ENVIRONMENTAL JUSTICE IN INDIAN COUNTRY: Using Equity Assessments to Evaluate Impacts to Trust Resources, Watersheds and Eco-cultural Landscapes[1]

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Native American cultures, genetics, nutrition, and ways of life co-evolved with their natural systems through thousands of years. This process has resulted in seamless eco-cultural systems of humans, plants, animals, rivers, landforms, and air sheds. These eco-cultural systems have also provided its peoples with unique and valid environmental management science that has sustained the peoples and their resources for thousands of years. This resource-based perspective could form the basis of environmental justice risk assessment methodology in Indian Country. Cumulative impacts to tribal cultures are a combination of pre-existing stressors (existing conditions or co-risk factors) and any other contamination or new activity that affects environmental quality. Characterizing risks or impacts in Indian Country entails telling the cumulative story about risks to trust resources and a cultural way of life. Equity assessments could also be performed in a way that describes these systems-level cumulative risks/impacts. This requires improvements in metrics based on an understanding of the unbreakable ties between people, their cultures, and their resources. Specific recommendations are presented for performing equity assessments in Indian Country and for developing a Risk Ethics discipline.

1. INTRODUCTION

The breadth of environmental justice in Indian Country has multiple tiers, and is very broad and amazingly complex because Tribal communities bear disproportionate deficits in so many areas, including but not limited to socioeconomic status, nutrition, health, access to jobs, education quality, physical and informational infrastructure quality, human rights protection, linguistic resource protection, cultural resource protection, and natural resource protection. These deficits affect American Indian Tribes in unique ways, such as the misappropriation of human and biotic genetic information, the theft of traditional botanical knowledge, theft of the plants themselves (echinacea and huckleberries, for example), natural resource exploitation (mining, timber, salmon canneries), contamination of ancestors and their cemeteries, theft of the ancestors themselves, intrusion into sacred landscapes and traditional use areas, and so on.

These factors can combine in many ways. For example, a tribal community may face inadequate health care and lack of available jobs while their natural resource base is simultaneously being depleted. A tribe's natural resource base is a source of cultural identity and religion, a nutritional and medicinal buffer against poverty, and a reservoir of environmental knowledge and biodiversity. Indigenous individual and collective health is derived from membership in a healthy community that has access to ancestral lands and traditional resources and from having the ability

to participate in traditional community activities that help maintain the spiritual quality and continuation of the resources. Native foods and medicines are not only essential for the most healthful lifestyle for the genetic makeup of the indigenous people, but they are also required for religious services. The combined effect of resource depletion combined with health and socioeconomic stress force people to compete in a market-based economy while denying them the health and skills to do so effectively.

In this paper we will focus on the natural resources, which are fundamental to the survival of many American Indian cultures, and we will consider the other factors as co-risk factors that interact with and magnify environmental impacts. We will also suggest a way to evaluate the cumulative effects to tribal communities in comparison to other communities.

2. THE MISSING ENVIRONMENTAL FOCUS OF ENVIRONMENTAL JUSTICE

The environmental justice movement began with information about race and income relative to the location of hazardous waste sites and facilities emitting hazardous substances. Because the initial focus was on urban areas and socioeconomic status, environmental justice evaluation methods developed along the lines of demographic and economic analysis. However, environmental justice in Indian Country revolves around environmental quality and jurisdiction over people and actions that adversely affect natural and cultural resources (Weaver, 1996; Fixico, 1998). As a consequence, the demographic-economic approach to environmental justice is not suitable for the types of impacts experienced by tribal communities or the scale on which they occur. The spatial scale of many regulatory decisions is very small compared to watersheds, ecosystems, or landscapes, and this must be taken into account when making remedial decisions, developing environmental quality standards, or issuing new permits in Indian Country.

Subsistence Native American Treaty-reserved and religious uses require large unbroken tracts of land and clean, functional ecosystems. Traditionally, ecosystems and watersheds were sustainably managed by tribal elders and resource managers who were responsible for regulating resource use based on their knowledge of the ecological processes and the interlinkages between people, activities and resources. A basic understanding of these interlinkages is necessary for appropriate evaluation of risks and impacts to tribal cultures, health, and resources.

