federating such systems across state and national borders) is offered by the National Research Council:

A regional scale approach grounded in ecosystem knowledge and cooperative and adaptive management constitutes an infrastructure for social learning—a way to lay out scientific knowledge in a form that can be accessible to non-specialists. As such these systems provide a mode of communication and negotiation that can draw opponents together for learning as well as conflict resolution, allowing learning to continue as action proceeds. Work at the regional scale shows that the way human and natural systems interact can be studied and acted upon in an integrated framework (NRC 1999: 6).

The Regional Workbench initiative is thus geared to meeting this larger, long term objective of developing a regional information system. A Binational Center can add value to this effort by developing a range of "knowledge clusters" in the environmental health sciences. A "knowledge cluster" is defined here as a coherent grouping of select topics, archives, professional and institutional contacts, data sources, data mining tools, metrics, methods and annotated guides for inquiry and action.

In an article titled "Information Technology for Public Policy," Roberta Balstad Miller (1996: 8) notes that understanding how human action affects environmental change is dependent upon the creation of merged, georeferenced, time-series databases. Such databases should contain both socioeconomic and physical data that reflect the interaction of human and physical forces over time. The data sets available for such a task are piling up--in government databases, digital libraries, data warehouses, company files, and research labs. However, as Miller and others point out, before policy analysts will be able to take full advantage of new information-rich technologies in environmental policy and assessment, a number of scientific and technical problems must be addressed. These include (1) the need to create merged data sets (i.e., data sets which encompass both socioeconomic and physical/biological data), (2) the need to develop both time-series databases and baseline data; and (3) the need to expand access and electronic capability in developing countries (Balstad Miller 1996: 8). But it can be difficult for firms in the border region to collect accurate and comparable information about their environmental impacts (US EPA, April 1998). The time and expense needed for firms to collect and report such data can be prohibitive. Also, it is not always clear what should be the appropriate geographic focus--local, regional, or global. Indicators of environmental improvement should consistently link or relate the performance of a firm to that of an industry, or a region and nation. This is especially difficult to do in a transborder regions where political boundaries fragment what may otherwise be an integrated ecosystem (such as the watershed basin shared by San Diego and Tijuana). The US EPA suggests that one way to minimize the data collection burden would be to utilize available governmental data or other surveys. Developing informational systems that can help contextualize a firms particular environmental impacts is a crucial step to achieve goals such as watershed protection, control of unregulated air emissions, protection of biodiversity, or transformation of a contaminated site to a beneficial use (US EPA April, 1998).

One way to provide such context is through the development of Geographic Information Systems (GIS). UC San Diego's new Superfund Basic Research Program (SBRP) has a strong GIS component. As part of the SBRPs Outreach and Training Cores, Ilya Zaslavsky and Keith Pezzoli will be organizing available spatial datasets into a federated set of GIS sources, taking advantage of the federated spatial database technology advanced by the San Diego Supercomputer Center. Since different geographic databases reside on different platforms, in different software environments and formats, at different geographic locations, and may have employed varying data definition and collection standards, GIS interoperability becomes the central issue in development such a federated environment. A technology being developed by Ilya Zaslavsky at the San Diego Supercomputer Center addresses this problem by XML-wrapping of existing geographic sources, and processing spatial queries to a Federated Database with an XMAS-based spatial mediator (<http://www.npaci.edu/DICE/MIX>). XML is the emerging Web standard for data exchange. These developments can add value to the operation of a Binational Center. As Zaslavsky pointed out at the June 12-13 Binational Conference, the spatial mediation of federated sources has the following advantages as a unique approach:

- It has an extensible architecture, allowing the users to register and incorporate new geographic sources as they become available;
- It will bring together diverse US and Mexican entities responsible for the shared border environment;
- It supports decentralization of environmental and health management through local information capacity building and improved communication between participating agencies;
- By providing a uniform Web-based access to the shared spatial data, it will empower community groups, non-governmental organizations and industrial entities without the need for expensive GIS software and expertise.

Below is a detailed outline of steps that Ilya Zaslavsky and Keith Pezzoli plan to take, in collaboration with Mexican and other regional partners, over the next five years, to build and deploy an integrated,

transborder GIS database. The Outreach and Training Core of UCSD's Superfund Basic Research Program will provide some of the support necessary to make this happen. But 12-point list is very ambitious. There are major challenges involved; and any one of these activities could easily be expanded into a major research program.

Steps to building and deploying an integrated, transborder GIS database (compiled by Ilya Zaslavsky and Keith Pezzoli).

1. In unison with SBRP priorities, develop a list of environmental and population datasets, and the technology for XML-wrapping of these datasets for integration into a Federated GIS.
2. Identify and inventory datasets and data layers which can be shared across the federated system (including those that need to be duplicated at several sites for system stability and performance), and data layers that need to be developed and maintained locally. Develop standardized metadata descriptions for all data layers in the inventory.
3. Conduct pilot projects to evaluate the compatibility of Mexican and US health, demographic, and land use datasets.
4. Secure the support of external GIS database holders in the border region; develop XML wrappers of the data sources making them capable of responding to Web queries.
5. In cooperation with industrial partners, assemble the available datasets in a locally-managed geographic data source.
6. Explore the available models of health impacts, integrate them with the Web interface of the Federated GIS database
7. Develop specific GIS applications and Web query interfaces addressing environmental health problems so that spatial health data integration becomes accessible to wide range of practitioners without specific GIS software skills.
8. Incorporate the existing GIS-based models of hazardous risk assessment in the query interface, and support them with explanatory interfaces.
9. Integrate Web-based spatial representation with on-line analysis tools.
10. Compare the effectiveness of a stand-alone and a federated organization of spatial information.
11. Integrate the access to shared GIS data with web-based collaborative environments, where participants from different agencies could collaborate in real time, exploring and analyzing the data.
12. Produce a report on appropriate software environments for health and industrial environmental practitioners, and ways to prepare them for the Web integration and XML.

During comments he made at the Binational Conference, Dr. Richard Wright (Professor, Department of Geography, San Diego State University and Co-Director Stephen & Mary Birch Foundation Center for Earth Systems Analysis Research) underscored the importance of transborder geospatial data acquisition and integration. Dr. Wright pointed out that a lot of people, such as Dr. Alan Sweedler, have worked on this for a long time. He mentioned that SDSU is one of nine universities within the Southwest Center for Environmental Research and Policy that is engaged in transborder geospatial data acquisition and integration. Dr. Wright drew attention to a number of specific activities, including those of the University Consortium of Geographic Information Science. There is a Transboundary Resource Inventory program underway which involves aerial photography flights for integrated data. A Transboundary Watersheds Research program is taking a watershed approach to transboundary issues. It's important that we somehow become more aware and build on these activities. The prospective Binational Center can help coordinate such efforts. Dr. Wright suggests that the technical issues are really not the major issues. There's a lot of research yet to be done to apply them.

2.4 Notes from the Breakout Session

Data and method challenges

- Need Science based metrics/indicators for industrial performance and integrated risk assessment/ very difficult to do in a binational setting.
- Develop environmental modeling for a better understanding of pollution transport mechanisms and impacts.
- Provide more user friendly and policy-relevant methods for data mining and presentation.

Legal and financial aspects of EMSs

- Develop a trilateral EMS protocol (now jointly underway by Mexico, the U.S., and Canada). What should an EMS contain to be considered worthy of government recognition and approval?
- Develop a compliance map to provide the public with more in-depth knowledge about industry in their region (who is in and out of compliance, what are the associated health risks)?
- What are the financial benefits of an EMS? How can we capitalize on this to promote EMS networking in a binational context?

Strategic Action Plan

- Build a web-based, partnership-driven tool for knowledge networking--a transborder Regional Workbench (portal) for EMS and Industrial Ecology initiatives and policy development. Focus on a number of strategically selected research challenges for the medium and long term.

3. Biomedical Research, Bioremediation

Authors: Palmer Taylor, Robert Tukey and Octavio Rivero Serrano, with input from David Stockwell and Mariano Cebrian Garcia

This is a key area that will need to be developed. There is a substantial amount of information available regarding the actions of hazardous wastes on biological systems. Many of these compounds, especially the PCBs, impact steroid regulation and have been linked to human diseases such as breast cancer. Outside of metals, the other major contaminants include PAHs, which have a global impact on gene expression through the dioxin receptor. This pathway is being linked to many human regulatory systems in humans, so its impact may in the future be very significant. In linking exposure with insult at the genomic level, tools need to be developed to assess the impact of these agents on biological systems. Some of this is outlined below. Pertinent to this section and the goals of the conference, the development of a cohesive database that provides the literature and results of this information would be enormously useful. One of the goals of the UCSD Superfund Program is to develop the tool necessary to examine the biological consequences of toxicants on genomics. Not only will it be possible to identify those genes responsive to exposure, but these methods could also lead to the development of tools to identify the specific toxicants. While certainly in its very early stages, it offers an excellent opportunity for basic biomedical sciences inroads that could lead to educational opportunities for investigators on both sides of the border. Major issues we identified prior to the conference were as follows:

Migrant worker exposure to agricultural chemicals and the impact of genetically modified agricultural products.

Of major importance is agricultural and pesticide exposure, because it occurs proximal to the border and the migrant farm worker contributes significantly to overall border traffic. Pesticides for commercial agriculture and for home and garden use constitute the largest source of poisoning in the State. We are

also dealing with pesticides in the run off in the Tijuana River valley, other rivers and estuaries in the border areas.

Hazardous materials/waste effects on humans.

How to access data repositories on materials and hazards for industries including waste/exposure and health? This must have community/University/public health department involvement. What educational and other linkages make use of US data on toxics, exposure, use of basic research techniques? The Superfund may make use existing sources of data for investigating the impact of these toxic substances on human health.

Smog and the effect on asthma.

There is a significant problem with the influence of smog on asthma in the region, and San Diego and TJ are starting to share pollutants, ozone, particulates.

Infectious disease agents and vectors.

One documented source of infectious agents is ocean currents, that transport bacterial diseases northward from unprocessed sewage outlets in Mexico. These problems may be amplified by immigrant populations from South East Asia or third world countries with public health limitations. Also our population densities and high border traffic are contributory. Climate change is affecting the distribution of insect vector-borne diseases, such as dengue fever and malaria. Global warming is increasing the northward range of these pests, posing increasing risk to US residents from disease of originating in the tropics.

Strategic action plan

Facilitating Binational collaboration

One obvious tool is the use of web-based technologies for low cost survey, interview and epidemiology studies. These range from web-based surveys to interactive collaborative sessions via the internet. Another trend is the development of 'knowledge centers' - web sites with multiple participating institutions that act as 'web content providers' - automatically generating a large body of timely, configurable information.

Leverage ongoing initiatives, institutions

Academic involvement is central, such as training opportunities between the different universities. The avenue to take here might be through the Superfund Centers where training in shared technologies could be given via scholarship training. New technologies could be examined for applicability to this area, as potential student and research projects. Such projects include:

Gene chip array technology is being used to assess inherited genetic problems in humans could potentially be used to examine sentinel genes for impact of toxicants. (Dan Masys). Other technologies might be developed through SDSC computational research, such as molecular biology research, predicting effects of combinations of toxics on biochemical pathways. Climate change studies,

particularly the prediction of distributions of disease vectors under future climate change scenarios, could be useful for informing disease prevention planning.

Strategies with respect to knowledge creation, integration and sharing

Setting up databases of information is an important scientific activity in any domain. Where the databases are distributed, then heterogeneous systems can promote community involvement and distribute costs to participating institutions. SDSC could become initiate a network hub of database information for the area, or for the nation. There could be a planned transition to a more permanent center. Visualization and analysis of the information residing the the databases is equally as important, as this provides value to the data, making it more easily accessible and useful to a broader community. Applications such at the VML workbench developed by Ilya Zaslavsky provide simple Geographic Information System functionalities over the internet.

