GUIDING PRINCIPLES OF SUSTAINABLE DESIGN

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We must take bold and unequivocal action: we must make the rescue of the environment the central organizing principle for civilization . . . we are now engaged in an epic battle to right the balance of our earth; the tide of this battle will turn only when the majority of people become sufficiently aroused by a shared sense of urgent danger to join an all-out effort. It is time to come to terms with exactly how this can be accomplished.

– Al Gore
Vice President of the United States

I believe in a created universe where all things have place and purpose and where we humans are challenged everyday to make this a better place. I believe it is our obligation to act respectfully toward all living things and to manifest an approach to life in which the dignity of all species is sustained and common interests flourish. It is my belief that we must learn all that we can about our world in order to live upon it wisely.

– Roger Kennedy
Director, National Park Service

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September 1993

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ACKNOWLEDGEMENTS

It has been said that the creation of a more environmentally responsible future requires a vision. This document is a pioneering step in realizing the vision of **John J. Reynolds, Deputy Director, National Park Service,** for the future of our parks and the global community. In 1990, John created the agency's sustainable design initiative while serving as the Assistant Director, Design and Construction, Denver Service Center Operations. He has worked tirelessly to develop, promote, and implement the broader concepts of sustainable practices in all aspects of the National Park Service.

The *Guiding Principles of Sustainable Design* represents the collaborative efforts of over 80 individuals, as noted in the "List of Contributors" (pp. 115-117).

Under the auspices of the **Office of Professional and Employee Development, Denver Service Center**, National Park Service, Senior Landscape Architect **Richard Giamberdine** and Senior Architect **Robert Lopenske** were responsible for the guidance, coordination, and ultimate completion of this project.

Leslie Starr Hart
December 15, 1994
Denver, Colorado

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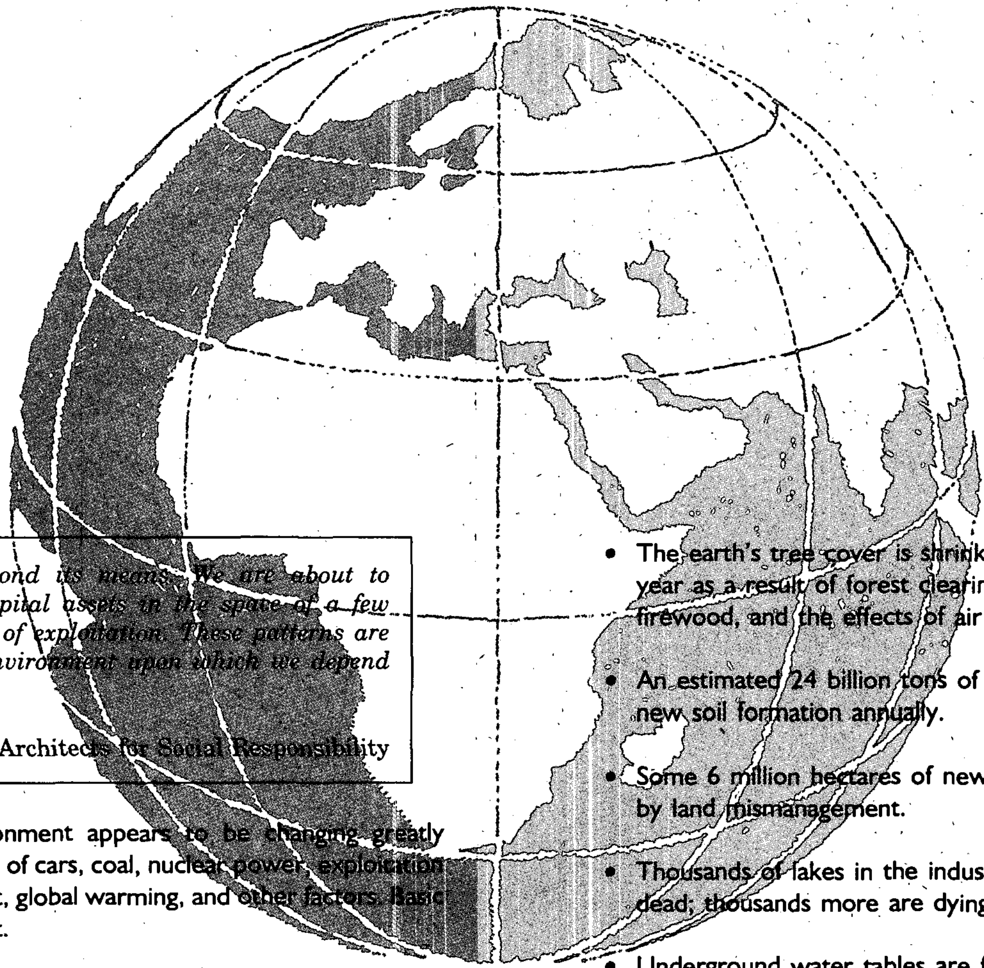


> *Our society is living beyond its means. We are about to dispossess the earth of capital assets in the space of a few lifetimes through patterns of exploitation. These patterns are devastating the natural environment upon which we depend for our long-term survival.*
>
> – Architects for Social Responsibility

The very nature of the environment appears to be changing greatly because of the interactive effects of cars, coal, nuclear power, exploitation of forestry, destruction of habitat, global warming, and other factors. Basic human needs are not being met.

How well are humans interacting with Earth? How can more acceptable relationships with the world be developed? Following is a list of indicators that reveal how very distant a balanced relationship is with the environment (Worldwatch Institute 1988-1992).

- The earth's tree cover is shrinking by 17 million hectares per year as a result of forest clearing for agriculture, lumber, and firewood, and the effects of air pollution and acid rain.
- An estimated 24 billion tons of topsoil are lost in excess of new soil formation annually.
- Some 6 million hectares of new desert are formed annually by land mismanagement.
- Thousands of lakes in the industrial north are now biologically dead; thousands more are dying.
- Underground water tables are failing in parts of Africa, China, India, and North America as demand for water rises above aquifer recharge rates.
- Extinctions of plant and animal species are now estimated at 140 daily; one-fifth of all species may disappear over the next 20 years.

- Some 50 pesticides contaminate groundwater in 32 American states; some 2,500 U.S. toxic waste sites need clean-up; the extent of toxic contamination worldwide is unknown.

- As a result of atmospheric increases in heat-trapping carbon dioxide, the mean temperature of the earth's surface is projected to rise between 1.5°C and 4.5°C between now and the year 2050.

- Sea level is projected to rise between 1.4 meters (4.7 feet) and 2.2 meters (7.1 feet) by the year 2100.

- The growing hole in the ozone layer over Antarctica each spring suggests a gradual global depletion could be starting.

These global conditions parallel David Wann's observations in his book *Biologic*, "that environmental deterioration is a lack of relevant information . . . [and that] poor design is responsible for many, if not most, of our environmental problems."

The statistics presented above also seem to support the statement of World Bank Economist Herman Daly that "we are treating the Earth as if it were a business in liquidation." The connotation of development has eroded from improving the quality of life for humans to an economic activity that assumes endless growth is both desirable and possible.

> *Building a more environmentally stable future clearly requires some vision of it. If fossil fuels are not to be used for power, then what? If forests are no longer to be cleared to grow food, then how is a larger population to be fed? If a throwaway culture leads inevitably to pollution and resource depletion, how can material needs be satisfied? In other words, if the present path is so obviously unsound, what picture of the future can be used to move toward a global community that can endure?*
>
> – Brown, Flavin, and Postel

THE CONCEPT OF SUSTAINABILITY

What can be done to counterbalance the damaging effects of human activities on this planet? Writer J.G. Nelson explains, "Today a powerful idea is at hand that may provide the general guidance humankind needs now. That idea is sustainable development, the awareness of which is sweeping the world. The concept contains two powerful ideas. The first is that of survival (sustainability) at a time when this seems far from certain in either the human or the natural contexts. The second is the old Greek idea of development, of various kinds of betterment for humans at a time when complacency and consumption have overshadowed human connections to natural systems."

Sustainable design in human developments has come to the forefront in the last 20 years. It is a concept that recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community is to sustain itself indefinitely. Sustainable design is the philosophy that human development should exemplify the principles of conservation, and encourage the application of those principles in our daily lives.

A corollary concept is that of bioregionalism — the idea that all life is established and maintained on a community basis and that all of these distinctive communities (bioregions) have mutually supporting life systems that are generally self-sustaining. The concept of sustainable design holds that future technologies must function primarily within bioregional patterns and scales. They must maintain biological diversity and environmental integrity, contribute to the health of air, water, and soils, incorporate design and construction that reflect bioregional conditions, and reduce the impacts of human use.

Sustainable design, sustainable development, design with nature, environmentally sensitive design, holistic resource management — regardless of what it's called, "sustainability," the capability of natural and cultural systems to maintain themselves over time, is key.

THE PRINCIPLES OF SUSTAINABILITY

Sustainability **does not** require a loss in the quality of life, but **does** require a change in mind-set, a change in values toward less consumptive lifestyles. These changes must embrace global interdependence, environmental stewardship, social responsibility, and economic viability.

Sustainable design must use an alternative approach to traditional design that incorporates these changes in mind-set. The new design approach must recognize the impacts of every design choice on the natural and cultural resources of the local, regional, and global environments.

A model of the new design principles necessary for sustainability is exemplified by the "Hannover Principles" or "Bill of Rights for the Planet," developed by William McDonough Architects for EXPO 2000 to be held in Hannover, Germany.

1. Insist on the right of humanity and nature to co-exist in a healthy, supportive, diverse, and sustainable condition.

2. Recognize Interdependence. The elements of human design interact with and depend on the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.

3. Respect relationships between spirit and matter. Consider all aspects of human settlement including community, dwelling, industry, and trade in terms of existing and evolving connections between spiritual and material consciousness.

4. Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems, and their right to co-exist.

5. Create safe objects of long-term value. Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creations of products, processes, or standards.

6. Eliminate the concept of waste. Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems in which there is no waste.

7. Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate this energy efficiently and safely for responsible use.

8. Understand the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not an inconvenience to be evaded or controlled.

9. Seek constant improvements by sharing knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers, and users to link long-term sustainable considerations with ethical responsibility, and reestablish the integral relationship between natural processes and human activity.

These principles were the basis for a "Declaration of Interdependence for a Sustainable Future" adopted by the World Congress of the International Union of Architects (UIA) and the American Institute of Architects (AIA) in June 1993. In summary, the declaration states that today's society is degrading its environment and that the AIA, UIA, and their members are committed to

- placing environmental and social sustainability at the core of practices and professional responsibilities
- developing and continually improving practices, procedures, products, services, and standards for sustainable design
- educating the building industry, clients, and the general public about the importance of sustainable design
- working to change policies, regulations, and standards in government and business so that sustainable design will become the fully supported standard practice
- bringing the existing built environment up to sustainable design standards

In addition, the Interprofessional Council on Environmental Design (ICED), a coalition of architectural, landscape architectural, and engineering organizations, developed a vision statement in an attempt to foster a team approach to sustainable design. ICED states: "The ethics, education and practices of our professions will be directed to shape a sustainable future. . . . To achieve this vision we will join . . . as a multidisciplinary partnership."

All of these activities illustrate that the concept of sustainable design is being supported on a global and interprofessional scale and also that a crucial goal in human development is to become more environmentally responsive. The world needs facilities that are integrated with natural systems, that are more energy-efficient, and that promote conservation and recycling of natural resources.

THE NATIONAL PARK SERVICE'S SUSTAINABLE DESIGN INITIATIVE

Two events in particular were instrumental in creating the National Park Service's sustainable design initiative.

National Park Service Vail Symposium. In October 1991, five working groups studied "the state of the parks" as part of organizational renewal activities associated with the 75th Anniversary of the National Park Service. They found that the National Park Service is being stressed by a variety of factors:

- Population increases
- Park visitation increases
- Demographic changes
- Increased numbers and types of sites to manage
- Environmental degradation
- Lack of capable leadership
- Need to protect whole ecosystems

The working groups acknowledged that certain environmental stresses are beyond the scope of standard park management, and that sustainability is a way of addressing these stresses on a broader scale.

Virgin Islands National Park, Maho Bay Resort. In November 1991 the sustainable design initiative was officially launched with a workshop in Maho Bay. This partnership forum included participants from the American Institute of Architects, American Society of Landscape Architects, the Ecotourism Society, National Parks and Conservation Association, National Oceanic and Atmospheric Administration, Greenpeace, local representatives from the Virgin Islands, private architectural and engineering firms, and ecotourism resort operators. Representatives from various National Park Service offices included professionals and managers from parks, regional offices, the Washington Office, and the Denver Service Center.

The participants brought diverse perspectives and ideas to the workshop as well as a strong commitment to provide guidance in meeting an increasing demand for practical advice on sustainable design. The outcome is a set of guiding principles for the application of sustainability to the management of sensitive natural and cultural resource areas.

PURPOSE OF THIS DOCUMENT

Guiding Principles of Sustainable Design is intended to provide a basis for achieving sustainability in facility planning and design, emphasize the importance of biodiversity, and encourage responsible development decisions in parks and other conservation areas, particularly where related to ecotourism. This merger of sustainable development and ecotourism provides tremendous opportunities for affecting visitor perceptions of the natural and cultural world, and developing conservation-oriented values. It is a marriage that would clearly distinguish sustainable development from traditional tourist development.

The suggested principles to be used in the design and management of park and other visitor facilities emphasize environmental sensitivity in planning, design, construction, operation, and maintenance; the use of nontoxic materials, resource conservation, recycling; and the integration of visitors with natural and cultural settings.

Sustainability principles have been developed for nine topics: interpretation, natural resources, cultural resources, site design, building design, energy management, water supply, waste prevention, and facility maintenance and operations. Although material is presented in separate sections, the interconnection of all systems and resources must be recognized; the resulting development should reflect the blending of disciplines to demonstrate respect for local, regional, and global environments.

INTERPRETATION

INTERPRETATION

ROLE OF INTERPRETATION

Sustainable park and ecotourism development, to be truly successful, needs to anticipate and manage human experiences. Interpretation provides the best single tool for shaping experiences and sharing values. By providing an awareness of the environment, values are taught that are necessary for the protection of the environment. Sustainable design should seek to affect not only immediate behaviors but also the long-term beliefs and attitudes of visitors.

> *Interpretation is an educational activity which aims to reveal meanings and relationships through the use of original objects, by firsthand experience, and by illustrative media, rather than simply to communicate factual information.*
>
> – Freeman Tilden

Interpretation is the communication path that connects visitors with the resources. Good interpretation is a bridge leading people into new and fascinating worlds. It brings new understanding, new insights, new enthusiasms, and new interests.

To achieve a sustainable park or resource-related operation:

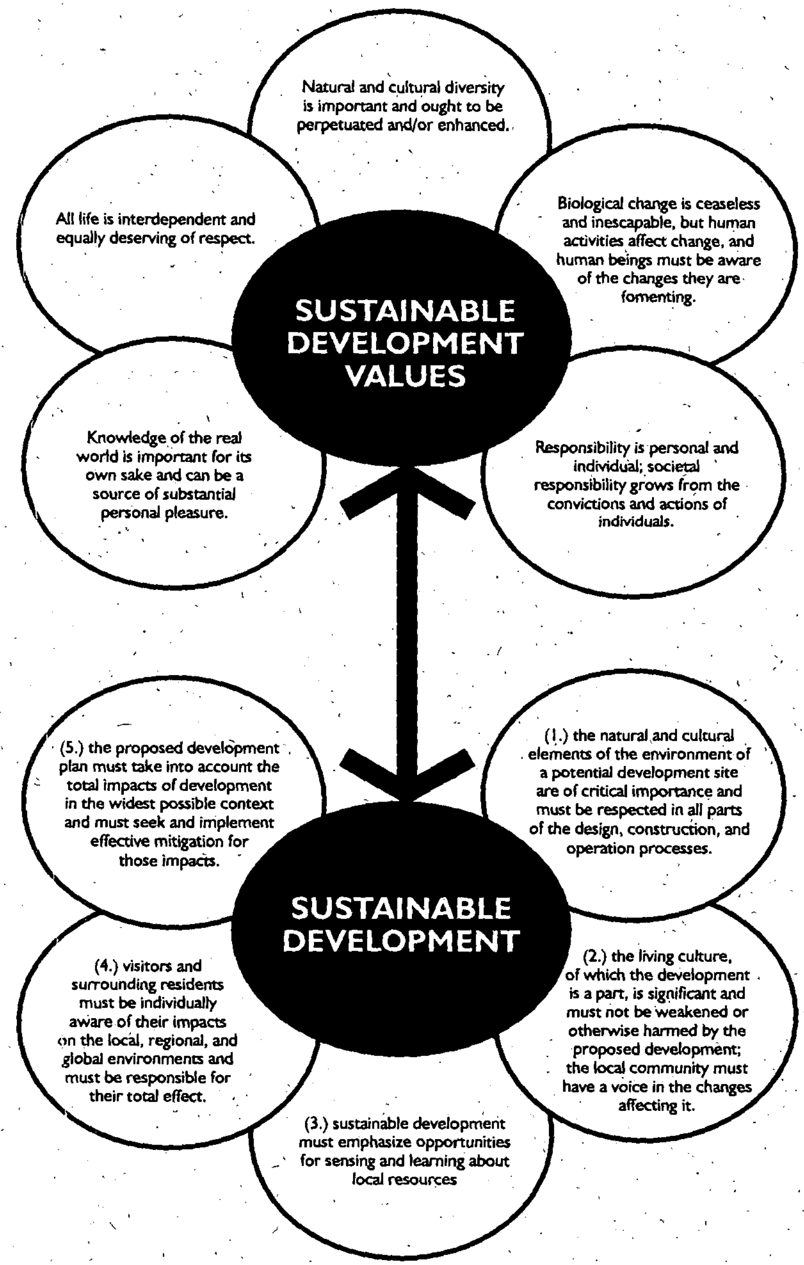
- Visitor experiences should be based on intimate and sensory involvement with actual natural and cultural resources. The local culture should be included. The experiences should be environmentally and culturally compatible and, through understanding and appreciation, should encourage the protection of those resources.
- Educational opportunities should include interpretation of the systems that sustain the development as well as programs about natural and cultural resource values of the setting.
- Site and facility design should contribute to the understanding and interpretation of the local natural and cultural environments.
- Interpretation should make the values of sustainability apparent to visitors in all daily aspects of operation, including services, retail operations, maintenance, utilities, and waste handling. A good example should be set in all facets of operation.

OPPORTUNITIES FOR INTERPRETATION

A value-based visitor experience requires interpretation as an essential part of the planning and design process. Interpretive values cannot be successfully added to a development or operation as a last minute enhancement.

The primary interpretive resources of a site must be identified early in the planning process. There can be no substitute for a scientific knowledge of the resources involved; however, interpretive opportunities can usually be identified in the planning stages of a new development by answering the following questions:

- What is special or unusual about the site? (Consider both the natural and cultural aspects)
- What is particularly interesting, scenic, or photogenic about the site?
- What do visitors come to see?



- What is fun to do? (Answers must be resource-oriented and nonconsumptive)
- What can be done on the site that is both environmentally sustainable and challenging?
- What resources provide particularly strong opportunities to demonstrate the underlying value system of sustainable development?
- What significant environmental controversies might be illustrated using local resources?
- What connections will the development have with the natural systems and/or cultural values of the area?
- What knowledge do visitors already have about the area?
- What knowledge and attitudes do neighboring residents have about the site and its resources?
- What messages can be offered about sustainability that visitors can use in their everyday lives?

In addition, interpretation must be reinforced in all visitor experiences and inherent in management's thinking and in the relationship of the proposed development to the larger cultural context. The value system that interpretation communicates must pervade the entire cycle of planning, design, construction, operation, and maintenance.

INTEGRATION OF INTERPRETATION INTO SUSTAINABLE DEVELOPMENT

Visitor experiences must be planned to provide actual knowledge of resources and to influence human values, thus leading to the protection of the overall environment. Table 1 provides a list of general goals and specific examples to facilitate the integration of interpretation into sustainable development.

TABLE 1: INTERPRETATION AND SUSTAINABLE DEVELOPMENT

Visitor Experiences	
Interpretive Goals	**Examples**
Visitors must	Visitors would benefit by
■ have the opportunity to see that the local natural and cultural worlds are interrelated.	• participating in organized cultural activities and demonstrations that allow local residents to share their values and skills with visitors.
	• being served meals that feature local foods and products and by seeing local food plants being cultivated within the development.
■ learn that the resources that surround them are important, interesting, and worthy of respect.	• attending evening programs featuring site-specific interpretive themes.
	• having plants and other features of the site identified by labels or in guidebooks.
	• participating in organized work/study programs that emphasize resources and sustainable design values.
	• ensuring that the beauty of the natural and cultural environments are preserved and revealed in the development.
■ have the opportunity to interact with the environment at every possible moment.	• participating in guided activities that focus on significant natural and cultural features found onsite or nearby.
	• participating in environmental education programs that include members of the community and local schools.
	• ensuring that the physical development is designed to grasp every opportunity to bring the visitor in close sensory contact with the environment.
	• ensuring that preservation of the environment takes precedence in all aspects of the development and that this goal is made visible.
■ have opportunities for learning through exhibits and literature as well as through guided activities.	• participating in organized volunteer activities that allow visitors to work on restoration or enhancement of the environment after appropriate training.
	• using the development's resource library.
	• ensuring that exhibits are integrated into the design to reveal unique aspects or solutions of the development.
	• providing sensory experiences using interpretive messages whenever possible as part of the design.
■ share in the responsibilities of caring for the natural and cultural environments.	• taking part in active programs that are planned for preserving and restoring the environment.
	• participating in routine operations of the develoment, such as recycling, energy conservation, and gardening.

Facility Planning/Design/Construction	
Interpretive Goals	**Examples**
Sustainable design must	Sustainable design would
■ include a professional understanding of the natural and cultural resources involved and clearly state that people must be subordinate to (or in harmony with) nature.	• ensure that the site plan, design, and construction preserve and emphasize key elements of the natural and cultural environments.
■ give the development a special sense of place based on the resources of the site.	• feature architectural materials that are native to the site or region and that are renewable and environmentally sensitive. • encourage opportunities for sensing, experiencing, and/or understanding resources in the architecture and site design.
■ provide education about the natural and cultural environments and the support systems that sustain the development while bringing visitors and resources together whenever possible.	• place interpretive exhibits within the development, allowing visitors to be aware of immediate resource protection concerns associated with the environment. • provide information in visitor facilities about the resource, using printed or electronic media as appropriate. • provide access to the support systems of the development through cutaway walls or other methods.
■ allow visitors to experience nature in an intimate, sensory fashion, providing opportunities for private moments in natural settings.	• limit outdoor night-lighting to low wattage, directional lighting, with consideration of photovoltaic power and control. • provide passive, quiet areas where visitors can reflect on the natural scene. • assist interpretive programming to set the stage for private moments in natural settings.
■ incorporate the living culture as a significant part of the visitor experience and encourage opportunities for visitors and local residents to interact and share their values and experiences.	• adaptively reuse existing buildings when they reflect part of the story of the site. • incorporate architectural traditions, names, and images into facility design.

Operations and Maintenance

Interpretive Goals	Examples
The values of sustainable development must be	The values of sustainable development are shown by
■ communicated by the manager who serves as the chief interpreter of a sustainable development.	• providing all staff with regular training regarding local natural and cultural features and resources. • organizing work/study programs that emphasize resources and sustainable design techniques. • organizing volunteer activities that allow visitors to work on restoration or enhancement of the environment after appropriate training. • developing volunteer programs that allow visitors to operate site support systems.
■ understood and appreciated by the entire staff, who should demonstrate understanding and respect for the local environment and share their knowledge with visitors.	• providing tours that present the sustainability goals of a development as shown in the operation and maintenance functions, such as utility and support systems. • providing visitors the opportunity to understand the relationships of local water, wastewater, solid waste, and electrical systems to local, regional, and global environments.
■ shared with those who live in the surrounding areas; the local culture should have a significant role to play in the operation of the facility.	• including representatives of the local culture in significant staff positions. • organizing cultural activities and demonstrations that allow local residents to share their values and skills with visitors. • organizing environmental education programs that include members of the local community and schools.
■ visible in all daily aspects of operation, including energy use, food handling, waste handling, maintenance activities, retail operations, and visitor services.	• providing a central staffed location for resource and activity information. • serving meals that feature local foods and products and by cultivating local foods within the development. • recycling all possible waste. • selling appropriate informational materials and quality items crafted by local people.

NATURAL RESOURCES

NATURAL RESOURCES

PHILOSOPHY/GENERAL CONSIDERATIONS

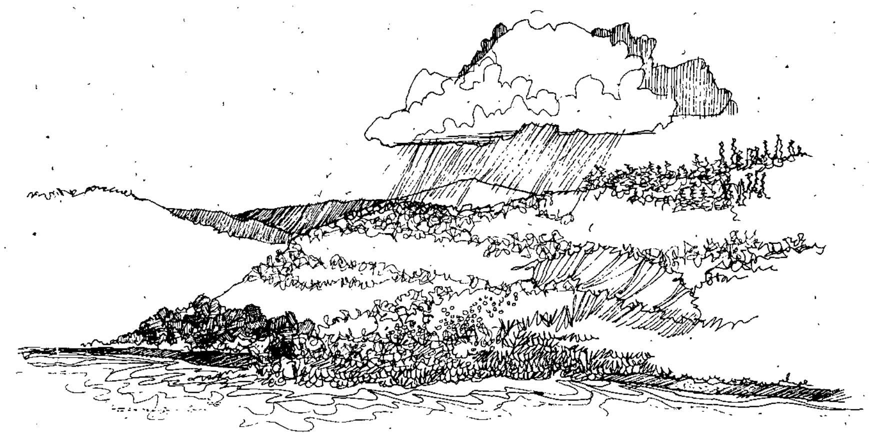
By their nature, park facility and ecotourism developments depend on close and intimate associations with the ecosystems around them. Instead of viewing from the outside, as in a museum, park visitors and ecotourists seek to participate, to join in, to experience, and to gain a better awareness, appreciation, and understanding of the development's ecological systems. Because ecosystems have the innate, though not easily quantifiable, capacity to provide energy, space, and waste disposal to their components, the act of "joining in" causes costs to, and changes in, the system. Sustainable use, planning, design, and development all attempt to minimize these costs so that the system will continue to function indefinitely within an acceptable limit of change.