3. TRADITIONAL ENVIRONMENTAL KNOWLEDGE AND TRADITIONAL ENVIRONMENTAL MANAGEMENT SCIENCE

Many indigenous communities are situated in and require the functional use of sustainably-managed ecosystems or watersheds. Additionally, the relation between Native American people and their homeland is not only physically and physiologically unbreakable, it is also spiritually unbreakable. Native Americans live within a sacred landscape. Only tribal cultural experts can explain the magnitude of impact to traditional lifestyles and Trust resources that pollution or other environmental stressors causes. Only these cultural experts can place the proper value on their natural or cultural resources, on songs or place names associated with a particular location or landform, or on an individual resource and its role in the ecological processes that comprise the web of life.

Knowledge of these interrelated environmental and human processes forms the basis for traditional environmental management sciences (TEMS) (Harris, 1998), or traditional environmental knowledge (TEK). In many ways, western science has yet to rediscover traditional knowledge. A few creative modern thinkers are rediscovering systems thinking as radical new ideas (Capra, 1996, and other systems ecologists such as David Suzuki, James

Lovelock and Rupert Sheldrake), although they are still ostracized. This is slowly changing, and Canada is leading the way in recognizing TEK as valid and credible data, and in using it in environmental management (Berkes et al, 1995). The true depth and breadth of TEMS is greatly under-appreciated, and it could serve as a basis for sustainable environmental management and tribally-relevant risk assessment methods.

All of the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one, but more often in many way (Harris, 1998; Turner, 1998; Sadler and Boothroyd, 1994; Stevenson, 1996; Durning 1992; many others). For instance, loss of salmon in the Columbia River and its tributaries means much more than loss of a source of protein to the tribes located there. Salmon return to spawn and contribute their bodies to replenish stream nutrients as part of the natural cycle, and salmon dependent families and communities are the genetic and cultural product of thousands of years of co-adaptation and careful resource management. Traditional tribal leaders were strict in how many fish could be taken from various locations, and they ensured that enough fish spawned and that spawning habitat and stream conditions were of good quality so that salmon runs would remain healthy. Loss of the salmon means loss of a ceremonial food, a religious co-participant, a source of protein and polyunsaturated fatty acids, a focus of social activity and cohesion, a teacher and role model, a source of belly fat used as an emollient, a source of adhesive, a personal relative, a source of food for eagles and other scavengers, a trade item, a primary source of amino acids in streams, an object of environmental education and cultural stories, and a psychological reassurance that the cycle is functioning and all the peoples will survive. Typically, western mental models have separated these elements into two categories: (1) "real quantifiable science" and (2) a vague second-tier category of "values-perceptions-beliefs-opinions-preference-weighting factors-risk management considerations-cross-cultural communication" (e.g., Pavlou et al, 1998;). The result of this false dichotomy has been a failure to develop methods that can evaluate the total suite of risks to tribal eco-cultural health and survival. Breaking out of this paradigm is probably the single most important step that we need to take with respect to risk assessment, environmental regulations and federal guidance.

4. CRITIQUE OF DOE AND EPA ENVIRONMENTAL JUSTICE STRATEGIES

The draft Department of Energy Environmental Justice Guidance (DOE, 1998) requires the identification of a “disproportionate share of negative environmental consequences.” It uses demographic data (current residence) without identifying whose natural or cultural resources and uses (past and present) are within the impact zones. While individual resources of cultural importance can be identified within an EIS, there is no adequate guidance on evaluating relevant metrics or cumulative impacts to tribal resources and communities. The same is true of many suburban communities -- environmental justice from the affected peoples’ perspective has as much or more to do with environmental insults than actual exposure levels (Sachs, 1995).