Notes from the June 12 Breakout Session

Sources

1. Agriculture - pesticide exposure** - cross border worker patterns
child health
2. Hazardous waste**
3. Air borne agents* - asthma, COPD, bronchogenic carcinoma
4. Infectious agents
5. Industrial sites** - industrial transfer – potential remediation (SuperFund)

Inventory

1. Airborne: PM-10 (dust borne pathogens), ozone, NO_x, HC, volatile heavy metals
2. Industry
 - a. Furniture – solvents, phenolics, hydrocarbons
 - b. Semiconductor – (metals – As)
 - c. Fabrication – endocrine disruptors – bisphenyls, PCB, phthalates, plasticizers
 - d. Agriculture – organophosphates, carbamates, organochlorines,
– nitrates, phosphates, ammonia – pathogen substrates
 - e. Hazardous wastes – heavy metals, PCB's, phenolics

Outcomes

1. Establish a binational data base and data exchange with both a binational and border perspective
 - a. Listing of toxicants
 - b. Information on the scientific basis of regulatory rulings
 - c. Transport and transfer of hazardous materials
2. Science as the driver of health policy
 - a. Training programs for scientific expertise
 - b. Linkages to industry, state governments, departments of public health
 - c. Information access to transport and transfer of hazardous chemicals (TRI)
3. Establish monitoring systems to encompass:
Exposure patterns → bioavailability → gene expression Proteomics
[susceptible species – knock outs]
4. Establish a border environmental health alliance
 - a. Information exchange – network
 - b. Training at the technician and research scientist levels

c. Separate toxicant, susceptible gene, responsive phenotype, geographic data base entries

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*Asterisks distinguish areas requiring unusual remediation procedures such as those used in Superfund sites

4. Binational Water Quality Issues in Regional Bays, Estuaries and Coastal Zones

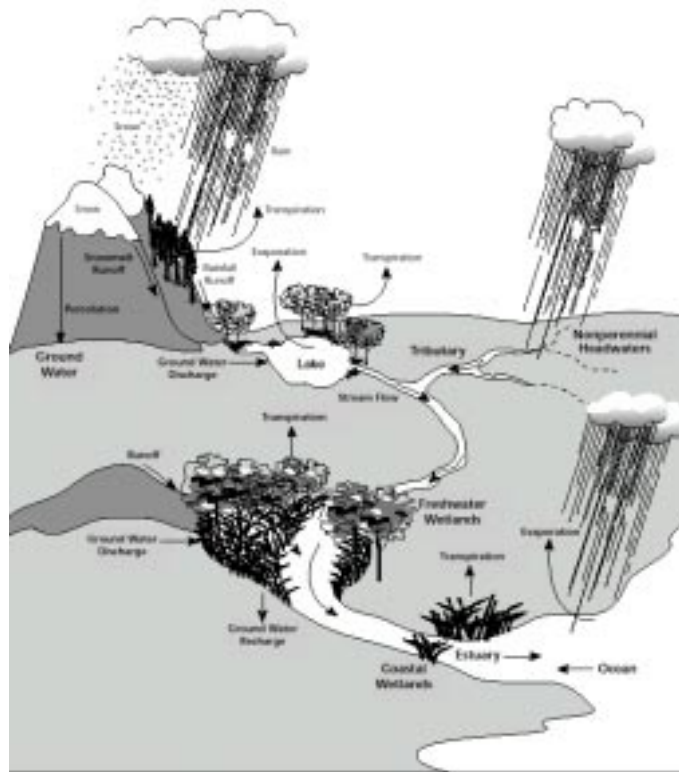
Authors: John Helly and Enrique Cifuentes

Introduction

The hydrologic cycle (Figure 5) is a major influence on all forms of life on, at least, the surface of the earth. As a scientific concept, it describes the processes by which air, land and water interact as water moves through the lithosphere (land) and atmosphere (air) by changing its phase from liquid to gas to solid and back to liquid. As it moves through the biosphere, it is consumed by living organisms, excreted in various forms and flows back into the hydrosphere with its attendant loads of dissolved and suspended biotic and abiotic materials. Material suspended in the atmosphere comes back to earth with wind and rain and flows across and through the lithosphere eventually to the sea; also accumulating a transport load as it does. By observing and measuring these processes and interactions we can develop an understanding of what, where and how material is moving through natural systems.



Figure 5. Hydrologic Cycle from [1]



The history of the west and southwest is a history of water. Societies have bloomed and perished in relation to availability of water resources. Water quality, in turn, is vital for preserving quality of life and human health. The management of the waters of the border of Mexico and the US are based on treaties from the late 1800's and early 1900's used to determine borders and partitioning of the border river water. It was one of these that created the International Boundary and Water Commission in 1848 for that purpose. In *Two Years Before the Mast*, Richard Henry Dana writes of events in San Diego Bay in the 1840's and 50's in which the ballasting rock used by coasters was illicitly thrown overboard within the Bay; necessitating hiding from the Port Authorities of the day who would occasionally visit the boats for inspection to prevent this type of stone-pollution.

Water-rights struggles between diverse users of an essentially limited resource continue to this day but there have been significant changes in the latter part of the 20th century. In the US, pollution control legislation began in the Rivers Act in 1899 to control refuse on the rivers. As populations throughout the world have increasingly concentrated in cities, the problems of human wastewater and high concentrations of agriculturally and industrially-derived contaminants began to create hazards to human and ecological health that could not be ignored. Through a series of water quality-related acts leading to the Clean Water Act of 1977 there is a pattern of increasingly specialized regulations to cope with the problem of development and water quality; primarily point-source oriented. However, the recent shift by the EPA to TMDL-based watershed management is a clear acknowledgement of the need to broaden the basis of water quality management across all political boundaries and to view the watershed as the fundamental hydrological unit.

Public health regulations in the form of guidelines and standards have evolved erratically, under the influence of varying historical forces and economic motivation. Countries adopt guidelines from WHO, EPA, and FAO and very seldom is the adoption based on epidemiological grounds. Scientific research is needed, to provide basis for risk management and protection measures and policy changes. To do so, policy making require accurate and credible community health data and timely environmental information.

The increasing recognition of the common interest in shared watersheds and coastal areas is reflected in a number of binational activities operating at the federal level between Mexico and the US. These include the 1983 La Paz Agreement for the Protection and Improvement of the Environment in the Border Area. Following this was the 1992 Integrated Environmental Plan for the Mexican-US Border Area (IBEP). This has been followed by the Border XXI Program. In 1993, NAFTA added further to the environmental agreements and plans. These are not limited to water quality but, as stated in Border XXI, are designed '...to achieve a clean environment, protect public health and natural resources, and encourage sustainable development'. These efforts should be considered in our review of water quality issues in this conference.

More recently (June 1997), a workshop was held at El Colegio de la Frontera Norte, Tijuana to address science, technology and policy issues related to water and health at the U. S.-Mexico Border. The report from this workshop provides a clear and concise description of the human health aspects of water in relation to border issues [2] and addresses issues regarding infrastructure and financing, data and research, training and education, collaboration, and information systems. More information about this activity can be found at <http://www.fumec.org.mx>. There is a great deal of overlap between the goals of that workshop and the one reported here but there are important differences. While that workshop (Tijuana, 1997) focused on the human health aspects of water at the border and, consequently, the delivery of potable water and the removal of wastewater, this workshop (San Diego, June 2000) is focused on identifying the ways in which research advances can be applied to understanding and managing the hydrologic cycle as it operates in the border area as well as the implications for human health and water resource management issues.

Binational Aspects of Water Quality

As shown in Figure 5., the interaction of air, land and ocean drive the dynamics of the watershed and consequently surface and groundwater runoff into the coastal oceans, rivers and streams. Figures 6-9 show that what goes on along our coastal atmosphere, ocean and watersheds is shared and span issues from fisheries to sewage. Both share desert terrain with rainfall that can be intense and non-uniformly distributed. We share a Mediterranean-type climate and in winter there is the first flush through the watershed, with large amounts of rain flushing through the system. The time-course and spatial distribution of this flow is difficult to follow.

The recent shift in regulatory policy in the United States toward an emphasis on non-point source pollution recognizes the importance of urban and agricultural runoff as a primary source of pollution and degraded water quality. Point sources are localized in a particular socio-economic location and therefore more clearly attributable to a particular population of waste-producers. In a non-point source situation, adjacent to a political border, it is much more difficult to determine the non-point sources and, second, to develop joint methods of controlling them. Usually, at watershed level, we do not have the data needed to define the sources and accurately analyze the dynamics of the watersheds. To approach these problems effectively on a binational basis will require coordinated and consistent data collection using in-situ sensors, remote sensing imagery and common laboratory and data protocols

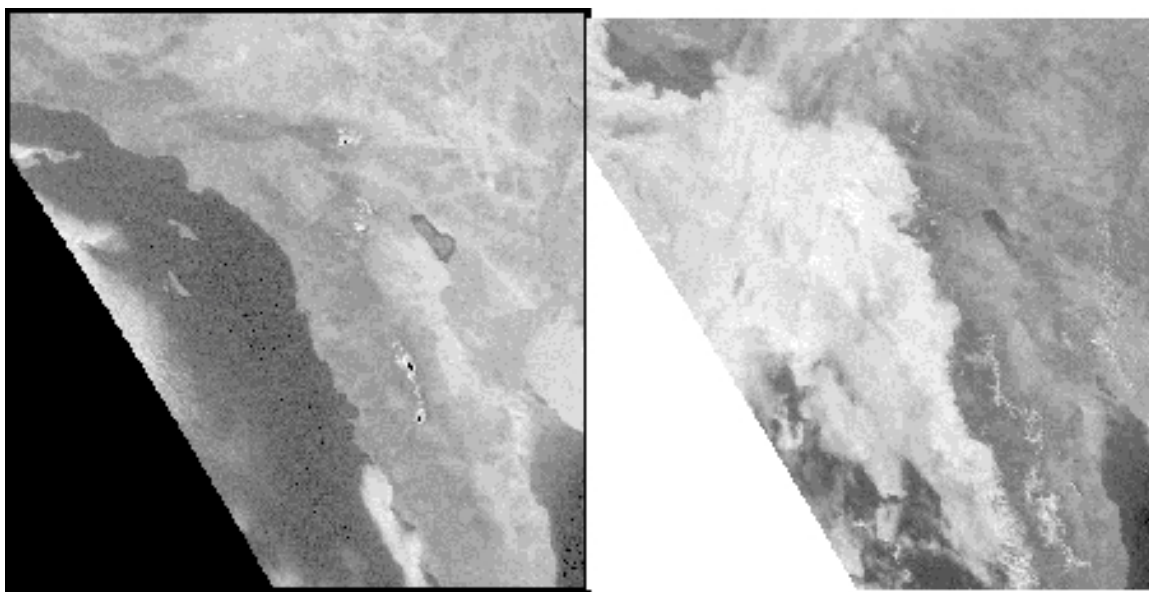


Figure 6. GOES-8 images showing continuity of coastal stratus

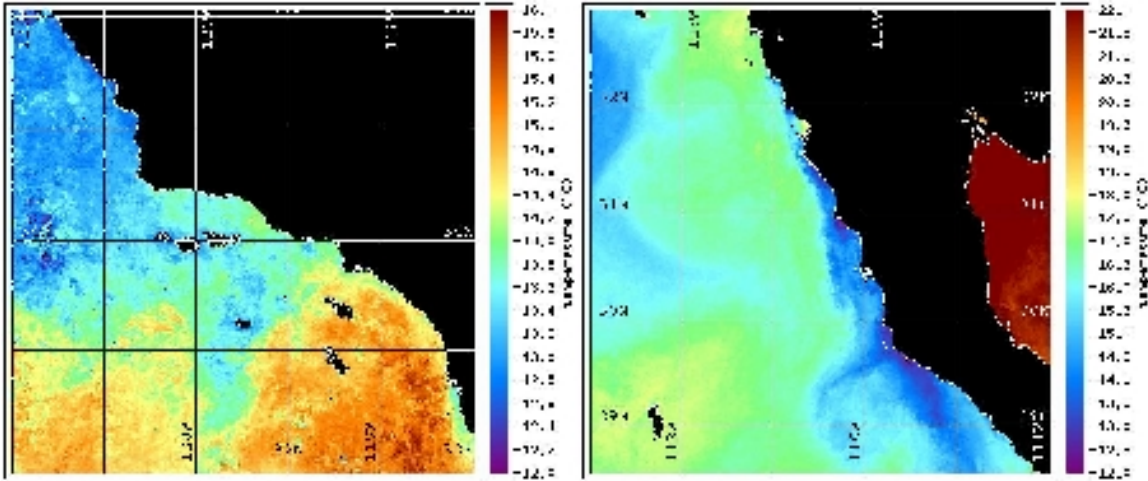


Figure 7. Sea surface temperature from AVHRR showing continuity of coastal water masses.