A basic premise of sustainable development is that facilities must, to the fullest extent possible, function within the ecosystem and its constraints rather than separately. Although it is not always readily apparent, ecosystems provide direct ecological services to the human developments within them. Obvious services are those such as vegetative screening, water/wastewater purification, maintenance, and recovery of the resources around a development (e.g., beaches, forests, reefs, and wildlife). If the ecosystem becomes overloaded or severely stressed, these services are jeopardized.

The following are essential considerations for the integration of park and ecotourism development with natural resources.

- **Natural Behavior Within an Ecosystem** – A basic understanding of the natural behavior of an ecosystem is required before designing facilities to function sustainably within it. It is crucial to identify key resources within that system on which ecotourism will be focused and to understand how these resources are linked.

- **Links Between Ecosystems** – There are links between ecosystems that may be geographically separate, e.g., between mountain forests and coastal mangroves, between mangroves and coral reefs. Changes in one ecosystem may have consequences in another; long-term resource protection involves planning and government controls on a wide geographical basis to account for these connections.



- **Fragmentation of Habitats** – Whether caused by constructing a specific facility or because of land use decisions throughout an ecosystem, habitat fragmentation causes loss of biological diversity and must be minimized.

- **Energy Subsidies for Ecosystems** – Of all the varied ecosystems in which modern-day humans live, few still function totally without imported energy — food, fuel, even water — to sustain human needs. It is therefore unrealistic to expect park and ecotourism development to function completely without imported energy. However, sustainable planning and design can keep that energy subsidy to a minimum by taking advantage of renewable energy sources within the local ecosystem. Questioning how the development could function (and even if it should) if the energy subsidy were unavailable will keep development more in harmony with existing resources and minimize the environmental impact of exporting energy from a distant ecosystem.

- **Human Demands on Ecosystems** – The demands of human use on an ecosystem are cumulative. New proposals must account for the previous use of resources so that effects of past activity, proposed development, and anticipated future use do not exceed the ecosystem's capability. The scale and type of any potential development should be determined by the capability and resiliency of the ecosystem rather than by the physical capacity of the site.

- **Acceptable Limits of Change** – Change in the system is inevitable, but limits of acceptable environmental change should be established before development begins. Acceptable change should not approach the upper limit of capacity because unpredictable events such as droughts and hurricanes may go beyond that limit and cause the whole system to collapse. All parties should recognize and respect limits of acceptable change and not attempt to extend them by simply importing more and more energy or creating other artificial supports.

- **Ecosystem Monitoring** – The effects on surrounding resources of developing and operating facilities should be routinely monitored and evaluated, and actions should be taken immediately to correct problems. This information can be used for improving design of future phases of the development. Monitoring will ensure that the limits of acceptable change are not exceeded and will provide information about the behavior of the system. Indicator species provide useful and efficient monitoring tools. Initial and repeated geographic information system (GIS) inventories of soils, hydrology, land use patterns, and plant and animal communities can aid this understanding.

IMPACTS OF DEVELOPMENT ON NATURAL RESOURCES

As a practical means of anticipating and minimizing possible negative impacts of park or ecotourism development on the environment, a matrix is provided (see table 2). Users of *Guiding Principles of Sustainable Design* should review the matrix before committing themselves to a particular approach. Once a potential approach is identified from the matrix, it is possible to reference other sections of the guidebook or other sources where the approach may be examined in greater detail.

If a particular development type/activity in the matrix is selected, it may lead to certain negative impacts on the environment. Potential impacts are arranged according to three main categories — pollution, physical processes, and biological systems. These categories are further divided into specific impacts on the environment — e.g., noise increased, erosion increased, vegetation altered. A solid black dot on the matrix indicates a negative impact.

Identifying negative impacts through the matrix is not intended to discourage or eliminate a certain development approach but rather to alert the designer/developer to aspects that may need further consideration or mitigation. Selecting one approach may dictate others. However, choosing a package of approaches that creates minimum impact at the lowest energy cost will probably result in the most appropriate design for sustainability.

TABLE 2: ENVIRONMENTAL IMPACTS OF DEVELOPMENT

Pollution

Development Type/Activity	Noise increased	Air quality deteriorated	Toxics released during construction	Toxic materials spilled or discharged	Pollutants introduced by vehicle transport	Petroleum products spilled	Toxics or sewage discharged by vessels	Odors released	Hot water discharged
Site Access									
Terrestrial									
Roads	●	●	●		●	●			
Trails	●								
Boardwalks	●		●						
Aquatic									
Docks and piers						●	●		
Open anchorage						●	●		
Air									
Airport/strip	●	●	●		●	●			
Helicopter pad	●	●	●		●	●			
Seaplane dock	●	●			●	●			
Remote/indirect									
Remote TV									
Construction and Landscaping									
Site preparation									
Excavation	●	●			●	●			
Filling	●	●			●	●			
Draining									
Grading	●	●			●	●			

Physical Processes

Development Type/Activity	Erosion increased	Sedimentation/siltation increased	Soil disturbed or compacted	Soil removed and disposed of	Surface water flow disrupted	Groundwater supply reduced	Groundwater supply depleted	Long-shore drift/beach dynamics altered	Dredging potentially required
Site Access									
Terrestrial									
Roads	●	●	●	●	●	●			
Trails	●	●	●		●				
Boardwalks									
Aquatic									
Docks and piers								●	●
Open anchorage									
Air									
Airport/strip	●	●	●	●	●				
Helicopter pad	●	●	●						
Seaplane dock									
Remote/indirect									
Remote TV									
Construction and Landscaping									
Site preparation									
Excavation	●	●	●	●	●				
Filling	●	●	●	●	●				
Draining					●	●			
Grading	●	●	●		●	●			

Biological Systems

Development Type/Activity	Vegetation altered	Vegetation destroyed	Habitat altered	Habitat destroyed or fragmented	Coral reefs disturbed or destroyed	Barriers to wildlife movement created	Collisions or road kills on wildlife increased	Corridors for exotic species invasion created	Exotic/alien species directly introduced	Diseases introduced	Life cycles of wildlife disrupted	Nutrient flow/food chains altered	Nonnatural foods or habitat introduced	Nontarget species destroyed	Animal rights issues raised
Site Access															
Terrestrial															
Roads	●	●	●	●		●	●	●	●		●	●			
Trails	●	●	●					●							
Boardwalks			●					●							
Aquatic															
Docks and piers					●										
Open anchorage	●	●	●	●	●										
Air															
Airport/strip	●	●	●	●		●									
Helicopter pad	●	●	●												
Seaplane dock															
Remote/indirect															
Remote TV	●														
Construction and Landscaping															
Site preparation															
Excavation	●	●	●	●											
Filling	●	●	●	●					●						
Draining	●	●	●	●		●						●	●		
Grading	●	●	●	●											

Development Type/Activity	Pollution									Physical Processes								
	Noise increased	Air quality deteriorated	Toxics released during construction	Toxic materials spilled or discharged	Pollutants introduced by vehicle transport	Petroleum products spilled	Toxics or sewage discharged by vessels	Odors released	Hot water discharged	Erosion increased	Sedimentation/siltation increased	Soil disturbed or compacted	Soil removed and disposed of	Surface water flow disrupted	Groundwater supply reduced	Groundwater supply depleted	Long-shore drift/beach dynamics altered	Dredging potentially required
Foundation																		
Slab												●		●				
Excavated	●	●										●	●	●				
Elevated			●															
Landscaping																		
Shaping/planting	●	●								●	●	●						
Ponds													●	●				
Swimming pools													●	●	●			
Restoration	●	●																
Energy																		
Supply Source																		
Wood-local		●																
Fossil-imported		●		●	●	●												
Biogas-local								●										
Propane-imported		●			●													
Solar-local																		
Windmill-local			●															
Hydroelectric (with dam and storage)			●									●	●	●				
Hydroelectric (small-scale, water wheel or ram)												●						
Hydrothermal			●									●	●		●			

Development Type/Activity	Biological Systems														
	Vegetation altered	Vegetation destroyed	Habitat altered	Habitat destroyed or fragmented	Coral reefs disturbed or destroyed	Barriers to wildlife movement created	Collisions or road kills on wildlife increased	Corridors for exotic species invasion created	Exotic/alien species directly introduced	Diseases introduced	Life cycles of wildlife disrupted	Nutrient flow/food chains altered	Nonnatural foods or habitat introduced	Nontarget species destroyed	Animal rights issues raised
Foundation															
Slab		●		●											
Excavated		●		●											
Elevated	●		●												
Landscaping															
Shaping/planting	●	●	●		●	●		●	●	●	●	●	●		
Ponds		●		●									●		
Swimming pools		●		●											
Restoration	●		●												
Energy															
Supply Source															
Wood-local	●	●	●												
Fossil-imported															
Biogas-local															
Propane-imported															
Solar-local															
Windmill-local	●														
Hydroelectric (with dam and storage)	●	●	●	●		●						●			
Hydroelectric (small-scale, water wheel or ram)	●		●												
Hydrothermal	●		●												

Development Type/Activity	Pollution									Physical Processes									Biological Systems														
	Noise increased	Air quality deteriorated	Toxics released during construction	Toxic materials spilled or discharged	Pollutants introduced by vehicle transport	Petroleum products spilled	Toxics or sewage discharged by vessels	Odors released	Hot water discharged	Erosion increased	Sedimentation/siltation increased	Soil disturbed or compacted	Soil removed and disposed of	Surface water flow disrupted	Groundwater supply reduced	Groundwater supply depleted	Long-shore drift/beach dynamics altered	Dredging potentially required	Vegetation altered	Vegetation destroyed	Habitat altered	Habitat destroyed or fragmented	Coral reefs disturbed or destroyed	Barriers to wildlife movement created	Collisions or road kills on wildlife increased	Corridors for exotic species invasion created	Exotic/alien species directly introduced	Diseases introduced	Life cycles of wildlife disrupted	Nutrient flow/food chains altered	Nonnatural foods or habitat introduced	Nontarget species destroyed	Animal rights issues raised
Electric-imported			●									●							●	●	●				●	●	●		●				
Electric-local	●	●	●		●	●		●				●							●		●												
Natural gas-imported			●	●								●							●		●												
Transmission of																																	
Powerlines																																	
Aboveground			●									●							●	●	●				●	●	●		●				
Buried			●									●							●		●												
Pipes																																	
Aboveground			●	●								●							●		●			●									
Buried			●	●								●							●		●												
Vehicle-bulk (also requires road access)	●	●		●	●	●																			●		●						
Boat-bulk (also requires docks, piers)	●	●				●	●											●					●										
Water																																	
Supply																																	
Wells															●	◐																	
Cisterns			●																														
Impoundments												●	●	●					●	●	●	●		●						●			
Diversions														●					●	●	●									●			

Pollution

Development Type/Activity	Noise increased	Air quality deteriorated	Toxics released during construction	Toxic materials spilled or discharged	Pollutants introduced by vehicle transport	Petroleum products spilled	Toxics or sewage discharged by vessels	Odors released	Hot water discharged
Desalinization			●						●
Recycling			●						
Importing (also requires road access)	●	●		●	●	●			
Distribution									
Aboveground pipes			●						
Buried pipes			●						
Vehicle transport (also requires road access)	●	●			●	●			
Waste Disposal / Storage									
Human/organic (secondary, onsite)			●	●				●	
Solid/trash (landfill, offsite)	●	●			●	●		●	
Communication									
Radio/microwave transmission tower			●						
Satellite									
Telephone									
Lines aboveground			●						
Lines buried			●						

Physical Processes

Development Type/Activity	Erosion increased	Sedimentation/siltation increased	Soil disturbed or compacted	Soil removed and disposed of	Surface water flow disrupted	Groundwater supply reduced	Groundwater supply depleted	Long-shore drift/beach dynamics altered	Dredging potentially required
Desalinization									
Recycling			●						
Importing (also requires road access)									
Distribution									
Aboveground pipes			●						
Buried pipes			●						
Vehicle transport (also requires road access)									
Waste Disposal / Storage									
Human/organic (secondary, onsite)			●		●	●			
Solid/trash (landfill, offsite)									
Communication									
Radio/microwave transmission tower									
Satellite									
Telephone									
Lines aboveground			●						
Lines buried			●						

Biological Systems

Development Type/Activity	Vegetation altered	Vegetation destroyed	Habitat altered	Habitat destroyed or fragmented	Coral reefs disturbed or destroyed	Barriers to wildlife movement created	Collisions or road kills on wildlife increased	Corridors for exotic species invasion created	Exotic/alien species directly introduced	Diseases introduced	Life cycles of wildlife disrupted	Nutrient flow/food chains altered	Nonnatural foods or habitat introduced	Nontarget species destroyed	Animal rights issues raised
Desalinization	●	●	●		●							●	●		
Recycling										●		●			
Importing (also requires road access)							●		●						
Distribution															
Aboveground pipes	●		●			●									
Buried pipes	●		●												
Vehicle transport (also requires road access)							●		●						
Waste Disposal / Storage															
Human/organic (secondary, onsite)	●		●							●		●	●		
Solid/trash (landfill, offsite)							●		●	●					
Communication															
Radio/microwave transmission tower	●						●								
Satellite															
Telephone															
Lines aboveground	●	●	●				●	●	●		●				
Lines buried	●		●												

Pollution

Development Type/Activity	Noise increased	Air quality deteriorated	Toxics released during construction	Toxic materials spilled or discharged	Pollutants introduced by vehicle transport	Petroleum products spilled	Toxics or sewage discharged by vessels	Odors released	Hot water discharged
Walls and Fences									
Stone wall									
Cement/brick wall			●						
Wooden fence			●						
Wire fence									
Open trench									
Operations and Maintenance									
Machinery/vehicles	●	●			●	●	●		
Routine recycling									
Fire management									
Fire breaks									
Controlled burns									
Wildlife management									
Introduce predators									
Trap/poison species				●					
Shoot species									
Sterilization									
Natural controls									

Physical Processes

Development Type/Activity	Erosion increased	Sedimentation/siltation increased	Soil disturbed or compacted	Soil removed and disposed of	Surface water flow disrupted	Groundwater supply reduced	Groundwater supply depleted	Long-shore drift/beach dynamics altered	Dredging potentially required
Walls and Fences									
Stone wall			●		●				
Cement/brick wall			●		●				
Wooden fence									
Wire fence									
Open trench			●	●	●				
Operations and Maintenance									
Machinery/vehicles									
Routine recycling									
Fire management									
Fire breaks	●	●	●		●				
Controlled burns									
Wildlife management									
Introduce predators									
Trap/poison species									
Shoot species									
Sterilization									
Natural controls									

Biological Systems

Development Type/Activity	Vegetation altered	Vegetation destroyed	Habitat altered	Habitat destroyed or fragmented	Coral reefs disturbed or destroyed	Barriers to wildlife movement created	Collisions or road kills on wildlife increased	Corridors for exotic species invasion created	Exotic/alien species directly introduced	Diseases introduced	Life cycles of wildlife disrupted	Nutrient flow/food chains altered	Nonnatural foods or habitat introduced	Nontarget species destroyed	Animal rights issues raised
Walls and Fences															
Stone wall		●		●		●					●				
Cement/brick wall		●		●		●					●				
Wooden fence				●		●					●				
Wire fence				●		●	●				●				
Open trench		●	●	●		●									
Operations and Maintenance															
Machinery/vehicles															
Routine recycling															
Fire management															
Fire breaks		●	●	●		●		●	●		●				
Controlled burns	●		●												
Wildlife management															
Introduce predators									●	●	●				
Trap/poison species														●	●
Shoot species															●
Sterilization											●				●
Natural controls															

	Pollution									Physical Processes									Biological Systems														
Development Type/Activity	Noise increased	Air quality deteriorated	Toxics released during construction	Toxic materials spilled or discharged	Pollutants introduced by vehicle transport	Petroleum products spilled	Toxics or sewage discharged by vessels	Odors released	Hot water discharged	Erosion increased	Sedimentation/siltation increased	Soil disturbed or compacted	Soil removed and disposed of	Surface water flow disrupted	Groundwater supply reduced	Groundwater supply depleted	Long-shore drift/beach dynamics altered	Dredging potentially required	Vegetation altered	Vegetation destroyed	Habitat altered	Habitat destroyed or fragmented	Coral reefs disturbed or destroyed	Barriers to wildlife movement created	Collisions or road kills on wildlife increased	Corridors for exotic species invasion created	Exotic/alien species directly introduced	Diseases introduced	Life cycles of wildlife disrupted	Nutrient flow/food chains altered	Nonnatural foods or habitat introduced	Nontarget species destroyed	Animal rights issues raised
Vegetation management																																	
Poisoning				●															●	●	●	●										●	
Cut/clear										●	●								●	●	●	●											
Natural controls																																	
Visitor activities (may require access roads, trails, docks, structures)																																	
Hiking	●									●					●																		
Boating	●					●	●																●		●								
Camping	●	●	●		●	●																											
Snorkel/SCUBA	●					●	●														●		●		●								
Horseback riding	●							●		●														●			●	●					
Nature study	●																																

CULTURAL RESOURCES

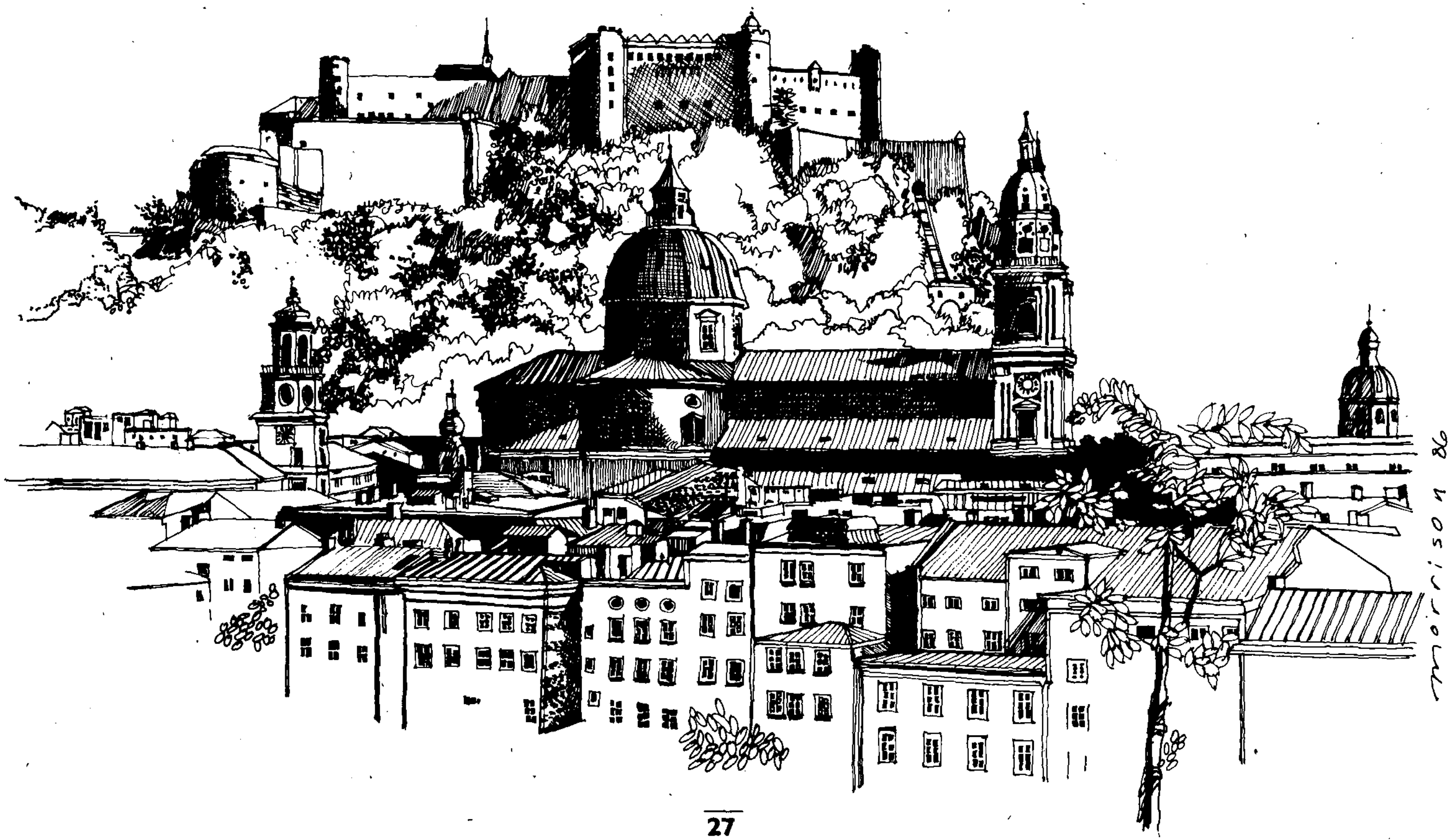
CULTURAL RESOURCES

TANGIBLE AND INTANGIBLE ASPECTS

Cultural resources are those tangible and intangible aspects of cultural systems, both past and present, that are valued by or representative of a given culture, or that contain information about a culture.

Tangible cultural resources include, but are not limited to, sites, structures, districts, landscapes, objects, and historic documents associated with or representative of peoples, cultures, and human activities and events, either in the present or in the past. Tangibles also include plants, animals, and other natural resources culturally defined as food, manufacturing, and ceremonial items; and naturally occurring or designated physical features, such as caves, mountain peaks, forest clearings, dance grounds, village sites, and trails, regarded as the sacred homes of deities, spirits, ancestors, and/or places of worship and ceremony. Such cultural aspects are ethnographically documented for the Sioux in relation to the Black Hills, the Navajo and Rainbow Bridge, resources used by the Miccosukee within Big Cypress Preserve, and resources used by Eskimo and native Hawaiian peoples in Alaskan and Hawaiian parks. Intangible cultural resources include the primary written and verbal data for interpreting and understanding those tangible resources.

Intangible cultural features including family life, myth, folklore, ideology, folk song, and folk dance are renewable and transmitted from generation to generation. Although material evidence of past cultures is finite, cultural resources in general are not, but are produced by each successive generation.



Most cultural resources are unique and nonrenewable. These cultural resources were created or occurred at specific geographic locations at certain points in time by different individuals. Although cultural resources fall into broad patterns of civilization, the circumstances that created each resource are unique and thus cannot be duplicated. Because the path of human history continues, new cultural features are created daily, and only time will provide the context for evaluating the relative significance of these new features.

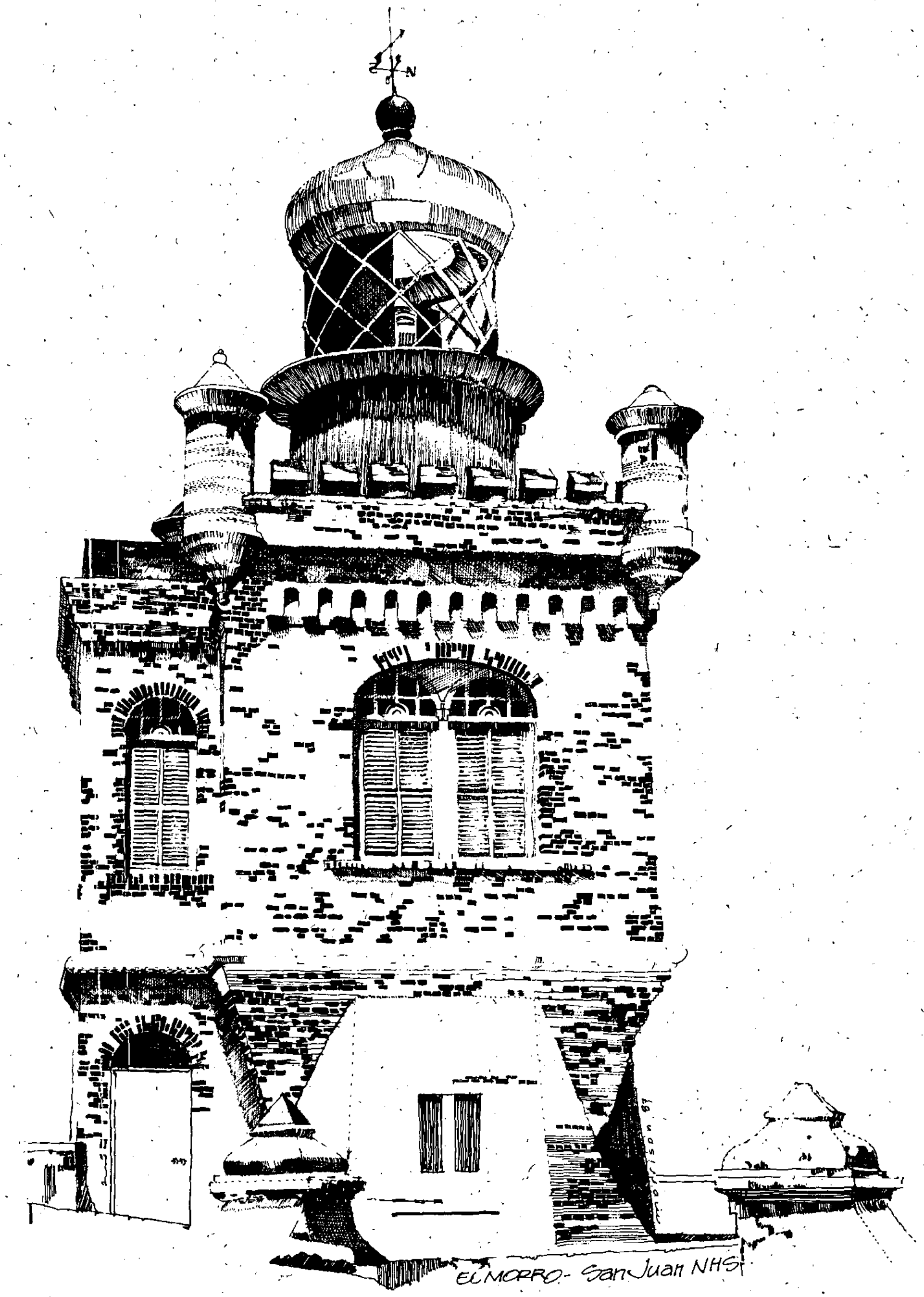
SUSTAINABILITY AND CULTURAL RESOURCES

Sustainability has often been an integral part of the composition of both tangible and intangible cultural resources. Ecological sustainability and preservation of cultural resources are complementary. In large part, the historic events and cultural values that are commemorated were shaped by humankind's response to the environment.

