Cultural Risk Assessment and Quality of Life Issues

Using Eco-Cultural Dependency Webs in Risk Assessment and Characterization of Risks to Tribal Health and Cultures

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Abstract. Peoples and communities, especially indigenous communities, are forced to deal with an increasingly complex set of environmental, social, cultural, and economic problems related to pollution. It is important to use evaluation tools that reflect the values and perspectives of the affected peoples, and which can evaluate risks and impacts to the natural resource base upon which we all depend. Evaluation tools, such as risk assessment, are being applied to spatio-temporal systems and lifestyles for which they were not designed, so new integrating tools are needed to bridge the gap between narrow sets of endpoints and western perspectives, on the one hand, and a much broader set of endpoints and more holistic indigenous perspectives on the other hand. The perspectives and even the necessity to account for traditional Native American lifestyles have gone unnoticed in classical environmental planning and risk assessment methods. If tribal rights and resources are affected, one way to ensure that those tools reflect the appropriate values is to redesign the risk tools using traditional environmental management principles. For example, Native American communities are inseparable from their lands and resources, so evaluation of their risks from contamination must integrate human physiological and mental health, ecological health, socio-economic health, and cultural and spiritual health within a single framework. This does not mean simply adding a quality-of-life component and calling it cultural risk, or using an exposure scenario that reflects additional routes of exposures. Rather, it means beginning the assessment by understanding the entire eco-cultural system (people and biota interlocked in a co-adapted system of behaviors and ecologies that is sustainable over time but which is now severely strained even without the addition of contamination). This paper provides some suggestions for improving risk assessment through the use of dependency webs that are drawn to represent the entire eco-cultural system that is at risk, and therefore that identify more consequences of environmental contamination. Dependency webs help identify the resources, uses, functions, and services associated with a resource or area that is at risk from contamination. They also help to structure the analysis so that all the elements important to the affected community are included in the risk assessment and not deferred to the risk management phase or omitted altogether. Finally, the ethics of risk assessments (their use and misuse) will be improved as information becomes more complete and transparent.

Abbreviations: **CERCLA:** Comprehensive Environmental Response Compensation and Liability Act; **CFR:** United States Code of Federal Regulations; **CTUIR:** Confederated Tribes of the Umatilla Indian Reservation; **EPA:** United States Environmental Protection Agency; **USDA:** United States Department of Agriculture; **NEPA:** National Environmental Policy Act; **NRDA:** Natural Resource Damage Assessment; **tek:** Native American traditional environmental knowledge

Keywords: Comparative risk; cumulative risk; dependency webs; eco-cultural systems; integrated risk; Native American perspectives; risk characterization; social/cultural risk

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1 Introduction

There is a growing recognition that conventional risk assessment methods do not address all of the things that are 'at risk' in communities facing the prospect of contaminated waste sites, permitted chemical or radioactive releases, or other environmental harmful situations. Conventional risk assessments do not provide enough information to 'tell the story' or answer the questions that people ask about risks to their community, health, resource base, and way of life (Patton 1999). As a result, cumulative risks, as defined by the community, are not described, and risk-based decisions may not be accepted. The full span of risks and impacts needs to be evaluated within the risk assessment framework in order for cumulative risks to be adequately characterized. This is in contrast to a more typical process of evaluating risks to human health and ecological resources within the risk assessment phase and deferring the evaluation of risks to socio-cultural and socioeconomic resources until the risk management phase (National Research Council 1994, 1996; President's Commission 1997). We present a methodology for adding social, cultural, and economic risks to the risk assessment framework.

Evaluation of social, cultural, and economic risks and impacts is just as 'scientific' as more conventional health and ecological risk evaluation. It is rigorous, verifiable, and repeatable, and does not inherently contain any more uncertainty than the computer-generated numerical results of fate and transport models and exposure scenarios that are typically defined as 'real risk.' These metrics are likely to be a combination of computer code-generated data, surveys, and some less quantifiable measures, and we also suggest that there are ways to combine different types of risk-related information into a coherent and balanced framework. We do not necessarily advocate reducing the assessment to a single number through multi-attribute utility analysis or other means. However, we suggest that this does not increase the uncertainty of the risk assessment. In fact, we believe that including social, cultural, and economic risk in the risk assessment framework actually reduces system-level uncertainty and increases overall accuracy by virtue of producing a more complete assessment. Our definition of accuracy has as much to do with completeness as it does with numerical precision. The value of this information to long-term decision stability should be readily apparent. The recent discussions about the relation of the Precautionary Principle to the uncertainty inherent in risk assessment (Charnley 1999, for example) is a case in point. The Precautionary Principle is not the antithesis of risk based decision making, but complements it by allowing decisions to be made in the face of uncertainty that is inherent in all predictive and variable situations.

This paper draws upon concepts of holistic ecology, Native American traditional environmental knowledge (tek), and traditional environmental management science. The individual and collective well-being of tribal members is often derived from membership in a healthy community that has access to ancestral lands and traditional resources and from having the ability to satisfy the personal responsibility to participate in traditional community activities and to help maintain the spiritual quality of our resources. Native American traditional environmental management science has proven its worth through the survival of indigenous peoples for thousands of years, through drought and flood, feast and famine. Indigenous cultures developed as conscious responses to sophisticated and systematic observation and inductive reasoning to determine the most probable reactions of very complex, interrelated ecosystem functions. The application of this science has been codified into tribal law and has been distilled into daily cultural practice. This knowledge is transferred between generations. Attention to and application of this knowledge means personal survival and enhancement of the ecology, culture, and religion. Our approach to improving risk assessment methodology is based on this type of teaching and on an understanding that human health is inseparable from ecological health and socio-cultural health.

