A NATIVE AMERICAN PERSPECTIVE ON SUSTAINABLE INFRASTRUCTURES[1]

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ABSTRACT

Infrastructure and sustainable development are two of the many intertwined threads of our traditional baskets. If infrastructure and sustainable development are to co-exist and co-evolve to form intelligent and pleasing patterns, there must be restraints on infrastructure design and use. Examples of engineering restraints include restraints on location, disturbance, and sprawl. Operational restraints include limiting emissions, and behavioral restraints include limiting off-road access. Sustainable development requires a robust and diverse natural resource base. It also requires a diverse and robust set of cultural and economic bases, and a recognition that mankind and his systems, forms, and patterns are inseparable from the evolving environmental basket into which he is woven. This has been taught for thousands of years as indigenous environmental management science. The role of infrastructure is, or should be, to protect values, biodiversity, cultural diversity, and land use options of future generations. This is true of both the physical infrastructure and increasingly the information infrastructure. We have an opportunity to consciously incorporate these values into physical infrastructure as we repair it and develop new projects, and also into the information infrastructure. But we must recognize that different people have different infrastructure needs. The European dream of conquering the wilderness, manicuring the forests, improving on nature, making the world look like England, and fulfilling the American dream of material possessions and white picket fences must be realigned. We must look at infrastructure within a larger context of long-term interwoven multi-species survival.

KEYWORDS: environment, culture, Native American, sustainable, infrastructure, traditional environmental knowledge.

[1] This paper represents the opinions of the author and should not be taken as official tribal policy.

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INTRODUCTION

Infrastructure is defined as the underlying foundation of an organization or system. This suggests that we begin by describing the organization or system that we want to support or sustain. As a scientist and tribal member, my cross-training has given me a long-term holistic perspective, so I would define the organization that I want to sustain as my culture and tribe, and the system as the native ecosystem on which our survival depends. Our culture and native ecosystem are overlain with modern infrastructures and societal contacts, but the fundamental need to repair, preserve, protect, and enhance the underlying eco-cultural system remains paramount. Actually, this is true for all communities and cultures, which suggests that we should apply a long-term perspective to infrastructure needs and planning everywhere. It also suggests that we use sustainable development or sustainability of cultures and ecosystems as the highest criteria for infrastructure planning.

Sustainable development and infrastructure may at first glance seem to be incompatible because large physical infrastructure projects can be so damaging to the environment. Further, their ultimate life-cycle costs and impacts to the environment are not typically accounted for. A cradle-to-grave lifecycle assessment would begin with extraction of the raw materials and finish with the complete post-closure degradation of all the waste streams and toxic byproducts until no trace remains. Placing constraints on infrastructure design for control of future human behavior during the planning stage should enhance or at least stabilize environmental functions and minimize environmental damage throughout the lifecycle. There are additional planning issues relating to environmental justice and competing rights, such as the right to lay a road versus the right to protect traditional use areas. This paper, however, will focus primarily on infrastructure itself.

Physical infrastructure could not exist at all without a natural resource base. We need to consider whether infrastructure should serve sustainable development and cultural survival, or whether it really just serves short-term economics, commercial markets, and suburban convenience. We must recognize that the benefits of infrastructure are not distributed equally, nor are the impacts. In fact, there are many people from my community for whom day-to-day survival takes precedence over infrastructure maintenance. Communities that are presently poor in physical infrastructure are in danger of also being left behind with respect to the growing information infrastructure, thus compounding the inequity. Additionally, rural communities may have compounding factors such as lower quality water or health care. On the other hand, communities that are poor in physical infrastructure may be rich in cultural infrastructure. One challenge is to maintain or repair the physical infrastructure and develop informational infrastructures, while protecting and enhancing ecological and cultural infrastructures. Another challenge is how to identify opportunities to evaluate and level the playing field for everybody, for all types of infrastructure.

THE INVISIBLE INFRASTRUCTURE:

We are conditioned to take infrastructure for granted in our everyday lives until something goes amiss. Infrastructure is not as visible to the general public as environmental factors (ecological, natural resources, energy, habitat, waste, agricultural), economic factors, equity, transportation and technology, social, cultural and ethical factors, political structure (governance and participation), population, health and diet, recreation, education, or information management (Courson 1994; Schmidheiny, 1992). Infrastructure is seldom mentioned in the sustainable development literature or in the futurist literature (Berry, 1991; Piel, 1992; Meadows et al, 1992). Conversely, sustainability of cultures and ecologies over time does not seem to be a primary driver of infrastructure development. This points to a need for more cross-fertilization between infrastructure, sustainable development, and future studies.

We need to evaluate the natural resource impact of our major infrastructures and determine whether there is a disproportionate impact on communities that are heavily natural resource dependent. Part of my work has focused on developing methods to evaluate and account for cultural impacts that may be "intangible" to a market economy but which are very serious and real to me and my people. If we transition to more sustainable economies, such as an information economy, without also using more environmentally friendly infrastructures and a truly cross-fertilized approach, we will be missing an opportunity.