Figure 8 . Land cover from Landsat Thematic Mapper showing similarity of terrain north and south of the border

Table 1. List of Point and Nonpoint Sources [3]

POINT SOURCES

- Wastewater effluent
- Runoff and leachate from waste disposal sites, animal feed lots, mines, oil fields, unsewered industrial sites
- Storm sewer outfalls from cities w/pop. > 100,000
- Runoff from construction sites > 2 hectares
- Overflows of combined storm and sanitary sewers

NONPOINT SOURCES

- Runoff from agriculture (incl. Irrigation return), pasture and range, urban (sewered and unsewered) w/pop. > 100,000
- Septic leachate and runoff from failed septic systems
- Runoff from construction sites < 2 hectares
- Runoff from abandoned mines
- Atmospheric deposition over water surface
- Land-based activities generating contaminants (logging, wetland conversion, construction & development of land or waterways)

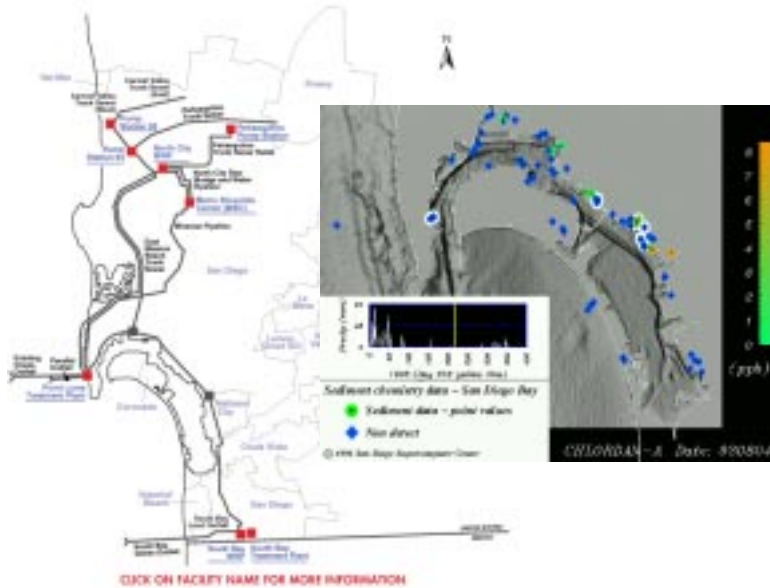


Figure 9 . Examples of point and non-point sources in San Diego

Opportunities for Application of Research Advances

From the discussion held in the breakout session on water quality, we were able to distill a number of issues that warrant attention and provide opportunities to exploit advances in research. These have been organized into the categories specified in the introduction.

Biomedical

- Assess the toxicity of bioavailable, persistent organics and metals and associated environmental risk.
- Assess risk due to conventional conservative biological agents (bacteria) as well as emergent pathogens including protozoans and viruses.

Information Technology

- Provide a network of in-situ bioassay and physico-chemical sensors with remote alarm and real-time sensing function. Consider especially nutrient loading sensors (i.e., Nitrogen, Phosphate, Silicon) that are already available and used in Europe.
- Provide quality assurance and control methodology and tools for data integration supporting the development of data sharing standards.
- Provide visual models for depiction, communication, analysis and evaluation of watershed dynamics and fate and transport of water-borne material. Consider especially the example of the San Diego Bay Project (<http://sdbay.sdsc.edu/bayview.mpg>) as an example as well as the work conducted at San Diego State University's Geography Department (<http://typhoon.sdsu.edu/>).
- Provide coordination network above, below and along the border for data sharing and resource identification, collaboration and communication between investigators, policy and regulatory agencies. A simple step in this direction would be to provide a resource directory of expertise and information to enable communication and ready access to expert knowledge. A further step would provide a communication infrastructure for collaborative analysis by investigators that are geographically separate. Through coordination (e.g., borderwide networking) leverage existing monitoring programs and exploit existing data collections while identifying gaps and redundancies specifying additional monitoring needs against environmental risks.
- Provide an information system for the centralization and publication of data and analysis tools related to the hydrologic cycle and notably including watershed and coastal processes. ensuring ability of individual investigators to obtain data and not be tied to centralized analysis tools although there is

need for computational servers for running analysis tools selected by individual researchers and managers. This involves the following key activities:

- **Data Acquisition.** Employ data storage resources and existing data repositories as well as acquire relevant, freely-available data (e.g., water quality, hydrology, land use, etc.) needed to develop and operate the model or models used in this project. This could extend to the development of wireless, Internet-based networks of sensors connecting back to a data collection system like REINAS. Consider lower Colorado river as water management prototype, focus on 'plumbing' information held by Bureau of Reclamation, flood-flow management scenarios for subverting intended allocation obligations and involve U of Utah experience in GIS-based analyses.
- **Data Management.** Data management includes quality control and quality assurance (QA/QC), report generation for quantitative and administrative needs. These data should be managed at a centralized repository and made freely-available.
- **Data Publication.** Web technology should be used to enable staff and the public to access data, reports, graphical images, models, modeling results, and other products. This site will be designed to enable the replication of this site on other servers.
- **Modeling.** Conduct an evaluation of available watershed models for suitability in this project and acquire those suitable which are freely available for use. Provide a server to support remote operation of these models and, to the extent feasible or allowable, make them freely available to other parties. Implement appropriate watershed models for key watersheds in the border region. This model or models should focus on supporting the development of Total Maximum Daily Loads (TMDLs) as well as general water quality management decision-making (e.g., pollutant load estimation, source identification, application of Best Management Practices, etc.). Model outputs shall be provided in a format suitable for use in commonly-used Geographic Information Systems (GIS).

Environmental Science

- Develop criteria for the ranking and selection of watersheds for monitoring, analysis and modeling to support specific water resource management issues using remote sensing and land use data.
 - Evaluate the location, fate and transport and bioaccumulation of persistent organics and metals in soil, water, benthic communities, and aquatic sediments considering erosion and transport scenarios, consequences and related risk.
 - Consider existing monitoring programs related to the US FDA and Mexican Ministry of Health based on an MOU (binational agreement) focusing on San Quintin and Ensenada Bay for total coliforms and shellfish poisoning episodes.
 - Provide for climate-related, extreme event impact analysis coordinated with Atmospheric, Land-use, and socio-political components.
 - Develop system for analyzing nitrogenous compound fluxes as well as related nutrient saturation mechanisms especially associated with airshed.
 - Assess invasive species issues in relation to environmental change, health risk from new vectors.
 - Develop flexible definitions of 'border' to consider static (e.g. political) borders as well as functional, context-sensitive definitions of 'border'.
 - Consider impacts of waterways engineering and flood-management.
 - Develop system for describing and analyzing coastal circulation.
- Develop preventive and controlled methodology for coping with trans-border development pressures. Consider especially the condition of estuaries on a comparative US-Mexico basis to evaluate alternative development scenarios including impacts such as population pressures in light of

sustainable growth, impermeable surface creation and agrarian uses of land (need input from NGO and those working in these areas) to evaluate preventive measures for printing environments in Baja California Sud versus Baja California Norte and San Diego lagoons and estuaries.

- Develop a binational approach to TMDL assessment and monitoring consistent with other regional efforts such as those being developed as a collaboration in Southern California. As the awareness of the need for collaborative natural resource management grows, the challenge to water resource management has shifted from point-source to non-point source efforts. In response to the need for TMDL-based planning and the regional character of watersheds, a group of POTWs, university, agency staff and consultants recently convened to consider what a regional plan for water quality monitoring should consider. This will extend to standards for data and metadata as well as field and laboratory protocols and methods and would consider the work done by SCCWRP and along the Alamo and New Rivers, as exemplars for TMDL development along the border.

Communications

- Enhance education and reporting of water quality problems especially in conjunction with information technology services. This might be done through a public-access system for problem reporting.
- Develop mapping of binational regulations, systems and approaches to environmental issues, policy and enforcement mechanisms.
- Develop culturally-acceptable reporting systems for public health events and incidents. Much confusion and misunderstanding can occur that significantly inhibits cooperation when cultural differences in interpretation of motives and priorities are not clear to collaborators from different cultures.

Social Science

- Consider grass-roots efforts (e.g., Ensenada groups) and those of NGOs in community-based monitoring and reporting of environmental hazard reporting. This resource is sometimes underutilized and potentially has considerable expertise and information not found elsewhere.
- Develop library of data and literature on historical information regarding land-use, water resources and narrative description of cultural aspects of these factors for comparative analysis relative to current monitoring results. This information is often anecdotal and bears on issues of legacy problems and patterns of usage that can affect present-day watershed dynamics.

Organizational Information

The National Institute of Public Health (INSP, Mexico) is a non-profit organization. The central purpose of INSP is training and research. The overall characteristics of INSP can be found in:

<http://www.insp.mx/nj/index.html>

INSP has been successfully conducted scientific collaboration with various groups from USA (e.g., UCLA, Harvard, CDC in Atlanta, Univ. Illinois), Europe (e.g., UK, France, Spain), and South America (e.g., Brazil, Chile, Peru, Bolivia). Topics of growing interest include water pollution & sanitation related health problems in childhood (e.g., enteric diseases, respiratory diseases / mortality), risk from lead and other heavy metals/ women and child health, occupational health, pesticides and genetic risk factors for neural tube defects, malaria control strategies, use of geographical information systems (GIS) and environmental health indicators, medical anthropology, to quote some examples.

Bibliography

1. *1998 National Water Quality Report to Congress*. 2000, US Environmental Protection Agency: Washington, D. C.
2. *Water and Health at the U.S.-Mexico Border: Science, Technology, and Policy Issues*. 1997, The United States-Mexico Foundation for Science: San Francisco 1626, Desp. 205, Col. del Valle, Deleg. Benito Juarez, 03100 Mexico, D. F. p. 1-112.
3. *Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen*. Issues in Ecology, **Summer 1998**(3), Ecological Society of America.

5. Prevention / Intervention Research with a Public Health Approach

Authors: David Cleveland

Background:

In 1993, the U.S. Department of Health and Human Services and U.S. Environmental Protection Agency established the Interagency Coordinating Committee for U.S.-Mexico Border Environmental Health (ICC) to address environmental health concerns. In Mexico, the Secretariat for Environmental, Natural Resources, and Fisheries (SEMARNAP) and the Secretariat of Health (SSA) have initiated efforts to generate information, investigations, auditing, and control of environmental risks. To increase binational collaboration between environmental and public health partners, the Border XXI Environmental Health Workgroup was established in 1996. The Workgroup recognizes the following conditions as environmental health challenges to border communities:

- Rapid industrialization without adequate health and environmental infrastructure
- Increased industrial and manufacturing development and the accompanying occupational risks
- Changing age demographics resulting from migration, which increases the number of young working adults and children
- Widespread poverty
- Lack of clean drinking water supplies
- Inadequate treatment and disposal of hazardous waste

Environmental Health Defined:

Environmental Health is defined as human health influenced by exposure to chemical, physical, and biological agents in the community, workplace, or home. Contamination of air, water, and soil by heavy metal, volatile organic compounds, hazardous materials and waste, pesticides, nitrates, raw sewage, untreated wastewater, parasites, and bacteria can cause health problems in the U.S. Mexico border region.¹

¹*Border XXI – Environmental Health Workgroup*

Aligning Discussion To Health Workgroup Focus Areas:

- Research to link environmental exposures and health risks using GIS/GPS
- Training and education
- Environmental monitoring and assessment
- Communications - Health Alert and Disease Outbreak Information Exchange

Linking Discussion to the Objectives of the Environmental Health Workgroup: Improve...

- the capacity to assess the relationship between human health and environmental exposures by conducting surveillance, monitoring, and research.
- capacity to deliver environmental health intervention, prevention, and educational services
- opportunities for all border stakerholders to participate in environmental health initiatives
- public awareness and understanding of border environmental health problems
- cross border training opportunities for environmental health personnel
- meaningful and scientifically defensible indicators that are inclusive and dynamic across multiple issues (e.g., it is necessary to determine success not only by a decrease in pollutants in a given media (air, water), but by a measurable improvement in a given health condition (decreases in asthma or waterborne diseases)
- early deflection of health problems using GIS to measure “hot spots”
- scientific research on health problems of workers and consumers related to argoindustry

Summary of Breakout Group discussion

Overarching Mission: "Equal Partners"

The Center should be developed through a Binational Performance Partnership

There's been a lot of discussion in social sciences, risk and protective factor research (cited scientists behind this, didn't get names: Dr. D. Hawkins and Dr. P. Catalano, University of Washington) effort to create national standards framework to 26 states across the country for input.

Our team had the issue of public health. Decided to focus on a systems-type approach. Came up with an overarching mission for the center. What does equal partners really means? Not necessarily everyone having equal resources, as financial, but could have sharing of wonderful research. The San Diego based NonProfit Agency, the TELESIS Corporation in Partnership with a multi-disciplinary group of community based agencies are designing a Quality of Life Index. This Performance Partnership should be reviewed during the Research Center design phase.

Conceptual Framework

A Binational Research Center can only be developed through a "Collective Effort"/Performance Partnership. A Performance Partnership is a method to measure collective efforts against collective results.

Core Principles

Center should...

- be designed through a participatory process with ALL stakeholders (e.g. funding sources, Academic institutions, Community, private business)
- Assist in id Public Health Priorities in the region (a new set of priorities could be developed. There is a major lag time between science and policy)
- facilitate the interlocking of "new knowledge" with public health policy
- id and share best practices related to public health service delivery
- facilitate the training of public health researchers
- create data protocol and web based GIS applications
- use GPS to id "hot spots" and measure relationships between multiple variable.