2 Background for Including Cultural Risk and Dependency Webs in the Risk Assessment Framework

When we started examining risk assessment methods for possible use in evaluating tribal risks at the Department of Energy's Hanford Site, it immediately became apparent that conventional methods were inadequate. We therefore developed a human exposure scenario that reflected subsistence activities and lifestyles practiced by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) (Harris and Harper 1997). While this was a major advance, it still did not capture the direct and indirect impacts of contamination to the tribal culture itself and to the exercise of Treaty-reserved rights. Thus, we turned to the U.S. Enivronmental Protection Agency's (EPA) Comparative Risk method, which includes a community quality of life component (EPA 1993). We have modified it to reflect traditional tribal cultural values as well as secular or social community aspects that apply to suburban as well as to tribal communities (Harper et al.1995, Harper and Harris 2000). We envisioned three or four components to the risk assessment process: human health (using appropriate exposure scenarios), ecological health, and socio-cultural/socio-economic health, all of which are elements of the overall eco-cultural system.

Adding these concepts to the risk assessment framework allowed us to include more elements in the risk analysis, but it was still compartmentalized and did not fully enable a description of the links between the elements that a holistic systems approach would take. In order to make the transition from 'complete' to 'holistic,' we turned to a concept developed by the Tulalip Tribe and the EPA, the natural-cultural resource dependency web based on cultural ecosystem stories (Williams and Mittelstaedt, Ankrah and Lombardi). **Fig. 1** is based on the Tulalip Tribe's salmon web showing resources and uses linked to salmon, including the services that salmon provide (food, role models for human behavior) as well as services from other resources that salmon need and other resources required for the proper use of salmon. Salmon are integral to the people of the Columbia River Basin and their way of life. Salmon are not just a conduit of contamination from water to the people (i.e., a route of exposure). Salmon are a nutritional resource, a ceremonial resource, and a focus of social, educational, ecological, linguistic, and other traditional activities. If

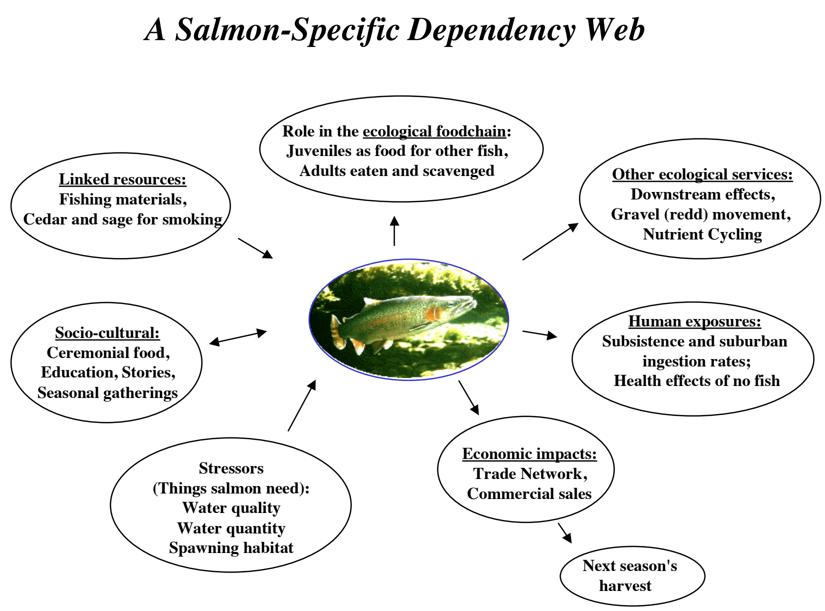

Fig. 1: A Salmon Dependency Web. This is a resource-based dependency web showing one key eco-cultural resource.

salmon are affected, all these linked resources and activities also suffer and the culture itself suffers. It is important to realize that because everything is simultaneously affected, it is improper to think of cultural risk as a ramification of human or ecological harm. Conceptual models must avoid this kind of cause and effect thinking.

3 Affected Resources, Affected Cultures: Identifying what is 'at risk'

The elements of this expanded risk assessment framework that are most difficult for bench-trained or computer-based scientists to grasp have to do with individual cultural risk metrics and how these individual metrics combine with health, ecological, and economic metrics to affect the entire community at large. When the community, such as a tribal community, is distinguishable from other communities by its cultural attributes, the overall integrated risks to the community and the individual socio-cultural metrics are both referred to as 'cultural risk.' Lacking better terms at present to distinguish between individual measures of cultural impacts and impacts to the overall system, however, we can only point out that we are addressing both the overall eco-cultural system and the individual socio-cultural metrics. 'Culture' is collective knowledge and systematic unity that gives members a sense of personal identity and cultural anchorage (Greaves 1996). A culture includes time from the past to the future, religious, economic, political, communication, and kinship systems, as it is the whole set of learned behavior patterns common to a group of people, their interactive behavior systems, their art, their material goods, their individual and collective health, and the natural resources and environment on which all of this depends. Any impact to those resources of which we are an inseparable part is a cultural risk (Harris 1998). While at first it may seem impossible to capture this within a computer code (the criterion for 'real' risk in many assessments), there are many metrics that are entirely quantifiable as well as some that are the qualitative yet verifiable and repeatable judgment of cultural experts (i.e., tribal elders or community leaders). There are ways that quantitative and qualitative risks or impacts can be compared, as described elsewhere (Harper and Harris 2000).