The President's Council on Sustainable Development says sustainable development has 3 elements: a healthy environment, a vibrant economy, and a good quality of life. A vibrant economy ultimately depends on a healthy environment. A good quality of life also depends on a healthy environment. Unfortunately, poorly designed infrastructure has led to massive unhealthy ecological change. I must therefore ask the question "Is my definitions of a healthy environment, economy, and quality of life different than yours?" I suspect that if our definitions were really the same, then pollution impacts from poorly controlled industrial and agricultural infrastructure development would be a thing of the past (Capra, 1982). Salmon that are impeded by dams and whose spawning habitat is degraded by physical and economic infrastructures would once again return in the numbers my parents remember.

As a society, we tolerate a great deal of degradation. A quick look around us indicates that there is a tendency to ignore long-term prevention or preparedness in favor of enjoyment today, and to elevate individual benefit over community survival (Kreiner 1995; Milbrath 1989; Hardin, 1993). The tension between hoarding for individual gain and giving for community well-being is always with us. Traditional tribal structures focus more on the family, band, or tribe as the unit of survival because the distribution of workloads and resources was and is especially important for community balance. The mainstream society values independence and being able to survive economically on one's own. Traditionally, a deliberate and delicate balance is applied by tribal elders and leaders while mainstream society assumes that the market system will balance things for us. A traditional person is responsible to the family (human and nonhuman), which is

emphasized more than in American society, and our traditional economies and status systems still reward generosity and responsibility.

Another reason why we tolerate the slow decline of systems is that we tend to live in the present without a sense of time. We are too close to the problem to see today's snapshot as only one time point in a long-term system (Wagar 1991; Ehrenfeld, 1991). We also lack "baseline" information and cannot easily compare today's condition with past (i.e., undegraded) conditions. Since we lack a clear definition of our target future conditions as well, we cannot compare today's conditions to a particular environmental quality goal. Due to the slow degradation and relative invisibility of both environmental health and the physical infrastructure without good environmental monitoring, it is hard to detect early indicators of failure at a system level. We allow our most valuable and most irreplaceable resources, such as clean water and healthy topsoil, to be placed at risk, even though these are the things that an "infrastructure" is supposed to protect. For example, genetic engineering for perfect vegetables, pesticide resistance, or shelf life is increasing our dependence on fewer and fewer species, which increases our vulnerability to collapse of the agricultural infrastructure. We need to look far enough ahead that we don't compound current problems for the sake of immediate convenience or profit. For example, the problem of farmland saltation is only compounded by adding more and more water and fertilizer as the quality of the topsoil declines. We easily get trapped into taking a passive approach to the future, letting it emerge as it will, rather than defining what conditions we want to ensure for future generations and then implementing a logical course toward them.

We might envision a global system of inter-linked infrastructures. How resilient could this global "system" be, and what are the infrastructure vulnerabilities? What gives a system resiliency? From an engineering perspective, it could be redundancy; from an ecological perspective it could be biodiversity. We can improve the resiliency of physical infrastructures to some extent, and we can certainly increase the resiliency of the information infrastructure (through multiple repositories and decentralization). However, long-term survival always takes place in a context of (a) finite resources, (b) people and institutions, and (c) uncertainty/risk.

As a risk manager, I have to understand system-level vulnerabilities and uncertainties, the full scope of risks and impacts, and sources of risk external to the system that can compound consequences of system breakdown. My risk management training may give me a more systematic and structured approach to system-level vulnerability assessment, and I look at the entire span of risks and impacts, from human health, to ecological and environmental, and cultural impacts from infrastructure development coupled with any environmental degradation due to contamination.

There are clearly downsides to infrastructure, at least if it is poorly designed, implemented, and maintained. We must not repeat past mistakes of building infrastructure for its own sake (Hardin 1993). Fortunately, the explosive growth of the Internet may portend a less materialistic society as well as a shift from individual economics to systems ethics (Henderson 1991). We are indeed entering the Information age, which makes information infrastructure of paramount importance. However, if

information is merely a way to get even more money, then we have to question whether this is really "progress" or "prosperity."

INFRASTRUCTURE HAVE-NOTS

It takes leisure time to address infrastructure issues. It takes time and money to participate in planning processes and to develop data and methods for cost-benefit analyses. Not all communities are able to do this. As a nation, however, we cannot afford to delay or defer these issues (National Research Council, 1996).