Benefits

- Shared science and technological gains
- Pooling of insights and experience
- Exporting new knowledge between Agencies

Spent quite a lot of time on issue relating to sharing of information. People have lots of problems retrieving info from Mexican sources. Must make commitment to share information from public, govt. and private sources. There will be a need to generate information for cross border projects. Also need to make information of the Center in public domain and that really means accessible to everyone.

6. Air Pollution and Global Climate Change

Authors: Mark Thiemens with input from Alan Swedler, Tom Rappolt and Jim Stirling

Without question, the greatest impact upon human health and sustainability at the broadest level, derives from atmospheric components and subsequent distribution within the environmental system. While hydrological contaminants effect broad localized regions, atmospheric contaminants are not as restricted by area. Cross border, and indeed, cross-hemispheric transport readily occur. The impact upon society is perhaps greater as the consequences are both direct (health) and indirect (agricultural, forestry, water degradation, and economic loss). There are specifically two major atmospheric concerns which are very specific to this region, gaseous and aerosol (particulate) emissions. These are species of significant impact upon atmospheric chemical health at the border. For example, anthropogenic sulfur impacts on every spatial scale. These species are respirable and exert considerable damage to human respiratory systems and serve as potential carriers of toxic pollutants. Along with respiratory and cardiovascular damage, sulfur releases upon interaction with the ground, toxic metals such as aluminum, iron, manganese, copper, zinc, and

mercury, lead, nickel, and cadmium, all toxins. Thus, airborne contaminants also induce local and regional hydrologic and health problems. The sustainability of populations is also affected by species such as transported sulfur. Direct damage by deposition of sulfur on tree and agricultural leaves reduces foliar nutrition from increased leaching. Indirect damage to trees and crops also occur from release of toxic metals such as aluminum, which interferes with root function and inhibits the uptake of essential elements such as magnesium, phosphorus, and calcium. Loss of agricultural yield in regions typically may exceed hundreds of millions of dollars from sulfur injections alone.

A major concern in a region such as San Diego-Tijuana is the nitric oxides. The EPA tracks its primary pollutants (CO, Pb, NO, SO₂, VOC and particulates) and has demonstrated that all have decreased since 1970, with the exception of the nitric oxides, which have increased more than 10%. Fossil fuel combustion, fertilization, animal waste, and other human activities all contribute, and all are rapidly increasing in this region. The rate and relative sources are poorly known at best. The health effects of these species are profound. For example, in nearby Los Angeles, the P.M. 2.5 fraction is over 1/3 of total PM 2.5 (PM 10 or TSP??). Medical expenditures related to air pollution are estimated at \$9.8 billion annually. Long range costs, tied to recent studies on increased mortality and cardiopulmonary disease in high particulate areas, are much higher. Soluble nitrate also migrates effectively through soils and concentrates in ground waters and rivers. In ground water for example, concentrations of 45 mg/l nitrate cause Methemoglobinemia (Blue Baby Syndrome) resulting in asphyxia. The carcinogenicity of nitrate remains unclear. Increases of nitrate results in the growth of phytoplankton and macrophytes. This growth results in oxygen depletion and accompanying fish kills, as well as toxic algae (red tide) leading to paralytic shellfish poisoning.

In the San Diego-Tijuana region another growing and specific health issue concerns ozone. There are numerous toxicological studies of ozone and the effects are well documented. At particular risk are elderly and children, particularly for cardiovascular and respiratory disease. In addition, animal toxicological studies find evidence of changes in lung cell type, formation of lesions, and evidence of loss of lung elasticity and inflammation for chronic exposure to ozone levels that typically occur in a region such as SD-TJ. Other work has suggested that high levels of ozone enhance the level of tumors in mice and enhances the ability of normal cell transformation to cancerous cells, both alone and concurrent with exposure to carcinoma in vitro.

The implications for the scientific evidence of ozone effect for public health are immense. Lung disease, including lung cancer, is the third leading cause of death in the U.S. and is the fastest growing cause of death among the top ten causes of death. Nearly 10% of the U.S. population currently suffers from chronic lung disease. The cost to the totality of society in terms of direct expenditures for health care, lost productivity, restriction of daily activity, and reduced quality of life, is in the billions of dollars for ozone alone. This does not include the costs associated from the loss of agricultural yield, which, in regions of fast growing crops, also approach the billion-dollar level.

In the San Diego-Tijuana region, sulfate, nitrate, and ozone increases will impact society at the most profound level. It is known from measurements at UCSD, SDSU and from EPA-sponsored programs through private industry that cross border transport of these species is pervasive, but very poorly characterized. In the Mexicali-Imperial Valley region of the border, particulates appear to be the most serious atmospheric contaminant. The amounts, distributions, sources, change with time, macro and micro transport of these species is simply not known. It is argued that in terms of the impact on human health by a chemical species, these will be by far, the most important in this region. Any study of the environmental health of the region and resulting policy which does not incorporate these issues, will be fatally flawed. Although some data regarding ambient concentrations of criteria pollutants have recently become available for Tijuana and Mexicali, full analysis of these data has not been completed to date. In order to make comprehensive, science-based policies, these analyses need to be completed. Currently models of the data do not exist, indeed, there are no coordinated cross-border studies of such issues anywhere on the planet. Since this area is among the fastest growing anywhere, this may serve as an ideal prototype for such investigations. What is needed is the link from the atmospheric measurement-modeling-health- and policy/decision makers.

Breakout group notes

Biomedical

What does not exist anywhere is the ability to take some sense of public health and disease and its distribution and map over that water quality or air quality distribution so on can understand what's going on and make that coupling between environmental health and public health. That doesn't exist. At the end of the day, if we could point to that accomplishment, it would be the first time anyone had been able to do that. And it could be replicated anywhere.

Needs a times series analysis of looking at these issues.
Look at asthma, cardiovascular, respiratory and linkages.

Other things we don't know is health affect of species including exotics with regard to toxicology and biochemistry. Issues of transport of species is that they release trace metals into the local water shed. You've got a coupling aspect, air, public, watershed, hydrology. Need to be able to id health issues.

Environmental Issues - Transport

Largest outstanding issues is source I.D.

Where does it come from? A really big issue and it doesn't matter where you live. We don't know that right now in a credible way to make the direct link to the public health. There is no environmental science or understanding of the public health unless you understand where thing come from. Our premise is we should be the first to do it. Anywhere. No one is doing this and attacking in an intensive way.

Here's the timeline part. There's a lot of data existing here in the areas. What we need to do in a phase. Say five years. Year and year and half. Take dedicated look at human health and species in an area in a concentrated modeling in an area. Set up a large scale focused regional study in a integrated way. Something like the Indian Ocean (INDOEX) experiment for our region. What do we want to concentrate on? Ozone? Particulates? Go in such a way so at the end we can say we understand the relationship between air quality and cardiovascular disease so it can be used by any agency. Whether is water or air. Study entire region including coastal area to understand where does it come from and where does it go and what are impacts on human health. Using the full computational resources. A complete coupling with a goal in mind and mechanism to go about it.

Information Technology

Have to develop new information technologies. Goal must be that society can use it in an intelligent fashion. Has to be usable. Would be an interesting academic exercise, but that's not enough. It's part of our goals, but not all. Users maybe e.g. Binational Air Quality Alliance (EPA, DOE, APCD, Industry, others)

I.D sources and transport of key species to observe populations and study health consequences.

7. Enabling Multidisciplinary Approaches to Environmental Research, Education and Training in the U.S.-Mexico

Authors: Geoffrey C. Bowker and Roberto Sanchez with input from Richard Wright

Background

Much binational attention to border issues has had a sectoral approach with a fragmented perspective of the problems, their causes and their consequences. The sectoral approach is a natural one to adopt, but poses precisely a key problem in the field of environmental health: how can we weave together analyses from different disciplines into a coherent and effective message? The same can be said about the culture of binational networking and communication in environmental research, training and education. Enabling a multidisciplinary approach is a difficult, but needed step to improve the assessment of problems and the discussion of actions and policies to improve the current situation. Having said this, we can recognize several initiatives that represent a contribution to a multidisciplinary approach. Several environmental groups have sponsored initiatives on environmental education that have led to the creation of directories of groups and organizations working on this topic. There are clearinghouses and data bases on border environmental issues, some created by environmental groups, some by academic institutions, and some by public agencies, that also means of transboundary communication and networking ([ECOWEB](#) , [Border Environmental Indicators](#), [BIOS](#) are some concrete examples). There are also training initiatives organized by environmental groups at the local and transboundary level. For example, programs carried out by the Environmental Health Coalition, the Border Ecology Project, The Texas Center for Policy Analysis and their counterparts in Mexican border communities. The two federal governments have also carried out limited training programs on specific environmental problems (air and water quality, hazardous waste, environmental hazards, etc.). What is missing in many of these initiatives is a multidisciplinary approach that links environmental issues with their social dimension (their economic, social and political causes and consequences). This multidisciplinary approach would enable comprehensive perspectives of the problems and the actions and policies needed to control them.

The proposed center must be truly binational because the entities that it will be studying – air basins; watersheds for example – do not respect national boundaries. Further, the research teams themselves must equally be binational in order to be able to negotiate the complex administrative and organizational context of research in both countries; and in order to be able to most effectively present results to policymakers on both sides of the border. It would be possible to organize the center into units based around certain fundamental household concerns common to both communities: water supply; clean air; poison control and so forth.

We believe that only a series of multidisciplinary teams will be able to produce effective solutions to our common problems. Firstly, there needs to be bridge-building between different sciences. For example, in order to deal with an issue such as metal toxicity, we need to be able to pool the skills of chemists, ecologists and planners. Further, we need to build bridges between the social and the natural sciences. There is no point in producing a theoretical solution to a complex environmental problem if we cannot translate that solution into terms understood by and implementable by politicians. In order to do this, we need to pay due attention to a series communications issues – communications between scientists from both sides of the border; between scientists and policymakers; and between citizens and scientists. We need to be able to bring the multiple stakeholders to the table; to tap into grassroots training (the ‘promoters’) for data collection; and to translate scientific results for end users and policymakers. One way to achieve this will be to ensure that data collections are not accessible only to scientists, but are designed in such a way that local communities can also make use of the data for their own purposes. This suggests designing multiple portals to the information interfaces developed. It also suggests the need for close study of the working practices and needs of both community groups and scientists in order to create a vibrant, useful series of databases. In sum, a truly multidisciplinary approach will allow us to work locally and act binationally.

Action Items

Due to the innovative nature of this multidisciplinary approach, it is difficult to highlight bullets of a strategic action plan. Valuable work that has been done (funded by the Kellogg Foundation, the EPA, the Hewlett Packard Foundation and so forth) has not been followed up: we do not know what went right and wrong, and what lessons can be learned. Quite simply, we need an inventory of our existing assets in this field; and use this to illustrate the benefits and importance of a multidisciplinary approach. We propose the development of pilot studies - three or four in different sectors and parts of the border - that can illustrate these benefits. These should include ethnographic and survey analysis of working practices on both sides of the border; and should arrange a series of issues from the compatibility of the material and information infrastructures to the working practices of scientists to the needs and work practices of policymakers. We can then use these studies to make a series of grounded recommendations about design an information and communication space that will optimally serve the community. We propose the creation of binational multidisciplinary teams with members from the academia, public, private and social sectors, that could facilitate knowledge creation, but also its transformation in concrete binational policies and actions. It would be interesting here to follow up on Mexican students who have been trained in US universities (ASU, USC etc) in Environmental Health and learning from their experience. The Center can work towards the codifying of informal binational political mechanisms which have worked around complex bureaucratic procedures also in place. A major trend in the exploration of multidisciplinary work has been to look at the development of working languages in 'trading zones' between disciplines and between the science and the policy field. An understanding of what communication processes occur now would provide input for the design of specialized binational training. In particular, it would allow us to examine the ways in which scientific knowledge can be transformed into culturally and politically useful knowledge.

The new Center can enable multidisciplinary work by encourage teams at the Center to explore implications of their work. For example, we could break traditional models by asking biologists to meet with planners and social scientists in order to work out policy implications of their work. Such teamwork would open the possibility both of making maximal use of a given research project and helping to iteratively focus scientific work on policy-relevant questions. Such an approach will involve close attention to the reward structures in place. Research has shown that multidisciplinary projects frequently fail because such work is not valued by home institutions – an assistant professor in biology needs publications in a biology journal; a co-authored publication in a policy journal may not count for her tenure. We need to create stable settings in which cross-fertilization is fostered and rewarded.