It is not just nostalgia that draws people to historic developments. Much of what is valued in these developments is their response to the climate, natural setting, and locally available building materials. Their usefulness as models for new buildings only adds to their value. Many preserved buildings, districts, and landscapes consist of vernacular design — architecture without architects — built with onsite or locally available materials.

A symbiotic relationship of human activities within their host environment is evident in the Anasazi cliff dwellings at Canyon de Chelly National Monument in Arizona. There, the natural sandstone, local mud, and logs were used to shelter communities in the cliffs. The occupants' structures were their direct response to the environment. They built them with what they had, and built them in such a way as to be cool in the summer, easily warmed in the winter, and with small openings that could be blocked over quickly when a room was set aside for storage or other purposes.

The vernacular response to climate, setting, and materials provides opportunities for presenting positive lessons in ecologically sound design. Conversely, many of our historic military, industrial, and engineering sites afford opportunities to discuss ecological excesses of the past.



Technical efforts to preserve cultural resources, however, must not contribute to degradation of the environment. The use of pesticides, fungicides, and other toxins has damaged the earth, so any preservation efforts should consider nonhazardous alternatives.

In some instances toxic materials, such as lead-based paint and asbestos, are inherited. Toxic materials that exist in many historic buildings must be removed and properly disposed of. Unfortunately, some of the inherited toxic materials are significant features of historic structures or sites. For example, development of a park at the Trinity Site in New Mexico (site of the explosion of the first atomic bomb), where there is radioactive waste, would not only require addressing removal of the inherited hazardous material, but also interpreting it as a significant feature. The problem of inherited toxins will need to be addressed in all proposed management and development projects in the future.

Another facet of dealing with cultural resources is the energy consumption that is required to protect them. In terms of numbers, the largest percentage of inventoried cultural resources is museum objects. Serious consideration must be given to their conservation. The use of mechanical heating, ventilating, and air-conditioning systems in a historic building or museum, to maintain desired temperature and humidity levels, must include not only a cost in energy/dollar figures but also the cost in resource dollars. More natural, less consumptive ways of achieving the same result must be assessed.

MANAGEMENT OF CULTURAL RESOURCES

When a cultural resource achieves sufficient importance that it is deemed historically significant in human history, it becomes a nonrenewable resource worthy of consideration for sustainable conservation. Management, preservation, and maintenance of cultural resources should be directed to that end.

Some of the groundwork required before preservation efforts take place is assessing the cultural and historical importance of affected resources to humankind. Preserving every cultural feature is impossible in terms of burdens on the economy, available energy, and other resources.

Both natural and cultural resource management share common approaches of mission and procedure for resource protection. While park and ecotourism developments usually feature natural elements, there is a growing awareness that heritage tourism is equally important to visitors.

When cultural resources become visitor attractions, the responsible authority must ensure that providing access to these resources does not create additional environmental deterioration. Getting people to the cultural resources can have major effects on the environment. The process can require the construction of roads, trails, and visitor facilities. The transportation aspect of bringing people to the resources is accompanied by energy consumption and pollution.

In addition, the carrying capacity of a historic building must be closely monitored. Normally, the very act of allowing public access to a significant cultural resource exposes the property to increased risk of deterioration. This must be countered with increased maintenance activity, the energy cost of which should be weighed as part of the decision about how much access will be allowed to that resource.

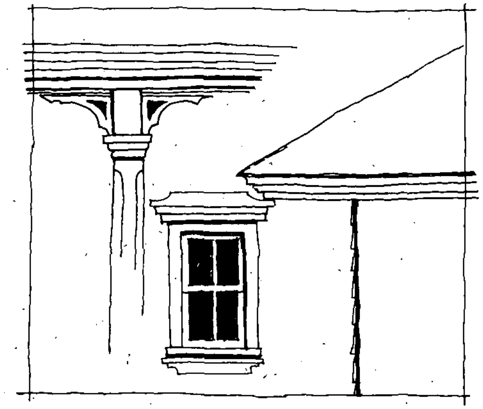
Cultural resource preservation intrinsically is a form of sustainable conservation. The built environment represents the embodied energy of past civilizations. Where resources can have a viable continued use, preservation is conservation in every sense of the word. Yet, the process of preserving cultural resources inherently is not sustainable. All materials deteriorate naturally over time, and with cultural resources every effort is made to prevent that natural progression.

Most tangible cultural resources contain energy that has already been expended, materials that have been mined or harvested, and components that have been manufactured. A cost estimate for the rehabilitation of a historic building should consider the life-cycle cost implications of fabric that can be retained.

The reuse potential of historic buildings should include an assessment of the original resources it took to construct the building as well as an assessment of the building's potential for economical heating and cooling. Often older buildings were designed to take advantage of natural light, nonmechanical ventilation, passive solar heating, and the ability of native materials to hold heat or cold when assembled in certain fashions. Conversely, more recent structures may rely on energy-consumptive systems for their continued use.

Historic buildings and landscapes can provide opportunities to discuss building construction prior to the 20th century, when most structures were built with locally available materials. Obtaining these materials and erecting the buildings were relatively low in energy consumption. In contrast, many modern buildings consist of materials from all over the globe, obtained at an enormous cost in energy and resulting in the rapid depletion of worldwide resources.

Interpretation of architectural styles through features such as thick adobe walls, broad eaves, double-hung windows, door transoms, and high ceilings can provide valuable lessons in sustainability. How these low-tech features functioned during times when energy consumption was limited provides examples of principles applicable to today's efforts to conserve energy.



Historic buildings, landscapes, and even museum objects often contain materials from sources that are today endangered. The appearance of certain woods in buildings can provide the occasion to discuss the plight of these endangered species and the importance of maintaining resources.

RECOMMENDATIONS

Cultural resources are reflections of past cultural, historical, and environmental influences. Any development in areas containing cultural resources should pursue appropriate methods during planning, design, construction, and throughout subsequent operation to ensure that these nonrenewable, environmentally sensitive resources are protected, conserved, interpreted, and left unimpaired for future generations.

The following general recommendations should be included in any sustainable design that affects cultural resources:

- Proposed development sites should be surveyed for cultural resources, and the significance, integrity, and tangible and intangible qualities of those resources determined.
- All site and facility designs should incorporate methods for protecting and preserving significant cultural resources over the long term.
- The architectural style, landscape design, and construction materials of new developments should reflect the cultural heritage of the locality or region.

- Cultural resource treatment and maintenance methods should be both environmentally and culturally sensitive and sustainable over the long term.

- When opportunities arise, cultural resources should be interpreted to include lessons about the environmental exploitations or sustainable, environmental successes of the past.

Any proposed development plan must take into account the total impacts of development in the widest possible context, and it must seek and implement effective mitigation for those impacts.

The conservation and management of cultural resources in an environmentally sensitive manner requires detailed planning; knowledge of materials and their interactions; knowledge of construction, craft techniques, skilled technicians, and available resources; and an ongoing commitment to resource conservation. Successful preservation must also address construction and operations associated with the proposed development.

To assist in this process, table 3 contains a general list of activities that should be part of any development project or operational plan involving cultural resources. For each activity of the construction and operation phases, the list identifies the objectives, important consideration criteria, and specific products that might be the outcome.

TABLE 3: PROCESS FOR PRESERVATION OF CULTURAL RESOURCES

Activity and Objective	Considerations	Product
Project Statement To establish a clear understanding of the proposed undertaking and what it intends to accomplish.	What is the purpose of the development (resource conservation and/or interpretation, recreation, resort, research)? Who is it intended for and who is involved? (List the owner, the operator, the intended user, local community and special interest groups, the insurer, the financier). What is its anticipated effect on any known or anticipated cultural or natural resources at the site? What is its anticipated effect on locally available resources, economy, and culture.	A complete statement of accountability will be available to the public prior to commencement of the project.
Site Survey To identify and quantify evident existing cultural resources at the site and to make predictions about the possible presence of buried or submerged resources; to allow informed decisions about the effects of the development on these resources.	Cultural resources are primarily objects or sites having historic, prehistoric, or sacred significance. Such resources exist both on land and under water (submerged cultural resources). Shipwrecks are a prime example of submerged cultural resources.	Inventories of cultural resources (e.g., cultural site surveys, historical base maps) will be produced and recommendations made for further testing if the probability of nonevident cultural resources is determined to exist.
Determination of Significance To establish a context against which a proposed development and resulting preservation or mitigation alternative may be weighed and justified. NOTE: After priorities of significance are determined, development of alternatives can begin. Not all alternatives lead to development; some will be minimal approaches that could result in a "do nothing" alternative.	The significance of a cultural resource is usually evaluated on the basis of • association with historic events or persons • cultural association • artistic or scientific merit • importance as part of a larger resource, such as a historic district, landscape, or viewshed The significance of a cultural resource may be rated according to its geographical range of importance. In general, the broader this range is, the more important the resource is considered to be. The levels of significance are as follows: <u>Local</u>: significant to a local community or cultural group (i.e., vernacular architecture) <u>Regional</u>: significant within a regional (state, territory) context <u>National</u>: significant to national history <u>Global</u>: significant to all humanity (world heritage sites)	Once the existing and historic setting are clearly understood, they must be evaluated both by professionals and other interested parties. As a result of this evaluation process, those resources that are determined to be significant at one or more levels are usually nominated to a registry of cultural resources. In the United States, there are national, state, and local registers of historic places. Nomination of resources meeting the criteria is, in many cases, required by law, particularly if the property is in public ownership or receives public funding. Once nominated resources have been accepted and formally listed on one or more of the registers, sanctions may be imposed for their damage or destruction. Such properties may qualify for various benefits that could aid in their preservation. Listing on these registers may produce peripheral benefits such as increased tourism.

Activity and Objective	Considerations	Product
Development of Preservation Alternatives To explore what can and should be done to the resource and determine a range of possible alternatives.	Certain factors are inherent in each cultural resource that should be considered when developing a range of alternatives. <u>Significance</u> – Do existing cultural resources have such significance that development cannot be warranted or can the development be accommodated within acceptable limits? <u>Location</u> – Is the cultural resource in an environmentally sensitive area where increased visitation or the preservation work itself might be detrimental? <u>Physical Condition of the Resource</u> – Is the proposed alternative technically feasible? What level of technology would be required? Consider the nature of the resource. Some structures were not designed to last; to try and preserve them in their original environment would be impossible. Even some very durable structures are not sustainable. <u>Integrity of the Resource</u> – Authentic ruins are preferable to accurate restorations; similarly, a restoration has more integrity than a complete reconstruction. Can the work be undone at some time in the future with no loss of resource integrity? <u>Carrying Capacity of the Resource</u> – If the existing resource must be altered to preserve it, the limits of acceptable change have already been reached or exceeded. <u>Impacts on the Local Community and Surrounding Environment</u> – Does the development prevent or restrict the traditional use of the land or resources by local cultures? Would treatments necessary to preserve the resource introduce toxic and nonbiodegradable products into the environment? Would the proposed treatment require the use of nonrenewable materials? There are certain intrinsic factors that should be considered when developing a range of preservation alternatives. These include: <u>Ownership</u> – If the property is owned by government or trust agencies, certain policies and standards must be followed. The same is true if such agencies fund either the preservation work or the development. <u>Visitors</u> – What are the expectations of the visitors (i.e., is complete restoration of a cultural resource an appropriate alternative where the primary purpose of visitation to the area is that of physical recreation)? Are there health or safety problems in presenting the resource to visitors? Can it be made accessible and be presented to special populations? <u>Local Population</u> – Will either the development or preservation of cultural resources be supportive or in conflict with local values, land use patterns, and restrictions? <u>Cost</u> – Does the significance of the resource warrant the cost of its preservation in terms of money, work effort, materials, and impact on the environment? <u>Availability of Funds</u> – No development should be allowed where there are significant cultural resources unless the project includes sufficient funding for preservation and protection during construction of the development and subsequent use of the site.	A range of acceptable and feasible preservation alternatives will be completed.

Activity and Objective	Considerations	Product
Selection of an Alternative To choose a preservation alternative that meets all applicable laws and standards and that is acceptable to all interested parties.	Each alternative will normally consist of a combination of one or more of the following treatments: Documentation – This option is a prerequisite for all other treatment. It is also the most sustainable treatment in that, except for very fragile sites, this procedure has no impact on the resource. Stabilization – The primary intent of stabilization is to prevent further deterioration or to improve safety. Often, this may include the backfilling of excavated archeological resources. Preservation – This treatment seeks to keep the resource in its present condition or appearance. It may require some initial and periodic repair, but most work involves maintenance. Restoration – This method attempts to return a resource to a previous appearance or condition. It is usually appropriate only if the importance of the resource lies in the story it can tell. Reconstruction – This option attempts to replace a resource or part of a resource that no longer exists with a replica. Minor reconstruction may be incorporated as part of preservation or restoration treatment. Reconstruction of an entire structure is seldom justified. Rehabilitation – This option seeks to reuse or find an alternative use for a cultural resource. It is appropriate where the resource is part of a larger one, such as a historic district, and where the exterior appearance is of primary importance. This may also be considered a sustainable option in that it reuses existing materials and extends the functional life of the structure. Revitalization – This option involves the reestablishment of the cultural landscape. Relocation – If the original location of the resource is not of primary importance, or if no other alternative is feasible, relocation may be acceptable. Demolition – If a resource is inherently unsafe, or the benefits of the proposed development outweigh cultural importance of the resource, or no other treatment is feasible, demolition may be the treatment of last recourse.	The resulting treatment plan should protect fragile cultural resources in an environmentally sustainable manner. With active community involvement, this plan should also reflect the best interests of the local population. If no development has been decided for a site that contains cultural resources, a strategy must be devised to protect them.

Activity and Objective	Considerations	Product
Construction Documents To provide instructions for treating nonrenewable cultural resources, and to ensure that the treatment is carried out in a sustainable, ecologically sensitive manner. NOTE: If the development project does not directly involve the cultural resources except as objects of interpretation and visitation, the plans and specifications for new construction may need only provide for the protection of cultural resources at the site. Where the development directly involves the resources (reuse or adaptive use or presentation of cultural resources to visitors) and for the various treatments that may be accorded them, several items should be considered in preparation of the construction documents.	In general, the materials and workmanship used to treat cultural resources should be as much like the originals as possible. This may not be possible, and it may not always be desirable. In many instances chemical treatment or the use of nonhistoric materials could be necessary, or the use of equipment that has the potential to damage both the natural and cultural resources could be contemplated. Considerations for the protection of both the cultural and natural environments include: <u>Replacement Materials</u> – Is the material ecologically sensitive and sustainable? If not, and the specific material is critical to the integrity of the resource, future availability should be ensured (e.g., plant trees to be used for future replacement of rare woods). If replacement by precisely the same material is not necessary, a different species, source, or manufacturing process should be identified for a similar and compatible product. New, ecologically sensitive products should be considered. Suitable recycled materials should be used. <u>Treatment</u> – Reversibility in the design of the treatment or facility should be considered. Can it ever be removed? If so, how? What would be the effect if it were? <u>Workmanship</u> – Most cultural resources in ecologically sensitive areas were probably built without mechanical equipment, so such equipment should not be necessary for repairs. The original method of construction is often the most compatible aesthetically and physically. These construction techniques may still be used by the local people. <u>Incentives</u> – Construction documents should include provisions to encourage environmental sensitivity. There could be credits for minimal disturbance during construction and fines for adverse effects. Shared savings or bonuses might be considered for contractors who recommend other suitable and ecologically sensitive materials, who locate sources of salvaged or reusable materials, or who identify potential users or recycling opportunities for salvageable material from the project. Any development should respond to and reflect the cultural heritage of the local environment. If there are cultural resources onsite or nearby, it may be desirable to include elements of the cultural past in the new design. These factors should reflect a contemporary interpretation of the cultural themes and character-defining elements without mimicry. Consider abstract representations and be compatibile in color, texture, scale, and mass.	Documents containing instructions for undertaking development in areas containing cultural resources, or for treating the resources themselves will result. These documents will incorporate special techniques for the protection of both natural and cultural resources and require the use of ecologically sensitive materials and construction techniques.

Activity and Objective	Considerations	Product
Construction To avoid damage to known and unknown resources. NOTE: If alternatives for development include a construction option, there will usually be ground disturbance. This could affect the natural environment and any possible cultural resources.	All of the research and planning that precedes the construction phase should ensure the preservation of any cultural resources. However, the following issues can still occur: <u>Discovery of Unknown Cultural Resources</u> – Such resources tend to be archeological and are uncovered during construction. There are usually three options. The <u>first</u> option is to avoid the resources. The <u>second</u> option is mitigation – incorporating the resource into the development or moving it. Both options frequently lead to redesign of the project. The <u>third</u> option is demolition after the data have been recorded and archived. The option chosen will depend on the relative importance of the cultural resources in comparison to the development. Additional funds and time will be required, and this is a contingency that must be accommodated. <u>Resource Protection</u> – Both natural and cultural resources must be protected from damage during construction. This may involve fences or barricades, covers, or other special measures. It may require the use of less efficient construction methods, such as hand tools or light equipment. Even minor impacts can be permanent. <u>Worker Health/Safety</u> – This is paramount. Construction materials, methods, and processes that involve toxins and debilitating noise levels must be avoided.	Plans for artifact salvage and curation and documentation of construction, monitoring, and a preservation process for future reference will result.
Work Force To involve the local population in appreciation and preservation of their resources.	Any development in a sensitive area is apt to have a significant effect on the local community and will probably affect the economy and land use patterns. Use of local workers will help ensure benefits to the local economy and create goodwill. In many areas, there is a tradition of taking existing cultural remains for reuse in new structures. While reuse of building materials in situ may be commendable from a sustainability standpoint, such involvement will teach the local population that existing structures considered to be of cultural importance are themselves resources to be conserved. Further, the craft methods and tools used in the original construction of the cultural resources may still be in use by the local people. If this is true, not only will the people be the most skilled at making any necessary repairs, but also it will provide an opportunity to perpetuate the use of artisan building practices and traditional tools as a viable part of the culture.	The use of local workers in the preservation of cultural resources enhances the local population's appreciation of the value of their resources, contributes to the conservation of local folkways, and trains future artists in traditional craft methods. It will also contribute to a pride of heritage and visitor education.

Activity and Objective	Considerations	Product
Preventive Maintenance Plan To prevent loss of or damage to nonrenewable cultural resources and reduce repairs by establishing a scheduled system of inspections and service. NOTE: Many cultural resources are examples of sustainable design. They have survived over time. A good preventive maintenance plan will ensure that cultural resources are protected for generations to come.	A preventive maintenance program requires a maintenance staff with the proper skills, knowledge, equipment, and materials. Before the decision is made to develop an area, consideration should be given as to whether the development can generate sufficient funding to provide for a cultural resource maintenance budget.	Resources will be preserved for future generations with the least loss of integrity; materials and techniques that are both appropriate and ecologically sustainable will be used; and a system of scheduled maintenance will ensure proper and timely treatment and documentation of all work done.
Cyclic Maintenance Plan To plan for foreseeable limited replacement of resources due to service life; and to ensure resource longevity through prudent sustainable maintenance procedures.	A cyclic maintenance plan should include: <u>Life-Cycle Costs of Materials</u> – Quality products last longer, but are they environmentally appropriate and sensitive when analyzed on a cradle-to-grave basis? <u>Funding</u> – Maintenance funding should be safeguarded. It should be separate from other funds. <u>Staff</u> – A dependable skilled work force is critical. <u>Monitoring</u> – Wear and tear should be checked for evidence that carrying capacity is being exceeded.	Cultural resources will be repaired in a timely manner; a multiyear plan of cyclic maintenance tasks will be prepared; a consistent local labor pool will be ensured; energy conservation will be achieved by extending the useful life of products; and records will be kept of monitored data and energy consumption feedback.
Operating Plan To provide daily ecologically sensitive housekeeping, interpretation, and use of cultural resources, and the means for monitoring and obtaining feedback for cyclic maintenance plan.	Ecologically sensitive use of cultural resources includes the following: <u>Interpretation</u> – Preservation methods will be interpreted through multimedia and/or tours. <u>Computerization</u> – Data analysis and sharing work plans will be managed by computer. <u>Video</u> – Videos will be used For training and job recruitment among locals and others. <u>Self-regulation</u> – A voucher system will be used for limiting stays at resource-sensitive areas to avoid negative impacts.	Sustainable property will be in a maintainable condition that is useful to occupants. Success will be measured and certificates issued for resource-sensitive operations by an independent evaluator (Ecotourism Society, International Travel Associations, etc.).

Activity and Objective	Considerations	Product
Disaster Planning To preplan specific actions for minimizing loss of and damage to nonrenewable cultural resources in the event of a disaster.	Most disasters can be attributed to wind, natural forces (e.g., hurricane, earthquake, flood), damage from domestic water and sewer systems, fire, war, vandalism, and theft. Some elements that should be considered are: <u>Design</u> – Facilities should be designed to either withstand natural forces (sufficient mass and detail) or to yield to them (light and of renewable materials). <u>Fire and Security Systems: Plans and Preparation</u> – There should be a plan for emergency removal and storage of artifacts. <u>Reinforcement</u> – Structural modifications should be made so resources could withstand winds, earthquakes, and floods.	Resources will be sensitively modified to withstand certain natural forces; systems will be in place to protect structures from fire, domestic water damage, and theft; plans will be in place for protecting or temporarily removing artifacts; safe display and storage of artifacts will be ensured; and necessary equipment, supplies, and human resources (rescuers or repair crews) will be available through an incident command system.

SITE DESIGN

SITE DESIGN

Site design is a process of intervention involving the sensitive integration of circulation, structures, and utilities within natural and cultural environments. The process encompasses many steps from planning to construction, including initial inventory, assessment, alternative analysis, detailed design, and construction procedures and services.

SUSTAINABLE SITE DESIGN PHILOSOPHY

In many places, the land is more damaged than previously believed. Soil erosion, groundwater contamination, acid rain, and other industrial pollutants are damaging the health of plant communities, thereby intensifying the challenge and necessity to restore habitats. As only one component of an interdependent natural system, the human species must develop a respect for the landscape and expend more effort understanding the interrelationships of soils, water, plant communities and associations, and habitats, as well as the impacts of human uses on them.

> *Sustainable design is not a reworking of conventional approaches and technologies, but a fundamental change in thinking and in ways of operating – you can't put spots on an elephant and call it a cheetah.*
>
> – Carol Franklin, Andropogon Associates, Ltd.

Beyond a change in basic approach, sustainable site design requires holistic, ecologically based strategies to create projects that do not alter or impair but instead help **repair** and **restore** existing site systems. Site systems such as plant and animal communities, soils, and hydrology must be respected as **patterns and processes of the living world**. These strategies apply to all landscapes, no matter how small or how urban.

Useful in understanding sustainable ecologically based site design are the "Valdez Principles for Site Design," developed by Andropogon Associates, Ltd. These strategies are precedent setting in their application and especially important to rightfully integrate the built environment into a setting or site.

- **Recognition of Context.** No site can be understood and evaluated without looking outward to the site context. Before planning and designing a project, fundamental questions must be asked in light of its impact on the larger community.

- **Treatment of Landscapes as Interdependent and Interconnected.** Conventional development often increases fragmentation of the landscape. The small remaining islands of natural landscape are typically surrounded by a fabric of development that diminishes their ability to support a variety of plant communities and habitats. This situation must be reversed. Larger whole systems must be created by reconnecting fragmented landscapes and establishing contiguous networks with other natural systems both within a site and beyond its boundaries.

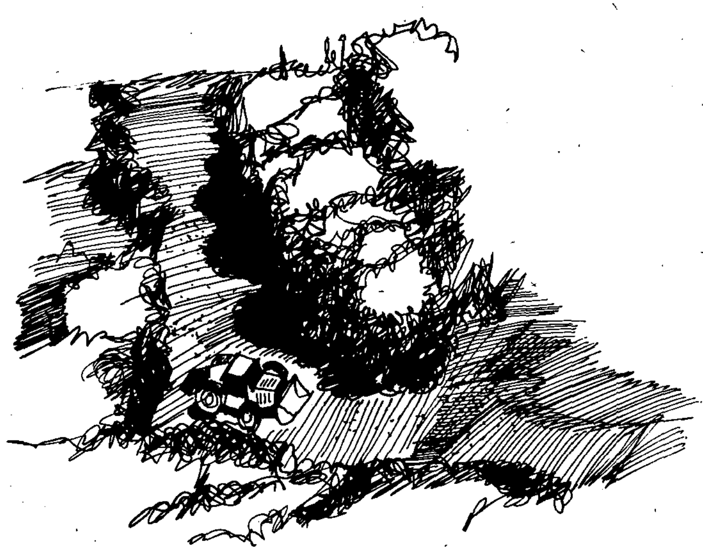
- **Integration of the Native Landscape with Development.** Even the most developed landscapes, where every trace of nature seems to have been obliterated, are not self-contained. These areas should be redesigned to support some component of the natural landscape to provide critical connections to adjacent habitats.