There are many issues relating to the distribution of infrastructure resources, benefits, and impacts, all of which reflect underlying capitalistic value sets that are focused on determining spending priorities. Is the goal of infrastructure to make the world a "better" place? If so, for whom? Is there a difference between economic prosperity and societal or cultural wellbeing (Espinosa and Duxbury, 1996)? What defines "better" infrastructure? For example, constructing dams on almost all of the major waterways in the United States during the heyday of the Corps of Engineers and Bureau of Reclamation "improved" flood control and irrigation for some (Reisner, 1986), and provided hydropower for us all, but also resulted in the extinction of several salmon runs which in turn devastated tribal fisheries. With the recent listing of many runs on the Endangered Species List, the bill has now come due.

Technology has largely failed tribes and tribal values (Mander 1991). As long as material possessions form the basis of self-identification and self-worth in affluent societies (Young and Sachs, 1997), there will be unsustainable use of virgin materials. Because my people depend on those resources for their identity and cultural survival and because large infrastructure projects can cause permanent damage now more than ever, we need more culturally sensitive evaluation of infrastructure lifecycle risks and impacts.

We also need full participation, mutual understanding, inclusive solutions and shared responsibility (Kaner et al., 1996). There are quite a few forums for indigenous peoples to have a voice in sustainable development, but the values are not spreading into the mainstream to the point where they are taught in schools or used as design criteria. Religious leaders are realizing that they also need to take responsibility for conditions in this world, and even Pope John Paul II recently said that pollution is a sin. Other forums seem to be paternalistic in flavor, with unconscious assumptions that indigenous people are primitive and simply need buffer zones around their homelands where they can live oblivious to the "real" world and "true" scientific understanding.

There must be an emphasis on direct consultation with the affected communities and cultures throughout the planning and implementation processes. If I were dean of this department I would require all of my students and faculty to visit the communities they are affecting, and to "walk a mile in my moccasins" before telling me what kind of infrastructure I need. Only we the tetokin, or people, know what is good for us. I do not think I need to walk you through the emotional morass tied to the environmental injustice

my people have gone through in siting waste facilities or prioritizing cleanups. There is tremendous inequity in providing any kind of infrastructure (health, education, physical, information, etc). More troubling still is the fact that the Treaty of 1855 that my forefathers made with the United States contained elements of infrastructure development (schools, farming equipment, etc.), but lacked clauses that required upgrading and sustaining them. Our natural and cultural infrastructure designs and practices were supposed to be protected from intrusion and contamination "for as long as the grass shall grow." We as a people have kept our part of the bargain and maintained our traditional environmental knowledge and kept our ecology as intact as possible given the tremendous damage and limited amount of economic resources available to us.

Technological imperialism is not just a North-South problem. Because of the vast inequality of the economic and physical infrastructure within our own borders, we need to pay attention to the cultural cost of structurally wasteful projects (Milbrath 1989; Ramphal 1992; Redclift, 1993b). One example is the construction of a highway through the Petroglyph National Monument, which is an ancient tribal information repository. Another example is the cold war Navajo uranium mining operations, which has caused tremendous adverse health effects. Both of these examples were imposed on indigenous peoples without their consent, no matter how "beneficial" they are to others. We shouldn't have to allow devastation of our culture and environment as the cost of daily (and often marginal) survival – suburbia doesn't have to.

Mainstream America does not know how desperately poor many reservations are, and if they know, they tend to blame the victims. Many reservations have been labeled third or forth world countries with respect to the quality of their infrastructure and economies. We must not simply rebuild infrastructure for the convenience of the wealthy when reservations do not even have their first round of decent housing, indoor plumbing, or power. Mainstream prosperity does not trickle down to reservations, for the most part. Most reservations have been relegated to poor remote lands that are a fraction of their original size, so I challenge you to help develop technologies that will allow us to replace the resources we are now denied access to, that will allow us to stop liquidating our remaining natural resources in order to buy basic necessities, and that will allow us to preserve our basic way of life. Such infrastructure would be environmentally minimalist and nonintrusive whenever possible. It would not consist of large rural projects (Goodland, 1991), but would bypass environmentally damaging technologies and jump immediately to high-tech, low-impact technologies coupled with modest physical infrastructure support. Examples would be solar power, fuel cells, satellite communications, and so on. I also challenge you to not let reservations always be the last in line to receive technology improvements just because they are remote and politically invisible.

The US Department of Commerce (1995) has a goal of "empowering the information disadvantaged." They have documented that Native Americans have the fewest telephones and telecommunications. As the information century takes off, will the differential between haves and have nots continue at its present magnitude or is there an opportunity to narrow the gap? Can you help design a robust telecommunication system

for remote areas that may lack telephones or even electricity, and help provide internet access, computers, technical support, and network administrators?

However, this issue is more complex than merely providing a few grants to tribes or building a few schools. I also need to remind you that European concepts of infrastructure may not match tribal values with respect to natural resource exploitation. I challenge you to help us design tribally sensitive infrastructure that respects nature, sovereignty, privacy and values. We are not asking for handouts – this is a common misperception; we are asking you to honor the treaties signed by your forefathers and gain a basic understanding of the intent of the Treaties to protect a religion and way of life. I also need to emphasize that assimilation of tribes into mainstream America would mean the loss of identify and death of the culture. Tribally-appropriate infrastructure absolutely must reflect the basic concepts of sovereignty and cultural identity. I think we can do this if we work together and put cultures and ecologies ahead of economic convenience.