How does cultural risk and impact occur as a result of environmental contamination? Social/cultural impacts may be due to (a) impaired quality of a resource or area due to contamination above or below a regulatory or risk-based standard, (b) ecological harm or lost environmental functions and services, (c) ramifications of health risk or exposure above or below a regulatory standard or risk-based level, (d) avoidance or restriction of access or use in order to reduce or prevent human exposure, (e) ecological harm due to the response to environmental contamination (e.g., development of additional infrastructure, excavation and use of clean fill), or (f) social and cultural ramifications of the costs of response, replacement of lost functions and services, avoidance, restriction, or restoration. The combination of these direct and indirect effects in a resource-based community can be considered as a single system.

In traditional tribal communities, the people, their geographic place, their resources, their culture, their health, their art, their religion, their trade networks, their social and survival activities, and their past and future are all interconnected (Harris 1998, Cajete 1999). A healthy **ethno-habitat or eco-cultural system** is one that supports its natural plant and animal communities and also sustains the biophysical and spiritual health of its native peoples. Ethno-habitats are places clearly defined and well understood by groups of people within the context of their culture. These are living systems that serve to help sustain modern Native American peoples' way of life, cultural integrity, social cohesion, and socio-economic well-being.[1] The lands, which embody these systems, encompass traditional Native American homelands, places, ecological habitats, re-

[1]Modified from the Eastside EIS; www.icbemp.gov/html/east_eis.html

sources, ancestral remains, cultural landmarks, and cultural heritage. Larger ethno-habitats can include multiple interconnected watersheds, discrete geographies, seasonal use areas, and access corridors. This concept is also applicable to suburban communities, which are re-learning about their links to and dependence on the environment.

Ethno-habitats or eco-cultural systems can be defined as the set of cultural, religious, nutritional, educational, psychological, and other services provided by intact, functioning ecosystems and landscapes. Ethno-habitats are also eco-cultural landscapes or sacred geographies (Walker 1991). They are landscapes with culturally familiar features defined by cultural knowledge and experience. The presence of and access to healthy habitats for traditional uses of useable and harvestable levels of resources is significant to Native American peoples as well as to healthy ecosystems.

4 Using Relational Dependency Webs to Describe Eco-Cultural Systems and to Structure the Risk Analysis

As contamination moves through different areas, different resources are affected, different impacts occur, and different people will be concerned. Dependency webs are relational descriptions or influence diagrams composed of the resources, uses, functions, and services at specific locations where contamination and impacts are likely to occur. The webs are intended to describe what is 'at risk' and what is at stake if different locations become contaminated. Dependency webs also help organize and manage the risk assessment process by identifying resources at risk and the connection among the resources. They support the decision process by showing the full consequences of each decision and how the consequences would change if different decisions were made or different environmental conditions occurred.

Fig. 2 shows a conceptual model of contamination moving through a series of locations with different resources and different human uses. Consequently, the people who are concerned about contamination will vary with the location and its resources and uses. The reasons that a location or resource is important to people or to the ecology may range from physical attributes important for aesthetic reasons, the historical significance, the presence of critical habitat or keystone biota, commercial value of the site or its products, the presence of sacred sites or cultural resources, recreational value, and so on. In order to identify what makes a place or resource important, subject matter experts must be consulted, including cultural experts such as tribal elders, modeling experts, ecologists, civic groups, environmental groups, and advocates for silent voices and future generations. The identification of specific web elements is aided by asking the following questions:

- What makes the place important (to anyone)?
- Who/what lives there or exists there (people and biota; what is the existing environmental quality or usability; what ecosystems are present; what human communities are present)?
- Who/what uses the location?
- What happens at the location (ecological migratory stop, human recreation, etc.) throughout the year?
- What type of infrastructure (both natural and man-made) is there?
- What environmental goods, functions, and services do the location and its natural, cultural, economic, and human resources provide?
- What is 'at stake' there if contamination arrives?
- Who/what is already 'at risk' there for various reasons (invasive biota, physical degradation, stressed economic conditions, pre-existing contamination; environmental quality or functions or species that have already been lost there; what would be expected there but isn't; what trends in environmental quality can be described there?)?
- How are the above factors related and shown in a location-specific dependency web (influence diagram); what dependency web is appropriate for that location?

By knowing what ecological systems are present throughout the year, appropriate foodwebs and ecotoxicity models can be selected and linked to human uses of those resources. By knowing what human activities occur there, the reasons for selecting particular human exposure scenarios can be communicated. By knowing the cultural importance of an area, and by knowing what social, recreational, educational, or cultural activities are dependent on particular resources from that location, the linkages between elements can be visualized.

An example of an initial description of the qualities and resources that make a particular place (the Hanford Reach) important is shown in **Fig. 3**. The Hanford Reach is the last free-flowing stretch of the mainstem Columbia River. This river segment provides recreation, salmon spawning habitat, tribal subsistence use, migratory bird habitat, native foods and medicines, aesthetics, ceremonial and spiritual resources and areas, educational areas, eco-tourism income, and public water and agricultural intakes, among other things. These elements can be organized into a web showing the linkages between uses and resources and showing which uses are dependent on or influenced by which resources.