- **Promotion of Biodiversity.** The environment is experiencing extinction of both plant and animal species. Sustaining even a fraction of the diversity known today will be very difficult. Development itself affords a tremendous opportunity to emphasize the establishment of biodiversity on a site. Site design must be directed to protect local plant and animal communities, and new landscape plantings must deliberately reestablish diverse natural habitats in organic patterns that reflect the processes of the site.

- **Reuse of Already Disturbed Areas.** Despite the declining availability of relatively unspoiled land and the wasteful way sites are conventionally developed, existing built areas are being abandoned and new development located on remaining rural and natural areas. This cycle must be reversed. Previously disturbed areas must be reinhabited and restored, especially urban landscapes.

- **Making a Habit of Restoration.** Where the landscape fabric is damaged, it must be repaired and/or restored. As most of the ecosystems are increasingly disturbed, every development project should have a restoration component. When site disturbance is uncontrolled, ecological deterioration accelerates, and natural systems diminish in diversity and complexity. Effective restoration requires recognition of the interdependence of all site factors and must include repair of all site systems — soil, water, vegetation, and wildlife.

The above strategies can serve as policy guidelines in site design for developed areas of national parklands and challenge the design of appropriate ecotourism development.

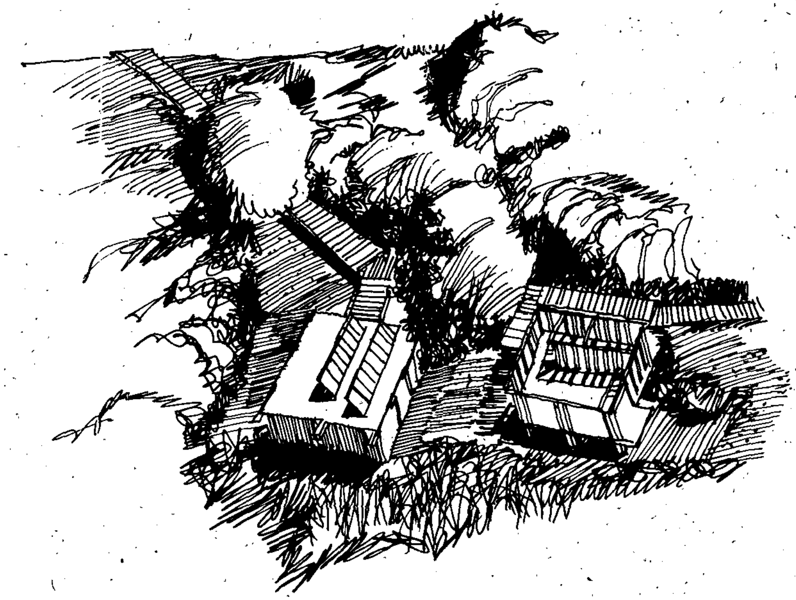


DESIGN AND CONSTRUCTION PROCESS

- Manage excavation to limit areas accessed by heavy equipment
- Build walks first – carry materials along walks
- Use photovoltaic power source for power tools

TRADITIONAL VS. SUSTAINABLE DEVELOPMENT

Sustainable site design reinforces the holistic character of a landscape. It conveys appreciation of, and respect for, the interrelationships of all parts of the natural systems and cultural context of the site. Using a resort as a model, the difference in focus between traditional and sustainable development can be illustrated (see table 4).



ENVIRONMENTALLY SENSITIVE DESIGN

- Small buildings fit between existing vegetation
- Cisterns under units for rainwater collection
- Wind scoops for natural cooling
- Orientation of buildings corresponds to prevailing winds
- Heat reflective materials in windows, roofs and exterior walls

TABLE 4: COMPARISON OF TRADITIONAL AND SUSTAINABLE DEVELOPMENTS

Activity	Traditional Development	Sustainable Development
Objectives	Traditional development consists of identifying target customers and assessing their desires, and then trying to make visitors comfortable in familiar surroundings and in heavily manipulated environments. Typically, much of the site is totally reconfigured with pools, patios, terraces, and vegetative compositions. The experience is very controlled and reflects the view that earth's resources are for human use.	Sustainable development for tourism focuses on the preservation and interpretation of indigenous natural and cultural resources rather than creating a contrived or artificial environment. The development accentuates the indigenous natural and cultural assets while respecting resource constraints. The basic programmatic objective of sustainable development is to help visitors appreciate the natural and cultural uniqueness of a site by bringing them physically closer to it. To achieve this, the development must be human-scaled and intimate so that sensory features of the native landscape, such as sights, smells, and sounds, are appreciated and preserved. The basic environmental objective is to achieve these experiences within acceptable limits of change. If these objectives cannot be achieved on the same site, the development cannot be justified.
Site Planning and Design	The traditional approach to site planning and design begins with collecting and mapping data pertinent to site development. A good geographic information system (GIS) is a practical method for collecting data on biological (vegetation, wildlife), physical (topography, soils, climate) and cultural (ownership, legal, historical) factors. Analysis for preliminary design then combines and compares these data to determine the best areas for development and the areas in which development would be very difficult, costly, or environmentally unsound. The major steps in a traditional approach to site planning and design are as follows: • Inventory site factors • Analyze opportunities and constraints • Design according to site suitabilities	The sustainable approach to site planning and design goes beyond combining and comparing site inventories. A sustainable process attempts to determine the relationships between site factors and how those factors will adapt to change. Understanding these relationships also clarifies how development impacts from one area of the site will affect other areas. An evaluation of potential development impacts requires that a predevelopment baseline or environmental model be produced. This model will describe the essential functions and interrelationships of the individual site factors and will establish acceptable limits of change during and after construction. Selected environmental monitoring and testing will be done during construction. The entire build-out of the development will be phased to allow time between construction projects to monitor environmental impacts and adjust the baseline model. The major steps in a sustainable approach to site planning and design are as follows: • Model the ecosystem to establish an environmental understanding • Assess social-economic context • Establish acceptable limits of change • Design facility within social and environmental thresholds • Monitor site factors throughout construction • Reevaluate design solutions between development phases

GENERAL SITE DESIGN CONSIDERATIONS

The following general considerations apply to sustainable site design:

- Promote spiritual harmony with, and embody an ethical responsibility to, the native landscape and its resources.
- Plan landscape development according to the surrounding context rather than by overlaying familiar patterns and solutions.
- Maintain both ecological integrity and economic viability in a sustainable development; both are equally important factors in the development process.
- Understand the site as an integrated ecosystem with changes occurring over time in dynamic balance; the impacts of development must be confined within these natural changes.
- Allow simplicity of functions to prevail, while respecting basic human needs of comfort and safety.
- Recognize there is no such thing as waste, only resources out of place.
- Assess feasibility of development in long-term social and environmental costs, not just short-term construction costs.
- Analyze and model water and nutrient cycles prior to development intervention — "First, do no harm."
- Minimize areas of vegetation disturbance, earth grading, and water channel alteration.
- Locate structures to take maximum advantage of passive energy technologies to provide for human comfort.
- Provide space for processing all wastes created onsite (collection/recycling facilities, digesters, lagoons, etc.) so that reusable/recyclable resources will not be lost and hazardous or destructive wastes will not be released into the environment.
- Determine environmentally safe means of onsite energy production and storage in the early stages of site planning.
- Phase development to allow for the monitoring of cumulative environmental impacts of development.
- Allow the natural ecosystem to be self-maintaining to the greatest extent possible.
- Develop facilities to integrate selected operational functions such as energy conservation, waste reduction, recycling, and resource conservation into the visitor experience.
- Incorporate indigenous materials and crafts into structures, native plants into landscaping, and local customs into programs and operations.

SPECIFIC SITE DESIGN CONSIDERATIONS

Site Selection

Premises. What makes a region or site attractive for recreational development? First and foremost, it must possess outstanding natural or otherwise unique characteristics — e.g., beaches, mountains, forests, lakes, rivers, oceans, landforms, cultural resources — that visitors will want to experience. Siting of visitor facilities focuses on these natural characteristics, and the site inventory and analysis should clearly identify the quality and extent of these geographic features. A site may also be attractive for its proximity to a feature or merely its remoteness from other development.

The environmental characteristics that make an area attractive to visitors may also pose problems. Some attractive areas may be very sensitive to disturbance and unable to withstand impacts of human activity. The limits of acceptable environmental change may be small for these areas, allowing only low density use to maintain a sustainable environmental quality. Other attractive areas may be too remote to justify development for direct visitor use. Conversely, some areas may be too close to safety hazards or overly developed to be appropriate for park or ecotourism development. However, some degraded areas may in fact provide opportunities for visitor development, allowing more options for site preservation and ecological restoration.

Many recreational developments are in remote locations, often at the "end of the line," making many product inputs and outputs quite expensive and environmentally consumptive.

The site selection process must pose the following questions:

- Can development impacts on a site be minimized?
- What inputs (energy, material, labor, products) are necessary to support a development option, and are required inputs available?
- Can waste outputs (solid waste, sewage effluent, exhaust emissions) be dealt with at acceptable environmental costs?

The process of site selection for sustainable developments is one of identifying, weighing, and balancing the attractiveness (natural and cultural environments, access) of a site against the costs inherent in its development (natural and cultural environments, access, hazards, energetics, operations). The characteristics of a region or site should be described spatially (either conventional or computer-generated maps) to provide a precise geographic inventory. Spatial zones meeting programmatic objectives, within acceptable environmental parameters, are likely development sites.

Factors. The programmatic requirements and environmental characteristics of sustainable development will vary greatly, but the following factors should be considered in site selection:

- **Capacity** — As difficult as it can be to determine, every site has a carrying capacity for development and human activity. A detailed site analysis should determine this capacity based on the sensitivity of site resources and the ability of the land to regenerate.
- **Density** — Siting of facilities should carefully weigh the relative merits of concentration versus dispersal. Natural landscape values may be easier to maintain if facilities are carefully dispersed. Conversely, concentration of structure leaves more undisturbed natural areas.
- **Climate** — Environments for resource-related developments range from rain forest to desert. The characteristics of a specific climate should be considered when locating facilities so that human comfort can be maximized while protecting the facility from climatic forces such as violent storms and other extremes.
- **Slopes** — In many park and recreational environments steep slopes predominate, requiring special siting of structures and costly construction practices. Building on slopes considered too steep can lead to soil erosion, loss of hillside vegetation, and damage to fragile wetland and marine ecosystems. Appropriate site selection should generally locate more intensive development on gentle slopes, dispersed development on moderate slopes, and no development on steep slopes.
- **Vegetation** — It is important to retain as much existing native vegetation as possible to secure the integrity of the site. Natural vegetation is often an essential aspect of the visitor experience and should be preserved. Site selection should maintain large habitat areas and avoid habitat fragmentation and canopy loss. In some areas such as the tropics, most nutrients are held in the forest canopy, not in the soil — loss of canopy therefore causes nutrient loss as well. Plants live in natural associations (plant communities) and should remain as established naturally.
- **Views** — Views are critical and reinforce a visitor experience. Site location should maximize views of natural features and minimize views of visitor and support facilities.
- **Natural Hazards** — Sustainable development should be located with consideration of natural hazards such as precipitous topography, dangerous animals and plants, and hazardous water areas. Site layout should allow controlled access to these features.
- **Access to Natural and Cultural Features** — Good siting practices can maximize pedestrian access to the wide variety of onsite and offsite resources and recreational activities. Low-impact development is the key to protecting vital resource areas.
- **Traditional Activities** — Siting should be compatible with traditional agricultural, fishing, and hunting activities. Some forms of recreational development that supplant traditional land uses may not be responsive to the local economy.

- **Energy and Utilities** — Conventional energy and utility systems are often minimal or nonexistent in potential park and ecotourism areas. Siting should consider possible connections to offsite utilities, or more likely, spatial needs for onsite utilities. The potential exists for alternative energy use in many places, particularly solar- and wind-based energy systems. Sustainable site design considers these opportunities.

- **Separation of Support Facilities from Public Use Areas** — Safety, visual quality, noise, and odor are all factors that need to be considered when siting support services and facilities. These areas need to be separated from public use and circulation areas. In certain circumstances, utilities, energy systems, and waste recycling areas can be a positive part of the visitor experience.

- **Proximity of Goods, Services, and Housing** — Park and ecotourism developments require the input of a variety of goods and services and often large staffs for operation. Siting should consider the availability of these elements and the costs involved in providing them.

Site Access

Site access refers to not only the means of physically entering a sustainable development but also the en route experience. For example, the en route experience could dramatize the transitions between origin and destination with obvious sequential gateways, or it could provide opportunities for interpretation and/or education. Other considerations for enhancing the experience of accessing a developed area include

- selecting corridors to limit environmental impacts and control development along the corridor leading to the facility
- providing anticipation and drama by framing views or directing attention to landscape features along the access route
- providing a sense of arrival at the destination

Site access can be achieved by various means of travel, including pedestrian, transit systems, private vehicles, boats, and aircraft. These transportation means impose limitations on users based on the capabilities of the traveler or the capacity of the particular transportation mode. Transportation means that are the least polluting, quiet, and least intrusive in the natural environment are the most appropriate for a sustainable development. Where environmental or other constraints make physical access impossible, remote video presentation may be the only way for people to access a site. The need to construct a road into a site is the first critical decision to be made. Building a road into a pristine site should be considered a serious intervention that will change the site forever. Roads tend to create irreversible impacts.

Road Design and Construction. A curvilinear alignment should be designed to flow with the topography and add visual interest; crossing unstable slopes should be avoided. Steep grades should be used as needed to lay road lightly on the ground, and retaining walls should be included on cut slopes to ensure long-term slope stability. The road should have low design speeds (with more and tighter curves) and a narrower width to minimize cut-and-fill disturbance. Overengineering of roads in resource-sensitive areas should be avoided.

Access corridors should be provided for multiple purposes — e.g., visitors, maintenance, security, emergency vehicles, underground utilities. Secondary access (road, dock, or helicopter landing site) should always be provided to permit emergency entry and evacuation in the event of a natural disaster. Multiuse corridors can be effective, especially in preconstruction planning. Using the same road during construction can limit site degradation and relandscaping.

Many soils are highly susceptible to erosion. Vegetation clearing on the road shoulders should be minimized to limit erosion impacts and retain the benefits of greenery. All fill slopes should be stabilized and walls provided in cut sections where needed. Exposed soils should be immediately replanted and mulched. Paved ditches are frequently used to stem erosion along steep road gradients. Whenever possible, landscape solutions that render a softer appearance are preferable to hard-surfaced approaches.

Unpaved surfaces are appropriate in areas of stable soils, lower slopes, and low traffic loads, but they require more maintenance. Permeable paved surfaces allow limited percolation of precipitation while providing better wear than unpaved surfaces. Impermeable paved surfaces are needed for roads with the highest load and traffic requirements. Whenever possible, recycled materials should be used in the construction of the surfacing, e.g., crushed glass, shredded rubber tires, or recycled aggregate. The surfacing material should blend with predominant landscape tones. Contractual arrangements should be developed with local businesses for the reuse/recycling of any construction waste.

Other Access Improvements. It is imperative that ship channels do not traverse or that boat docks are not constructed over fragile marine environments such as coral reefs. Marine facilities should be developed to allow natural beach sand movement to continue unimpeded. Permanent anchor buoys should be installed in harbor areas to mitigate anchor damage to underwater environments.

Airstrip and approach flight paths should be located safely and to protect visitor and residential developments from visual and noise impacts of airplanes. Permeable pavements should be used to increase water recharge and lessen runoff.

Core Site Access. Access within recreation-related development is typically pedestrian. Automobiles are usually restricted to the edges of the development. Paths should be laid out to avoid sensitive resources and be built at-grade. In areas that are particularly environmentally sensitive or very steep, elevated walkways can be used. Elevated walkways also limit indiscriminate pedestrian access to fragile vegetation.

While all visitor facilities should be accessible to visitors with disabilities, some natural features and site opportunities may by their very nature limit total accessibility. Rather than forcing unacceptable physical disturbance to make these areas accessible or precluding access to all visitors with disabilities, the concept of challenge levels should be used. The degree of difficulty is determined and made known to visitors in advance much the same way ski slopes are classified as beginner, intermediate, or expert. Challenge levels assume that while key facilities will be readily accessible to all visitors, other sections of the park or ecotourism development will be more difficult to access, and will involve some sense of adventure and accomplishment.

Utilities and Waste Systems

Utility Systems. With the development of a site comes the need for some level of utility systems. Even the smallest human habitat requires sanitary facilities for human waste and provisions for water. More elaborate developments have more extensive systems to provide water, waste treatment, and energy for lighting, heating, cooling, ventilation, etc. The provision of these services and the appurtenances associated with them may create adverse impacts on the landscape and the functioning of the natural ecosystem. Early in the planning process utility systems must be identified that will not adversely affect the environment and will work within established natural systems. After appropriate systems are selected, careful site planning and design is required to address secondary impacts such as soil disturbance and intrusion on the visual setting.

Utility Corridors. Due to environmental impacts of utility transmission lines, onsite generation and wireless microwave receivers are preferred. When utility lines are necessary, they should be buried near other corridor areas that are already disturbed, such as roads and pedestrian paths. Overhead lines should not be located in desirable viewsheds or over landform crests. Low-impact alternatives for utility lines such as shielded conduit placed on the ground or on low pedestal mounts should be considered. Many utility lines can be concealed under boardwalks and thereby eliminate ground disturbance.

Utility System Facility Siting. Sustainability considerations for the development of the infrastructure include reduction of scale, dispersal of facilities, and the use of terrain or vegetative features to visually screen intrusive structures. Mechanical equipment noise and treatment odors are nuisance factors that must be mitigated by site location and buffering. The exception to this rule may be to feature alternative utility systems for the purposes of interpretation for the environmentally conscious visitor.

Night Lighting. The nighttime sky can be dramatic. Light intrusion and overlighting glare can obscure what little night vision is available to humans. Care is required to limit night lighting to the minimum necessary for safety. Urban lighting standards do not apply. Low-voltage lighting with photovoltaic collectors should be considered as an energy-efficient alternative. Light fixtures should remain close to the ground to minimize eye level glare.

Storm Drainage. In undisturbed landscapes, storm drainage is typically handled by vegetation canopy, ground cover plants, soil absorption, and streams and waterways. In a modified landscape, consideration must be given to the impacts of storm drainage on the existing natural system of drainage and the resulting structures and systems that will be necessary to handle the new drainage pattern. The main principles in storm drainage control are to regulate runoff to provide protection from soil erosion and avoid directing water into unmanageable volumes. Removal of natural vegetation, topsoil, and natural channels that provide natural drainage control should always be avoided. An alternative would be to stabilize soils, capture runoff in depressions (to help recharge groundwater supply), and revegetate areas to replicate natural drainage systems.

Irrigation Systems. Low-volume irrigation systems are appropriate in most areas as a temporary method to help restore previously disturbed areas or as a means to support local agriculture and native traditions. Restoration projects should consider the use of ultraviolet-tolerant irrigation components laid on the surface of the soil and removed when native plants have become established. Irrigation piping can be reused on other restoration areas or incorporated into future domestic hydraulic systems. Captured rain water, recycled gray water, or treated effluent could be used as irrigation water.

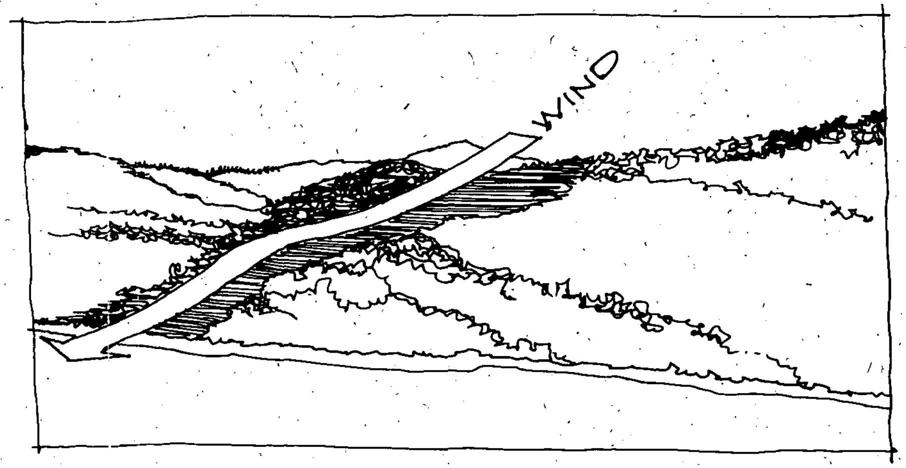
Waste Treatment. It is important to use treatment technologies that are biological, nonmechanical, and do not involve soil leaching or land disposal that causes soil disturbance. While a septic system can be considered, treatment methods that result in useful products such as fertilizer and fuels should be investigated. Land-intensive methods that significantly alter the natural environment may not be appropriate in sensitive environments. Constructed biological systems are being put to use increasingly to purify wastewater. They offer the benefits of being environmentally responsive, nonpolluting, and cost-effective. (See "Waste Prevention" section for more specific information.)

Site-Adaptive Design Considerations

Increased ecological knowledge is at the core of sustainable design. Instead of human functional needs driving the site design, site components need to respond to the indigenous spatial character, climate, topography, soils, and vegetation as well as be compatible with the existing cultural context. For example, when facilities conform to constraints of existing landforms and tree locations, the character of the existing landscape will be largely maintained. Natural buffers and small openings can be used for privacy rather than artificially produced through planting and clearing. Hilly topography and dense vegetation can provide natural ways of separating site components.

Natural Characteristics. Of greatest help in achieving sustainable site design is to realize that much can be learned from nature. When nature is incorporated into designs, spaces can be more comfortable, interesting, and efficient. It is important to understand natural systems and the way they interrelate in order to work within these constraints with the least amount of environmental impact. Like nature, design should not be static but always evolving and adapting to interact more intimately with its surroundings.

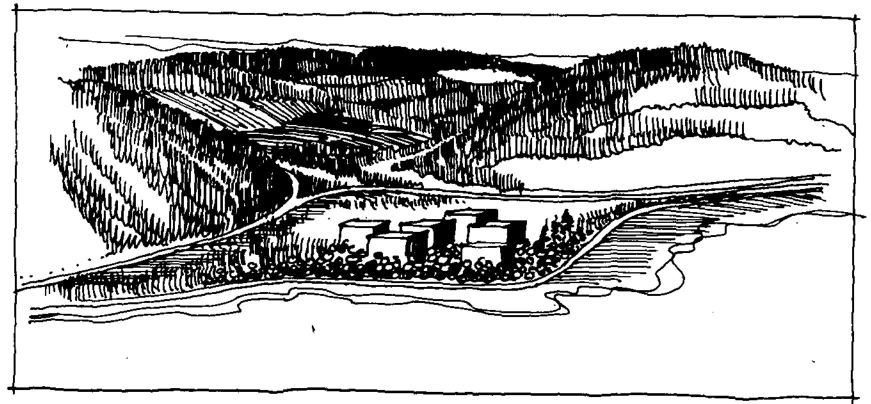
- **Wind** — The major advantage of wind in recreational development is its cooling aspect. For example, trade winds in the Caribbean come from the northeast to the southeast quadrant, so many of the structures and outdoor gathering places of the native population are oriented to take advantage of this cooling wind movement, or "natural" air conditioning. Native cultures understand this technique quite well, and local structures reflect these principles.



- **Sun** — Where sun is abundant, it is imperative to provide shade for human comfort and safety in activity areas (e.g., pathways, patios). The most economical and practical way is to use natural vegetation, slope aspects, or introduced shade structures. Additional solar considerations for environmentally responsive site design include orientation of facilities to capitalize on daylighting and photovoltaic opportunities.

- **Rainfall** — Even in tropical rain forests where water is seemingly abundant, clean potable water is often in short supply. Many settings must import water, which substantially increases energy use and operating costs, and makes conservation of water important. Rainfall should be captured for a variety of uses (e.g., drinking, bathing) and this water reused for secondary purposes (e.g., flushing toilets, washing clothes); see "Water Supply" section. Wastewater or excess runoff from developed areas should be channeled and discharged in ways that allow for groundwater recharge instead of soil erosion. Minimizing disturbance to soils and vegetation and keeping development away from natural drainageways protects the environment as well as the structure.

- **Topography** — In many areas, flatland is at a premium and should be set aside for agricultural uses. This leaves only slopes upon which to build. Slopes do not have to be an insurmountable site constraint if innovative design solutions and sound construction techniques are applied. Topography can potentially provide vertical separation and more privacy for individual structures. Changes in topography can also enhance and vary the way a visitor experiences the site by changing



intimacy or familiarity (e.g., from a canyon walk to sweeping hillside overview). Again, protection of native soil and vegetation are critical concerns in high slope areas. Reducing the size of the footprint of development, eliminating the use of automobiles and their parking requirements, elevating walkways, and using point footings for structures are appropriate design solutions to this problem.

- **Geology and Soils** — Designing with geologic features such as rock outcrops can enhance the sense of place. For example, integrating rocks into the design of a deck or boardwalk brings the visitor in direct contact with the resource and the uniqueness of a place. Soil disturbances should be kept to a minimum to avoid erosion of fragile fertile soils and to discourage growth of exotic plants. If a limited amount of soil disturbance must take place, a continuous cover over disturbed soils with erosion control netting should always be maintained.