HOW MANY INFRASTRUCTURES ARE THERE?

I want to expand the infrastructure horizon, but this paper is not an attempt to define all the types of infrastructures. Rather, I want to focus on the relationships and linkages between some common infrastructures and attempt to understand how they fit together and mutually support each other.

A typical Indo-European list of infrastructures might include:

- Physical (transportation, utilities and their distribution)
- Commercial Economies: commodity economy, service economy, information economy (and distribution of commodities, services, information and their common surrogate money)
- Intellectual and educational infrastructure and their distribution systems
- Informational systems and structure for coordination and identifying needs
- Institutional and political infrastructure (governance and decision making) processes

This typical list seems to be predicated on common but unstated assumptions that a vibrant economy is a good goal, and that a suburban lifestyle is what everyone wants and needs. Additionally, there are unspoken biases about what has dollar value and what doesn't. Also, there are more insidious and pervasive assumptions about stereotypes, definitions of progress and what is an "advanced" society. We should examine these values to determine if they are derivatives of the eco-imperialism of the 1800's intended to make the world like England. For instance, the list above could rank technology capability over harmony or aesthetics or ethics. Is this in agreement with our vision of what life should be like in 100 years? 1000 years? If it isn't, then we should define what our vision is and decide whether our infrastructure designs will allow us to get there.

If we went through a process of defining types of infrastructures for suburban and tribal communities, we would probably develop a single list of common infrastructure

elements. However, I suspect that, due to different underlying values or worldviews, the specific metrics would be different. The fundamental difference is due, in part, to the fact that our tribal environmental knowledge for survival requires sensory connectivity to the environment, not isolation from it. A contemporary Indo-European trend seems to be geared to refining an individual's personal protection equipment to increase isolation from the environment. Determining where food or medicines are available throughout the year can only be experienced in person. "Experiencing" shopping at the grocery store just isn't the same.

Table 1. Examples of parallels between traditional and suburban infrastructure elements.

Infrastructure element	**Traditional counterpart**
Governance	Traditional decision making processes
Information repository	Elders as guides and repositories of information
Science & Technology	Traditional Environmental Knowledge and environmental management science
Education	Oral history, direct observation
Land Ethic	Stewardship and kinship versus dominion; equality of all species
Commerce	Trade networks; "Intangibles" worth as much as commodities
Energy	Fuel usage follows biological distribution patterns

NATIVE AMERICAN PERSPECTIVES ON INFRASTRUCTURE PLANNING

My people recognize that there are two types of infrastructure: ecological infrastructure that depends on a natural resource base (food, transportation, shelter), and cultural infrastructure that depends on a base of cognitive resources (technology, creativity, data), ethical resources (religion, stewardship, responsibility) and institutional resources (decision processes, stakeholder ownership of the problem, commitment, laws, education). This paper briefly discuss the environmental infrastructure, the cultural infrastructure, and then combine them into a single eco-cultural infrastructure.

The Environmental Infrastructure

The environment is a system of energy flows, biological and physical elements, relationships, and dynamic transfers of goods, functions, and services. Current training often leads us to emphasize the tangible elements of a system because we can count them or measure them easily. We need to teach young people to pay as much attention to the relationships, linkages, and interactions among elements as to the elements themselves. This will allow them to see dynamic systems instead of static collections of system elements, and it will allow them to understand how affecting one part of the system can affect the whole system.

My elders taught me to see the whole system. They taught me that our traditions and behaviors are conscious responses to rigorous environmental shaping, They understood the value of systematic observation and used inductive reasoning to determine the most probable reactions of very complex, interrelated ecosystem functions. They understand that ecological thermodynamics forms the basis of our resilient and adaptive holistic environmental management science. The application of this science has been codified into law and has been distilled into daily practice. This knowledge is still transferred between generations. Attention to and application of this knowledge means personal survival and enhancement of our ecology, culture, and religion. Disregarding this knowledge can result in eating a poison, starving, degrading resources, or societal collapse.

The threads of this tradition are woven into a single tapestry that extends from the past into the future. Because the tapestry of our culture, and the very fabric of our existence are truly dependent upon the health of our ecology, any impact to those environmental resources into which we have been woven is a cultural risk. If pollution affects our resources now or in the future, the health and well-being of everyone could suffer. A risk from nuclear or hazardous waste may ripple throughout all of our communities like a wave generated and propagated in a tapestry.