On both sides of the border, there is need for deeper understanding of the others' bureaucracy, beliefs and cultures. The Center can provide support people who can guide research teams through these complex issues; and training sessions devoted to sensitizing the teams to the settings in which they will work. In short, the Center must create a structure for and a culture of facilitating multidisciplinary work.

How can this be done?

As a first step we recommend looking at possible models for organizing multidisciplinary research centers. Thus the World Bank might serve as a possible model; so could integrated assessment in Global Warming research; or the National Institute of Public Health environmental program.

We could immediately learn from the NNRS model and propose long term programs of work to be funded by the Center. True multidisciplinary work cannot be attained within a three year funding cycle; there are just too many day to day local complications.

The Center can institute scenario planning and regional planning programs. In order to achieve this, it should be clear that the Center needs key players from outside of academia to be actively participating in its work.

VII. Considerations for a Binational Centers Program

Introduction

The keynote dinner address at the June 2000 Binational Conference, presented by Dr. Samuel H. Wilson (Deputy Director, NIEHS), introduced a challenging new vision of environmental health. Dr. Wilson described:

"...a beautiful, livable environment for humans and other living species; an environment that promotes well-being and a high quality of mental and physical health for its inhabitants; and an environment that can sustain its own quality into the future. This vision is for a beautiful, livable environment in which we raise our children in good health, with safe, clean water and recreational resources. And, an environment where manufacturing and agriculture can thrive, utilizing the most modern and effective technologies"⁸

Dr. Wilson argues that this broader conception of environmental health is more meaningful than the commonly held view that environmental health is only about removing toxic chemicals from the air, water and land (Wilson 2000). It addresses basic issues of survivability and quality of life. In some respects, it implies something approaching an environmental Bill of Rights. The purpose of the Bill of Rights, as well as the Magna Carta from which it was derived, was to establish an expectation of the human condition in a new society. Given the dramatic pace of social change today, such expectations for the coming generation will be difficult to define.

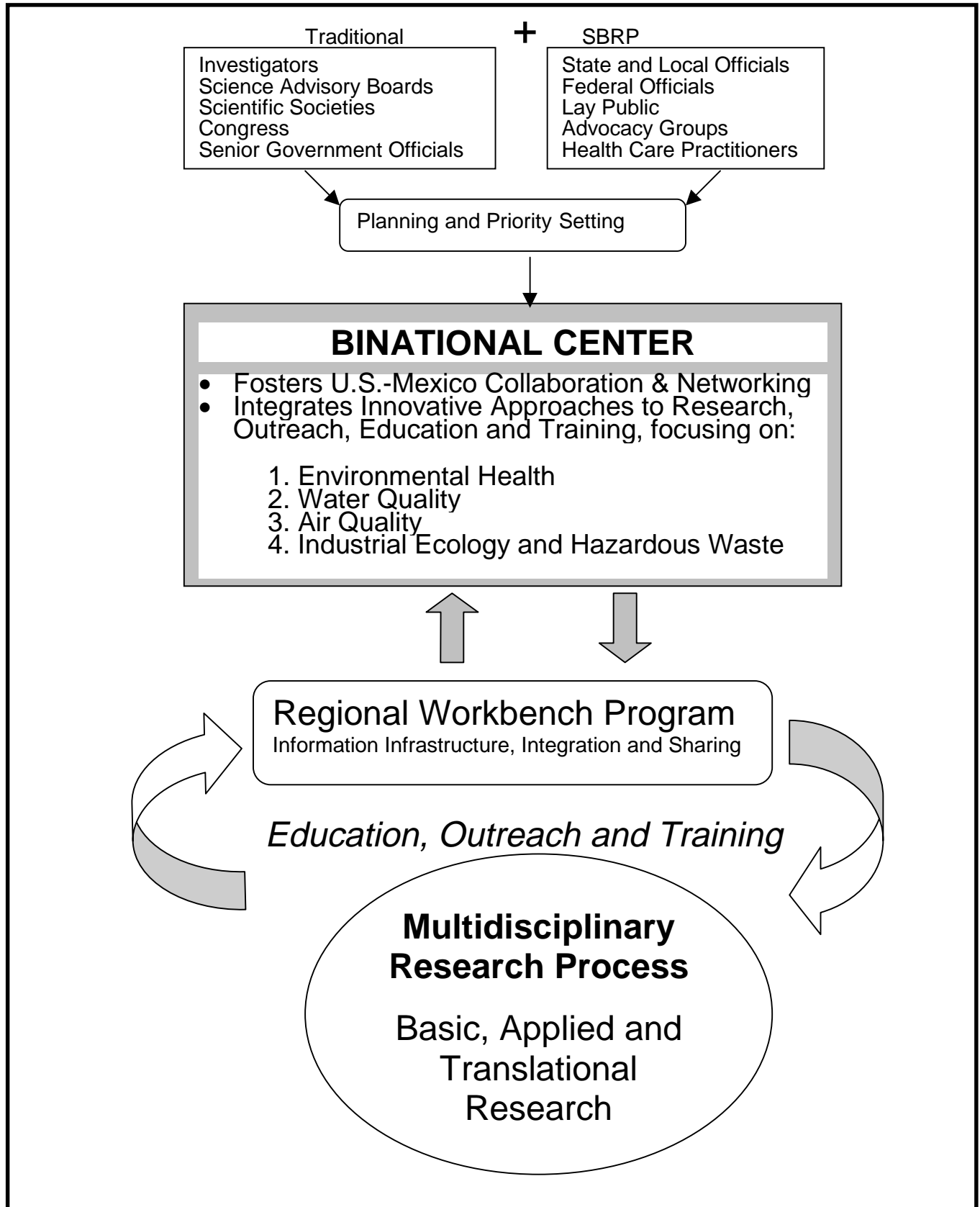
Economic globalization and rapidly shifting political conditions present radically different environmental challenges to governments and citizens; making it imperative to think beyond political borders and jurisdictions and adapt to new circumstances in more integrated ways. Along these lines, Dr. William A. Suk (NIEHS, Director of Program Development) emphasized that the efficacy of a Regional Binational Centers Program hinges on its ability to cultivate multidisciplinary collaboration across cultures with an emphasis on detection and prevention of environmental health hazards. During his opening keynote address, Dr. Suk argued that bringing together one or even two biomedical disciplines alone is insufficient to cope with the environmental stresses imposed by current and anticipated societies and that a different approach, based on sound basic research, social-political analysis, and effective international cooperation is needed (see Suk et al. 1999; Suk and Anderson 1999).

Rapid Global Economic and Political Change

There is an urgent need to define an architecture of environmental health research and policy to cope with the global environmental, political, economic and urban-industrial changes taking place in the world today. Consider in contrast, whether any rational business would fail to monitor its suppliers, competitive environment and marketplace to the extent that our societies weakly comprehend the products and services assumed from the earth's systems. The pace at which natural resources are consumed and waste is produced is so great and accelerating so rapidly that human society may outstrip its ability to recognize environmental threats; much less protect against them. The present limitations in content and function of traditional environmental policy, much of which took shape in the U.S. during the 1960s and 1970s, is compelling individuals and organizations to collaborate across academic disciplines and across public-private sectors divides. The NIEHS recognizes this in its consideration of Binational Centers as a way to comprehend the emerging multidisciplinary, collaborative and global dimensions of environmental health. Figure 10 outlines one approach to structuring a prospective Binational Center.

⁸ Binational Conference keynote dinner address, June 12, 2000, Birch Aquarium, San Diego, California

Figure 10. Conceptual Architecture of a Binational Center



The top of Figure 10 lists the kinds of organizations and participants that should inform the planning and priority setting of a Binational Center. The objective is to collaboratively build binational capacity for environmental research, education, training and outreach using state-of-the-art information technology and communication systems. The goal is to improve environmental health by establishing more efficient, interactive, and equitable methods for integrating university-based environmental science with the fast-changing needs of industry, government, and community-based organizations. To reach this goal, as outlined in Figure 10, the Binational Center must foster genuine U.S.-Mexico collaboration and cross-border networking, and it must find ways to innovatively integrate research, outreach, education and training. One way to do this, as explained in the body of this report, is through a Regional Workbench Program that places a concerted emphasis on Information Infrastructure, Integration and Sharing. The Binational Center must also have a clearly defined mission; if it is too eclectic it will fail. Figure 10 lists four areas that together constitute a good set of priorities for research and action: environmental health, water quality, air quality, industrial ecology and hazardous waste. Prospective agendas for each of these areas are spelled out in the body of the report and in the series of Tables at the end of this section. As discussed at the Binational Conference, a number of changes taking place regionally and globally suggest that these particular focus areas, as well as the associated development of a Regional Workbench program, are timely and of the utmost importance from an environmental science and policy perspective.

The Changing Scope and Scale of Environmental and Anthropogenic Interactions

First generation environmental policy was drafted several decades ago when many of the types of environmental problems we face today were not yet prevalent. Now there are serious gaps in what environmental regulations address and bureaucratic responses are slow. Most environmental laws focus on manufacturing and municipal waste, especially the industries that have historically been the most heavily polluting (e.g., refineries, chemical and power plants, automobile industry, wastewater dischargers). Yet, in the US today, fully 75 percent of the economy is in the services sector including telecommunications, health care, banking and insurance.

The growth associated with today's information economy is not as obviously polluting as that of the industrial growth of the late-1800s to mid-1900s; but the energy requirements are indisputable and new types of environmental problems have emerged in proportion to economic vigor. Throughout North America's urban and agricultural regions, non-point source runoff from residences, farms, streets, parking lots and buildings into rivers, creeks and storm drains pose an enormous environmental problem to aquatic resources. Population growth amplifies these and other diffuse sources of pollution including atmospheric emissions from power plants, incinerators, landfills, motor vehicles; in fact any energy transforming process.

There are other sorts of systemic, non-point source problems that "first generation" environmental laws did not consider. These include atmospheric build-up of greenhouse gases and the yet-unconsidered impacts of 'exotic' chemical species with organochlorines as an example. The potential environmental impacts of genetically modified organisms, urban sprawl resulting in loss of habitat and biodiversity, pesticides that might disrupt human endocrine cycles, and the erosion of earth's protective ozone layer in the upper atmosphere, all raise concerns that cut across disciplinary, political and cultural boundaries.

Organizational and Institutional Legacies

First generation environmental policy has focused on controlling pollution in a highly fragmented pollutant-by-pollutant, industry-by-industry basis. Yet, the complexities of today's environmental problems demands integrated, pollution-preventing and resource conserving approaches (e.g., watershed-based, industrial cluster). Through applied and translational research, a Binational Center can play an important networking and educational role.

Current environmental laws, in both the US and Mexico, operate largely on the basis of Federal statutes that limit the amount of pollution put into the air, water, or land. Most laws, regulations and environmental agencies have been organized around specific media (air, water, and land) or around select material types (pesticides, toxic substances, and municipal solid waste). While some pollutants are heavily regulated, others are not regulated at all. Pollution control measures are reactive—typically involving the addition of equipment to remove pollutants that were being released to the natural environment. However,

once pollutants are generated they are not easily reduced or eliminated—more often than not they simply change form. The result is a cross-media transfer of pollution (i.e., substances get moved from one environmental medium to another such as from air to water or from water to land, or one community to another).

At the conference, Antonio Azuela made this observation: We assume that once society detects a problem government will deal with it by developing some form of legal instrument. In the case of Mexico, there are indeed strong environmental laws (many fashioned after U.S. law). And in the post-NAFTA period, Mexico's enforcement of environmental law has been significantly stepped up. However, as Dr. Azuela points out, it is not clear that the enforcement actions are leading to improved health outcomes. Compliance is not enough. There is data in Mexico on fines and level of compliance, but there is little understanding of the relationship this has to quality of health. To more fully understand the ramifications of a fragmented regulatory regime and the cross-media transfer of pollutants, a Binational Center should enable serious, long-term, regional (place-based) studies of environmental health. The following quote by the National Research Council drives this point home: "The major threats and opportunities of the sustainability transition are not only multiple, cumulative, and interactive, but also place-based. In other words, it is in specific regions with distinctive social, and ecological attributes that the critical threats to sustainability emerge, and where a successful transition will need to be based" (NRC 1999: 285).

Environmental Economics and Industrial Ecology

It is not within the mandate of first generation environmental policy to question economic growth. Yet the environmental externalities associated with unbridled growth are increasingly problematic. Indicators, methods and policies to discern meaningful differences between growth and development are sorely lacking. A Binational Center can play an important role as the developer of regional environmental health metrics and quality of life indicators.