5 System Elements Included in the Dependency Webs

A detailed dependency web can be decomposed into individual elements and organized into conventional risk assessment categories. Because our examples (and indeed most examples) start with environmental contamination and ecological consequences, we have shown ecological health before human health. Both the original harm (contamination) as well as any damage caused by a response action should be included in each category because both types of impacts are consequences of the original contamination event. **Fig. 4** is a conceptual model showing how the elements fit within the assessment organization. In the example shown, the description of the overall eco-cultural system starts with ecosystem stories and local environmental knowledge (Zerner 1996, Carmichael 1994).

- Ecological health – ecotoxicity, ecosystem health, ecological diversity, ecological maturity, natural resource injury, and environmental goods, uses, functions and services. Also, ecological consequences of the other types of effects.
- Human health – individual and community doses and risks, multigeneration exposures and risk, flexibility in choosing exposure scenarios that reflect community lifestyles. Also, human health consequences of the other types of effects.

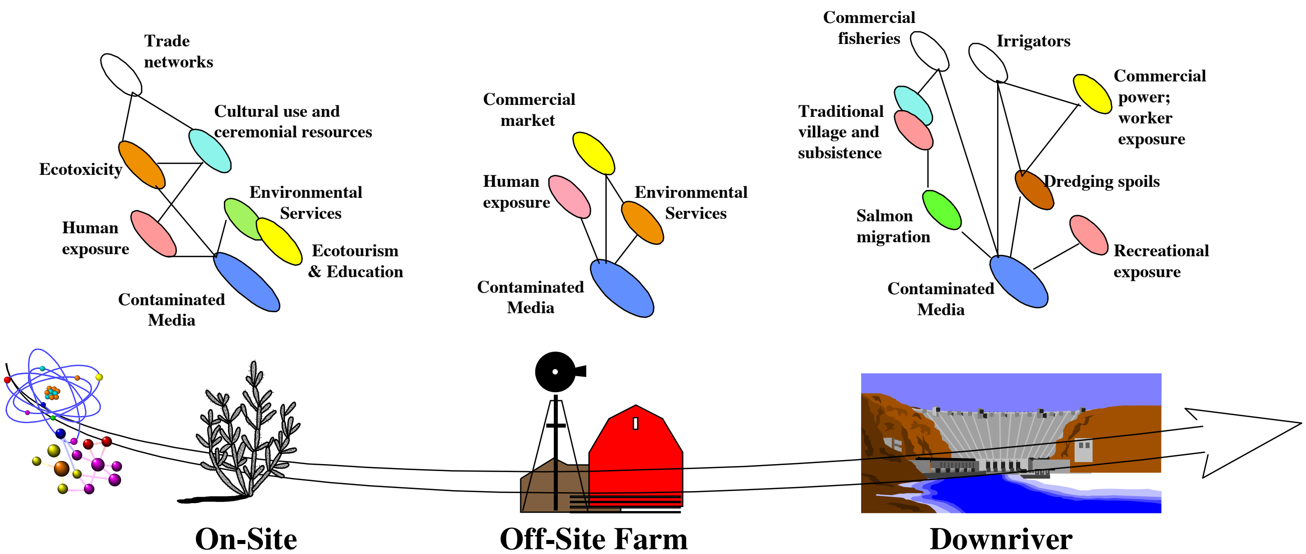

Fig. 2: Dependency Resource/Use Webs. As contamination moves through different areas, different resources are affected, different impacts happen, and different people will be concerned. Dependency webs help tell the whole story about what will happen if different locations are contaminated, and provide a way to organize the metrics that will be included in the risk analysis.