Physical infrastructure depends on a natural resource base because infrastructure requires materials and energy which come from the environment. Technology reduces peoples' (direct) dependence on the diversity of resources obtained from their immediate environment (Bawa and Gadgil, 1997). Modern society relies on a dozen major crops. My elders use hundreds of native foods and medicines. Although we shouldn't need a market incentive to preserve biodiversity or choose renewable resources, we clearly need to preserve biodiversity for market reasons (pollination, CO2 sink, crops, medicines, pharmaceuticals, plant materials of other commercial use)(Myers, 1997; Grifo and Downes, 1996; Daly 1996). It takes large unbroken tracts of land to preserve biodiversity, so we might say that sustainable development requires that the environment be protected from infrastructure.

All natural resources are cultural resources and Trust resources. This is because my culture is a living religion that requires the Treaty-reserved use of native foods and medicines in its practice. Thus, my people receive cultural services from the environment as well as nutrition, food, medicine, and shelter. The ecological functions of an intact ecosystem and the ecological and human services that the ecological functions provide are increasingly recognized as an important part of impact evaluation. Cultural uses and services are provided both by individual resources and localized areas, and also by entire ecosystems, watersheds, landscapes and viewsheds. Physical infrastructure might affect access, distribution, goods, functions, services and uses provided by the environment, as follows:

- Goods are tangible items of value to plants, animals, or people, such as food 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 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 or religious services can also be provided by an intact, healthy environment.
- Uses are things people or animals do at the location that are dependent on natural resource quality, such as recreation or public water intake or seasonal nesting grounds for birds.

The Cultural Infrastructure

There are many ways to describe the culture of a society or group of people, and many ways to measure societal well being. This is not just the realm of sociologists or anthropologists, but must be understood by engineers as well. In designing infrastructure for a particular culturally defined group such as American Indian Tribes, the engineer must understand much more than the superficial appearance of style. He or she also needs to know something about the culture itself, and the elements of food, clothing, shelter, medicine, governance, information exchange, trade networks, land ethic, spiritual nourishment, and many other things. Together this might be called a "cultural infrastructure."

The value of sustaining peoples and cultures are manifold. Two of the more evident are gene pools of diverse peoples and their world views and value sets. As we recognize more clearly that there is a need to promote the social value of taking care of the environment, it is natural that indigenous people in whom environmental stewardship is deeply ingrained should be actively consulted. As our general ethic moves more toward prevention and taking care of things as opposed to using things (Redclift 1993a), and as we move into the information age, cultural diversity as sources of ideas and values should finally become "valuable" to the dominant societies.

The Eco-Cultural Infrastructure

The CTUIR culture, which has co-evolved with nature through thousands of ecological education, has provided its people with their unique and valid version of holistic environmental management. Because my culture and my religion are synonymous with and inseparable from the environment, the relationship can be termed a single eco-cultural system or single ethno-habitat.

An ethno-habitat can be defined as the set of cultural, religious, nutritional, educational, psychological, and other services provided by intact, functioning ecosystems and landscapes. An ethno-habitat refers to the cultural survival of a people within its traditional homeland. A healthy ethno-habitat is one that supports its natural plant and

animal communities and sustains the biophysical and spiritual health of its native peoples through time. Ethno-habitats are also eco-cultural landscapes. They are places defined and understood by groups of people within the context of their culture. They are landscapes with culturally familiar features defined by cultural knowledge and experience. These lands serve to help sustain modern Indian peoples' way of life, cultural integrity, social cohesion, and socio-economic well being. These lands encompass traditional Indian homelands, places, habitats, resources, ancestral remains, cultural symbols, and cultural heritage. The presence of *and access for traditional use* to healthy habitats is fundamental to useable and harvestable levels of resources significant to Indian peoples as well as to healthy ecosystems.[3]

A cultural landscape is defined as "a geographic area, including but not limited to cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person, or exhibiting other cultural or aesthetic values." There are four general types of cultural landscapes: historic sites, historic designated landscapes, historic vernacular landscapes, and ethnographic landscapes. None of these are mutually exclusive. Infrastructure impacts on (or enhancement of) these landscapes should be a part of infrastructure planning, and should not be left solely to the Environmental Impact Assessment.

In addition to restoring and preserving traditional ethno-ecologies, we can also apply this concept prospectively as we realize that cultures and ecologies evolve together (Norgard 1994) and that there is an inseparable link between ecological, economic and cultural sustainability (ref: International Society for Ecological Economics: http://kabir.cbl.cees.edu/ISEE.) Many non-profit groups are promoting sustainable communities that are ecologically sustainable, socially sustainable, and economically sustainable, and rediscovering the notion of integrating human settlements and activities with the natural environment.

INFRASTRUCTURE DECAY: OBSTACLE OR OPPORTUNITY?

Decaying infrastructure creates opportunities for environmentally-friendly replacements (Wann, 1994). Perhaps we should even let some things deliberately decay until they can be completely replaced with best available technology, and perhaps we could remove some infrastructure that has been extremely damaging such as roads or dams. If we must have the hydropower, perhaps someone could develop in-stream turbines that do not require dams.