- **Aquatic Ecosystems** — Development near aquatic areas must be based on an extensive understanding of sensitive resources and processes. In most cases, development should be set back from the aquatic zone and protective measures taken to address indirect environmental impacts. Particularly sensitive habitats such as reefs and marshes should be identified and protected from any disturbance. Harvesting of any aquatic resources should be based on definitive assessment of sustainable yield and subsequently monitored and regulated.

- **Vegetation** — Exotic plant materials, while possibly interesting and beautiful, are not amenable to maintaining healthy native ecosystems. Sensitive native plant species need to be identified and protected. Existing vegetation should be maintained to encourage biodiversity and to protect the nutrients held in the biomass of native vegetation. Native planting should be incorporated into all new developments on a 2:1 ratio if any native plants are removed. Vegetation can enhance privacy, create "natural rooms," and provide a primary source of shade. Plants also contribute to the visual integrity or natural fit of a new development in a natural setting. In some cases, plants can provide opportunities for food production and other useful products on a sustainable basis.

- **Wildlife** — Sensitive habitat areas should always be avoided. Encouraging wildlife to remain close to human activity centers enhances the visitor experience. This can be achieved by maintaining as much original habitat as possible. Creating artificial habitats or feeding wildlife could have disruptive effects on the natural ecosystem and should normally be avoided.

- **Visual Character** — Natural vistas should be used in design whenever possible. Creating onsite visual intrusions (road cuts, utilities, etc.) should be avoided and views of offsite intrusions carefully controlled. A natural look can be maintained by using native building material, hiding structures within the vegetation, and working with the topography. It is easier to minimize the building footprint initially than it is to heal a visual scar at the end of construction.

Cultural Context. Local archeology, history, and people are the existing matrix into which visitation must fit. Sustainability principles seek balance between existing cultural patterns and new development. Promoting an understanding of local cultures and seeking their input in the development processes can make the difference between acceptance and failure. (See "Cultural Resources" section.)

- **Archeology** — A complete archeological survey prior to development is imperative to preserving resources. Once resources are located, they can be incorporated into designs as an educational or interpretive tool. If discovered during construction activities, work should be stopped and the site reevaluated. Sacred sites must be respected and protected.

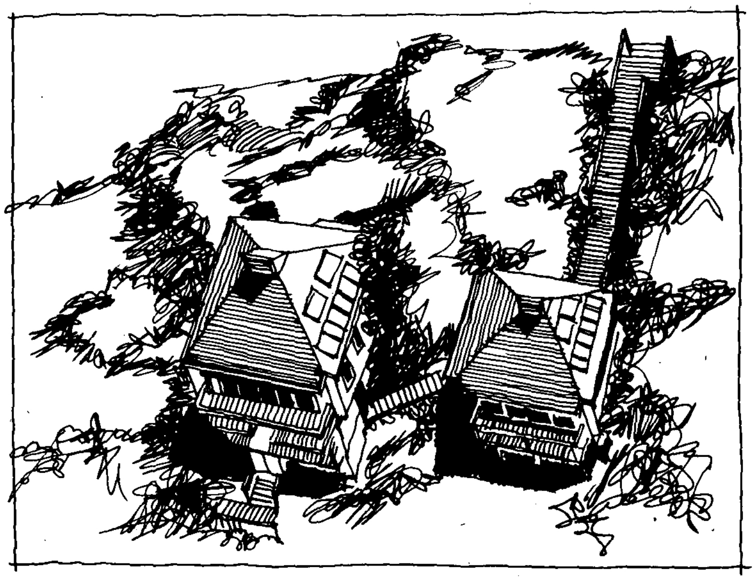
- **History** — Cultural history should be reinforced through design by investigating and then interpreting vernacular design vocabulary. Local design elements and architectural character should be analyzed and employed to establish an architectural theme for new development.

- **Indigenous Living Cultures** — Cultural traditions should be encouraged and nurtured. A forum should be provided for local foods, music, art and crafts, lifestyles, dress, and architecture, as well as a means to supplement local incomes (if acceptable). Traditional harvesting of resource products should be permitted to reinforce local cultural values *if* the resource is renewable and sustainable.

Construction Methods and Materials

The complexity of construction is magnified in park and ecotourism areas by the value of the resource, physical remoteness, and the limited availability of craftsmen and materials. The goal to leave the landscape visually unimpaired after development drives the need to evaluate every construction method and material used. Vernacular construction techniques, local economic development, and locally available building materials should be used as long as they do not adversely affect the natural and cultural resources of the area. The methods and techniques used should ensure that there will be no residual signs of construction or environmental damage. The products and materials specified should be nontoxic, renewable or recyclable, and environmentally responsible. (See "Building Design" section.)

Certain site design strategies may be discouraged based on the probable environmental impacts of the construction methods necessary to build them. Providing fewer vehicular roads and more pedestrian circulation paths may allow smaller structures in a more dispersed arrangement and be a means of providing greater experience of the landscape. The desire to incorporate structures sensitively into the landscape may suggest the use of a few small light structures in place of one larger one. For example,



warm climate residences may combine outdoor or semioutdoor living, cooking, or bathing facilities with enclosed sleeping facilities to reflect local custom and create less disturbance to the site.

Construction Process Program. This required program serves as a primer for developers, construction contractors, and maintenance workers. The plan covers materials, methods, testing, and options. Careful organization and sequencing of construction is emphasized. Examples include building walkways first, then using them as access to the site. Also it is important to plan material staging for areas in conjunction with future facilities. A knowledgeable construction supervisor must be involved, and all new construction methods should be tested in a prototypical first phase. Maintenance and operations staff should also be involved in this construction program and should participate in the development of an operations manual.

Construction Limits and Landscape Features. All undisturbed soil and vegetation located outside specifically designated construction limits should be fenced or otherwise protected (e.g., drop cloths, tree barriers). Where disturbance occurs, the site should be restored as soon as possible. All topsoil from construction areas should be collected for use in site restoration. Preplanning the construction process will help identify alternative methods that minimize resource degradation. Flexibility in revising construction plans should be allowed to change materials and construction methods based on actual site impacts. Not all of the design will be constructed as drawn; therefore, the construction supervisor must be knowledgeable of the design intent and project environmental philosophy of the project to redesign or adapt it as necessary. Throughout construction, resource indicators should be monitored to ensure that resources are not being adversely affected.

Native Landscape Preservation/Restoration

Preservation of the natural landscape is of great importance during construction because it is much less expensive and more ecologically sound than subsequent restoration. Preservation entails carefully defining the construction zone; do not "clear and grub" any unnecessary soil areas because it encourages volunteer exotic growth in scarred areas.

Restoration of native planting patterns should be used when site disturbances are unavoidable. All native plants disturbed by the construction should be saved, healing them first in a temporary nursery. The site should be replanted with native materials in a mix consistent with that found in a natural ecosystem. In some instances, native materials should be used compositionally to achieve drama and visual interest for human benefit.

Noxious or toxic plant materials should not be used adjacent to visitor facilities. Eradication or control of exotic species should be considered, without creating negative effects on native plants. Some exotics are relatively benign; others are highly invasive. There should be an awareness of the hazards of removing exotics that may have displaced a native species, but in the process achieved a useful or even symbiotic relationship with other native plants. Ideally, plantings of native materials to control exotics should be used. Water for new plantings can be provided by locating plants in drainage swales or using temporary irrigation. New plantings should be mulched with forest cover.

Interpretation of the restoration areas will inform and educate the public on the value of native landscape restoration. Protection of existing resources in the ecosystem is the fundamental purpose of sustainable design.

Visitor Safety and Security

The design of a park or ecotourism development involves a closer, more integrated relationship of visitors with nature. To some extent, this concept is contrary to some conventional provisions for visitor security and safety. Visitor awareness of the natural surroundings is the best safety insurance. Written and personal briefings by staff could help foster awareness of safety risks and allow visitors to take responsibility for their own safety and security.

Some important design considerations are as follows:

- Visitors must have a sense of personal safety and security to be attracted to recreation areas. The facility must have reasonable provisions to protect visitors from natural and manmade hazards. Location of walks and lodging must be designed to discourage visitor contact with dangerous plants or animals.
- The design should consider safety from climate extremes; visitors may be unaware of natural hazards, including intense sun, high wind, heavy rainfall, and extreme humidity.
- Ecological integrity must be balanced with safety concerns in a development where adventure and challenge are integral to the experience. Various challenge levels in site facilities should be provided to accommodate all visitors, including visitors with disabilities.
- The use of artificial lighting should be limited to retain natural ambient light levels — baffle lights or use ground-mounted light fixtures to limit spillover light impacts while providing a basic sense of security.
- Appropriate atmosphere and security can be enhanced by remote location and controlled access to the facilities — incorporate natural barriers into facility design to minimize need for security fencing or barriers.
- An alternate means of access should be available to provide essential emergency provisions of water, food, and medicine, and a reliable communication system.

BUILDING DESIGN

BUILDING DESIGN

SENSE OF PLACE

The concept known as bioregionalism is based on the idea that all life is established and maintained on a functional community basis and that all of these distinctive communities (bioregions) have mutually supporting life systems that are generally self-sustaining. Human civilization is an integral part of the natural world and is dependent on the preservation of nature for its own perpetuation. Over the ages the complex interaction of natural evolution and human adaptation has given every place on earth a unique set of qualities that sets it apart from all other places.

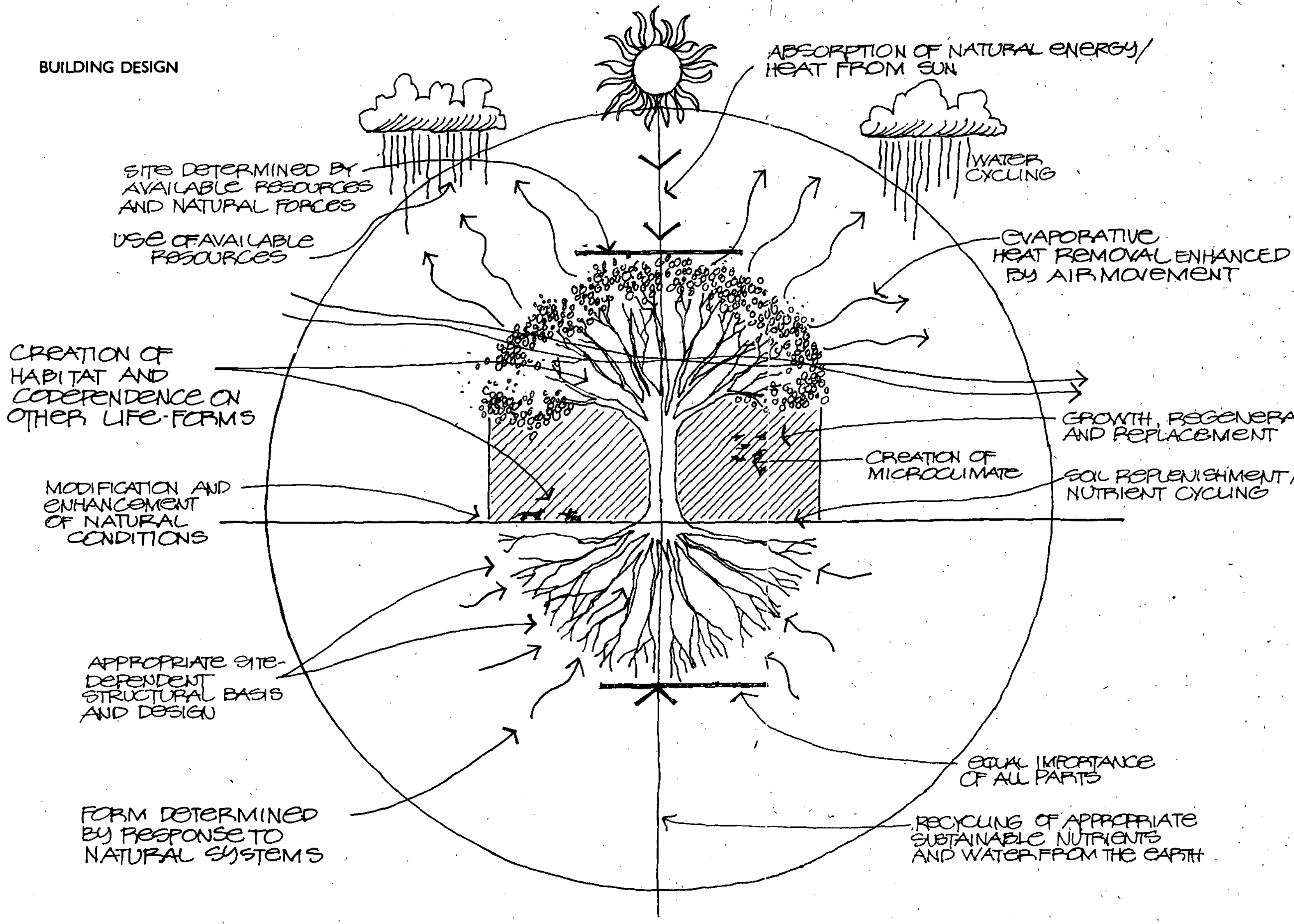
Preserving the special characteristics of a place requires in-depth understanding of the natural systems in place and immersion into the time-tested cultural responses to that environment's assets and liabilities. In meeting the needs of the human community, development must be designed and built with an awareness of the interrelationships between natural, cultural, social, and economic resources both locally and globally. Development must be limited to improving human life within the carrying capacity of resources and ecosystems. Development must not be an economic activity fueling the belief in endless growth. Thus the goal of sustainable development and sustainable building design is to create optimum relationships between people and their environments. More specifically, sustainable development should have the absolute minimal impact on the local, regional, and global environments. Planners, designers, developers, and operators have **an opportunity and a responsibility to protect the sanctity of a place, its people, and its spirit.**

It is the uniqueness of certain environments that creates the curiosity for tourism and the desire to experience their special relaxative, recuperative, or recreative qualities. In providing facilities and activities for visitors, special care must be taken not to destroy the very resources or qualities they come to experience. This requires built environments that can sensitize and educate its users. Those responsible for park and ecotourism developments must recognize that by providing knowledge of the environment, they create the knowledge that is necessary to protect it.

SUSTAINABLE BUILDING DESIGN PHILOSOPHY

Sustainable design balances human needs (rather than human wants) with the carrying capacity of the natural and cultural environments. It minimizes environmental impacts, importation of goods and energy, as well as generation of waste. The ideal situation would be that if development was necessary, it would be constructed from natural sustainable materials collected onsite, generate its own energy from renewable sources such as solar or wind, and manage its own waste.

Sustainable design is an ecosystematic approach that demands an understanding of the consequences of certain actions. As a tool to understanding this principle, a metaphoric example is drawn using an organism to symbolize functional appropriateness, habitat harmony, and survival based on adaptation and cultivation.



The organism makes use of immediately and locally available materials to construct itself, and does so with economy and efficiency. The same strategies when used in development can minimize global and local impacts on resources.

The organism adapts to its environment through instinctive reaction and an evolutionary process of generations. Through the ability to rationalize and mechanize, humans have the ability to adapt psychologically and physically in a matter of hours, but with little instinct for harmony with the environment.

The organism maintains a harmonious relationship with its environment by establishing a balance between its needs and available resources. Similarly, the ecologically sensitive design adjusts demands, lifestyles, and technologies to evolve a compatible balance with the natural and cultural systems within its environment.

UNDERSTANDING RESOURCE-SENSITIVE DESIGN

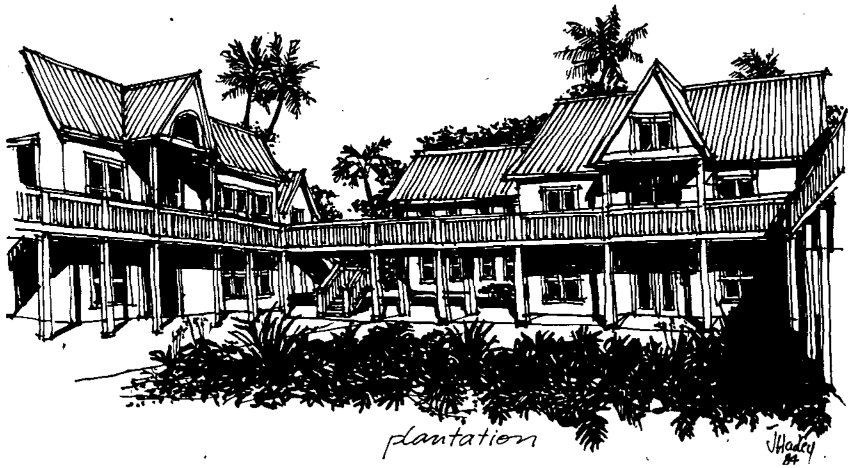
One method of describing sustainable building design is to compare it to other forms of resource-based development. Metaphorical interpretation of traditional forms of tourist resorts provides insight into the relationship that their facilities and visitors have with the resources on which they are based. Although obviously attempting to capitalize on available resources, few resort developments actually provide or can sustain a harmonious relationship with those resources.

Plantation

The plantation represents a significant piece of the history of many tropical, subtropical, and temperate areas. Characteristics of the traditional plantation include:

- a strong hierarchial organization of building forms (i.e., large main buildings for owners and visitors, small outbuildings for laborers, animals, agricultural processes, and storage)
- exploitation/importation of energy such as by slavery
- environmental degradation through the removal of native plant material and the introduction of cash crops with an emphasis on profit rather than the environment
- importation and exportation as primary operational mode, including exportation of capital
- to some extent, importation of building forms and technologies

For centuries, the plantation model carried many negative connotations as a result of these very characteristics. Although representational of a harsh disregard for local natural and cultural resources, the plantation model can be seen in design and operation of numerous tourist resorts around the world. All too often, tourist-related development is conceived as a resource in and of itself. The indigenous natural and cultural curiosities that lure visitors to the site are disrupted, depleted, or displaced by the contrived environment of the development. This type of plantation approach to tourism development satisfies its own needs through exploitation and importation, rather than through harmonic integration with its host environment.



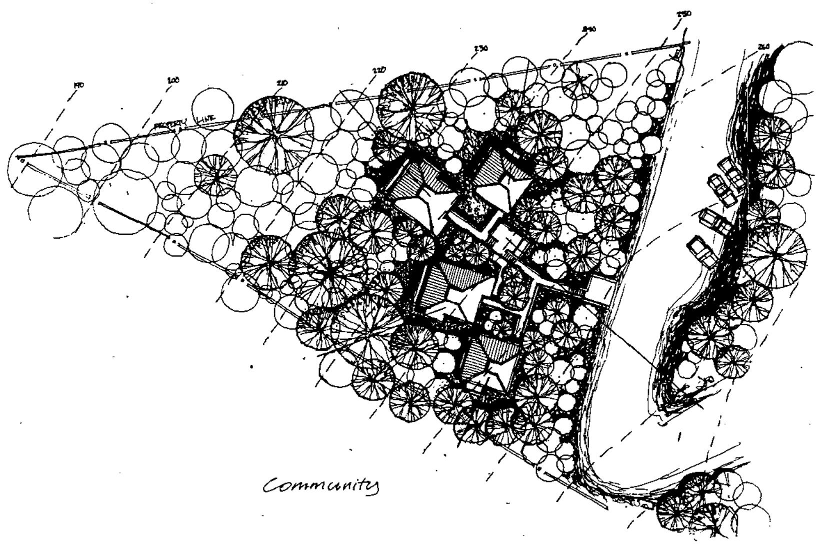
Community

The community metaphor depicts resorts focused on activity more than the built environment. Characteristics of the activity-related resort include:

- dispersion of building units in a functional but nonhierarchial pattern; oftentimes the resorts are conceptualized as "villages"
- strong interaction of staff and visitors in a more democratic manner than the plantation model
- integration of maintenance and operational staff into the life of the resort as a necessary element to sustain its operation

- resource-based activities that override concern for the local ecology or interest in interaction with native culture

While the community model recognizes a dependency on the resources for its activities, it makes marginal investment in sustaining the health of those resources and typically operates in isolation from the local community.

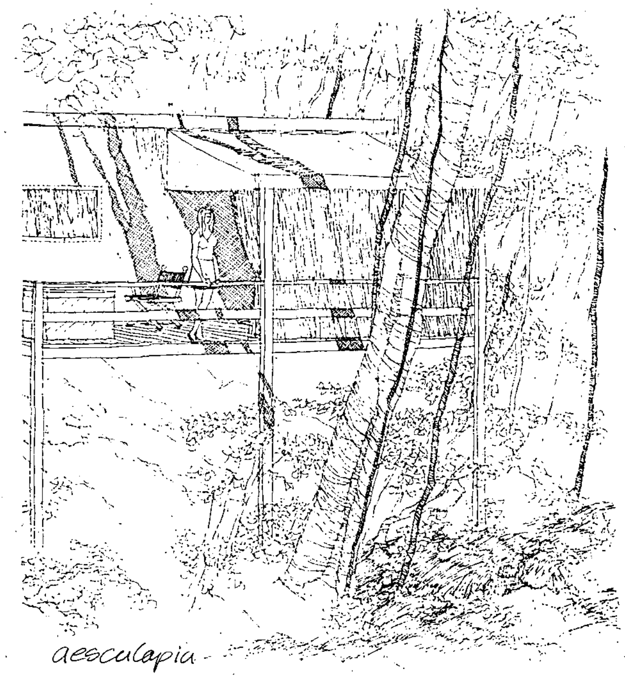


Aesculapia

A more appropriate metaphor for resource-related design may be Aesculapia, the Greek place of healing. In this model, nature is respected for its restorative qualities. The human experience is set in harmony with the environment, and an opportunity is created to allow a reconnection of human needs to the natural systems on which all life is based. Applying these objectives to a park or ecotourism area, any visitor development would embrace the following characteristics:

- the visitor experience must incorporate the primary senses (sight, hearing, smell, taste, and touch) to enhance understanding of the environment's uniqueness

- the visitor experience (to be healing) must involve an organic connection with the natural and cultural context of the surroundings so as to appreciate their worth and to seek ways to minimize biological disturbances



SUSTAINABLE TOURISM DEVELOPMENT

Today's increasing demand for park and ecologically oriented tourism experiences provides a prime opportunity for applying the attributes of Aesculapia. As ecotourists seek close involvement with authentic natural and cultural experiences, Aesculapian-based building design could establish a "rite of passage" to place human activities in harmony with local, regional, and global resources. The resulting sustainable development would serve as a "classroom" to demonstrate environmental conservation, understanding and respect for indigenous cultures and resources, and ways to live environmentally better in the 21st century.

Following are criteria or standards that a sustainable park and ecotourism development should strive to meet:

- Provide education for visitors on wildlife, native cultural resources, historic features, or natural features.
- Involve indigenous populations in operations and interpretation to foster local pride and visitor exposure to traditional values and techniques.
- Accomplish environmental restoration.
- Provide research and development for, and/or demonstration projects of, ways to minimize human impacts on the environment.
- Provide spiritual or emotional recuperation.
- Provide relaxation and recreation.
- Educate visitors that knowledge of our local and global environment is valuable and will empower their ability to make informed decisions.

SUSTAINABLE BUILDING DESIGN OBJECTIVES

The long-term objective of sustainable design is to minimize resource degradation and consumption on a global scale. Thus the primary goal of sustainable building design must be to "lead through example" to heighten environmental awareness. Sustainable building design must seek to

- use the building (or nonbuilding) as an educational tool to demonstrate the importance of the environment in sustaining human life
- reconnect humans with their environment for the spiritual, emotional, and therapeutic benefits that nature provides
- promote new human values and lifestyles to achieve a more harmonious relationship with local, regional, and global resources and environments
- increase public awareness about appropriate technologies and the cradle-to-grave energy and waste implications of various building and consumer materials
- nurture living cultures to perpetuate indigenous responsiveness to, and harmony with, local environmental factors
- relay cultural and historical understandings of the site with local, regional, and global relationships

CHECKLIST FOR SUSTAINABLE BUILDING DESIGN

General

The design must

- be subordinate to the ecosystem and cultural context
  - respect the natural and cultural resources of the site and absolutely minimize the impacts of any development
- reinforce/exemplify appropriate environmental responsiveness
  - educate visitors/users about the resource and appropriate built responses to that environment
  - interpret how development works within natural systems to effect resource protection and human comfort and foster less consumptive lifestyles
  - use the resource as the primary experience of the site and as the primary design determinant
- enhance appreciation of natural environment and encourage/establish rules of conduct
- create a rite of passage
  - develop an entrance into special natural or cultural environments that emulate the respectful practice of removing shoes before entering a Japanese home . . . leaving cars and consumptive values behind

- use the simplest technology appropriate to the functional need and incorporate passive energy-conserving strategies responsive to the local climate
- use renewable indigenous building materials to the greatest extent possible
- avoid use of energy-intensive, environmentally damaging, waste producing, and/or hazardous materials
  - use cradle-to-grave analysis in decision making for materials and construction techniques
- strive for smaller is better, optimizing use and flexibility of spaces so overall building size and the resources necessary for construction and operation are minimized
- consider constructability, striving for minimal environmental disruption, resource consumption, and material waste, and identifying opportunities for reuse/recycling of construction debris
- provide equal access to the full spectrum of people with physical and sensory impairments while minimizing impacts on natural and cultural resources

Also, the design should

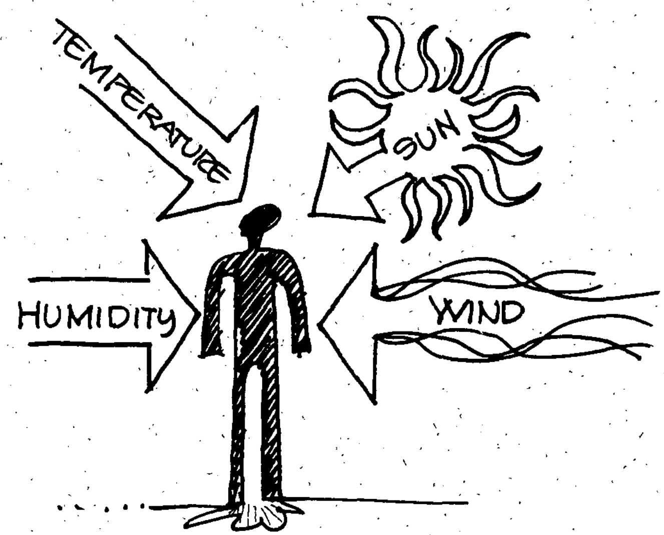
- consider phasing the development to allow for monitoring of resource impacts and adjustments in subsequent phases
- allow for future expansion and/or adaptive uses with a minimum of demolition and waste
  - materials and components should be chosen that can be easily reused or recycled.
- make it easy for the occupants/operators to recycle waste

Natural Factors

By definition, sustainable design seeks harmony with its environment. To properly balance human needs with environmental opportunities and liabilities requires detailed analysis of the specific site. How facilities relate to their context should be obvious so as to provide environmental education for its users. Although the following information is very general, it serves as a checklist of basic considerations to address once specific site data are obtained.