The EPA Environmental Justice Strategy (EPA, 1998) is much stronger and clearer. It says that “EPA will implement its programs both for American Indians and indigenous communities, recognizing the government-to-government relationship, the Federal Trust responsibility, Tribal sovereignty, treaty-protected rights, other tenets of Federal Indian law, and particular historical and cultural needs of Tribes and indigenous populations.” The EPA strategy specifically applies environmental justice to NEPA, the Clean Air Act, the Clean Water Act, and RCRA but does not mention CERCLA or Natural Resource Damage Assessment. The EPA Guidance methodology starts with demographics but then includes specific language relevant to “potential effects to on- or off-reservation tribal resources (i.e., treaty-protected resources, cultural resources and/or sacred

sites)" and specifically mentions federal trust responsibility to tribes. The footnote includes "tribal government, land, resources, or interest." The EPA Guidance also says that "with respect to natural resources, analysts should look to the community's dependence on natural resources for its economic base as well as the cultural values that the community and/or Indian Tribe may place on natural resources at risk. Further, it is essential for the EPA NEPA analyst to consider the cumulative impacts from the perspective of these specific resources or ecosystems which are vital to the communities of interest." The EPA Guidance also mentions "social, cultural, and economic impacts [that] would also be indirect, since they are likely to occur over time rather than immediately." The factors that the EPA Guidance directs analysts to consider for indigenous populations include trusteeship, treaties, consultation, financial resources, health and socioeconomic effects, risk assessments, and differences in "worldview." Finally, the EPA Guidance states that "[i]n the case of activities potentially affecting Native Americans, potential impacts, both direct and indirect, can occur to sacred sites and/or other natural resources used for cultural purposes. For example, the loss of a sacred site, or other impacts to larger areas of religious and spiritual importance may be so absolute that religious use of the site abruptly ceases – a direct impact."

Overall, the EPA Environmental Justice Guidance is very good, but is still somewhat incomplete in the factors that need to be considered, and it lacks any practical guidance on how to actually evaluate relevant impacts to Indian Tribes. The Draft EPA Risk Characterization Guidance begins to look at cumulative health risk but fails to develop a truly holistic approach wherein all types of risk are included. EPA's Comparative Risk approach (EPA, 1993) is a broader approach to risk evaluation (more like the NEPA approach) that would benefit CERCLA actions and standards for individual media. The Draft Integrated Risk Report (EPA Science Advisory Board) represents a step forward toward harmonization and integration, and the committee had a subcommittee on "ecology-related quality of life values," but it appears that the holistic indigenous perspective was not captured and therefore the metrics are still incomplete, and cost-benefit and natural resource valuation methods are still inadequate. Taken together, these EPA documents could form the basis of a truly harmonized and integrated risk assessment methodology. Previous reports have also suggested that this be done (National Research Council, 1994, 1996).

5. PROBLEM STATEMENT

The key objective of environmental justice methodology might be stated as the need to evaluate cumulative disproportionate impacts to individuals, communities, and cultures not only through human health but also through natural resource quality, ecosystem health, socio-cultural health, and socio-economic health. The challenge is to address all the risks faced by a community if the resource base is contaminated in ways that affect exposure, ecological toxicity, cultural use, or environmental goods, functions, and services. It is also a challenge to address impacts to cultural quality of life, or community health. In a holistic system where human and natural elements are so interlinked as to be inseparable, there are system-level effects that would not be predicted solely through evaluation of key elements of the system. Human health responses are a combination of exposures and sensitivities, where multiple exposures may interact and where co-risk factors can magnify a predicted response or even result in an unanticipated response. Human health effects can also be synergistic with ecological or cultural effects (and vice versa) to affect not only an individual's personal health but also the health of the community as a single social organism. A true systems approach to assessment is needed, since system-level impacts are more than the sum of individual metrics.

6. EQUITY ASSESSMENTS: A SOLUTION TO THE DATA GAP

Three major steps we've identified in assessing inequitable distribution of risks are: (1) knowing what is relevant to the community, (2) knowing how to measure relevant impacts, and (3) knowing how to aggregate different kinds of risks into a meaningful whole (risk characterization).