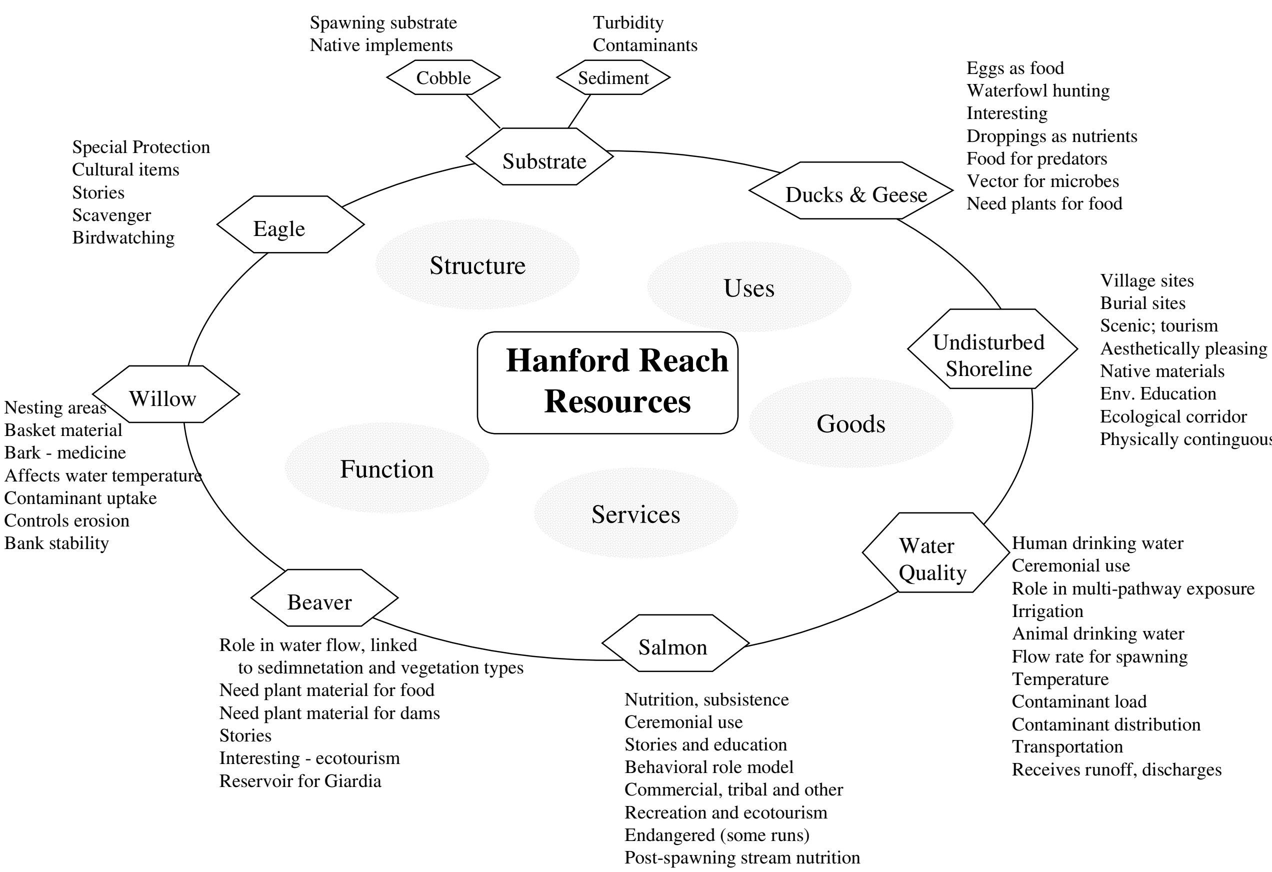

Fig. 3: Identification of important aspects of a particular location. This figure illustrates an initial listing of important aspects of the Hanford Reach of the Columbia River. It includes some important species (endangered, culturally important or ecologically important), important aesthetic attributes (free-flowing, scenic), important ecological attributes (salmon spawning habitat) and economic services (water intakes, tourism). These elements can then form the basis for a detailed dependency web that shows how these elements interact and could be mutually affected by contamination.

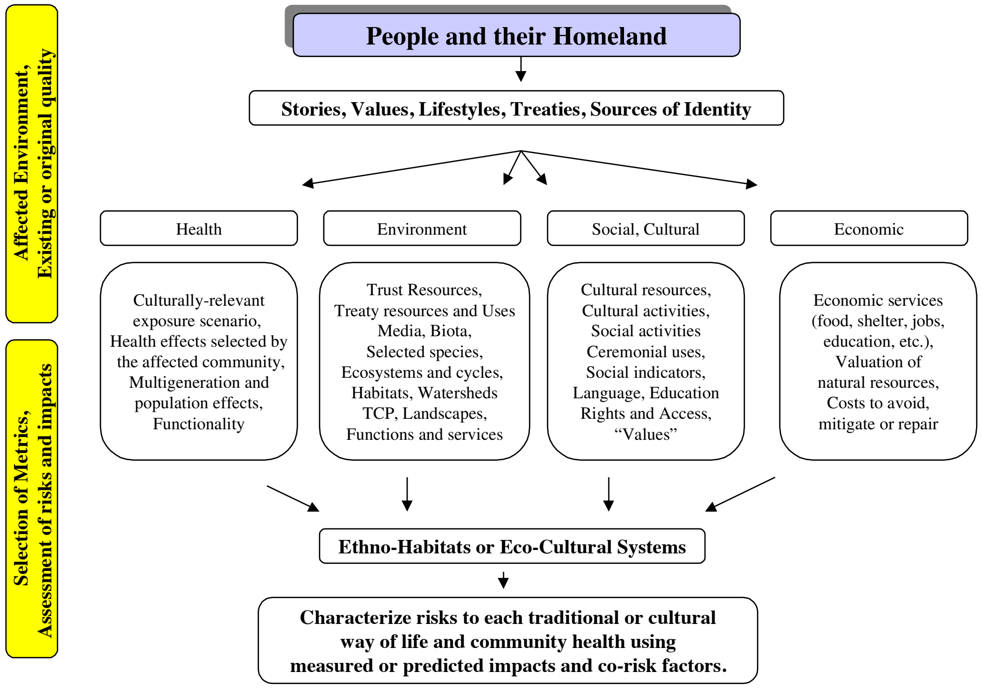

Fig.4: Overall conceptual model showing web elements categorized into conventional bins

- Socio-cultural health – social and cultural indicators appropriate to the community, and cultural resources, properties and landscapes. Also, social/cultural consequences of the other types of effects.
- Socio-economic health – market and non-market (i.e., suburban and parallel tribal subsistence) economic attributes, natural resource valuation, costs of the other effects or costs to respond and fix them, stewardship costs if not fully remediated, and mitigation costs.

Additionally, since risk is the product of both exposure and sensitivity, pre-existing stressors or co-risk factors should be identified for each type of effect. For instance, co-risk factors for human health such as other exposures, underlying health status of the community, or sensitive subgroups could be identified. For ecological health, other physical, biological, or chemical stressors could be identified, along with the intrinsic resiliency of the affected ecosystem as a predictor of recovery time. For social/cultural health, the existing cultural deficit or community well-being could be identified as a multiplier for disproportionate impacts. For economic health, existing market conditions or socioeconomic status could be identified.