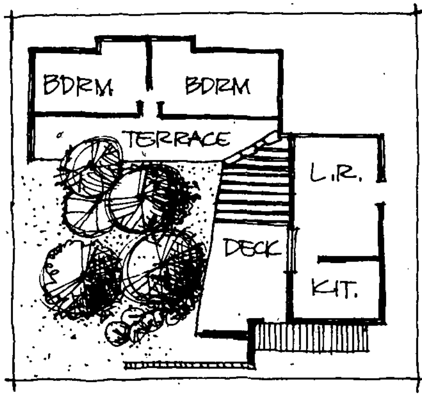
Climate

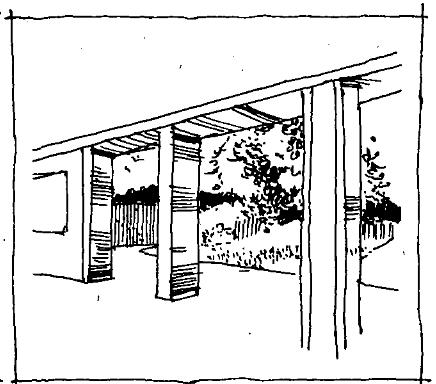
- apply natural conditioning techniques to effect appropriate comfort levels for human activities; do not isolate human needs from the environment
- avoid overdependence on mechanical systems to alter the climate (such dependency signifies inappropriate design, disassociation from the environment, and nonsustainable use of resources)
- analyze whether the climate is comfortable, **too cold,** or **too hot** for the anticipated activities, and then which of the primary climatic components of *temperature, sun, wind,* and *moisture* can make the comfort level better (**asset**) or worse (**liability**).

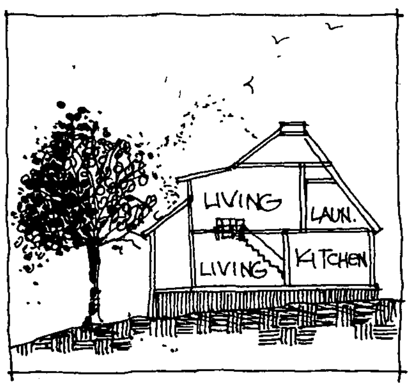


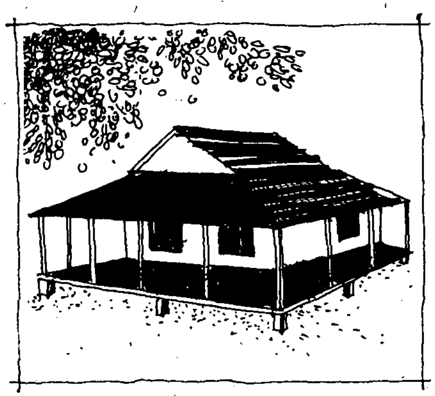
Temperature

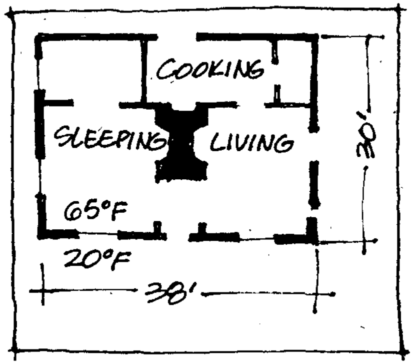
- temperature is a **liability** in climates where it is consistently too hot or too cold
- areas that are very dry or at high elevation typically have the **asset** of large temperature swings from daytime heating to nighttime cooling, which can be flattened through heavy/massive construction to yield relatively constant indoor temperatures
- when climate is predominantly **too hot** for comfort:
  - minimize solid enclosure and thermal mass
  - maximize roof ventilation
  - use elongated or segmented floor plans to minimize internal heat gain and maximize exposure for ventilation
  - separate rooms and functions with covered breezeways to maximize wall shading and induce ventilation
  - isolate heat-generating functions such as kitchens and laundries from living areas
  - provide shaded outdoor living areas such as porches and decks
  - capitalize on cool nighttime temperatures, breezes, or ground temperatures
- when climate is predominantly **too cold** for comfort
  - consolidate functions into most compact configuration
  - insulate thoroughly to minimize heat loss
  - minimize air infiltration with barrier sheeting, weather-stripping, sealants, and airlock entries
  - minimize openings not oriented toward sun exposure

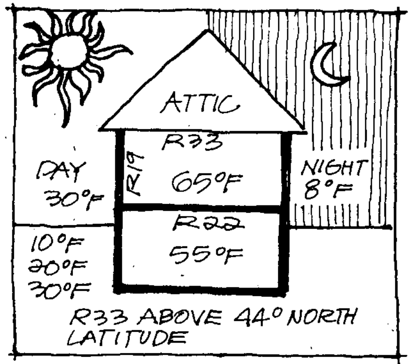


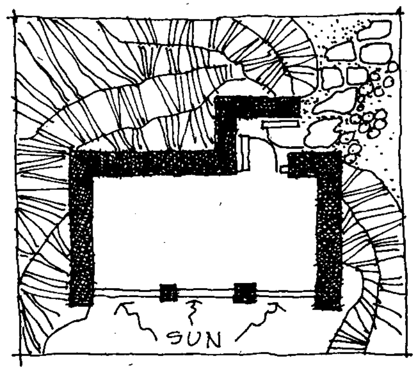












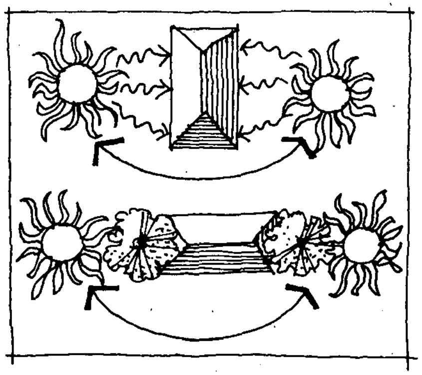
Sun

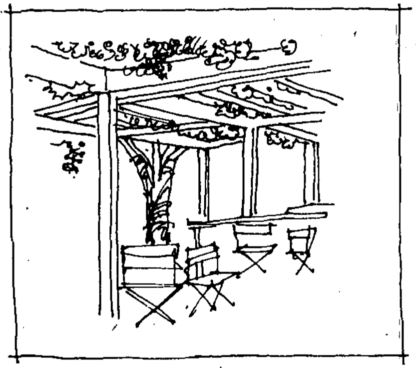
- sun can be a significant **liability** in hot climates, but is rarely a liability in cold climates

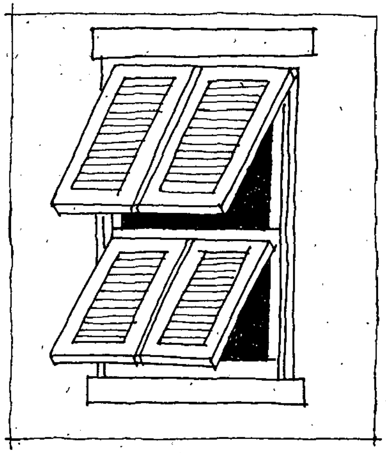
- sun can be an **asset** in cool and cold climates to provide passive heating

- design must reflect seasonal variations in solar intensity, incidence angle, cloud cover, and storm influences

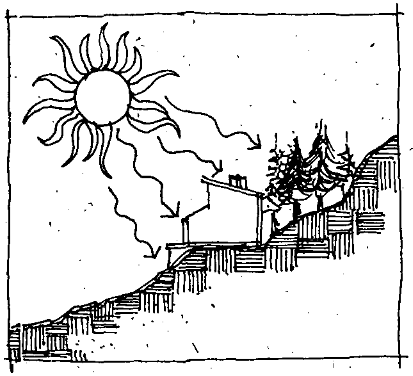
- when solar gain causes conditions **too hot** for comfort
  - use overhangs to shade walls and openings
  - use site features and vegetation to provide shading to walls with eastern and western exposure
  - use shading devices such as louvers, covered porches, and trellises with natural vines to block sun without blocking out breezes and natural light
  - orient broad building surfaces away from the hot late-day western sun (only northern and southern exposures are easily shaded)
  - use light-colored wall and roofing material to reflect solar radiation (be sensitive to resulting glare and impact on natural/cultural setting)
  - in tropical climates, use shutters and screens, avoiding glass and exposures to direct solar gain

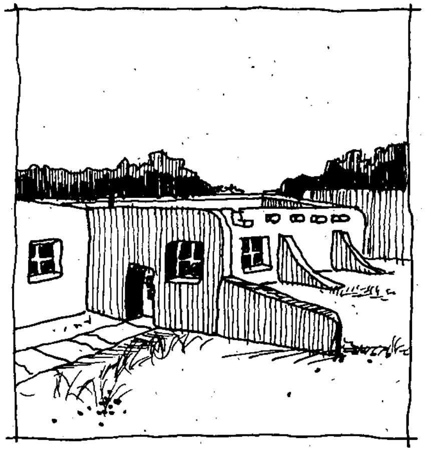






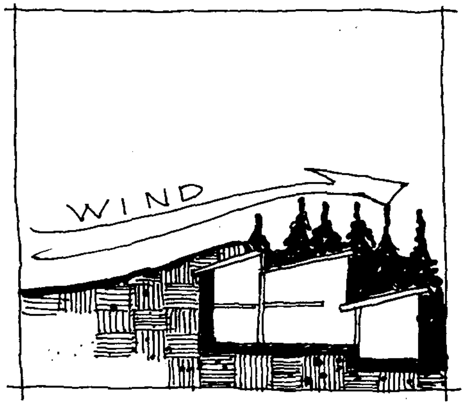
- when solar gain is to be used to offset conditions that are **too cold** for comfort
  - maximize building exposure and openings facing south (facing north in the southern hemisphere)
  - increase thermal mass and envelope insulation
  - use dark-colored building exteriors to absorb solar radiation and promote heat gain



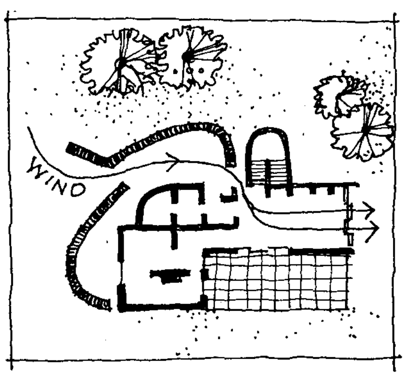


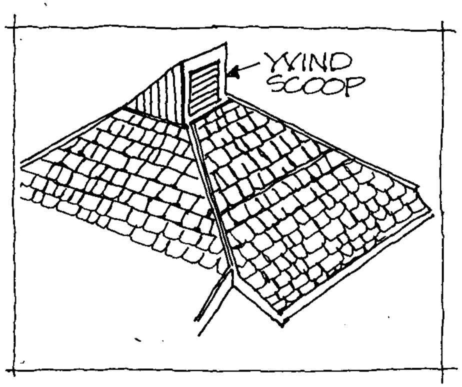
Wind

- wind is a **liability** in cold climates because it strips heat away quicker than normal; wind can also be a liability to comfort in hot dry climates when it causes the human body to dehydrate and then overheat



- wind can be an **asset** in hot, humid climates to provide natural ventilation
  - use natural ventilation wherever feasible; limit air-conditioning to areas requiring special humidity or temperature control such as artifact storage and computer rooms
  - maximize/minimize exposure to wind through plan orientation and configuration, number and position of wall and roof openings, and relationship to grade and vegetation
  - use wind scoops, thermal chimneys, or wind turbines to induce ventilation on sites with limited wind

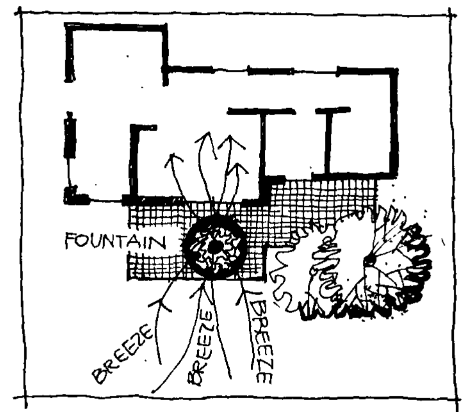




Moisture

- moisture can be a **liability** if it comes in the form of humidity, causing such stickiness that one cannot evaporatively cool (cooling by perspiring) in summer
  - strategies to reduce the discomfort of high humidity include maximizing ventilation, inducing air flow around facilities, and venting or moving moisture-producing functions such as kitchens and shower rooms to outside areas

- moisture can be an **asset** by evaporating in hot, dry climates to cool and humidify the air (a natural air-conditioning)
  - techniques for evaporative cooling include placing facilities where breezes will pass over water features before reaching the facility, and providing fountains, pools, and plants



Other Climatic Considerations

- rainfall can be a **liability** if any concentrated runoff from developed surfaces is not managed to avoid erosion

- rainfall can be an **asset** if it is collected off roofs for use as drinking water

- storms/hurricanes/monsoons/typhoons
  - provide or make arrangements for emergency storm shelters
  - avoid development in floodplain and storm surge areas
  - consider wind effects on walls and roofs

  - provide storm shutters for openings
  - use appropriate wind bracing and tie-downs
  - design facilities to be light enough and of readily available and renewable materials to be safely sacrificial to large storms, or of sufficient mass and detail to prevent loss of life and material

Vegetation

- locate and size facilities to avoid cutting mature vegetation and to minimize disruption to, or disassociation with, other natural features

- use natural vegetation and adjustments in building plan to diminish the visual impact of facilities and to minimize imposition on environmental context

- in warmer climates, strengthen interplay of facilities with their site environment through minimizing solid walls, creating outdoor activity spaces, etc.

Topography

- consider building/land interface to minimize disturbance to site character, skyline, vegetation, hydrology, and soils

- consolidate functions or segment facilities to reduce footprint of individual structures to allow sensitive placement within existing landforms

- use landforms and the sensitive arrangement of buildings to
  - help diminish the visual impact of facilities
  - enhance visual quality by creating a rhythm of open spaces and framed views
  - orient visitors to building entrances
  - accentuate key landmarks, vistas, and facilities

Water Bodies

- capture views and consider advantages/disadvantages of offwater breezes

- safeguard water from pollutants from the development itself and its users

- minimize visual impact of development on waterfront zones (also consider views from water back to shoreline)
  - use building setbacks/buffer zones
  - consider building orientation and materials
  - avoid light pollution

Hydrology

- locate and design facilities to minimize erosion and impacts on natural hydrological systems

- safeguard hydrological system from contamination by development/activities

- allow precipitation to naturally recharge groundwater, wherever possible

Geology/Soils

- minimize excavation and disturbance to groundcover

- minimize erosion by avoiding large impervious surface areas and building footprints that collect rain and create concentrated runoff onto site

Seismic

- determine soil substrate and potential seismic risk

- use shear walls and appropriate building anchorage and bracing details

Pests

- design facilities to minimize intrusion by noxious insects, reptiles, and rodents

- ensure that facility operators use natural means for pest control

Wildlife

- respect importance of biodiversity and the humble role of humans in design

- avoid disruption of wildlife travel or nesting patterns by sensitive siting of development and by limits set on construction activity and facility operation.

- allow opportunities for users to be aware of indigenous wildlife (observe, but not disturb)

Human Factors

Cultural Resources

Archeological resources

- use preservation and interpretation of archeological features to provide insight into previous cultural responses to the environment, their successes as well as failures

Vernacular architecture

- analyze local historic building styles, systems, and materials used for time-tested approaches in harmony with natural systems

- use local building material, craftsmen, and techniques to the greatest extent practicable in the development of new facilities

Historic resources

- reuse historic buildings whenever possible to assist in their preservation, contribute to the special quality of the place, and extend the payback of their embodied energy and materials

Anthropology/ethnic background/religion/sociology

- understand the local culture and the need to avoid introduction of socially unacceptable or morally offensive practices

- consult with local indigenous population for design input as well as to foster a sense of ownership and acceptance

- include local construction techniques, materials, and cultural considerations (that are environmentally sound) in the development of new facilities

Arts and crafts

- incorporate local expressions of art, handiwork, detailing, and, when appropriate, technology into new facility design and interior design

- provide opportunities and space for demonstration of local crafts and performing arts

Sensory Experience

Visual

- provide visitors with ready access to educational materials to enhance their understanding and appreciation of the local environment and the threats to it

- incorporate views of natural and cultural resources into even routine activities to provide opportunities for contemplation, relaxation, and appreciation

- use design principles of scale, rhythm, proportion, balance, and composition to enhance the complementary integration of facilities into the environmental context

- provide visual surprises within design of facilities to stimulate the educational experience

- limit height of development to below top of tree canopy to preserve visual quality of natural and cultural landscape

- use muted colors to blend facilities with natural context, unless contradictory to other environmental considerations (reflection/absorption) or cultural values (customs/taboos)

Sound

- Locate service and maintenance functions away from public areas

- space lodging units and interpretive stops so that natural, not human, sounds dominate

- use vegetation to create sound baffle between public and private activities

- orient openings toward natural sounds such the lapping of waves, babbling of streams, and rustling of leaves

- restrict the use or audio level of unnatural sounds such as radios and televisions

Touch

- allow visitors to touch and be in touch with the natural and cultural resources of the site

- vary walking surfaces to identify or give different quality to different spaces

- use contrasting textures to direct attention to interpretive opportunities

Smell

- allow natural fragrances of vegetation to be enjoyed

- direct air exhausted from utility areas away from public areas

Taste

- provide opportunities to sample local produce and cuisine

ENVIRONMENTALLY SENSITIVE BUILDING MATERIALS

Cradle-to-Grave Analysis

The complete life-cycle energy, environmental, and waste implications of each building material must be examined. This cradle-to-grave analysis is the tracing of a material or product, and its by-products, from its initial source availability and extraction through refinement, fabrication, treatment and additives, transportation, use, and eventual reuse or disposal. This tracing includes the tabulation of energy consumed and the environmental impacts of each action and material.

Source of raw ingredients (renewable? sustainable? locally available? nontoxic?)

Raw material extraction (energy input? habitat destruction? topsoil erosion? siltation/pollution from runoff?)

Transportation (most local source? fuel consumption? air pollution?)

Processing and/or manufacturing (energy input? air/water/noise pollution? waste generation and disposal?)

Treatments and additives (use of petrochemicals? exposure to, and disposal of, hazardous materials?)

Use and operation (energy requirements? longevity of products used? indoor air quality? waste generation?)

Resource recovery/disposal (potential for recycling/reusing materials? disposal of solid/toxic wastes?)

Two of the best sources for information on the cradle-to-grave implications of commonly used building materials are the American Institute of Architects' *Environmental Resource Guides* (1992-present) and the National Park Service's *Environmentally Responsible Building Product Guide* (1992). As a subjective means of recording, tabulating, and reporting positive and negative environmental actions, report cards should be kept for each material or product in a development. The selection of materials for a sustainable design is then a matter of evaluating the report cards for the lowest total environmental loss.

Selection Priorities

When the source is sustainable:

- Natural materials are less energy-intensive and polluting to produce, and contribute less to indoor air pollution.
- Local materials have a reduced level of energy cost and air pollution associated with their transportation, and can help sustain the local economy.
- Durable materials can save on energy costs for maintenance as well as for the production and installation of replacement products.

In selecting building materials, it is helpful to prioritize them by origin, avoiding materials from nonrenewable sources.

Primary – materials found in nature such as stone, earth, flora (hemp, jute, reed, wool), cotton, and wood

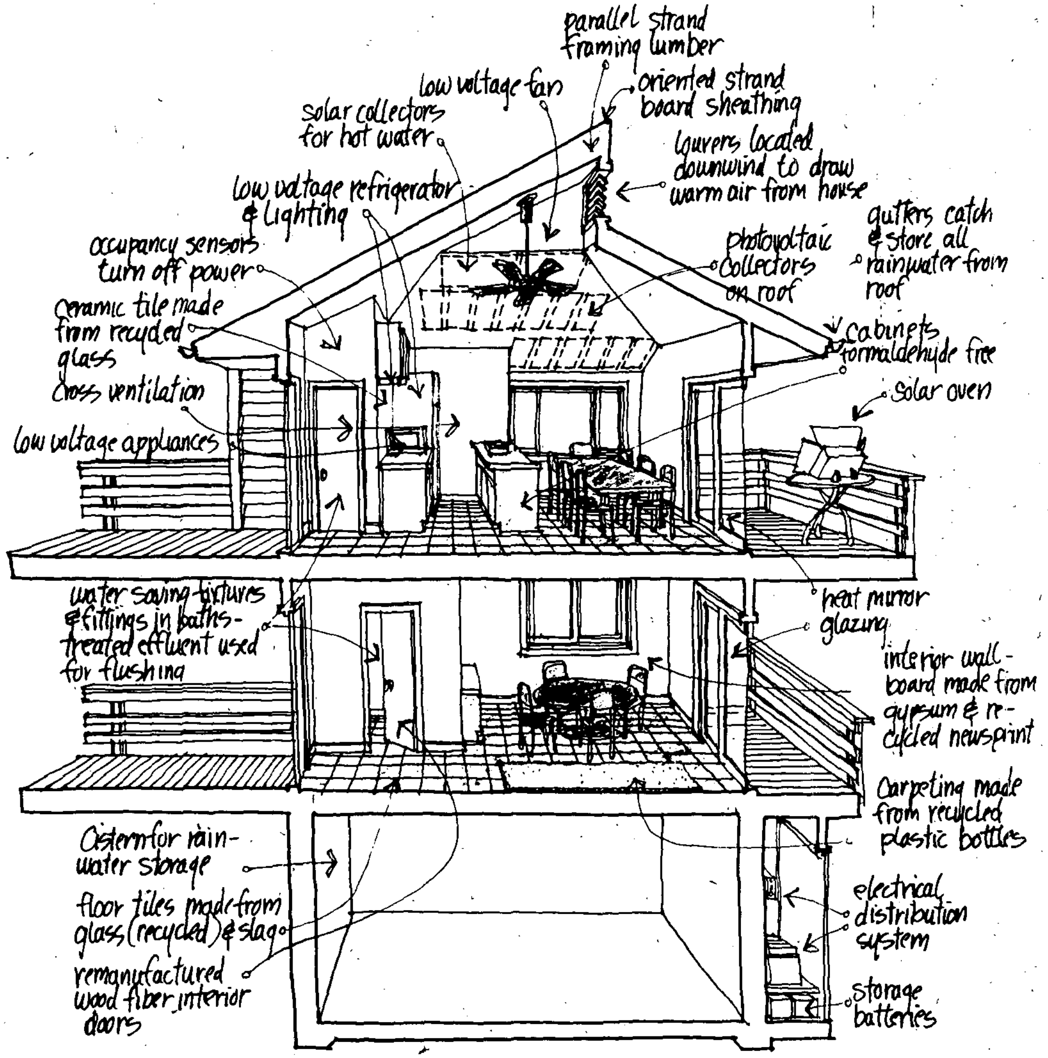
- ensure new lumber is from certified sustainably managed forests or certified naturally felled trees
- use caution that any associated treatments, additives, or adhesives do not contain toxins or off-gas volatile organic compounds that contribute to indoor air/atmospheric pollution

Secondary – materials made from recycled products such as wood, aluminum, cellulose, and plastics

- verify that production of material does not involve high levels of energy, pollution, or waste
- verify functional efficiency and environmental safeness of salvaged (reused) materials and products from old buildings
- look closely at the composition of recycled products; toxins may still be present
- consider cellulose insulation; it is [redacted] and provides a greater R-value per inch thickness than fiberglass
- specify aluminum from recycled material; it uses 80% less energy to produce over initial production
- evaluate products containing recycled hydrocarbon-based products; they may help keep used plastics out of landfills but may do little to reduce production and use of plastic from virgin resources
- keep alert for new developments; new environmentally sound materials from recycled goods are coming on the market every week

Tertiary – man-made materials (artificial, synthetic, nonrenewable) having varying degrees of environmental impact such as plywood, plastics, and aluminum

- avoid use of materials and products containing or produced with chlorofluorocarbons or hydrochlorofluorocarbons that deteriorate the ozone layer
- avoid materials that off-gas volatile organic compounds, contributing to indoor air/atmospheric pollution
- minimize use of products made from new aluminum or other materials that are resource disruptive during extraction and a high energy consumer during refinement



- INDEPENDENT ENERGY SYSTEM
  - Energized by wind power and photovoltaics
  - Appliances selected for compatibility with power source
- WATER CONSERVATION
  - Waste water for toilet flushing and irrigation
  - Flow restrictors on all faucets
  - Low-flush toilets
  - Rainwater collected in cisterns
- CONSTRUCTION MATERIALS MADE FROM RECYCLABLES
  - Waste or farmed trees for framing lumber
  - Waste newsprint wall board
  - Waste glass
  - Waste plastic
  - Waste cardboard
  - Waste rubber tires

Example of Integrating Energy and Water Conservation with Environmentally Responsible Building Materials

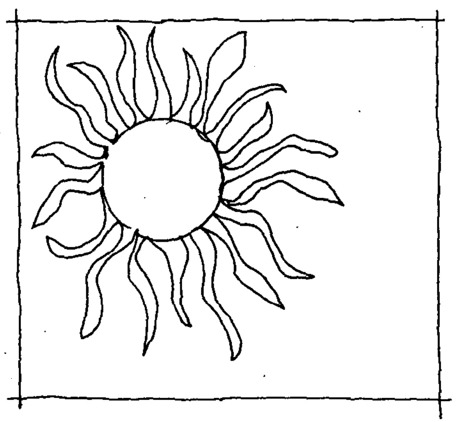
ENERGY MANAGEMENT

ENERGY MANAGEMENT

THE CONSUMPTION OF ENERGY

Most modern architecture, transportation, and food production was created on, and is dependent on, the assumption that using fossil fuels for energy is economical and that their supply is inexhaustible. Few people are aware of the true costs associated with the overuse of fossil fuels. Mining that displaces habitats, forest cover, and farmland; oil spills that foul beaches, marine environments, and groundwater; and air pollution that reduces the chances for species survival are difficult to associate with flipping on a light switch, running an air-conditioner, or driving a car.