Step 1: Knowing what is relevant to the community. Risk assessments are frequently done without eliciting from the community statements about what is important and what risks or impacts need to be evaluated. This can result in community outrage, lack of credibility, and unstable decisions (e.g., Kuehn, 1996). Any community that is dependent on a location or resource base may need information about the resource or location being affected, and about the goods, functions, services, and uses that are at risk if the resource or location is degraded. A community may be concerned about the health of this and future generations. The definition of what is at risk from a tribal perspective may be expressed as "Trust resources and a cultural way of life."[2] If risk assessment were performed from a tribal environmental justice perspective, the information would be different (example shown in Figure 1).

Step 2: Knowing how to measure relevant impacts. The process of moving from values to metrics includes developing criteria for including or excluding metrics based on both the needs of the community and the needs of the decision. There may be a need to assess more impacts than in a conventional assessment (and to include more metrics than minimally required by regulation), as well as a need for surrogate measures (especially in the area of cultural risk). In the case of many tribal situations, extra care must be taken to ensure that the measurements are made with respect and sensitivity, without compromising the need to keep certain information confidential yet ensuring that the results are technically defensible and legally admissible. Since tribes are sovereign nations, the data should remain the property of the tribe even if gathered with federal funds. Table 1 presents a list of possible metrics based on a natural resource focus. Table 2 presents an example of similar metrics based on and organized around natural resources important to a particular lifestyle and culture.

Table 1. Examples of metrics within five categories of risks/impacts.

AFFECTED SYSTEMS: Categories of Risk or Impact with Types of Metrics
A. Ecological health (species, system processes, locational attributes, attributes of whole system)
• Affected environment (soil, water quality, biochemical cycles, etc)
• Location attributes (unique features, watersheds, traditional cultural properties, landscape, historic districts)
• Trust resources, critical habitat, T&E species, cultural species, ecosystem descriptions and linkages
• Ecotoxicity in individual organisms, including tissue-level effects. Toxicity to plants, animals, microbes
• Community or population effects, foodweb effects
• Scales: spatial (e.g. trophic levels, overlapping home-range sizes) and temporal (e.g. overlapping lifespans, multigeneration cycling of persistent chemicals or long-lived radionuclides)
• Habitat and Ecosystem indices of diversity, integrity and functionality (several to choose from). Ecological structure (the elements), relationships, and the function of the parts and the system.
• Identification of ecological co-stressors (physical, thermal, radiologic, biological, fragmentation, trends, and so on)
B. Environmental goods, uses, functions, and services (ethno-habitat)
• **Goods** are tangible items of value to plants, animals, or people, such as food and medicine obtained

from the location • **Functions** are specific roles that elements of the local area play within the area or within a larger ecosystem. Examples are nutrient production needed by local fauna and migratory birds. • **Services** are process or ends of importance to people, such as soils stabilization provided by intact groundcover, which in turn reduces dust and associated visibility reduction and cleaning costs. Cultural services are provided by places, resources, intergenerational transfer of knowledge, and so on. • **Uses** are things people or animals do at the location that are dependent on natural resource quality, such as recreation or seasonal nesting grounds for birds.
C. Human Health • Exposure scenario relevant to the lifestyle that is at risk • Cancer and many non-cancer endpoints (hazard index and individual endpoints); synergisms. • Public health metrics such quality of life-years (QALY), and other measures for functionality and quality • Multigeneration effects, summed over the lifespan of the material • Community-level effects, summed over spatial and temporal scales • Co-risk factors (multiple exposures, biochemical genetics – see NIEHS web page, underlying health effects and disease patterns, nutritional status, access to health care, poverty, loss of native food and medicine, loss of language and religion, encroachment on land base and traditional resources) • Identification of sensitive groups such as children, nursing mothers or elders, and groups with unique exposure pathways. • Proportion of community that is at risk.
D. Sociocultural Health (system elements, processes, and attributes) • Social indicators such as social cohesion, recreation, education, learning systems, etc. • Cultural indicators such as access and use of traditional lands, intergeneration continuities, other ways of defining cultural systems and cultural identity • Religion (access to and quality of ceremonial and religious areas and resources,) • Cultural and historic resources and landscapes • Treaty Rights, Trusteeship, Values and Principles (preservation of future options, sustainability, etc.) • Socio-cultural co-risk factors or co-stressors (past history and cultural deficits, ease of access to and responsiveness of decision processes)
E. Socioeconomic Health • Suburban economic metrics (jobs, services rendered and required, infrastructure etc.) • Tribal or non-dollar economies (parallel role of tangible goods for food, shelter, barter, specialization of roles, survival…) • Natural resource valuation; intrinsic value (CVM, etc.) • Costs associated with avoiding, mitigating or repairing ecological, human, cultural impacts • Economic co-stressors (SES status, historical economic deficit, discounting as a stressor itself)