The emphasis one sees today on pollution prevention marks an important shift toward more proactive and systems-based approaches. At the same time though, it is important to also realize that conceptualizing environmental problems primarily in terms of toxics and pollution can be misleading. Societies that have made the most progress toward "solving" (at least the most evident) pollution problems are the most affluent—and typically the most resource-intensive—ones which, on balance, are exacting a far greater toll on the environment than are countries such as Mexico, Colombia or Thailand. A recent study of Germany, Japan, the Netherlands, and the US documents the immense volume of natural resources required to run a developed economy--in the range of 45 to 85 metric tons of material per person each year.⁹ Much of this material flow--including mine tailings, eroded soil, logging debris, and excavated earth and rock--does not end up in final products. The staggering tonnage of such flows accounts for as much as 75 percent of the total materials used in industrial economies.¹⁰ Given that such flows do not enter the economy as commodities they are not accounted for in national gross domestic product. This omission is problematic in so far as it impedes accounting for the massive scale of environmental alteration and externalities associated with such flows. And given the globalization of the economy, the resulting impacts of these flows (e.g., watershed pollution, habitat degradation) often register in poorer countries outside the developed economies that benefit most from the process. This dynamic presents itself as a major concern in U.S.-Mexico relations.

The global economy as a whole is expected to grow four or five-fold over the next 50 years. Likewise, the U.S.-Mexico border region is expected to grow dramatically. Even as the regulation of hazardous waste and toxic substances grows, the generation of these wastes and the production of toxic chemicals is expected to continue growing as well. The capacity to resolve hazardous waste problems could be greatly enhanced by the creation of a Binational Center. GIS, modeling, visualization, the Regional Workbench are all tools that could be developed and utilized. The grand challenge, together with the aim to deepen social

⁹ A. Adriaanse et al., *Resource Flows: The Material Basis of Industrial Economies*, a joint publication of the World Resources Institute (WRI); the Wuppertal Institute; the Netherlands Ministry of Housing, Spatial Planning and the Environment; and the National Institute for Environmental Studies (WRI, Washington, D.C., 1997), p. iv.

¹⁰ WRI et al 1998-1999 World Resources, A Guide to the Global Environment, p. 161

justice and equity, is to move us toward more sustainable, resource conserving and healthy methods of production and consumption (i.e., industrial ecology).

Political and Regulatory Weaknesses

Economic globalization and capital mobility in the world economy have made governments skittish about market intervention for any purpose other than promoting growth. Those national, regional, or city governments that do attempt to construct market rules for explicit social and/or environmental purposes risk the consequences of capital flight or restricted access to capital. In this new global economy, the importance of empowering communities and advocacy groups with high quality, user-friendly, environmental information is crucial.

The NIEHS is, of course, well aware of the importance of community input. The NIEHS requires that each of its Centers around the country have a Community Outreach and Education Program (CEOP). A Binational Center should also have a strong emphasis on outreach, education, and translational research. Theories developed within the framework of strategic management, organizational, and innovation studies suggest that public pressures have been among the most important driving forces for changes in firm behavior (Fischer and Schot 1994). Such theory suggests that the mobilization of environmental NGOs has contributed to a new kind of social interaction and learning process among firms and the public (Gottlieb 1995, Zabin and Brown 1995).

First generation environmental policy shaped markets by directly restricting the rights of producers and consumers to do environmental harm and by penalizing polluters. Now, such direct intervention is no longer the principal method of choice. Tietenberg (1997) notes how efforts to inform the public about pollution forms the basis for what has become the "third wave" in pollution control policy (the first being legal regulation; the second, market-based instruments). The level of investment in information strategies is likely to rise. There are a number of reasons for this. Rising benefits and falling costs (to collect, aggregate, and disseminate information), coupled with times of fiscal austerity are bound to make information strategies an attractive method to complement regulatory efforts. Indeed, in both Mexico and the U.S. significant emphasis is being placed on developing such strategies. The U.S.-Mexico Border XXI program, for instance, has an Information Working Group that is identifying what information already exists, systematizing its availability, and defining ways to deliver information more effectively to border communities. Large investments in data collection and information system development--especially Geographic Information Systems (GIS) are being made. But the Good Neighbor Environmental Board (a U.S. Presidential and Congressional Advisory Committee on U.S.-Mexico Border Environmental and Infrastructure Issues) has expressed concern that there is excessive duplication of effort and a lack of overall coordination. A Binational Center could help eliminate such duplication. And if such a Center were to develop a *Regional Information System* of the sort described above (under "Regional Workbench"), new capacities for cross-border outreach and education could be advanced.

Tendencies Toward Research Isolation

Scientific disciplines are long-established and difficult to transcend. Barriers to entry within a discipline are high and the priorities and measures of success within each discipline, and fostered by research institutions, provide strong incentives to be inward looking rather than seeking collaboration across disciplinary boundaries. This type of parochialism inhibits interdisciplinary cooperation and is a difficult limit to cross in support of collaborative research. It is not by accident that the categories of research activities were chosen as they were for this conference. These correspond to fields and disciplines that can be recognized by practitioners in them and for which research programs exist. The need to specifically create incentives to encourage and cultivate interdisciplinary research and collaboration will depend critically on the recognition of the intra-disciplinary priorities, value systems and incentives. Commitment from academic institutions will be essential to mobilize the kind of scientific resolve necessary to make this happen.

Access to Data and Intellectual Property Restrictions

The commercialization of information and data is a relatively new but accelerating problem for the research community. Complicating this trend are international restrictions and differences in the openness

and availability of data that may be considered sensitive. The ready availability of data is possibly the most critical factor to the success of any scientific endeavor. It was noted by most workgroups that access to data about Mexico is problematic and the reasons diverse. It was also noted that much of the important remote sensing data needed to conduct effective GIS-type analyses is expensive. Coping with these problems will require not only funding assistance for data costs but significantly different mechanisms for acquiring and sharing data than those that have been attempted in the past.

Results

The results of the conference breakout sessions are summarized in Tables 1-6 as edited lists of the issues identified by participants in the seven conference workgroups: 1) hazardous waste management, 2) industrial ecology, 3) biomedical research, 4) water quality, 5) prevention/intervention research, 6) air pollution, and 7) enabling multidisciplinary approaches to environmental research, education and training in the U.S.-Mexico transborder context. In summarizing the workgroup results, we elected to condense the seven groups into four in the following way:

EH	Environmental Health (biomedical, prevention/intervention)
WQ	Water Quality
AQ	Air Quality
IE/HW	Industrial Ecology and Hazardous Waste

These acronyms are used as column headings in the tables and the **X**'s in the columns indicate the workgroup(s) provide traceability to the workgroup originating the corresponding entry in the table. We did this to, hopefully, improve the logical organization of the results and to simplify the description of related issues emerging from the workgroups. Where there are multiple **X**'s, more than one workgroup contributed to the item and there has been some editorial license taken in combining entries from workgroups and rewording them into a narrative form. There is a temptation to use this scheme also as a means of determining commonalities, and therefore priorities, across the groups. This temptation should probably be resisted since many items can be probably interpreted as desirable in each of the four new categories. The traceability is nonetheless interesting as it shows the somewhat surprising independence of the individual workgroup results and we present it for its value in that way.

In conclusion, certain functions and capabilities emerge as essential to an effective binational center. We suggest that they be organized as follows with a brief description of approximate role of each component:

Environmental Health Practice: responsible for Center's activities and collaborations in translating research results into effective public health interventions, policy and protocols.

Multidisciplinary Research Division: responsible for the interactive development and synergy of basic biomedical research (e.g., mechanistic-based studies, epidemiology, genetic susceptibility) with non-biomedical research, including both natural and social science-based inquiry (e.g., earth systems, ecological risk assessment, fate and transport, hydrogeology, engineering, remediation, urban and cultural studies, economics, geography), for the purpose of understanding the processes by which environmental health risks emerge and proceed.

Education, Outreach and Training Service: responsible for continuing education and training of graduates, professionals and the public-at-large in the issues of environmental health, research methods as well as developing systems for acquiring and sharing public health data from the border community.

Information Infrastructure Integration Division: responsible for computing, data and communications, including the development of a Regional Workbench Program, in a manner that services the mapping and analysis requirements of research collaborations, data acquisition, publication standards and protocols management.

Table 1. Biomedical Research Summary	EH	WQ	AQ	IE HW
Identify sources of toxicants including agricultural pesticides and exposure of cross border workers and assess the toxicity of bioavailable, persistent organics and metals and associated environmental risk and evaluate the health affects with regard to toxicology and biochemistry including exotic chemical species.	X	X	X	
Develop an inventory of human health effects of toxicants and assess risk due to conventional conservative biological agents (bacteria) as well as emergent pathogens including protozoans and viruses.	X	X		
Establish a data base and data exchange program with both a binational and border perspective listing of toxicants including information on the scientific basis of regulatory rulings, transport and transfer of hazardous materials	X			
Establish monitoring systems to encompass exposure patterns including bioavailability, gene expression and proteomics [susceptible species, knock outs] and map public health and disease and its distribution correlated with water quality or air quality distribution including fate and transport of contaminants. Consider also the needs for times series analysis looking at asthma, cardiovascular, respiratory and linkages.	X		X	X
Develop exposure models tied with qualitative and quantitative risk assessment. Consider the need for different models for occupational, community and child exposures including the role and interaction of nutrition as a factor of susceptibility to injury from exposure to toxic wastes.			X	X

Table 2. Environmental Science Research Summary	EH	WQ	AQ	IE HW
Evaluate the source, fate, transport and bioaccumulation of important chemical species, considering exotics, including persistent organics and metals in soil, water, plants and animals, and aquatic sediments. Explicitly address the environmental fate of hazardous waste.		X	X	X
Develop science-based metrics and indicators for industrial performance and integrated risk assessment including evaluation and mitigation of trans-border development pressures.		X		X
Develop environmental modeling of pollution transport mechanisms and impacts.				X
Provide more user friendly and policy-relevant methods for data mining and presentation.				X
Develop a compliance map to provide the public with more in-depth knowledge about industry in their region (who is in and out of compliance, what are the associated health risks)?				X
Develop criteria for the ranking and selection of watersheds for monitoring, analysis and modeling to support specific water resource management issues using remote sensing and land use data.		X		
Consider existing monitoring programs related to the US FDA and Mexican Ministry of Health based on an MOU (binational agreement) focusing on San Quintin and Ensenada Bay for total coliforms and shellfish poisoning episodes.		X		
Provide for climate-related, extreme-event impact analysis coordinated with air, land, water, and socio-political components.		X		
Develop system for analyzing nitrogenous compound fluxes as well as related nutrient saturation mechanisms especially associated with airshed.		X		
Develop a binational approach to Total Maximum Daily Load (TMDL) assessment and monitoring consistent with other regional efforts such as those being developed as a collaboration in Southern California. Consider erosion and transport scenarios their consequences and related risks.		X		
Evaluate the degradation of cross-border ecosystems affected by hazardous waste and consider an integrated approach to ecosystem study and analysis of the circle of hazardous materials. Develop rules for locating new sites for storing hazardous waste				X

Table 3. Information Technology Research Summary	EH	WQ	AQ	IE HW
Provide a network of in-situ bioassay and physico-chemical sensors with remote alarm and real-time sensing function. Consider especially nutrient loading sensors (i.e., Nitrogen, Phosphate, Silicon) that are already available and used in Europe.		X		
Provide visual models for depiction, communication, analysis and evaluation of watershed dynamics and fate and transport of water-borne material.		X		
Provide coordination and information network above, below and along the border for data sharing and resource identification, collaboration and communication between investigators, policy and regulatory agencies. Provide for the collection and publication of data and analysis tools related to air and water including terrestrial and atmospheric sources, transport and coastal processes. Negotiate access to data and developing a mechanism for data sharing. Provide quality assurance and control methodology and tools for data integration supporting the development of data sharing standards.		X		X
Catalogue relevant and available databases (in the US: EPA, USGS, CalEPA, SanDAG; in Mexico: INE, INEGI) and check consistency of existing databases on toxic releases and hazardous waste (following EPA HAZTRAKS vs INE example).				X
Create data protocol and web based GIS applications using GPS to id "hot spots" and measure relationships between multiple variable. deploy an integrated, transborder GIS database. This would be a web-based, partnership-driven tool for knowledge networking--a transborder Regional Workbench (portal) for EMS and Industrial Ecology initiatives and policy development.	X			X
Develop a trilateral EMS protocol (now jointly underway by Mexico, the U.S., and Canada) considering what an EMS contain to be considered worthy of government recognition and approval?				X
Develop a compliance map to provide the public with more in-depth knowledge about industry in their region (who is in and out of compliance, what are the associated health risks)?				X