In reality, unchecked consumption of the finite fossil fuel reserves drives more and more exploration and extraction at a higher economic cost, and displaces more and more natural resources at a higher environmental cost. A compounding reality is that generating energy by burning coal, oil, and natural gas is a major source of atmospheric contamination responsible for global warming and climate change, acid rain, and smog. The resulting impact damages water bodies and groundwater, soils, crops, wildlife and wildlife habitat, building materials, and mankind's personal health. The combined effect is the inability to sustain life. Thus, the true cost of using fossil fuels for highly consumptive energy needs is not just the price humans pay, it is also the price the environment pays.



ALTERNATIVE ENERGY SOURCES

Just as a site has primary natural and cultural resources, it has **primary renewable energy resources**, such as sun, wind, and biogas conversion. Solar applications range from hot water preheat to electric power production with photovoltaic cells. Wind-powered generators can provide electricity and pumping applications in some areas. The biogas conversion process reduces gas or electricity costs and eliminates the release of wastewater effluent into water resources. With known technologies the intelligent use of primary renewable energy resources can benefit any development.

The availability, potential, and feasibility of primary renewable energy resources must be analyzed early in the planning process as part of a comprehensive energy plan. The plan must justify energy demand and supply and assess the actual costs and benefits to the local, regional, and global environments.

STRATEGIES FOR SUSTAINABLE DEVELOPMENT

Responsible energy use is fundamental to sustainable development and a sustainable future. Energy management must balance the justifiable demand with the appropriate supply. The process couples energy awareness, conservation, and efficiency with the use of primary renewable energy resources.

Energy Awareness

To sustain its own wise use of energy, the sustainable development must demonstrate benefits rather than sacrifices to its users (which includes visitors and operators).

Functional requirements and user comfort are maintained while efficient lighting, ventilation, and appliances make prudent use of renewable energy resources. Energy production and efficient use are visible and interpreted components of the total sustainable development experience. The user enjoys learning about sustainable energy concepts and feels good about it. The demonstration of sustainable energy use offers an opportunity for changing perception, patterns, and value systems.

As an example, in areas where there is visitor lodging, energy awareness could be enhanced by in-room energy meters. The meters would let visitors know how much energy they have used much like exercise machine meters have workout analogues. Interpretation would encourage and reinforce prudent energy use. Visitors who conserve energy could be rewarded with facility perks or a discounted bill. The meters should be simple, informative, and fun.

The comprehensive advantages of sustainable alternatives over conventional approaches can be communicated through comparison of the source and amount of energy required for a particular service, and the associated environmental and economic cost implications. By promoting less consumptive lifestyles and demonstrating more sustainable energy alternatives, the sustainable development can more effectively balance the demand and supply sides of energy management responsibilities.

Energy Conservation

At the beginning of the planning process, a determination must be made to avoid energy-intensive or unnecessary operations. Considerable energy can be conserved if access to, from, and within a development is planned around alternative transportation systems, bicycle routes, and pedestrian walkways rather than personal automobiles.

Facility design can contribute to energy conservation in several ways. Through recycling existing facilities, building only the minimum to satisfy the functional requirements, and having facilities serve multiple functions, the embodied energy of new building materials and the energy of transporting and constructing them are minimized. In addition, considerable electrical and thermal energy can be saved through facility design that incorporates daylighting and the other passive energy-conserving strategies appropriate to the local climatic environment. Food service should also contribute to energy conservation by emphasizing fresh, locally available items that minimize the amount of energy required for transportation processing, freezing, and refrigeration.

In all cases, mechanical air-conditioning of facilities is energy-intensive, and in most cases, proper attention to the principles of site planning and building design can effectively eliminate its need. Awareness of the cooling sense of moving air and the connection to the natural resource can enhance the user comfort and the visitor experience without air-conditioning.

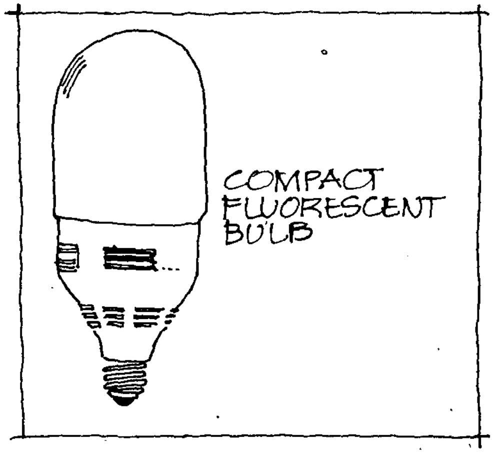
Fresh air is desired in a resource-related development. Breezes, the sound of birds or the surf, and the smell of flowers are fundamental to the perception of air. Wind chimes, used in traditional Japanese architecture, serve as a gentle reminder of a cool breeze. The sound of trickling water in a courtyard fountain can impart the perception of coolness. A ceiling fan spinning overhead can provide not only a sensory but also a psychological feeling of a cool breeze.

In visitor lodging, energy use can be minimized through "designed-in" restrictions or charges on consumption to visitors. Elimination of electrical outlets in individual lodging units would curtail the use of visitor appliances such as hair dryers and electric cooking utensils. Instead, electricity should be provided only at central locations such as bathhouses, and limited in individual units to fixed devices or appliances, such as lighting or a fan. Certain services such as laundry or showers or high wattage electrical outlets could be coin-operated and timed because they are so energy intensive. The visitor could be informed of their energy use with a continuous display, and rewarded or charged depending on consumption.

Energy Efficiency

Efficient methods, devices, and appliances should be employed at the sustainable development to conserve energy. Almost all facets of the development and visitor services and amenities can profit from recent innovations in energy efficiency.

As an example, no bulb is cheaper to buy and more expensive to use than an incandescent bulb. Over 90% of the energy consumed by most incandescent lamps is released as heat. The substitution of one compact fluorescent bulb for an incandescent bulb will save a barrel of oil (money), and keep about 2,000 pounds of carbon dioxide (global warming) and 20 pounds of sulfur oxides (acid rain) out of the atmosphere. For the owner,



each $10 compact fluorescent bulb will save approximately $40 in energy cost over the life of the bulb. The 100-year-old incandescent bulb will soon go the way of the oil lamp.

Lighting. Natural lighting should be used wherever possible. The quality and ambiance of natural lighting are unsurpassed and it is free. Lighting design should be based on standards of reduced general lighting with task lighting and highlighting for specific functional considerations.

Where artificial light is needed, regular and previously mentioned compact fluorescent lighting should be used. Fluorescents are greatly improved with color rendition comparable to incandescents and electronic ballasts to totally eliminate perceptible flicker. They use 75% less electricity. Average life is 10 times longer than incandescents, reducing maintenance and transportation costs. In most circumstances, the economic payback for new fluorescents is under two years (a smart investment). The environmental payback is immediate.

Sensors and Controls. Lighting, ventilation, and other devices or systems can be controlled with a variety of sensors that reduce electricity consumption significantly. A photocell can control day and night operation. Occupancy sensors (motion or ultrasonic) can operate lighting. An infrared sensor uses less energy to operate and is less sensitive to air movement but does not see around corners. An ultrasonic sensor can be used in a restroom and even detect movement around partitions. Other sensors are available that can control operation of a device by door opening, time of day, specified noise level, and proximity.

Refrigeration. Efficiency of refrigeration mostly depends on insulation but also on the temperature of the condenser. High insulation levels and efficient compressors are available in only a few refrigerators and freezers. They will reduce energy consumption significantly, using only 20% of conventional units. Any site-constructed walk-in freezer should strive for similar efficiency through a combination of superinsulation and heat exchange with a relatively cooler reservoir. Open chest freezers should be avoided. In some situations individual dwelling units could be supplied with a well-insulated cooler and centralized ice source to eliminate the constant power requirements of a refrigerator.

Laundry Facilities. Energy-efficient conversion kits are available for standard electric washing machines, which reduce energy consumption by two-thirds by replacing the motor with an energy-efficient model. Laundry should be air-dried whenever possible.

Low Energy Transportation. Resource-related development should be laid out with an emphasis on pedestrians and a reduced dependency on fossil fuels. Walkways and hiking paths can encourage walking. The rental of bicycles and sailboats, rather than scooters and jet skis, and the coordination of efficient public transportation to the development can all serve to reinforce less consumptive lifestyles.

Load Management. Additional system efficiencies can be realized by controlling the duration, time, and timing of loads to increase the use of the supply system. This decreases peak demands. Control strategies will depend on characteristics of the energy supply system as well as loads. For example, water may be pumped to a storage tank in a gravity system during sunlight hours by a solar electric system, during off-peak hours by a small hydro system, or during generating periods by a wind system. Intelligent load management will increase the amount of energy delivered to perform useful tasks and decrease the size of the supply system.

Renewable Energy Resources

Once energy awareness, conservation, and efficiency measures have been employed, renewable energy resources should be investigated for providing the needed energy. Site conditions and available resources as well as energy demand will indicate the sources to develop. Energy systems should be decentralized, reliable, and locally maintainable. Spare parts should be stocked, and maintenance and operating expertise must be perpetuated through documentation, education, and training programs.

If a technology is chosen that does not meet these criteria, i.e., a new technology or a system for which no local expertise or experience exists, and if its operation is critical, then a standby system, such as a propane generator, should be considered. A long-term support and training agreement with the supplier is also necessary.

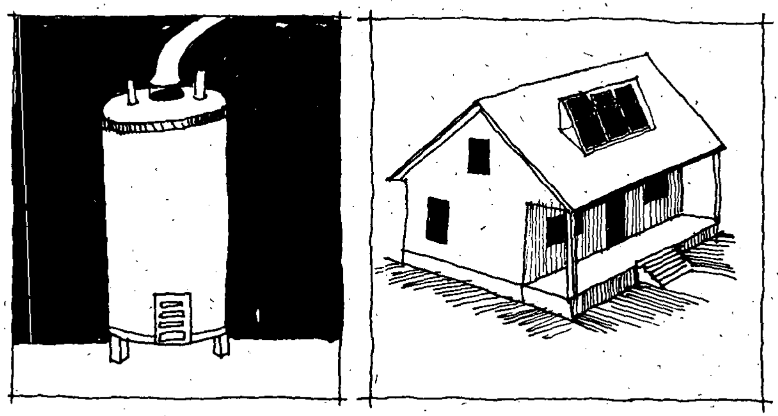
Specific examples of renewable energy resources and their characteristics, applicability, advantages, and disadvantages are described below.

Solar Technologies. A broad range of solar technologies exists — some are as simple as suntempering a building by orientation and shading as discussed in the "Building Design" section. A clothesline is an example of simple solar technology that should be used in a sustainable development. Low technology systems are readily available to preheat water and dry foods. Medium temperature systems can provide refrigeration. Solar collectors with multiple units ensure reliability.

- **Low Temperature Thermal Systems.** This class of systems is commercially available, and both installation and maintenance requirements are familiar to the electrical and plumbing trades.

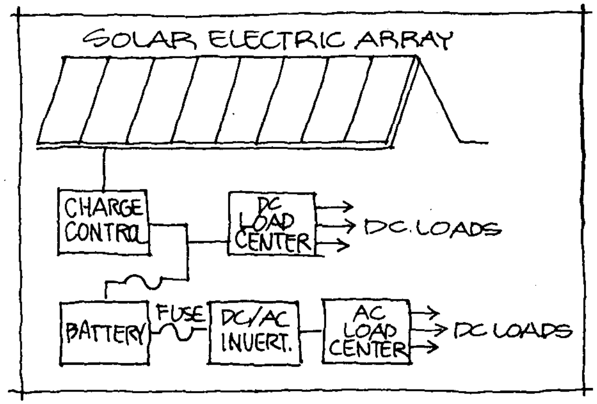
  - **Swimming Pool Heaters.** Swimming pool heaters are commonly manufactured of low-cost PVC or CPVC materials and are in the form of a simple piping loop with a circulator pump. Controls are simple and can even be omitted in warmer latitudes.

  - **Domestic Hot Water Heaters.** Domestic hot water heaters are typically closed-loop systems used for providing potable hot water to household or commercial facilities. They come in a variety of shapes and sizes, but generally include a water-heater storage tank, either of the common household water heater type, or of a solar applications design that has an additional heat exchanger and superinsulation. The solar collectors are generally flat-plate designs that vary from manufacturer to manufacturer. These systems are simple to install, and maintenance is low. Payback varies with comparison to local rates, but is generally two to three years.



- **Medium Temperature Thermal Systems.** Air-conditioning or industrial-process water heating are typical applications of these systems. These systems are less common than low temperature systems, and installation requires an experienced contractor and several weeks of project time. Payback is extended when the application is for air-conditioning. Domestic hot water can be a by-product of the absorption unit, and will defray operating costs somewhat. The collectors themselves are cost-effective, and systems using them to pump water and other such uses are very cost-effective.

- **Photovoltaic Systems.** Ample sunlight, low maintenance, high reliability, and widespread support make photovoltaic systems an attractive option for remote energy generation. System design is flexible and easily expanded. A development can be energized by a single centralized large array and battery storage, or smaller autonomous systems serving local areas, even individual dwelling units. Although there may be cost advantages for a centralized system, there

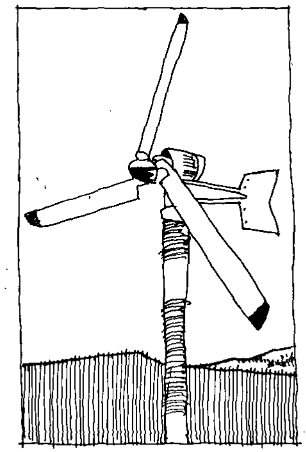


are reliability advantages for a number of small modular systems with interchangeable components.

Electrical storage is by lead-acid deep-cycle batteries, similar to those used in golf carts. Although there are many variables, a typical hotel room or studio apartment could be powered by batteries of 300 amp hours at 12 volts, including a four-day reserve. Typical battery costs would be about $1 per amp-hour. This would include fans, lights, TV or stereo, an occasional high load such as a hair dryer or whirlpool bath, and a high-efficiency refrigerator. Peak loads such as cooking would be best handled by natural gas or propane. Direct current electricity is generated and stored. Reliable, efficient, high-capacity inverters that convert the stored energy to 120 volts AC for running conventional appliances are available.

- **Hydroactive Systems.** Small-scale hydroplants are generally comprised of Pelton wheel generators that operate from low-head, running streams of water. They are reliable and cost-effective, and can be serviced by competent mechanics with hydraulic and electrical skills. Storage batteries can be used to buffer peak electrical demands.

  Wave-action generators are comprised of hydraulic or pneumatic pumps that pressurize an accumulator to drive motor/generators. These systems can stand alone or be disguised by incorporating them into docks and other shore emplacements. They work well wherever there is small wave action, such as in harbors and marinas, or in seashore facilities. Storage is designed into the system to meet electrical demands. They work best where demand is intermittent, such as for cycling pumps.



- **Wind Systems.** As with solar technology, the simplest use of the prevailing winds is incorporation into the architecture. Wind scoops, cross-ventilation, and passive thermal chimneys use air movement to keep buildings comfortable. Wind generators can be a good choice for remote applications and small power demands such as pumping water. Major maintenance should be performed by the dealer.

- **Biogas Use.** As a by-product of the anaerobic digestion of the solid waste stream (see "Waste Prevention" section), biogas offers the comprehensive benefits of waste and wastewater processing, methane pro- duction for cooking and refrigeration, and generation of organics for soil enhancement. Depending on the quantity of waste that is available, possibly all the energy needs within a sustainable development may be met through the use of biogas.

  Biogas should be used to directly fuel gas refrigerators, stoves, absorption-chillers, and water heaters. A simple orifice change is required to adapt these appliances to the Btu value of the gas supply. This will typically be done by the manufacturer if specified. Gas-fired engine generators should be used if the energy balance indicates that sufficient energy is available for that purpose. Proven heavy duty propane generators will be more reliable and quieter than the diesel-converted models of some U.S. manufacturers. One caution in this process is to not buy used equipment unless it is fully researched and warranted and the parts readily available and the service available within one week. Biogas might also be used in the production of ice at off-peak periods to sustain the marketability of local produce or the fishing industry.

ACTIONS FOR SUSTAINABLE DEVELOPMENT

With the ultimate goal of sustainability, the following actions summarize an approach to reduce energy consumption:

- Identify the availability, potential, and feasibility of primary renewable energy sources such as solar, wind, biogas, and geothermal to satisfy the justifiable energy needs of the development.
- Apply the best principles of siting and architectural design to reduce energy demands and to minimize the need for energy-consuming utilities (air-conditioning, water heaters, high-level artificial lighting).
- Make energy production and use a visible component of the sustainable development. Broaden visitor experiences by awareness of energy use issues and the use of efficient appliances, conservation methods, and renewable energy sources. Install energy meters to monitor and illustrate energy consumption.

WATER SUPPLY

WATER SUPPLY

WATER RESOURCES

Water is a major natural resource, one of the big three: land, water, air. Water is used in many ways — e.g., as a nourisher of plant and animal life, a bearer of food, a prime element of industrial processes, and a medium for transportation. The importance of water can be put into perspective by the fact that a significant portion of the earth's surface is water. When our planet is viewed from space, the dominant blue color makes water appear to be an abundant resource. The reality is that 97% of the earth's water is salty, and the majority of the remaining 3% is freshwater locked in glaciers and polar ice caps.

The freshwater pool on which we are most dependent is the resultant runoff of a water cycle driven by the sun. Evaporation lifts purified water from the oceans and land, which then falls again as rain and snow. Our backup reserve of freshwater is held in underground aquifers, but they can be energy intensive to extract from and slow to replenish. As is often the case with natural resources, a major problem arises from their uneven distribution. Certain land areas receive immense amounts of freshwater through precipitation, while others receive scant amounts. In some environments this imbalance is exhibited in just a few surface miles.

Worldwide population growth (and associated food production) as well as increases in industrialization and consumptive lifestyles create ever-increasing demands on the planet's relatively finite sources of freshwater. To ensure a global water resource to meet the demands of the future, immediate improvements are needed in techniques for water conservation, collection, storage, treatment, and reuse.

Sustainable design will respect the water resources with diligence whatever the natural distribution. The challenge of sustainable design applies more to areas where freshwater is not limited than to dry areas where the economics of high-cost water tends to promote wise stewardship. The principles of sustainable design apply, without reservation, to all types of climates. In a park or ecotourism development, where health considerations are paramount, water issues center on providing safe drinking, washing, cooking, and toilet-flushing water.

STRATEGIES FOR SUSTAINABLE DEVELOPMENT

Water Conservation

The cornerstone of any domestic water supply program is conservation. Water conservation also includes using water of lower quality such as reclaimed wastewater effluent, gray water, or runoff from ground surfaces for toilet flushing or irrigation of vegetative landscape or food crops. These uses do not require the level of water quality that is needed for internal consumption, bathing, or washing. With the proper type of wastewater treatment and plumbing hardware, sea water can be used as a toilet-flushing medium.

User education and awareness is a key to a successful water conservation program. At a resource-related development, the visitor should receive interpretation about the source of the water and the types of energy required to process and distribute the water at the development. If an offsite utility provides water, the same type of information should be obtained by management and furnished to the visitor, along with a description of the water conservation measures being used.

Positive reinforcement should be provided to visitors by informing them of their actual water savings as well as their responsibility in achieving the goal of water conservation. Appropriate signs of high-quality material should be put in restrooms or bathrooms to indicate that management places high priority on water conservation and to confirm goals and expected behavior of visitors.

Flush toilets are the largest indoor user of water. To conserve water, the maximum permissible water use per flushing cycle is 1.6 gallons. Water-conserving flush toilets are widely manufactured. Characteristics that should be evaluated before purchasing a low-flow toilet include operational noise, solids evacuation, bowl cleaning, and water surface seal area (water standing in bowl after flush cycle; i.e., the more water surface area the less cleaning of skid marks may be required). Double flush units also save water by providing a partial flush for liquid wastes and a complete flush (1.6 gallons) for fecal wastes. In some environments, waterless toilets such as composting toilets may be appropriate (see "Waste Prevention" for more discussion on composting toilets).

Lavatory fixtures should be spring-loaded and have a maximum flow rate of 2.2 gallons per minute (gpm) at a test pressure of 60 pounds per square inch (psi). Although most water systems operate in the 25-40 psi range, the high test pressure ensures that a purported conservation device actually does conserve water over a wide pressure range. Electronic proximity devices are now commercially available for controlling lavatory fixtures. These units are water efficient but should be used only after evaluating local repair capabilities.

Shower fixtures should be rated for a maximum flow rate of 2.5 gpm at 80 psi. Shower fixtures of 2.0 and 1.5 gpm are available and work very satisfactorily depending on user preference. In public facilities where water use is more difficult to monitor, shower fixtures should have a timed cycle after activation by user or be spring-loaded with chain operator. Instead of a hot water shower, tempered water using a solar thermal collector may be a good median between a cold shower and an energy-intensive hot shower.

Urinals should have a maximum flow rate of 1.0 gpm and be spring-loaded.

Commercial appliances used in kitchen and laundry areas should also be water-saving models. Garbage disposals should not be used as they are water consumptive and exert a huge load on the wastewater treatment facilities. Park and ecotourism visitors typically are not in direct contact with the kitchen, laundry, or other centralized facilities, so water conservation efforts in these areas should be part of the interpretive program of the development.

In areas having lodging facilities, check-out time or perhaps at the mid-point of a week-long stay is a good opportunity to let visitors know how much water was saved using conservation devices versus conventional devices. This does not need to be an actual measured volume but can be a computer-generated figure based on length of stay and number of visitors in the room. Also, a list of manufacturers and suppliers of water conservation and other energy savers should be made available so that visitors can take it home and use it in their everyday lives. A nice touch would be issuing a reusable or recyclable card to departing visitors reiterating management's pledge to the environment, or offering a tangible object of this pledge such as a faucet aerator.

Water Sources

Groundwater (Wells and Springs). An uncontaminated groundwater source or spring usually requires the least input (energy, chemical, financial) to provide safe water for drinking, bathing, and cooking. Extreme efforts should be made to protect existing and potential groundwater sources from contamination. To ensure that groundwater is not contaminated by surface water or other influences, wells should be a minimum of 50 feet deep and generally 200 feet horizontal from surface water.

Use of groundwater is probably the least energy-intensive, because renewable energy sources (wind, photovoltaic) can be used to pump the water to a hillside storage reservoir for distribution by gravity. This type of system has so many advantages from both an environmental and economical perspective that the source can be developed up to several miles from the final use point.

Surface Water (Fresh). Fresh surface water can be used when groundwater is not available. Some locations have an abundance of fresh surface water such as streams, rivers, and lakes.

Lack of Groundwater or Surface Water. In those cases where there is a lack of water, rain catchment becomes an option as a stand-alone supply of water or a supplement to a limited ground or surface supply. Rainfall catchment from the roofs of structures is a recognized option for water supply, provided the necessary treatment processes are used prior to distribution. Care should be used in selecting a roofing material (e.g., hard and smooth) that does not collect dirt. Metal roofs may release heavy metals into the drinking water if the rainwater is acidic. Rainwater collected from ground surfaces can be used for secondary uses such as toilet flushing and irrigation of food crops, or groundwater recharge.

Extraction of Freshwater from Sea Water, Brackish Water, or Water Vapor in the Air. Some areas have no readily available supply of freshwater and must rely on converting salt water to freshwater. Reverse osmosis, electrodialysis, distillation, and vapor compression are processes used. All are complex, extremely energy consumptive, costly and difficult to operate and maintain, and present significant disposal problems caused by the brine concentrate. It is probably beyond the means and capabilities of most small park units or sustainable developments to produce freshwater from salt water. The scale of most desalinization plants is very large. The fact that freshwater produced from salt water is very precious needs to be emphasized to visitors at every opportunity because the economic cost is just a fraction of the environmental cost. An example of how far-reaching the costs are is that energy used at desalinization plants in the Virgin Islands is produced by hydrocarbons from Alaska.