Table 2 - Example of resource-based risk characterization. *Each category of measures has attributes of magnitude (exposure x sensitivity), duration of exposure and/or impacts, and quantity (numbers of people or acres or species, etc.)*

Group-specific access, use, and rights. Institutional controls cause lost access and cultural costs. Includes treaties and trusteeship access to or use of a place or resource (duration of loss, percentile of loss relative to original conditions, residual quality if partially lost or not fully restored).
Group specific use of local natural resources. Everyday life and material implements derived from the place or resource, and living and social activities and practices associated with the place or resource, and cultural use of natural resources. Existing environmental stressors are co-risk factors.
Group-specific individual and community health concerns or sensitivities. Multi-generational effects, effects on individuals within the group such as children, women, & elders, community-level exposures, total contaminant burden, preexisting health conditions and disease patterns, stressors such as nutritional status or low socioeconomic status. Includes cancer, mutagenic, endocrine, neurological, reproductive,

developmental, immunological, and other effects. Applies to both the maximally exposed individual, to the most sensitive individuals, and to the community as a whole (total community contaminant burden).
Group-specific ecological concerns and key species. Ecological toxicity at the organism and population level, sublethal effects including mutation, multigeneration effects for long-lived contaminants or persistent effects, biodiversity and ecosystem integrity, environmental functions and services. Species of particular concern from a tribal perspective or endangered species perspective reflect a greater impact level.
Group-specific economic/trade impacts. Full set of metrics beyond direct impacts such as jobs and services; costs of lost access, use, etc.; replacement costs; costs of health care or restoration; natural resource valuation, costs of intangibles or externalities; costs of monitoring and surveillance now or in the future; issue of discounting (or not). Existing SES and similar factors are co-risk factors for sub-groups.
Group-specific family and social impacts. Community well-being and social and family cohesiveness maintained through use of the place or resource, civic or secular activities dependent on the place or resource, indicators of community health; stability of governance systems. Other social indicators may be used here.
Elder-defined religious and ceremonial impacts. Religious, ceremonial well-being and overall health gained through use of the place or resource
Cultural & historical sites or properties (NHPA). Physical integrity of historical or cultural resources located in the place or associated with use of the resource; importance of the resources as evaluated by the "owners" of the resource. Location of the impact relative to cultural landscapes, traditional cultural properties, individual sites, historic districts, or National Register sites or properties would result in a greater impact.
Trust Resources, traditional use areas, sites, resources, and landscapes. Other uses of the site or resource such as education or art; intergenerational continuity in knowledge, language, traditions, values, and education related to the place or resource; preservation of future use options; contribution to sustainability; relation to land ethic and self-identity.
Proportion of group affected compared to population at large. Distributions of impacts; determination of any inequities
Overall community well being. Psycho-social statistics, health statistics, law enforcement records, school attendance records, employment records, current status of community satisfaction (e.g., existing outrage, existing cultural deficit, trends in community well being, history of governmental responsiveness and openness, community access to experts), etc.