Infrastructure decay may also portent a destabilizing period of changing beliefs, conflict, and social stress due to declines in the agricultural and water infrastructures. Each major development in food, production or technology invalidates what went before it (Laszlo, 1994; Kingdon, 1993). We may be approaching the threshold of an infrastructure paradigm shift, which challenges us to detect early changes and technology trends, and to anticipate new technologies that could render obsolete some of the infrastructure that we

[3] Modified from the "Eastside EIS"

are currently anxious to repair. Ideally, we will shift from competition to cooperation and to better information and communication.

Again, do we passively wait for change or do we ensure that traditional values actually guide the change? The inertia of social, economic and political systems does not anticipate change or even the need for preventive maintenance. What "mindquakes" are needed to force us to abandon stereotypical mindsets and assumptions that are inconsistent with some future quality goal (Theobald 1992; Tough, 1991)?

INFRASTRUCTURE ETHICS

There is probably an ethics of infrastructure that we could explore – whose resources are used to build physical infrastructure; who benefits: is infrastructure design based on western assumptions about economics and well-being; is new information infrastructure equitably distributed? We all know about the social implications of technology and about human ecology that is being used to design user-friendly architecture, and this discussion should be expanded.

Technology mirrors both the practical environment and the worldview or cultural-religious belief system of the society in which it develops. Infrastructure by extension also mirrors societal values and environmental practicability. If our worldview were eco-centric (Goldsmith 1993), how would our infrastructure look? Is infrastructure driven by economics, by service to a sustainable society (Milbrath 1989), or by a stewardship ethic where the rights of nonhumans are honored (Beatly, 1994)? New societal norms are emerging, but stewardship is not yet a universally recognized value, so growth is still an obsession (Caldwell 1990). If growth and free markets are progress and if growth is supposed to lead to a cleaner environment, then we must abandon our antiquated notions of progress and redefine it in terms of health, culture, and environmental equity (Kidder, 1994; Gowdy, 1994; WorldWatch, 1999; World Bank, 1994).

Taking the long view (for instance, 10,000 years, as is standard practice for evaluating long-term effects of nuclear waste) could create a culture of permanence (Durning, 1992), but since uncertainty is inevitable and inherent in all systems, we also need an adaptive management process (Lee, 1994). Our obligations to future generations are largely environmental, since short-term decisions that affect environmental quality accumulate to influence land use (Beatly, 1994). Additionally, the prospect of global climate change would logically cause us to engineer more resiliency or contingency into all types of infrastructure.

CONCLUSION

This paper has addressed the need to regain a connection with the environment, the need for holistic environmental management systems with restraints on infrastructure development and use, and the need to level the infrastructure playing field.

Sustainable development requires a robust and diverse natural resource base. It also requires a robust and diverse set of cultural and economic bases, and a recognition that Homo sapiens and his systems are inseparable from the environment in which they are evolving. Conventionally trained people are taught that they are disconnected from other people (and species) in time and space. As a result they typically do not see themselves as part of a larger natural system that has evolved over eons. Conventional training also teaches that humans have more inherent rights than other species, that markets behave "rationally," that wilderness must be conquered, and that continual growth is necessary. The consequences of this training are current unsustainable environmental practices resulting in endangered species, land air and water pollution, and destruction of entire ecosystems. On the other hand, traditional tribal education teaches that traditional environmental management science resulting in long-term ecological health is the fundamental requirement for survival, that humans are an integral part of the ecology with no more and no less rights to existence and freedom than any other species, and that self-restraint is necessary for the well being of the community. Indigenous children are taught these rules of self-restraint and responsibility when they are young; so there is less reliance on external rules and laws than on traditional environmental knowledge.

Infrastructure can reflect either of these mindsets. Because we may be beginning a transition from an industrialized economy to an information-based economy, it may be appropriate to examine what is driving that shift and whether the underlying infrastructure is ripe for change as well. We clearly need to maintain roads, bridges, clean water supply systems, and so on, at least in the short term, but we also need to envision a future where some of these things have become obsolete. If this comes to pass, will the remnants of existing infrastructure cause residual damage to the environment, or can we implement a holistic and environmentally friendly planning process now to avoid that residual damage? Will there be increasing environmental stress from population growth, and will we need to have developed a more environmentally friendly infrastructure to compensate? Finally, can we identify infrastructure inequities and begin to reverse them in ways that preserve the cultural values and needs of every community?

REFERENCES

Bawa, K.S. and Gadgil, M. "Ecosystem Services in Subsistence Economies and Conservation of Biodiversity." In: Nature's Services: Societal Dependence on Natural Ecosystems, Daily, G.C., ed., Washington D.C., Island Press, pp. 295-310, 1997

Beatly, T. Ethical Land Use: Principles of Policy and Planning. Baltimore, the Johns Hopkins University Press, 1994.