Table 4. Social Science Research Summary	EH	WQ	AQ	IE HW
Develop Binational Air Quality Alliance (EPA, DOE, APCD, Industry, others) and consider extending this to water and land or other type of generalization..			X	
Consider grass-roots efforts (e.g., Ensenada groups) and those of NGOs in community-based monitoring and reporting of environmental hazard reporting. This resource is sometimes underutilized and potentially has considerable expertise and information not found elsewhere.		X		
Develop library of data and literature on historical information regarding land-use, water resources and narrative description of cultural aspects of these factors for comparative analysis relative to current monitoring results. This information is often anecdotal and bears on issues of legacy problems and patterns of usage that can affect present-day watershed dynamics.		X		
Conduct a survey, on both sides of the border, of common environmental priorities (by regions), determining where toxic waste exposure is in this list of priorities, and building collaboration and education strategies accordingly				X
Compare definitions of hazardous waste on both sides of the border, communicate the differences and explore the consequences and conduct a comparative study of hazardous waste perceptions and understanding at different levels (individual – community – municipal – state), how it is handled and transported.				X
Compare legal issues in clean-up of abandoned properties (in Mexico, especially, this is a problem)				X

Table 5. Education, Outreach, Training Research Summary	EH	WQ	AQ	IE HW
Develop stakeholder workshops and “train the trainer” activities on environmental health designed through a participatory process with all stakeholders (e.g. funding sources, academic institutions, community, private business. Provide regionally focused education about hazardous waste and providing pollution prevention data back to firms.				X
Assist in identifying public health priorities in the region. Facilitate the interlocking of "new knowledge" with public health policy and share best practices related to public health service delivery	X			
Facilitate the training of public health researchers.	X			
Develop training programs for the development of scientific expertise with linkages to industry, state governments, departments of public health.	X			
Establish a border environmental health alliance to support information exchange, training at the technician and research scientist levels, separate toxicant, susceptible gene, responsive phenotype, geographic data base entries	X			

Table 6 Communications Science Research Summary	EH	WQ	AQ	IE HW
Enhance education and reporting of water quality problems especially in conjunction with information technology services. This might be done through a public-access system for problem reporting. Develop culturally-acceptable reporting systems for public health events and incidents. Much confusion and misunderstanding can occur that significantly inhibits cooperation when cultural differences in interpretation of motives and priorities are not clear to collaborators from different cultures		X		X
Develop mapping of binational regulations, systems and approaches to environmental issues, policy and enforcement mechanisms.		X		X
Conduct pilot studies; three or four in different sectors and parts of the border, to include ethnographic and survey analysis of working practices on both sides of the border addressing issues ranging from the compatibility of the material and information infrastructures to the working practices of scientists to the needs and work practices of policymakers.	X			
Codify informal binational political mechanisms that succeed in complex bureaucratic settings. A major trend in the exploration of multidisciplinary work has been to look at the development of working languages in 'trading zones' between disciplines and between the science and the policy field. Examine the ways in which scientific knowledge can be transformed into culturally and politically useful knowledge.	X			
Survey models for organizing multidisciplinary research centers considering the World Bank and the National Institute of Health environmental programs.	X			

Websites

June 2000 Binational Conference website:

<http://www.sdsc.edu/niehsconference/program.html>

June 2000 Binational Conference webforum:

<http://tsrtp-forums.ucdavis.edu/webx?14@168.vfVOafRDr6C%5E3@.ee6beb7>

Regional Workbench <http://regionalworkbench.org>

Recommendations by the NIEHS, representatives from EPA national and regional offices, and the Agency for Toxic Substances and Disease Registry (ATSDR)

<http://benenson.niehs.nih.gov/sbrp/descrip/respri.cfm>

A direct link to EPA Region 9 Research Needs:

<http://benenson.niehs.nih.gov/sbrp/descrip/reg9need.cfm>

U. S. Environmental Protection Agency:

<http://www.epa.gov/ebtpages/whazardouswaste.html>

California Department of Toxic Substance Control:

<http://www.dtsc.ca.gov>

Secretaria del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP):

<http://www.semarnap.gob.mx/>

Instituto Nacional de Ecología (INE)

<http://www.ine.gob.mx/>

Border XXI: <http://www.epa.gov/usmexicoborder/ef.htm>

World Bank. What Improves Environmental Performance. Evidence from Mexican Industry

http://www.worldbank.org/nipr/work_paper/1877/index.htm

Rio Principles [Http://www.un.org/esa/sustdev/agenda21.htm](http://www.un.org/esa/sustdev/agenda21.htm)

NSF Knowledge Networking and Distributed Intelligence (KNDI)

<http://www.ehr.nsf.gov/kdi/>

TELESIS Quality of Life and Interactive Mapping Portal

<http://qolsandiego.net/>

Association of Collegiate Schools of Planning (ACSP)

<http://www.uwm.edu/Org/acsp/index.htm>

Multi-State Working Group on Environmental Management Systems

<http://www.mswg.org>

The Sociology Workbench

<http://edcenter.sdsu.edu/KAMIL/index.html>

Literature (policy emphasis)

- Ahmed, Kulsum; Paul Martin and Shelton Davis. 1998. Report titled, Guadalajara Environmental Management Pilot (Report No. 18071-ME). September 8, 1998. http://www.worldbank.org/nipr/work_paper/guada/
- Allen, David; John Ehrenfeld; and Reid Lifset. 1997. "What is Industrial Ecology?" *Journal of Industrial Ecology* 1:1 (Winter): 1 online at <http://mitpress.mit.edu/journals/JIEC/jie-call.html>.
- Amin, A. and N. Thrift. 1994. "Living in the global." In *Globalization, Institutions and Regional Development in Europe*, edited by A. Amin and N. Thrift. Oxford: Oxford University Press.
- Ayres, Robert U. 1989. "Industrial metabolism." In *Technology and Environment*, edited by Ausubel and Sladovich. Washington, D.C.: National Academy Press.
- Ayres, Robert U. 1996. "Creating industrial ecosystems: a viable management strategy?" *International Journal of Technology Management* 12:5/6, Special Issue.
- Ayres, Robert U. and Ayres, Leslie. 1996. *Industrial Ecology: Towards Closing the Materials Cycle*. London: Edward Elgar Publishers.
- Balstad Miller, R. 1996. "Information technology for public policy." In *GIS and Environmental Modeling: Progress and Research Issues*, edited by M.F. Goodchild, L.T. Steyaert, and B.O. Parks. Fort Collins, CO: GIS World Books.
- Bowen, Mace M.; Thomas Kontuly and George F. Hepner. 1995. "Estimating Maquiladora Hazardous Waste Generation on the U.S./Mexico Border." *Environmental Management* 19 (2): 281-296.
- Bowker, Geoffrey C. and Susan Leigh Star (1999) *Sorting Things Out: Classification and Its Consequences*. Cambridge: MIT Press.
- Branscomb, Lewis M. and Richard Florida (1998) "Challenges to Technology Policy in a Changing World Economy." In *Investing in Innovation: Creating a Research and Innovation Policy that Work*. pp. 3-39, edited by Lewis M. Branscomb and James H. Keller. Cambridge, MA.: MIT Press.
- Bunker, S. G. 1996. "Raw material and the global economy: oversights and distortions in industrial ecology," *Society and Natural Resources* 9:419-430.
- California Environmental Strategy Panel. 1996. *Collaborating to Compete: An Economic Strategy for California*. California Trade and Commerce Agency, <http://commerce.ca.gov/business/select/industry/economy/ne07.html>
- Castells, Manuel and Peter Hall. 1994. *Technopoles of the World: The Making of Twenty-First-Century Industrial Complexes*. New York: Routledge.
- Castells, Manuel. 1996. *The Rise of the Network Society*. Cambridge, Mass.: Blackwell Publishers.
- Carter, Dean E.; Carlos Peña; Robert Varady; and William A. Suk 1996. "Environmental Health and Hazardous Waste Issues Related to the U.S.-Mexico Border." *Environmental Health Perspectives* 104: 6 (June).
- Chase, Carolyn. 1999. "Pollution politics persist," *Daily Transcript* (April 23) <http://www.sddt.com/files/library/99/04/23/tz.html>
- Commission for Environmental Cooperation (CEC). 1996. *Status of Pollution Prevention in North America*. Montreal: Prospectus Inc.
- Commission for Environmental Cooperation (CEC). 1997. *1996 Annual Report*. Montreal: Prospectus Inc.
- Costanza, R; dArge, R; deGroot, R; Farber, S; Grasso, M; Hannon, B; Limburg, K; Naeem, S; ONeill, RV; Paruelo, J; Raskin, RG; Sutton, P; vandenBelt, M. 1997. "The value of the world's ecosystem services and natural capital," *Ecological Economics* 25:1 (April): 3-15. [Reprinted from *Nature*, vol 387, 1997].
- Costanza, R; King, J. 1999. "The first decade of Ecological Economics," *Ecological Economics* 28:1 (1-9).
- Dasgupta, Susmita; Hemamala Hettige and David Wheeler (1997) "What Improves Environmental Performance? Evidence from Mexican Industry." Washington, D.C.: World Bank, Development Research Group.
- Dicken, Peter. 1998. *Global Shift: Transforming the World Economy*. (3rd ed.) New York: The Guilford Press.
- Earwicker, David P. and Victor M. Castillo. 1995. *Competitive Advantage Through Environmental Technology*. Summary Proceedings of the International Conference on Competitive Advantage

- Through Environmental Technology, May 1994. Published by the Center for International Business Education and Research (CIBER), SDSU; and the Small Business Development and International Trade Center, Southwestern College.
- Ehrenfeld, John R. 1994. "Industrial Ecology and Design for the Environment: The Role of Universities." In *The Greening of Industrial Ecosystems*, edited by B. R. Allenby and D. J. Richards. Washington, D.C.: National Academy Press.
- Ehrenfeld, John R. 1997. "Industrial Ecology: A New Paradigm for Technological Innovation," *Journal of Cleaner Production* 5 (1-2): 87-95.
- Ehrenfeld, John R. and Nicholas Gertler. 1996. "The Kalundborg Industrial Symbiosis -- Industrial Ecology in Practice." Working Paper, MIT.
- Eisenberger, Peter M. 1996. "Basic Research Needs for Environmentally Responsive Technologies of the Future: An Integrated Perspective of Academic, Industrial, and Government Researchers." A report sponsored by the National Science Foundation and the Department of Energy, <http://www.pmi.princeton.edu>.
- Environmental Health Coalition. 1999. San Diego Bay Project, <http://www.environmentalhealth.org/cleanbay.html>
- Environmental Protection Agency (EPA).1997. *Pollution Prevention 1997: A National Progress Report*. Washington D.C.: EPA Pollution Prevention Information Clearing House.
- Evans, Peter. n.d. "Introduction." In *Livable Cities: The Politics of Urban Livelihood and Sustainability*, edited by Peter Evans (forthcoming University of California Press).
- Fischer, Kurt and Johan Schot. (eds) 1993. *Environmental Strategies for Industry: International Perspectives on Research Needs and Policy Implications*. Covelo, CA: Island Press.
- Fountain, Jane E. 1998. "Social Capital: A Key Enabler of Innovation." In *Investing in Innovation: Creating a Research and Innovation Policy that Work*, edited by Lewis M. Branscomb and James H. Keller. Cambridge, MA. MIT Press.
- Freeman, Chris and Luc Soete. 1997. *The Economics of Industrial Innovation* (Third edition). Cambridge: MIT Press.
- Gladwin, Thomas N. 1993. "The Meaning of Greening: A Plea for Organizational Theory." In *Environmental Strategies for Industry: International Perspectives on Research Needs and Policy Implications*, edited by Kurt Fischer and Johan Schot. Covelo, CA: Island Press.
- Gottlieb, Robert (ed). 1995. *Reducing Toxics: A New Approach to Policy and Industrial Decisionmaking*. Pollution Prevention and Education Research Center, UCLA. Covelo, California: Island Press.
- Graedel, T.E. and B.R. Allenby. 1995. *Industrial Ecology*. Englewood Cliffs, N.J.: Prentice Hall.
- Groenewegen, Peter, Kurt Fischer, Edith G. Jenkins and Hohan Schot (eds.). 1996. *The Greening of Industry Resource Guide and Bibliography*. Published as part of the Greening of Industry Network Series. Washington, D.C.: Island Press:
- Gunderson, Lance H.; C.S. Holling and Stephen S. Light (eds.). 1995. *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York: Columbia University Press.
- Harrison, Bennett, and Marcus Weiss. (1998) *Workforce Development Networks*. Sage Publications.
- Haztracks, a website maintained by the EPA, <http://www.epa.gov/earth1r6/6en/h/haztracks>.
- Heiman, Michael K. 1997. "Community Attempts at Sustainable Development through Corporate Accountability," *Journal of Environmental Planning and Management* 40(5): 631-643.
- Herzog, Lawrence A. 1990. *Where North Meets South: Cities, Space, and Politics on the U.S.-Mexico Border*. Austin: Center for Mexican American Studies, University of Texas Press.
- Herzog, Lawrence A. 1991. "Cross-national Urban Structure in the Era of Global Cities: The U.S.-Mexico Transfrontier Metropolis," *Urban Studies* 28 (4): 519-533.
- Herzog, Lawrence A. (ed.). 1992. *Changing Boundaries in the Americas: New Perspectives on the U.S.-Mexican, Central American, and South American Borders*. San Diego: Center for U.S.-Mexican Studies.
- Hinojosa-Ojeda, Raul. 1995. "The North American Development Bank," notes taken from the Internet at: <http://sppsr.ucla.edu>.
- INEGI, Banco de Información Económica. 1999. *Industria Maquiladora de Exportación*. <http://dgcnesyp.inegi.gob.mx/BDINE/J15/J15.HTM>. December 7.