Step 3: Meaningful aggregate risk characterization. Risk characterization should be the step where all the impacts are considered as a whole and the total story is told. We recommend two phases within this step. The first phase includes characterizing risks within each category of impact (health, ecology, culture, economics) as the product of "exposure x sensitivity," or "impact x co-existing risk factor or vulnerability." Figure 2 shows an example for health, where exposures might differ for different populations with different lifestyles and therefore different degrees of exposure, and their sensitivity might also differ due to genetic makeup or other factors. This process can be repeated for as many populations or sensitive subpopulations as are appropriate, after consultation with the affected community.

The second phase would combine all the different types of risk into a single story that describes the cumulative effects of the resource or location on the ecological and cultural systems occurring there. This might be a narrative or a numerical combination. While the narrative approach may be somewhat easier, the linkages between the individual resources or metrics still need to be shown. If the narrative summation is used to support a demonstration of inequitability, a definition of how much "variance in average exposure levels" is necessary before some threshold of disproportionality is reached. The Executive Order (EO 12898) also requires that the disproportionality must be "significant." Although Zimmerman discussed this issue in 1993, there is no formal guidance yet (cited in Risk Policy report, 1998). Figure 3 illustrates the difference between identifying tribal exposures as a high-end tail of the general public's exposure

range and recognizing tribal lifestyles as a legally protected lifestyle practiced by members of a sovereign nation.

A more numerical summation will need a method for comparing disparate types of risk, even at its most simple application. We have presented one such method, called a Universal Harm Scale.[3,4] In the case shown here, the proxy scale used for the socio-cultural category was based on a combination of the probability of adverse impacts to cultural resources, cultural activities, and values associated with a specific location. The advantage of anchoring the scales with labels that are in common usage but generally lack numerical standards is that a discussion is triggered in which the affected peoples have as much say as the "experts." This is an advantage for gathering acceptable and defensible information even if it appears to be more subjective on the surface, because each expert (e.g., a toxicologist, an ecologist, an economist, and a tribal elder) gets to determine what is catastrophic for him or her or relay that which is convention within his or her discipline. It also recognizes that for some measures low-level contamination can indeed perturb the system in a way that may make a difference to the outcome. A "No Effect" column would be largely but perhaps not completely synonymous with zero contamination or no elicitation of even an adaptive response.

Table 4 – *Universal Harm Scale with hypothetical thresholds for impact severity levels*

	Perturbation (some effect above zero)	**Harm (may be de minimis)**	**Injury (may be reversible)**	**Severe or Irreparable Injury**	**Catastrophic Injury**
Public health	<1E-6 cancer HI < 1	1E-6 HI = 1	1E-6 to 1E-4 HI = 1 to 10	1E-4 to 1E-2 HI = 100	Loss of life 1E+0 HI = 1000
Ecotoxicity	Detected but below standard	NOEL, NOAEL, AWQS or other standard	1-10 x std.	10-100 x std.	1000 x std.
Environmental Functions and Services	Transient but noticeable effects; adaptive responses in organisms; Detectable body burdens.	Localized ($100m^2$) and short-term (< 1 year to full recovery); few individual organisms; no T&E species; No intervention	Larger ($1000m^3$) and/or longer term (1-3 yrs); Community level effects; Little intervention required.	Widespread (> 10000 m3) and/or long-term (>5 yrs); Population level injuries; Recovery only with significant intervention	Irreversible injury; Permanent loss; Ecosystem level effects; "Important" species irreversibly harmed.
Socio-cultural; points from a proxy scale	0-100	100-250	250-400	400-550	>550
Socio-economic; impact costs and restoration costs	< $1000	$10,000	$100,000	$1M	>$1M; Costs of life, image, studies, penalties, remedies, etc.