Berry, T. "Transition from the Cenozoic Era to the Ecozoic Era." In: Approach to a Consensus for the Basis of Regulation of Environmental Chemicals. Arens, J.C., Argus. M.F., and Woo, Y-T., eds. New York: Marcel Dekker, Inc., pp. 391-400, 1991.

Brundtland Commission (World Commission on Environment and Development), Our Common Future. Oxford: Oxford University Press, 1987

Caldwell, L.K. Between Two Worlds: Science, the Environmental Movement, and Policy Choice. New York, Cambridge University Press, 1990.

Capra, F. The Turning Point: Science, Society, and the rising Culture. New York: Bantam Books, 1982.

Courson, W.H. "Changing Course: An Outline of Strategies for a Sustainable Future." Futures 26(2): 206-223, 1994.

Daly, H.E., "Sustainable Growth: An Impossibility Theorum." In: Valuing the Earth, Daly H.E. and Townsend, K.N., eds., Cambridge, MA, The MIT Press, pp. 267-273, 1996.

Durning, A.T. How Much Is Enough? The Consumer Society and the Future of the Earth. (Worldwatch Environmental Alert Series) New York: W.W. Norton & Co., 1992.

Ehrenfeld, D. "The Arrogance of Humanism" in: Willers, B., ed., Learning to Listen to the Land. Washington D.C.: Island Press, pp. 74- 104, 1991

Espinosa, J. and Duxbury, P. "Review of Proposed National Environmental Goals." In: National Research Council. Linking Science and Technology to Society's Environmental Goals. Washington D.C.: National Academy Press, 1996 pp. 437-447.

Goodland, R., Daly, H., and El Serafy, S. Environmentally Sustainable Economic Development Building on Brundtland. The World Bank Environment Working Paper No. 46, July 1991.

Goldsmith, E. The Way: An Ecological World-view. Boston: Shambala, 1993.

Gowdy, J.M., :Progress and Environmental Sustainability." Environmental Ethics, 16:41-55, 1994.

Grifo, F.T. and Downes, D.R., "Agreements to Collect Biodiversity for Pharmaceutical Research: Major Issues and Proposed Principles." In: Valuing Local Knowledge: Indigenous People and Intellectual Property Rights, Brush, S.B. and Stabinsky, D., eds., Washington D.C., Island Press, pp: 281-304 ,1996

Hardin, G. Living Within Limits. New York: Oxford University Press, 1993.

Kaner, S., Lind, L., Toldi, C., Fisk, S., and Berger, D. Facilitator's Guide to Participatory Decision-Making. Philadelphia: New Society Publishers. 1996.

Kidder, R.M. Shared Values for a Troubled World. San Francisco: Jossey-Bass, Inc., Publishers, 1994.

Kingdon, J. Self-Made Man: Human Evolution from Eden to Extinction. New York: John Wiley & Sons Inc., 1993.

Kreiner, A. "Green Morality: The Ethics of Sustainable Development." Insights on Global Ethics, 5(3):1, 1995.

Laszlo, E. Vision 2020: Reordering Chaos for Global Survival. New York: Gordon and Breach, 1994.

Lee, K. Compass and Gyroscope: Integrating Science and Politics for the Environment. Washington D.C.: Island Press, 1995

Mander, J. In the Absence of the Sacred.: The Failure of Technology and Survival of the Indian Nations. San Francisco: Sierra Club Books, 1991.

Meadows, D.H., Meadows, D.L., Randers, J. Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future. Post Mills, VT: Chelsea Green Publishing Company, 1992.

Milbrath, L. W. Envisioning a Sustainable Society: Learning Our Way Out. Albany: State University of New York Press, 1989.

Myers, N. "Biodiversity's Genetic Library." In: Nature's Services: Societal Dependence on Natural Ecosystems, Daily, G.C., ed., Washington D.C., Island Press, , pp.255-273, 1997

National Research Council. Linking Science and Technology to Society's Environmental Goals. Washington D.C.: National Academy Press, 1996

Ramphal S. Our Country, The Planet. Forging a Partnership for Survival. Washington, D.C., Island Press. 1992

Redclift, M. 'The Meaning of Sustainable Development." Geoforum 23(3): 395-4-3, 1993a.

Redclift, M. "Sustainable Development: Concepts, Contradictions, and Conflicts." In: Allen, P., ed., Food for the Future: Conditions and Contradictions of Sustainability. New York, John Wiley & Sons, Inc., pp. 169-192, 1993b.

Reisner, M. Cadillac Desert: The American West and Its Disappearing Water. New York: Penguin Books, 1986.

Schmidheiny, S. Changing Course: A Global Business Perspective on Development and the Environment. Cambridge, MA: The MIT Press, 1992

Norgard, R.B. Development Betrayed: The End of Progress and a Coevolutionary Revising of the Future. New York: Routledge Press, 1994

Theobald, R. Turning the Century: Personal and Organizational Strategies for Your Changed World. Indianapolis: Knowledge Systems, Inc. 1992.