6 Identifying Resources at Risk and their Existing Quality

This section lists examples of data that are needed for a more complete evaluation of each type of risk or impact. The specific metrics chosen for a particular analysis will depend on site-specific conditions, including surrounding community concerns and identification of groups who would be affected. For instance, the identification of Trust Resources and Natural Resource Trustees[2] such as Tribes may include groups of people not typically identified because their spatial, temporal, cultural, and other links to the area or resource are not recognized by decision makers from outside the community. The following lists include the types of metrics that are relevant to our own tribal situations, but each assessment must be site specific and Tribe-specific.

7 Ecological Resources and Environmental Functions and Services

a) Effects on natural resources and media (concentrations, duration relative to ecological lifespans and recycling, location within a watershed, and areal extent)
b) Habitat quality measures such as index of diversity, functionality, fragmentation, fragility, duration of effect (recovery time or resiliency)
c) Ecotoxicity to individual organisms, indicator species, or trophic levels, including sub-lethal, genetic, reproductive, and behavioral effects including NRDA injury metrics
d) Population effects including direct effects, indirect effects such as loss of shelter, nutrients, access to discreet areas or migration zones, and multigeneration reproductive effects
e) Ecosystem measures such as population stability, species abundance, species diversity, and species distribution.

[2] Natural Resource Trustees are legally identifiable as government officials with authority over and/or responsibility to take care of natural resources. Under the authority of the National Contingency Plan (40 CFR 300.210(c)(4), 300.615(c)(3)(i), 300.910(a) and CERCLA section 107(f)(2), Trustees are federal, state, Indian officials who act on behalf of the public, nation, state, or tribe and who participate in activities intended to minimize injury to natural resources, assess damages for injuries to resources under their trusteeship, obtain compensation for these damages, and who develop and implement plans for restoration of injured resources. Various Acts or regulations give responsibliity or jurisdiction for specific resources (groundwater, endangered species, and so on) to specific governmental agencies

f) Landscape ecology, landscape functions and services, aesthetics and visual integrity
g) Environmental goods, functions, services, and uses
   - Goods are tangible items of value to plants, animals, or people, such as food, clothing, shelter, and medicine, obtained from the location
   - Functions are dynamic roles that elements of the local area play within the area or within a larger ecosystem. Examples are nutrient production, shade, and shelter, needed by local fauna and migratory birds and animals.
   - Services are processes or ends of importance to people, or things people pay for (or don't have to pay for if the ecosystem provides it). These services can be impaired at contaminant concentrations well below regulatory standards. The area over which the service is impaired by contamination and the duration of impairment is measured as service-acre-years (Friant et al. 1998, Scott et al. 1998).
   - Uses are things people or animals do at the location that are dependent on natural resource quality, such as recreation, navigation, education, traditional cultural activities, public water intake, or seasonal nesting grounds for birds.
h) Identification of existing or predicted stressors such as contaminants from other sources, physical/thermal stress, infrastructure fragmentation, existing water/air/soil quality, or invasive species.

8 Human Resources

a) **Selection of receptors.** Identification of populations of concern (children, elders, lactating women), people with extra exposure, selected community-based activities or lifestyles that could affect the exposure pattern or dose including unique cultural activities, other people with linked exposures such as members of a trade network or consumers of agricultural produce, and populations over time that could continue to be exposed to the contamination or that could continue to suffer the consequences of a lost or contaminated resource.
b) **Selection of endpoints.** Health endpoints (cancer, hazard index, specific tissue effects depending on the contaminant, mutagenicity, and so on), exposure pattern (acute, seasonal, intermittent, chronic); individual exposures and total population burden within this generation and through as many generations as the contamination persists; other health indicators (individual and community psychosocial health effects of known exposure or lost access, and so on). Cultural endpoints (loss of use of a resource, specific loss of practices, etc.) can cause culturally related health problems (for example, stress-induced health effects due to the inability to reduce exposure)
c) **Identification of health risk co-risk factors.** Multiple exposures, ethnopharmacologic practices, underlying health status of the individual or community, underlying nutritional states including the results of a substitute diet if the original foods are now contaminated or unavailable, socioeconomic states, access to health care and education, and health consequences of lost heritage/religion/culture.

9 Socio-Economic Resources

Socio-economic resource evaluation includes conventional suburban economic effects (jobs, housing, community services, etc.) and tribal economies (obtaining foods, medicine, shelter, and so on directly from the environment rather than going through a market step). The process of estimating risks to market and non-market economies also uses the same contaminant location, duration, and concentration information as the human and ecological aspects. This section also includes new methods for natural resource valuation (Costanza et al. 1997, Daily 1997, Daly 1996, Goulder and Kennedy 1997).

- Economic impacts of losing the place or resource (direct impacts of commerce, trade, jobs, services, housing, schools, etc.)
- Replacement costs (duration of loss x annual cost x quality and convenience of replacement, x proportion of community members affected by the loss)
- Other costs of 'intangibles' and 'externalities' using contingency valuation methods without discounting (since discounting is generally objectionable to communities)
- Other natural resource valuation measurements including existence value
- Cost to future generations, such as monitoring and surveillance costs, or increased remediation and restoration costs if contamination spreads or the resource is impaired. Permanent loss may mean infinite costs or requirements for permanent mitigation.
- Cost of medical treatment of exposure
- Cost of replacement medicine due to loss of native foods, medicine, and religion
- Cost of restoration
- Cost of lost health, lost cultural goods, functions, and services, lost treaty rights, lost access or use (acres x degree of restriction x duration), or of contaminated ancestral remains

10 Socio-Cultural Resources

Socio-cultural resource evaluation includes both community quality of life (or societal well-being) and tribal cultural well-being associated with the affected resource or location. There are several models being developed for addressing social and cultural impacts, as well as existing EPA guidance for Comparative Risk (EPA 1993). Community and tribal technical staff must be involved in, or actually perform, the evaluation of risks to their people, cultures and economies, as well as the determination of any potential disproportionate impacts to their communities. The following list includes a mix of resources, uses, and metrics that could be at risk from contamination.