7. SPECIFIC RECOMMENDATIONS

a. Risk-based equity assessments need to be done in Indian Country, with several specific distinctions from current methodology:
   - Culturally-relevant metrics for health, ecology, social well-being, community health, human eco-cultural systems, economics, cultural activities, religious practices;
   - Better identification of co-risk factors (nutritional status, education, multiple exposures, stress factors, pharmacogenetics, infrastructure deficits, and so on);
   - Instead of counting the number of Native Americans living in a certain area, the federal agency should evaluate whether traditional uses and Trust resources will be affected, whether tribal activities will be more affected than suburban uses, and what proportion of the tribe would be affected by the placement of the facility or its emissions;
   - The valuation of the land, landscapes, natural resources and their functions and services, cultural resources, and cultural use of natural resources needs to be improved, and then used in cost-benefit analysis;
   - A study of the number of waste sites, facilities (from the Toxic Release Inventory database), and non-point source releases within reservation boundaries, within ceded areas, or affecting Trust resources or traditional use areas needs to be done;

b. A discipline of Risk Ethics needs to be developed:
   - A curriculum needs to be developed separate from an environmental justice curriculum;
   - Develop better criteria for defining what is "at risk;"
   - Develop criteria for determining who gets to define what is at risk;
   - In a public forum, revisit the issues of rights (whose rights prevail over another's rights, do non-humans have inherent God-given rights, and so on) and rights versus regulation (e.g., do individual rights to remain unexposed supercede recent environmental regulations that allow some level of pollution and exposure), and how to balance one group's risks against anothers' or one person's risks against his/her benefits (e.g., Egelund and Midbaugh, 1997);
   - Reinvigorate the sustainability and precautionary decision making discussions.

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Figure 1. Values-Based Risk Assessment Modifications.

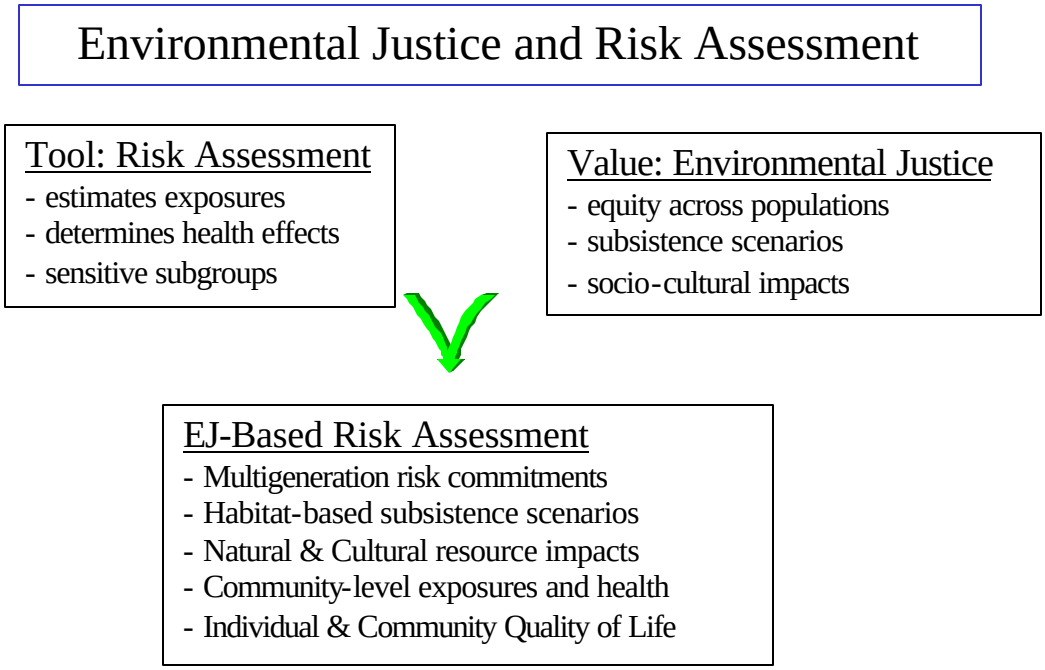


Figure 2. Example of characterizing human health risk as the product of exposures and sensitivity. If two groups have different exposures and different co-risk factors, the cumulative risks could be magnified.