Tough, A. Crucial Questions about the Future. New York, University Press of America, 1991

U.S. Department of Commerce, "Falling Through the Net: A Survey of "Have Nots" in rural and Urban America. July 1995

Wagar, W.W. The Next Three Futures: Paradigms of Things to Come. New York: Greenwood Press, 1991

Wann, D. BioLogic: Designing with Nature to Protect the Environment. Boulder: Johnson Books, 1994.

World Bank, Making Development Sustainable. Washington D.C., 1994.

WorldWatch Institute, State of the World 1999; New York, W.W. Norton & Company, 1999.

Young, J.E., and Sachs, A. "Creating a Sustainable Materials Economy." In: The Consumer Society, Goodwin, N.R., Ackerman, F., and Kiron, D., eds. Washington, D.C.: Island Press, pp.296-299, 1997.

APPENDIX:

SPECIFIC QUESTIONS ABOUT INFRASTRUCTURE

- How do various sectors of society, delineated by culture, geography, demographics, occupation, professional training, and aptitude resonate with, rely upon, and/or ignore/neglect the influence that infrastructure has upon their lives?

  We must recognize that there are a range of lifestyles outside of the dominant society. They may be materially poor but culturally rich – how do we protect the culture while improving quality of life (or returning it to its former quality)? How relevant is technology-based sustainable growth or development or management to people living in extreme poverty? Does growth causes further degradation of someone else's heritage and trust resources? We are also sustaining cultures, so we must break some stereotypes that those cultures are quaint and colorful anachronisms that must give way to "progress." Does democracy mean the freedom to maximize personal benefit at the expense of sustainability? Does the wording of the question imply that uneducated people neglect their infrastructure more due to ignorance or is it due to more urgent needs?

- What are the consequences for the evolution of infrastructure, its use and reliability for society as a whole?

  We have an amazingly clean water supply compared to the rest of the world and we take it for granted. We assume that emergencies or natural disasters are only temporary. However, infrastructure must indeed evolve to environmentally friendly technology. We agree that there is both a need to sustain resources and to sustain infrastructure through more robust design and a continual process of repairs that functions without much attention (or despite) changing politics. Perhaps a way to ensure that both resources and infrastructure are sustained (i.e., evolve together) is to recognize that we depend on resource-based infrastructure.

What changes may be desirable in:

- Design and engineering approaches

  Some civil engineering projects damage other people's lives (dams), so the full span of impacts throughout the entire lifecycle must be understood. A true cost-benefit lifecycle analysis would include the cost of lost cultures, and so on. It would also include natural resource valuation for all ecological impacts, including impacts on environmental functions and services. Tribal elders and scientists in particular need to be consulted for new approaches to community planning.

- Political, administrative, institutional decision making and structure

  How do we get peoples' attention for continual upgrading of infrastructure? The same is true of all the public health fields (sanitation, radon, preventive medicine) – they are enormously important but not "glamorous" or high-paying, and often respond to crisis rather than being preventive. There are a few success stories, particularly in the areas of vaccination – it is now part of our "culture" to get a flu shot every year, just as it is to change the oil in our car. Effects are immediate

and personal if we don't. The psychology is personal, not global or community-level. Since our sphere of influence does not extend much beyond our immediate family and pocketbook, we do not regard the community as "us" nor the environment as "mine" or "part of me." People won't pass school bonds even if their own children are in those schools, and won't increase teachers' salaries.

- R&D and technology initiatives

  If we really wanted to, we could develop low-cost, low-impact solar panels that would be good for people (but bad for a politically powerful market sector). We could move toward higher-tech/lower impact technologies. However, since we allow markets to make decisions for us, there needs to be a market incentive (such as a carbon tax) in order to force us to preserve our environment.

- Public attitudes and aspirations

  The dominant society has a certain land ethic (the attitude toward nature and places) that is different than the fairly typical indigenous land ethic based on respect, kinship, and so on. Religious leaders are recognizing a stewardship ethic, and this need to be reinforced.

  There is a psychology of roads as insulated linear tubes surrounded by private property that makes the thought of leaving the road and going cross-country unthinkable. If we moved to individual flying cars where we did not have to follow linear lines we would think more 3-dimensionally.

- Education (K-professional)

  First, we need to ingrain an environmental ethic based on principles of preservation, rights of all species, and so on, beginning in kindergarten.

  Second, we need to allow college majors in individual resources such as "water" – the hydrology, politics, ecology, mythology, regulatory aspects, international problems, ethical aspects, conflicts, protection, etc. There is no inherent reason why this should be seen as a "generalist" degree (with negative associations) – one could just as easily specialize in a resource as in an "ology." There used to be resource chiefs, such as salmon chiefs, who were responsible for knowing all about their resource and regulating people's use of the resource for sustainability.