- Ingram, H., L. Milich, and R.G. Varady. 1994. Managing Transboundary Resources: Lessons from Ambos Nogales. *Environment* 36(4):6-9, 28-38.
- International Boundary and Water Commission (IBWC), United States Section. 1999. *Homepage*. <http://www.ibwc.state.gov/>. December 7.
- Jerret, Michael, Keith Pezzoli and Nico Calavita. 1998. "Sustainability Indicators for the Tijuana Watershed: Current Practice and Future Opportunities in San Diego." Unpublished manuscript.
- Jacott, M., C. Reed, and A. Villamar. 1999. *Hazardous Waste Management in the United States-Mexico Border Region: More Questions Than Answers*. Preliminary Version. Austin: Texas Center for Policy Studies.
- Kjos, Kaare; Elena Eger and Marc Beyeler. 1995. "Binational Coordination of Environmental Activities in the San Diego-Tijuana Border Region." A Report prepared for the California State Coastal Conservancy (December).
- Kostoff, Ronald. 1998. "Science and Technology Innovation." Working paper, Office of Naval Research, Arlington, VA.
- LaFee, Scott. 1998. "San Diego lives up to reputation as science center ." *San Diego Union-Tribune* (Page E-2) October 7, 1998.
- Lee, Martin R. 1997. "Environmental Protection Legislation in the 105th." A Congressional Research Service Issue Brief. Committee for the National Institute for the Environment, <http://www.cnie.org/nle/leg-30.html>
- Liverman, D., R. G. Varady, R. Sánchez, and O. Chávez. 1999. Environmental Issues along the US-Mexico Border--Drivers of Change and the Response of Citizens and Institutions. *Annual Review of Energy and the Environment* 24(1999):607-643.
- Lexington Group. 1997. "Industrial Environmental Management in Mexico: Report on a Survey." Report submitted to The World Bank.
- Lowe, Ernest. 1995. *Designing, Financing, and Building the Industrial Park of the Future*. Indigo Development: Oakland, CA.
- Lowe, Ernest A.; Warren, John L.; and Moran, Stephen R. 1997. *Discovering Industrial Ecology: An executive briefing and sourcebook*. Cleveland: Battelle Press.
- McMichael, AJ; Bolin, B; Costanza, R; Daily, GC; Folke, C; Lindahl-Kiessling, K; Lindgren, E; Niklasson, B. 1999. "Globalization and the sustainability of human health - An ecological perspective," *Bioscience* 49(3):205-210.
- Milich, L. and R. G. Varady. 1998. Managing Transboundary Resources: Lessons from River-Basin Accords. *Environment* 40(8):10-15, 35-41.
- Mumme, Stephen. 1993. "Innovation and Reform in Transboundary Resource Management: A Critical Look at the International Boundary and Water Commission, U.S. and Mexico," *Natural Resources Journal* 33: 94-120.
- Mumme, S. 1999. NAFTA's Environmental Side Agreement: Almost Green? *Borderlines* 7(9): 1-4, 16.
- Mumme, Stephen and Pamela Duncan. 1996. "The Commission on Environmental Cooperation and the U.S.-Mexico Border Environment." *Journal of Environment and Development* 5 (2): 197-215.
- National Pollution Prevention Roundtable (NPPR), <http://www.p2.org/index.html>
- National Research Council, Board on Sustainable Development (1999) *Our Common Journey: A Transition Toward Sustainability*. Washington D.C., National Academy Press. < <http://www.nap.edu> >
- North American Development Bank (NADB). 1999. *Homepage*. <http://www.nadbank.org>. December 7.
- Nyden, Philip; Anne Figert; Mark Shibley; and Darryl Burrows (1997) *Building Community: Social Science in Action*. Thousand Oaks, CA: Pine Forge Press.
- Organization for Economic Cooperation and Development (OECD). 1995. *Technologies for Cleaner Production and Products: Towards Technological Transformation for Sustainable Development*. Paris: OECD Publications.
- Organization of American States. 1999. *North American Free Trade Agreement between the Government of Canada, the Government of the United Mexican States, and the Government of the United States of America*. <http://www.sice.oas.org/trade/nafta/naftatce.stm>. December 7.
- O'Rourke, Dara; Lloyd Connelly and Catherine P. Kosterland. 1996. "Industrial Ecology: A Critical Review," *International Journal of Environment and Pollution*, 6(2/3): 89-112.

- Pezzoli, K. (2000a) "From Pollution Prevention to Industrial Ecology: An agenda for research and practice," In *Shared Space: Economic Integration and the Environment Along the U.S.-Mexican Border*, edited by Lawrence A. Herzog. La Jolla: Center for U.S.-Mexican Studies.
- Pezzoli, K. (2000b) "Environmental Management Systems and Regulatory Innovation." *California Western Law Review*, 36 (2): 335-366.
- Pezzoli, K. (1998). *Human Settlements and Planning for Ecological Sustainability: The Case of Mexico City*. Cambridge, Mass: MIT Press.
- Pezzoli, K. (1997a) "Sustainable Development: A Transdisciplinary Overview of the Literature." *Journal of Environmental Planning and Management*, 40 (5): 551-576.
- Pezzoli, K. (1997b) "Sustainable Development Literature: A Transdisciplinary Bibliography." *Journal of Environmental Planning and Management*, 40 (5): 577-603.
- Pezzoli, Keith; Kathy Kopinak, Greg Lorton, Walter Platkus, and Jennifer Kraus, The San Diego-Tijuana Industrial Ecology Group 1999. "Sustainability Through EMS Partnerships (STEP)," a proposal submitted to the EPA Sustainable Industries Grant Program.
- President's Council on Sustainable Development (PCSD). 1996. "Science and Technology: Shaping the Twenty-First Century," cited at url, <http://whitehouse.gov/WH/EOP/OSTP/SNT/>.
- President's Council on Sustainable Development (PCSD). 1997. *Eco-Industrial Park Workshop Proceedings*. Workshop held in Cape Charles, Virginia October 17-18, 1996. U.S. Department of Energy: Washington D.C.
- Richards, Deanna J. and Robert A. Frosch. 1997. "The Industrial Green Game: Overview and Perspectives." In *The Industrial Green Game: Implications for Environmental Design and Management*, edited by Deanna J. Richards. Washington, D.C.: National Academy Press.
- Robillard, David. 1995. "Industrial Competitiveness and Environmental Responsibility," *EnviroMexico: The Newsletter focusing on Mexican Environmental Issues* IV (8):1, 7.
- Sanchez, Roberto. 1993. "Urban Growth and the Environment of Tijuana." In *San Diego-Tijuana in Transition: A Regional Analysis*, edited by Norris C. Clement and E. Zepeda Miramontes.
- Sanchez, Roberto and Paul Ganster, with a Rapporteur's Report by Steven J. Bachelor. 1999. Sustainable Development in the San Diego-Tijuana Region. San Diego: Center for U.S.-Mexican Studies.
- San Diego Association of Governments (SANDAG). 1998. "Industrial Clusters in the San Diego Region." http://www.sandag.cog.ca.us/rta/transfer/ic_sandiego.pdf
- San Diego Dialog. 1999. San Diego Dialog Report, March (4). La Jolla: University of California, San Diego. <http://www-esps.ucsd.edu/sdd>.
- San Diego Dialog. 1999. San Diego Dialog Report, June (1). La Jolla: University of California, San Diego. <http://www-esps.ucsd.edu/sdd>.
- San Diego Regional Economic Development Corporation. 1997. <http://www.sdedc.com>
- San Diego Regional Technology Alliance. 1998. <http://www.sdrta.org/sdrta/clusterdata/clusterdata.html>
- Scott, Allen J.; John Agnew, Edward Soja, and Michael Storper (1999) "Global City-Regions," Theme Paper for the Global City-Regions Conference hosted by the UCLA School of Public Policy and Social Research, Oct. 21-23, 1999 <<http://www.sppsr.ucla.edu/globalcityregions/Overview/intro.html> >
- Socolow, R.; C. Andrews; F. Berkhout and V. Thomas (eds.). 1994. *Industrial Ecology and Global Change*. Cambridge: Cambridge University Press.
- Southern California Coastal Water Research Project. 1992. "Surface Runoff to the Southern California Bight." *Annual Report 1990-1991 and 1991-1992*).
- Spalding, Mark. 1995. "Resolving international environmental disputes: public participation and the right to know," *Journal of Environment and Development* 4: 1 (Winter).
- Spalding, Mark (ed). 1999 *Sustainable Development in San Diego-Tijuana: Environmental, Social, and Economic Implications of Interdependence*. San Diego: Center for U.S.-Mexican Studies.
- Storper, Michael. 1997. *The Regional World: Territorial Development in a Global Economy*. New York: The Guilford Press.
- Suk, W. A., Anderson, B. E., Thompson, C. L., Bennett, D. A., and Vandermeer, D. C. Creating multidisciplinary research opportunities. *Environmental Science & Technology*, 33 (11): 241A-244A , 1999.

- Suk, W. A. and Anderson, B. E. A holistic approach to environmental health research. *Environmental Health Perspectives*, 107 (7): A338-A339 , 1999.
- Susskind, Lawrence; Joshua Secunda and Gabriela Krockmalnic. 1998. "The Risks and Advantages of Agency Discretion: Evidence from EPA's Project XL ." Working Paper ETP97-02, Environmental Technology Program, MIT, <http://web.mit.edu/afs/athena.mit.edu/org/d/dusp/etpp/orderform.html>
- Tietenberg, Tom. 1997. "Information Strategies for Pollution Control." Paper presented at the Eighth Annual Conference of the European Association of Environmental and Resource Economists, Tilburg University, The Netherlands, June 26-28.
- UN (United Nations) (1998) *Knowledge Societies: Information Technology for Sustainable Development*. UN Commission for Science and Technology for Development. R. Mansell and U. When, eds. Oxford: Oxford University Press.
- UNEP (United Nations Environment Program) (1999) *Global Environmental Outlook 2000*. London: EarthScan.
- US EPA. 1998. "EPA Position Statement on Environmental Management Systems and ISO 14001 and a Request for Comments on the Nature of the Data to be Collected from Environmental Management System/ ISO 14001 Pilots," *International Environmental Systems Update* 5 (4): 3-5.
- U.S. EPA and SEMARNAP. 1997. *Environmental Indicators for the Border Region*. (EPA909-R-99-001). Border XXI Program
- USEPA. 1999. *HAZTRAKS: US-Mexico Hazardous Waste Tracking System*. <http://www.epa.gov/earth1r6/6en/h/haztraks/wastepry.htm>. December 7.
- Varady, Robert G., Robert G. Arnold, Dean E. Carter, Roberto Guzmán, Carlos Peña, William A. Suk (Jan. 2000) "Hazardous Waste and the US-Mexico Border Region: Toward a Binational, University-based Institution." Udall Center Publications, Working Paper 00-1.
- WCED (World Commission on Environment and Development) (1987) *Our Common Future*. Oxford, UK: Oxford University Press.
- Wernick, Iddo k. and Jesse H. Ausubel. 1997. "Industrial Ecology: Some Directions for Research." A pre-publication draft. Office of Energy and Environmental Studies and the Lawrence Livermore National Laboratory (http://phe.rockerfeller.edu/ie_agenda/).
- Wilson, Samuel H. "Environmental Medicine at a Crossroad: Health in the United States," *Environmental Health Perspectives*, 108, A56 February, 2000
- World Resources Institute, et al. 1998. *1998-1999 World Resources: A Guide to the Global Environment, Environmental Change and Human Health*. New York: Oxford University Press.
- Zabin, Carol and Andrea Brown (1995) "Building Community and Improving Quality of Life in the Mexican Border Region: An Analysis of NGOs and Grassroots Organizations." A report prepared for the Inter-American Foundation. The North American Integration Development Center, University of California @ Los Angeles.