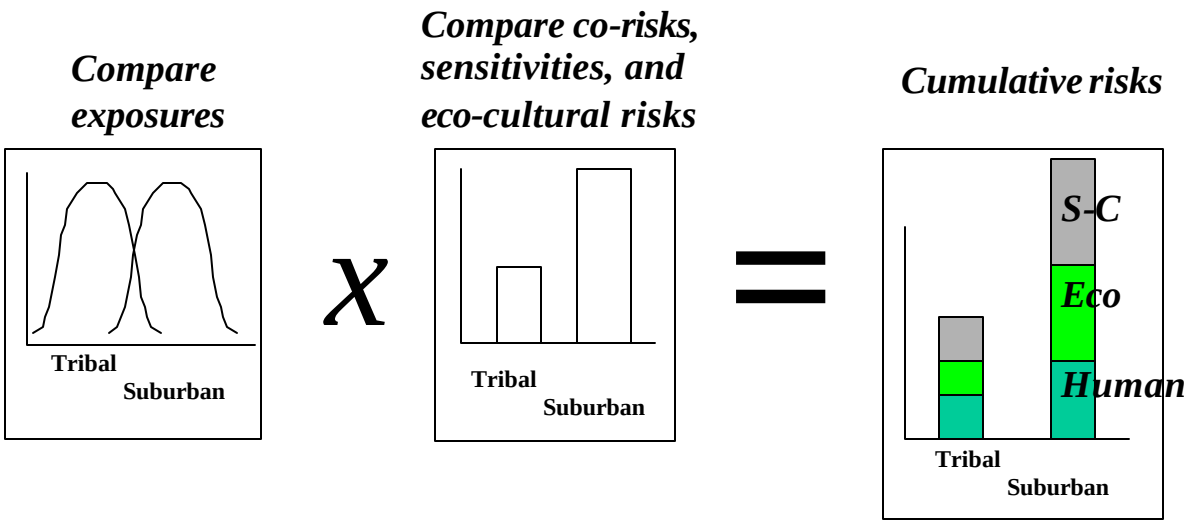
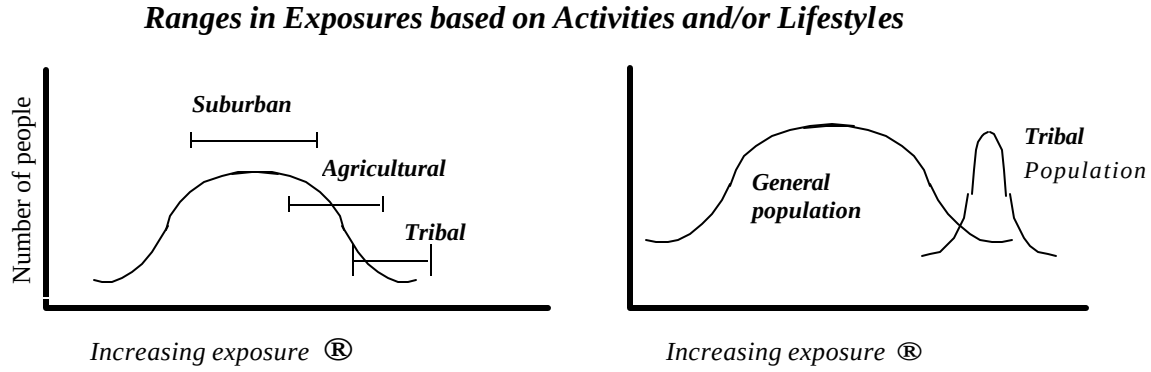


Figure 3. Identifying discrete populations. *In this example, tribal exposures are not part of the continuum of the general public's exposure range, but a discrete population.*



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[2] Personal communication, Armand Minthorn, CTUIR Board of Trustees.

[3] BL Harper and SG Harris, "Measuring Risks to Community Health and Quality of Life," ASTM meeting 9th Symposium on Environmental Toxicology and Risk Assessment, Seattle, April 19-22, 1999, Paper ID #6034; Committee E47.

[4] Personal communication, G. Bilyard, Battelle Pacific Northwest National Laboratory, Richland, WA, 99352.