- Lost access or use of place or resource (duration of loss, percentile of loss relative to original conditions, residual quality if partially lost or not fully restored)
- Community well-being and social and family cohesiveness maintained through use of the place or resource
- Everyday life and material implements derived from the place or resource, and living and social activities and practices associated with the place or resource

- Religious, ceremonial well-being gained through use of the place or resource; effects on the spiritual landscape, or percent of landscape or viewshed affected
- Other uses of the site or resource such as education, art, or trade.
- Intergenerational continuity in knowledge, language, religious practice, spiritual knowledge, traditions, values, materials, and education related to the place or resource (this can refer to the resources located on the contaminated site or affected by contamination migrating off-site, or disturbances within the viewshed, and so on)
- Physical integrity of historical or cultural resources located in the place or associated with use of the resource, or number of resources affected.
- Preservation of future land use options
- Preservation of additional values such as sustainability
- Contaminated tribal areas, artifacts, ancestral remains, traditional foods and medicines, measured by the area, number of species, or number of individual organisms affected.
- Current adequacy of social services that might increase monetary costs of the impacts proportionally more than in affluent communities
- Background health conditions and health statistics
- Past history of impacts to specific cultures and peoples and cumulative impacts up to the present
- Current cultural 'resiliency' and current quality of treaty rights
- Cost of alternatives (if any); cost of mitigating adverse effects.
- Preservation of land use options at the location or at adjacent/downstream sites

11 Social/Cultural Metrics and Attributes

Table 1 gives some example of quantitative metrics that can be used as an indicator (or surrogates for the actual indicator) for social or cultural harm. **Table 2** lists some principles that form the basis for particular metrics. For example, tribal leaders repeatedly state that all natural resources are cultural resources and that any degree of contamination impairs their cultural utility or quality. For this reason, the total area of contamination that is above background or detection limit (either statistically distinguishable, or, say,150% of background or detection) is a necessary data input from the fate and transport modeling. Similarly, the requirement for multigeneration impacts, without discounting, leads the assessor to run the model for as long as the material remains intrinsically hazardous or radioactive or for as long as the environmental harm persists.

Social and Cultural metrics, as well as many of the other metrics, have attributes of:

- **Likelihood:** probability of occurrence or adverse effect; cumulative probabilities,
- **Magnitude:** severity, with degree of secondary effects,
- **Sensitivity:** number and significance of co-stressors or co-risk factors or vulnerability, or importance of resource or area, and proximity to sensitive resources or areas,
- **Duration** of exposure and/or impacts (the converse of resiliency or recovery time) and persistence in the body or environment (the converse of detoxification or biodegradation),
- **Quantity:** numbers of people or acres or species affected,
- **Proportionality:** proportion of resource or group affected;

Table 1: Sample metrics for social/cultural impacts

Direct social or cultural harm related to natural & cultural resource effects: • Number of plant and animal species or organisms harmed or contaminated, weighted or multiplied by social/cultural importance (Threatened & Endangered, Trust resource, etc.) • Number of sites, historical buildings, etc. harmed or contaminated, x weighting (importance) • Number of contaminated sub-locations within total area above background or detection limit important for social, educational, recreational, religious, or other reasons. • Ecological functional/integrity index relative to original condition x duration of harm x area (ecological service-acre-years) • Percent of original landscape, viewshed, and/or soundscape remaining in original condition x duration of impact
Degree of impairment of Social/Cultural quality or use due to contamination above background or detection limit (acres / river miles/soil mass / gallons / curies x time)
Social/Cultural effects due to restricted access (degree of restriction x time; hours of full restriction; percent of visits lost, acre-years now restricted)
Social/Cultural effects due to number of sustainable future use options lost, lost trust or peace of mind (High-Medium-Low scale), proximity of contamination to other resources/areas (measured distance).
Social/Cultural effects due to human exposure or health effects in subpopulations (cumulative individual and population effects summed over time x sensitivity x fractional multiplier)
Social/Cultural effects due to economic effects and response costs
Proportion of target cultural or social group affected by harm to the area or resource
Example of overall metric: Risk = [$number_{biota}$ + $number_{sites}$ + etc. + α(health) + β(ecological) + χ(economic)] proportion α, β, and χ are multipliers based on subpopulation characteristics such as sensitivity or a judgmental weighting factor (e.g. children might be weighted more heavily and some sites or resources might be valued more by different communities) Proportion = what percent of a group is actually affected rather than absolute numbers of people. For example, 1% of recreational fishermen may be more people than 50% of a small group of migrant workers, but environmental justice considerations requires small but unique groups to be separated and evaluated by themselves.

Table 2: principles of social/cultural impacts with sample metric

Typical Tribal Principle	Sample Metric
Any amount of contamination can cause social or cultural impacts.	Acreage above background or detection limit (whichever is lower) as well as area above regulatory standards. (Note that this is real contamination even if this category is falsely labeled 'perceived' risk.)
All natural resources are cultural resources.	Acreage as above, weighted by numbers and species of organisms contaminated or affected.
Communities need to know complete and cumulative effects	Complete contaminant accountability, Total area contaminated by any/all contaminants
Protect Trust resources	Mass of soil or volume of groundwater contaminated, summed for all contaminants
Multigeneration impacts	Peak concentrations, whenever they occur; Time profiles of release and concentrations in each medium; Total time above detection limit or background (whichever is lower)
Cultural metrics can be and are both point-located and area-wide.	Both hotspots and ecosystem-level contamination information is needed, some metrics require summation of all contaminants rather than single-chemical evaluation.
Both individuals and communities bear cultural risk	Numbers of people affected over time, and proportion of 'at risk' group actually affected.
Precautionary Principle	Sensitivity and uncertainty analyses must always be included, both within each metric, within each type of metric, and system-level.

- **Distribution:** distribution of impacts among the people or species or ecosystems, or distribution of hotspots in the landscape, or degree of clustering/nonhomogeneity.
- **Time to impact or time to initiating event:** includes both prevention of the initial environmental release and/or remaining time until exposure.
- **Equitability:** is the impact or cost to one group larger than to another; is the proportion of one affected group larger than another; are the resources of more value to one group than to another?
- **Confidence:** a qualitative or quantitative measure of uncertainty that the impact is real and measured accurately

There are many issues embedded within these attributes that space does not permit us to discuss, but which are important for the analysts, the affected communities, and the decision makers to understand because they often are hidden in 'simplifying assumptions' that haunt poor decision processes. The risk community frequently discusses the need to make all assumptions transparent, and there has been improvement, but there are still many examples of biases that are embedded within the very choice of metrics and interpretation of results. There are additional confusing and controversial issues about the need to understand the many sources of uncertainty about the assumptions, the analysis, the results, and the decision.

12 Environmental Data Needed for Social/Cultural Risk Analysis

There are also many issues regarding the data provided by the fate and transport modeling to the risk assessor. Both the analyst and the affected communities need to jointly select the method, the required level of precision relative to the type of decision that is to be made, and so on. Some initial points of discussion include:

- Selecting contaminants of concern (screening methods should include the issue that impairment of cultural use can occur at concentrations above background but below regulatory standards, for instance)
- Completeness in contaminant accountability (based on mass balance, using one contaminant modeled in detail as surrogates for similar contaminants)
- Peak concentrations in soil or water with total profiles for area under the curve even if this persists for many generations
- Total area (e.g., acres) and mass (e.g., kg of contaminated soil or gallons of contaminated surface or groundwater), summed for all contaminants and presented as acre-years (based on a community-developed preference for handling multiple contaminants at different concentrations within a single site)
- Biota monitoring results above background or detection limit, and above or below human health-based standards.

13 Integrating the Risks

There are several ways to integrate disparate types of risks, or to integrate qualitative with quantitative risks. In this paper we must limit the discussion to a single example that is useful when very different types of impacts are involved. The basic concept is to allow the affected peoples, along with regulators, to normalize scales of risk on a conceptual rather than numerical basis. By allowing the community to determine its own no-effect level, *de minimis* level, injury level, irreparable harm level, and catastrophic level for each type of risk, first at a conceptual level and then at a numerical level, much of the community outrage (at the contamination, the decision, or the process) will be diminished. For health effects, for instance, the community might choose an excess cancer risk level of 1E-6 as the Perturbation or *de minimis* level, and loss of life as the catastrophic level, with later discussions to determine how much exposure actually results in lethality (cancer risk of 1 in 1 or 1 in 10; Hazard Index of 100 or 1000; Threshold Limit Value at 100-fold excess, and so on).

14 Discussion and Conclusion

We believe that most environmental decisions would be improved if this expanded risk assessment framework were used. For instance, remediation decisions could be improved if Trusteeship, stewardship, and cultural resources and uses were included up front. Environmental Jjustice concerns would be reduced if the full span of impacts were included in the initial assessment. Cost-benefit analysis would be less controversial to affected communities if the full costs of all the consequences of an environmental decision were evaluated initially. Lifecycle assessment analysis should include the environmental and cultural impacts of the initial extraction of natural resources through the ultimate disposal and post-closure monitoring period.

We would like to stress a need for systematic consideration of risk ethics. Because risk assessment can be used against communities as easily as on their behalf, it would improve the image of risk professionals if professional societies as well as academic departments discuss and teach the ethical and philosophical ramifications of the assumptions and methods they use.

Use of of a combination of lifecycle dependency webs can demonstrate the fallacies of risk-benefit comparisons that plague discussions of contaminated tribal lands or foods. For example, the problem of contaminated fish is generally presented as a tradeoff between the health benefits of eating fish (due to polyunsaturated fatty acids) and the adverse health effects of the contaminants that are also present in the same fish. The use of the salmon dependency web would illustrate the flaw in this comparison by showing that traditional communities that are dependent on salmon for nutrition, trade, ceremonies, and other aspects of tribal life face many consequences beyond simply human exposure. When viewed in this light, fish advisories are not a benefit to people by breaking an exposure pathway, but an added cultural harm. Similarly, the imposition of land use controls can cause cultural harm through lost access and use on top of exposures. The restriction in the number of visits to a traditional homeland (for instance where nuclear tests occurred) should not be viewed as a benefit provided to indigenous people who are allowed to visit their homeland, but as a continued, if lessened, deficit due to incompletely restored access. The debate about spatial and temporal discounting relative to the ethics and obligations of protecting Trust resources and honoring Treaties is long overdue, economic discounting arguments notwithstanding.

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