Whatever the water supply, information on the source of water used must be made known to users. This information can be transferred through interpretation (as part of the orientation packet, slides at evening shows, or a scheduled tour of the facilities once per week). The tour would be especially appropriate if sustainable water processing or pumping techniques are being employed.

Water Treatment

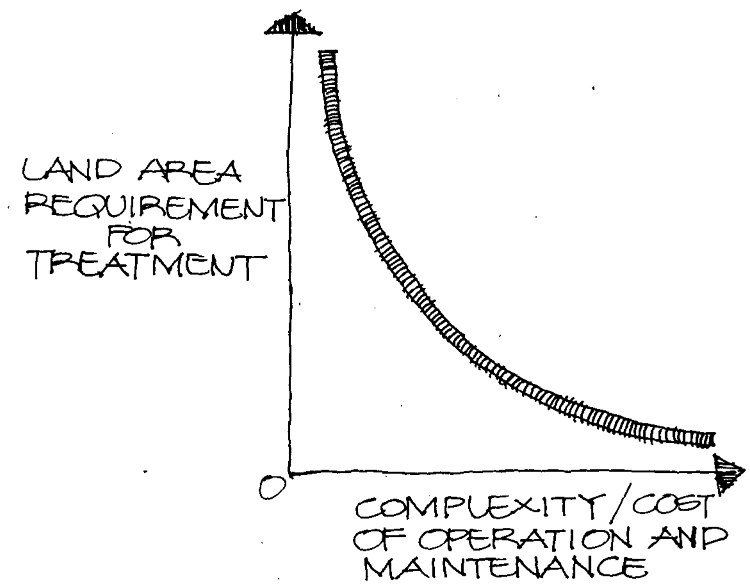
The type(s) of treatment required will depend on the source of water and the quality of source water.

Groundwater. Treatment of groundwater is accomplished by simple disinfection using sodium hypochlorite (laundry bleach). The sodium hypochlorite can be proportioned into the water being delivered to the storage tank using a water-powered or photovoltaic metering pump. Contact time in the storage tank is required to ensure proper disinfection.

An emerging water disinfection technology involves the use of liquid chlorine dioxide (Aqua Chlor). This technology provides excellent bactericidal qualities while minimizing the formation of environmentally harmful disinfection by-products.

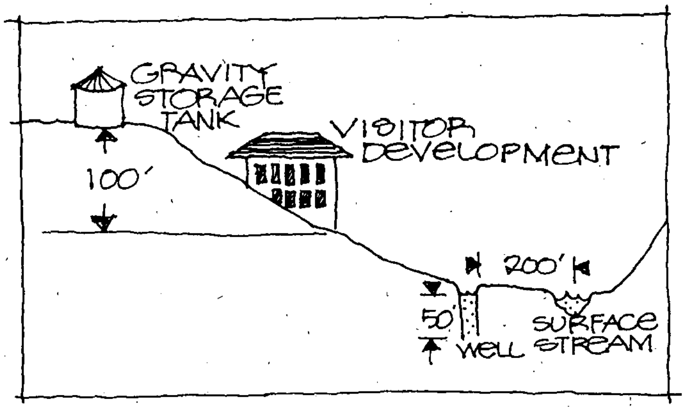
Surface Water with Low Turbidity. Before disinfection, surface water requires filtration. For resource-related developments, the recommended filtration processes would be slow sand filtration or cartridge filtration. Only the water used for drinking, washing, and cooking would need to be completely treated. Dual distribution systems are required — one for drinking water and one for lesser quality uses such as toilet flushing.

The slow sand filter is an old technology that has recently reemerged. An even graduated natural sand (3 feet deep) is placed in a constructed basin. The supply water is introduced into the top layer of sand and travels downward through the sand filter to perforated collection pipes on the bottom of the filter. Impurities in the water are removed in the top layer of the filter and accumulated for periodic removal by scraping. The removed impurities and top 1/2-inch of sand can be dried and used as a soil conditioner. No chemical additions or additional power are required. Operations and maintenance requirements are low. However, a certain land area is required for the filter basin. The illustration below depicts the general relationship between land area for treatment versus complexity/cost of operations and maintenance. Disinfection with bleach is the final step.



Cartridge filters using microporous filter elements (ceramic, paper, or fiber) with small pore sizes are suitable for low turbidity surface water. (Use a graduated series of cartridge sizes to prevent rapid clogging of filter.) Again, a dual distribution system is recommended to lessen the volume of high-quality water needed. Head loss through a cartridge filter is higher than through a slow sand filter, so a booster pump may be required to maintain adequate pressure in the water system. The paper and fiber filters are consumptive as they must be disposed of when full of sediment (disposal frequency depends on turbidity in supply water). The ceramic cartridge filter can be cleaned mechanically (scraped) and reused. Sediment cleaned from the ceramic cartridge can be dried and used as a soil amendment. Operations and maintenance is minimal. Disinfection with bleach is the final step.

Surface Water with High Turbidity. If the source water has a turbidity above 15-20 NTUs (nethelometric turbidity units), complete conventional treatment is required. This involves the addition of synthetic chemicals such as alum and polymer in a coagulation stage, followed by a flocculation stage before filtering in a rapid sand filter. The filter is hydraulically backwashed (usually once per day) to remove accumulated sediment from the filter. This backwash waste (containing the added chemicals) must be dried and disposed of in an approved manner. The complexity and cost of operation is high, maintenance costs are high, and chemical and power inputs are required. Dried waste sediments cannot be used as a soil amendment without further processing. The final step is disinfection with bleach.



Water Storage

Gravity storage of any water product (raw, finished, reclaimed) should be used wherever possible. For every 1 foot of elevation a storage tank is located above a use point, 0.433 psi static pressure is generated. Gravity storage enables wind and photovoltaic pumping systems to be effective. Because these pumping systems work at relatively low pumping rates, the gravity storage tank acts as an accumulator to store water for heavy demand periods or for days when the wind does not blow or the sun does not shine. Photovoltaic pumping systems can provide moderate daily flows of up to 25,000 gallons per day and produce total dynamic heads of 100-150 feet.

Another means of transferring raw water from a source to a storage tank at a higher elevation without electrical or hydrocarbon input is the hydraulic ram. The hydraulic ram is a self-acting impulse pump that uses the momentum of a slight fall of water to force a part of the water to a higher elevation. A hydraulic ram is noisy, but the noise can be successfully mitigated with the use of sound-attenuating materials in an enclosure. It is practicable to operate a ram with a fall of only 18 inches, but as the fall increases, the ram forces water to proportionately greater heights. The hydraulic ram is well suited for areas where electrical power is not available and where an excess supply of water is available.

As a gravity storage tank will be located in an elevated location, visual quality will be important. Multiple smaller tanks may be easier to screen than one large tank. Multiple tanks also provide greater flexibility in operation. Tank materials should be noncorrosive and sectionalized for minimal transportation requirements to the tank site.

Water Distribution

Most distribution systems are either buried or placed at grade. At-grade distribution systems have minimal effect on the site and vegetation during construction, but are subject to problems with accidental breakage, frost exposure, vandalism, and visual quality. Burying has the advantage of protecting against accidental breakage, but leaks are more difficult to locate on a buried distribution system. Leak detection and repair is imperative when dealing with such a precious resource as water.

Dual distribution systems are very effective in that different qualities of water can be delivered to different use points. Pipe contents should be color-coded so that cross-connection problems can be prevented.

Other Water-Related Amenities

Water should be allocated to the highest use. Degradation of water quality in activities not associated with higher water uses are not part of sustainable design.

Regulations

The World Health Organization and individual countries and associations all have health regulations governing drinking water. For many parameters the maximum allowable contaminant levels are not identical. A resource-related development should determine applicable regulations prior to initiating a water supply program.

WASTE PREVENTION

WASTE PREVENTION

THE NEGATIVE EFFECTS OF WASTE

Almost 160 million tons of solid waste are generated in the U.S. each year. By the year 2000, the municipal solid waste stream is expected to increase by 20% to 193 million tons. Today, each American generates between 3 and 4 pounds of solid waste per day. This means that U.S. citizens generate the most garbage per capita in the world.

Experience has now shown that there is no completely safe method of waste disposal. All forms of disposal have negative impacts on the environment, public health, and local economies. Landfills have contaminated drinking water. Garbage burned in incinerators has poisoned air, soil, and water. Many water and wastewater treatment systems change the local ecology. Attempts to control or manage wastes after they are produced fail to eliminate environmental impacts.

The toxic components of household products pose serious health risks and aggravate the trash problem. In the U.S., about 8 pounds in every ton of household garbage contains toxic materials, such as lead, cadmium, and mercury from batteries, insect sprays, nail polish, cleaners, and other products. When burned or buried, toxic materials also pose a serious threat to public health and the environment.

The only way to avoid environmental harm from waste is to prevent its generation. Pollution prevention means changing the way activities are conducted and eliminating the source of the problem. It does not mean doing without, but doing differently. For example, preventing waste pollution from litter caused by disposable beverage containers does not mean doing without beverages; it just means using refillable bottles.

POLLUTION PREVENTION IN RESOURCE-RELATED SETTING

Preventing pollution in a sensitive resource-related setting means thinking through all of the activities and services associated with the facility and planning them in a way that generates less waste.

Waste prevention leads to thinking about materials in terms of reduce, reuse, recycle. The best way to prevent pollution is not to use materials that become waste problems. When such materials must be used, they should be reused onsite. Materials that cannot be directly reused should be recycled.

Everyone associated with the facility must change their habits and adopt a more responsible attitude toward waste. This includes the ownership and management of the facility, as well as the designers, contractors, employees, and visitors. Each of these groups needs to consider the issues so that no waste will be generated that adversely affects the environment.

Visible, Participatory Systems

The "out of sight, out of mind" mentality regarding waste is perpetuated because the systems that deal with waste problems are all behind the scenes and off-limits. Prevention can only be accomplished by paying attention to the issue up front, rather than waiting until after the problem has been created. An environmentally sound facility would ensure the visibility of systems to prevent the generation of waste. Such systems require conscious participation by visitors, users, and operators, but should not dominate the experience of a visitor at the facility. If each visitor does his or her share, the facility can be operated in a more environmentally sound manner. An additional benefit is that this can lead to long-term changes in behavior benefiting the participant and the earth.

Training and Maintenance

Waste prevention requires training the operators, educating all users of the system, and performing diligent maintenance. Most waste problems are created by lack of attention. Users who have received previsit and onsite instructions will avoid disposing of items that create major treatment and disposal problems. Because waste prevention represents a change in the way activities are carried out, it requires an extra effort to ensure that these practices are maintained until they become routine. In situations with high turnover of both employees and visitors, continuous training and education would be essential.

Host and Visitor Attitudes

Preventing waste means taking a measure of responsibility for activities. This can conflict with the attitude that going on vacation means escaping responsibilities. Without an attempt to change this attitude, the necessary participation may be difficult to obtain. Fostering a sense of responsibility in visitors is an important element of environmentally sound development in many other ways as well. One way to encourage this attitude is to convey to visitors that they are privileged visitors, and as a result, they may naturally feel obliged to follow certain guidelines established by their hosts. Facility operators should behave as hosts that care about making waste prevention work. Employees of the facility must care about it, and that caring must be visible to the visitors.

GARBAGE/SOLID WASTE PREVENTION STRATEGIES

In planning for visitor facilities, a comprehensive design strategy is needed for preventing generation of solid waste. A good garbage prevention strategy would require that everything brought into a facility be recycled for reuse or recycled back into the environment through biodegradation. This would mean a greater reliance on natural materials or products that are compatible with the environment.

Any resource-related development is going to have two basic sources of solid waste — materials purchased and used by the facility and those brought into the facility by visitors. The following waste prevention strategies apply to both, although different approaches will be needed for implementation:

- Use products that minimize waste and are nontoxic.
- Compost or anaerobically digest biodegradable wastes.
- Reuse materials onsite or collect suitable materials for offsite recycling.

Ideally, nothing should be brought into a resource-related development that is not either durable, biodegradable, or recyclable.

Use of Products that Minimize Waste

Much of the growing volume of garbage is from the use of disposable consumer products and excess packaging. Consideration must be given to materials or products that minimize waste disposal needs — purchase items with minimal packaging, buy in bulk, and replace disposable products with durable, reusable items. Durable, reusable products can be substituted for disposable ones, such as the use of returnable glass bottles instead of aluminum cans or the use of rechargeable batteries. Use of plastics for packaging is increasing, thereby replacing recyclable products and materials. Plastics, which account for about 20% of solid waste by volume, are nonbiodegradable, difficult or impossible to recycle, have a high volume-to-weight ratio, and are toxic when burned. Consequently, communities across the U.S. are beginning to pass laws banning certain types of packaging that inevitably become disposal problems. Cutlery and dishes need not be disposable.

When selecting materials and goods, nothing should be purchased that will ultimately become toxic. Nontoxic materials can often be substituted for products that cause contamination problems during disposal.

Materials should be purchased locally whenever possible. Locally produced goods needing less transport and less storage should have less packaging waste.

No matter how diligent people are in purchasing materials, certain items will need to be handled. There are two methods to consider — biodegradation or recycling. Technology and economics are continually changing, and the system selected must have the flexibility to adjust to market conditions. The scope of composting or anaerobic digestion of organic materials and the availability of markets for recycled materials should be considered in planning for a facility. These decisions are site-specific and must be made at the outset before final design is completed. Factors such as land availability, local markets, and isolation all contribute to that decision.

Biodegradation

In the process of biodegradation, microorganisms break down the products of other living things and incorporate them back into the ecosystem. Biodegradable or bioconvertible material includes anything that is organic. Plastics are not considered includable, despite industry contention that they are. Most of the organic components of garbage, such as paper and food wastes, can be eliminated through composting. Between 60% and 75% of the solid waste is bioconvertible.

In a park and ecotourism development, the greatest fraction of waste would be generated by the support and maintenance services. Wastes that are bioconvertible include newspapers, magazines, and wet wastepaper in the kitchen and restaurants. Also included are food waste, cardboard materials, paper office supplies, and leaves, grass, and tree trimmings. The solid fraction of the sewage waste is also considered available for the bioconversion process, and is often the most costly to dispose of otherwise, usually in a special landfill.

The biodegradable or bioconvertible percentage of the waste stream is large enough to consider at least two options for the conversion process. Two obvious options for conversion are composting and anaerobic digestion.

Composting. Composting is a familiar concept, and is used for handling yard waste and even sewage sludge. Both of these organic wastes require mixing of other materials to achieve a nutrient balance. Large chunks of relatively inert material (most commonly wood chips) add bulk and aeration to make the process work. This is typically done in open windrows or piles, with mixing done daily to provide aeration and homogeneity. This takes land space on a drainable surface, and a collection of any runoff for redispersal of the liquid to the process. It produces a quality soil amendment and reduces the bulk of the original material by approximately 40-50%.

Composting does off-gas ammonia and carbon dioxide and produces offensive odors. It typically takes 50-60 days to process. Screening of the final product is necessary to remove the bulking material and provide granulation before use in the soil bed.

The use of this product as a soil amendment is valuable, particularly in a tropical environment, because the soil is essentially sterile, with only about 2% organic content. Affected by humidity, rainfall, temperature, and normal soil activity, the organic material placed on the soil will typically last only 30-40 days in the tropics. In a temperate climate, that same material may last as long as six months.

Most composting operations of the size typical for communities could be suitable for ecotourism development use, considering the opportunity to also process construction debris and landscape waste. This will typically be the smallest scale and cost approximating $250,000. The construction debris process equipment can be transferred directly to the operations management and be capable of handling the full volume of waste.

Anaerobic Digestion. Anaerobic digestion is used extensively worldwide for the processing of food waste, animal waste, the solids of human waste systems, and for the total array of solid waste such as waste paper, green waste, and landscape waste. This wet fermentation process converts the waste stream into three usable by-products: (1) biogas — an energy-rich gas stream, comparable to natural gas, that can be used to offset the cost of energy utilities of the development; (2) a high-quality organic fertilizer solid that may be useful in landscaping efforts or even crop production; and (3) a diluted liquid organic fertilizer that may be used in drip irrigation as an additive to any planting program, for feeding ornamentals, or in landscape plots for replenishing native or endangered species of plants.

The anaerobic digestion process does need management supervision in startup. Design of the system should be simple and modular as well as easy to operate. The modular design allows seasonal loading rather than using one large vessel. This also provides for stages of digestion that help the natural biology of the fermentation reach its optimum capacity. While this requires more capital investment, the savings to be made in maintaining operations through seasonal fluctuation will prove to be cost-effective. The advantages of this system are in the smaller space it would require and in the energy it would produce, which may make the facility more self-sufficient. The value of the by-products cannot be understated, particularly in the case of remote development.

Recycling

A material doesn't become waste until it is thrown in the garbage can. If a material can be reused it is a resource, not waste. Reuse is the best form of recycling.

There are markets in the United States, Europe, Asia, and other parts of the world for many recyclable materials, including aluminum, paper, glass, steel, and some types of plastics. These may be available to a facility depending on location and the quantity of the materials generated.

Recycling can be maximized through the purchase of products for which there is a ready market as recycled materials. The feasibility of recycling a given material depends on the price offered by a buyer for that material and shipping costs, both of which may vary over time. However, if no other reuse or recycling option exists, materials used at the facility should be recycled even at a net loss rather than sent for disposal.

In circumstances where there is no available market for a given material, often a beneficial end use can be developed locally. Every effort should be made to work with the local community to determine if any of the materials generated by the facility can be used — e.g., glass beverage containers can be ground up and incorporated into materials for construction and road building.

Efficient recycling requires sorting of materials; convenient bins should be provided at the facility for the materials being recycled.

Offsite Disposal

If a garbage prevention strategy has been fully executed, actual remaining waste should be minimal. Remaining residuals mean that the facility is not entirely environmentally sustainable. All residuals must be collected separately and disposed of offsite. Although disposal of residual waste anywhere would have an adverse impact on the environment, in an environmentally sound development special care must be taken that this will not be borne locally. In most cases residuals must be returned to their place of origin. Toxic material residuals must be segregated and disposed of separately.

Materials Brought in and/or Purchased Onsite

Visitors and guests normally bring various materials that are consumed onsite, often leaving behind disposal problems. Products purchased onsite and in the surrounding community can exacerbate the problem. Such materials may include toxic and difficult to dispose of items (e.g., batteries, flash bulbs, instant film refuse, and repellents. Education, including what is incorporated in the written materials about the facility and what is available, is important in minimizing these types of waste materials.

DOMESTIC WASTE MANAGEMENT STRATEGIES

General Considerations

Domestic wastes in park and ecotourism developments come from toilets and urinals, showers, bathroom sinks, kitchen sinks, laundry facilities, and most floor drains. Varying amounts of water are used to carry these wastes through pipes to a treatment point. Different processing techniques are used to convert the wastes for reuse or disposal. True sustainable development would not permit direct disposal of either liquids or solids before reuse.

Responsible waste management recognizes the value of reducing water needs. Properly treated wastewater can be used for toilet flushing (after approved disinfection) and irrigation (landscape needs or agricultural plantings).

The solids separated from domestic waste may be incorporated into the solid wastes (garbage) and composted into an excellent soil amendment product or anaerobically digested to produce a gaseous energy source and a residue that can also be used as a soil amendment.

If wastewater recycling for toilet flushing is used without concurrent irrigation of vegetation, there will be a volume of excess liquid that must be sensitively disposed of. This will be the amount of liquid wastes coming in each day from all sources, less the recirculated amount used for toilet flushing. The best disposal practice would use a suitable area for subsurface movement of the liquid through soils that provide good filtering and additional treatment before reaching any body of water. Direct discharge to a waterway should be the lowest priority of alternatives investigated.

Using treated, recycled wastewater for toilet flushing, rather than an equal volume of drinking-quality water, would save a large amount of water. There are also strong economic and environmental reasons for using one of more than 20 different low-volume flush toilets (1.6 gallons per flush) currently on the market, rather than the more conventional water-wasting models. In coastal development sites, toilets may be flushed with seawater and processed with septic tank and subsurface treatment and disposal. This provides a reliable system if the corrosive nature of seawater is addressed in selection of materials used in the piping, plumbing, pumping, and treatment systems.

Similar water conservation can be realized through the use of flow-restricted, fine-spray shower heads, and sink faucet aerators. Spring-loaded handles should be installed on faucets. Laundry waste volume can be reduced through the use of machines with suds-saver cycles.

Park and ecotourism developments that make use of water conservation devices should make an effort to educate their visitors on the amount of water (or energy) they have conserved during their stay, compared with the conventional development. It is important to monitor the conservation devices in order to evaluate their performance.

As with all pollution, sewage is best treated by not creating it in the first place. Human waste only becomes waste when there is no use for it.

Specific Waste Treatment Technologies

Technologies that avoid or minimize the use of water and reuse the nutrients in domestic waste in beneficial ways are described below.

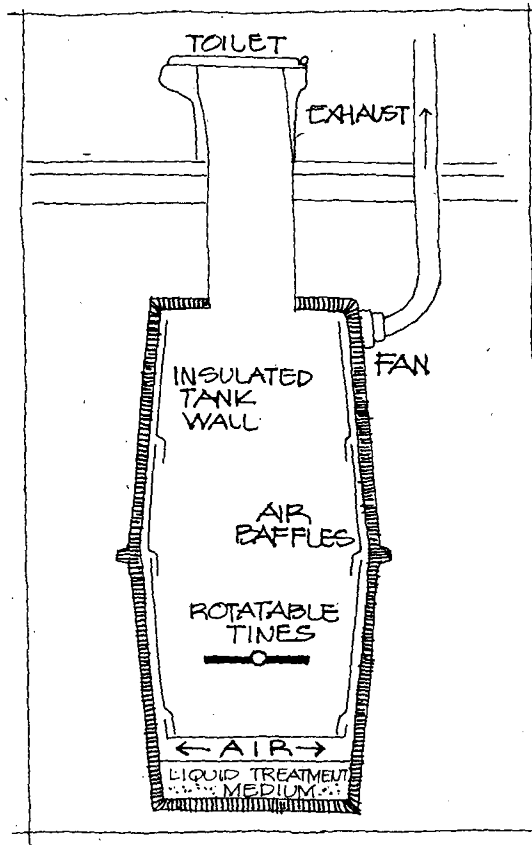
General. Conditions at sustainable developments favor simple, reliable, passive techniques for waste treatment. Systems that have few moving parts, controls, and monitoring requirements should be used. Continuity of operation and maintenance knowledge is essential.

Waste treatment systems must also be able to withstand seasonal fluctuations in use. Preparation for an idle period should be simple, and no energy should be required when the system is not being used.

If an innovative technology is to be employed for waste treatment, it should have a conventional backup system, or be sufficiently redundant that multiple failures are unlikely.

Dry Toilets (Composting Toilets). A composting toilet consists of a large tank located directly below the toilet room. Wastes enter the tank through a large diameter chute connecting to the toilet, and decompose in an oxygen rich environment. No water is used for the toilet, but a bulking agent (such as wood shavings) is added to improve liquid drainage and aeration, and to provide fuel. A small fan draws air through the tank and up the vent pipe to ensure adequate oxygen for decomposition and odorless operation. Internal components (such as ducts, baffles, and rotating tines) enhance the composting process. The finished compost can be removed from the lower end of the tank about once each year. It can be used as a fertilizer for soil.

Composting toilets need a mild temperature, moisture, fuel, and air to function. Liquid may have to be added to the tank to keep the compost pile moist during periods of little use or a bulking agent added periodically to improve the compost texture.



Composting toilets have several advantages over other systems — e.g., no water is used and only a small amount of energy is needed for an exhaust fan; valuable nutrients are used to benefit soils; proper maintenance requires little time.

There are some disadvantages to this system. The user is close to the sewage treatment systems and this bothers some visitors. Without proper maintenance, the tank can become anaerobic and unpleasant odors arise. Undesirable pests can take up residence in the composting tank. The availability of a bulking agent in some areas can also be a problem.

Anaerobic Waste Treatment. Anaerobic waste treatment (septic systems) is accomplished through microorganisms living in the wastewater. Anaerobic microorganisms work in an environment where there is no free oxygen. Complex reactions and interactions take place with the resulting generation of some offensive gaseous by-products. These unpleasant odors are actually an indication of an efficient progression of the anaerobic process to remove the pollutants from the waste stream.

This type of system is reasonable to consider for smaller developments, where the by-product gases can be separated from occupancy areas, dissipated with good air movement, or neutralized with soil or carbon filters. Since slow treatment means longer holding periods (shallow depth tanks), large, isolated treatment and disposal areas are needed. Treated wastewater (effluent) is usually disposed of in an underground system that passes the effluent through carefully selected undisturbed soil profiles. These soils must further filter and remove nutrients as the effluent makes its way to the groundwater or other bodies of water.

One variation of this type of treatment uses part of its treated effluent for toilet flushing. The stored recycled effluent should receive some aeration to ensure odor-free recycled water in the toilets.

Anaerobic waste treatment systems have several advantages. They are relatively inexpensive to install, are not complex to operate and maintain, and provide a consistently good quality effluent. Most components can be installed aboveground or they can be buried or partly buried. Good quality flushing water can be provided to reduce water supply needs and final disposal volumes.

The disadvantages are that septic tank odors must be dealt with properly. Several pumps and blowers can be involved, which create maintenance and power costs and cause noise in some developments. Septic tank solids require proper disposal. An aerobic digestion tank would reduce disposal volumes. A sand-drying bed can be used for digested sludge drying, and the dried sludge should be buried in a landfill. A fairly large area is required for installation. There is no known manufacturer of a complete package system.

Prior to committing time and resources, it is prudent to contact users of similar systems — talk with a designer, system operator, an owner, and possibly a regulatory agency inspector who has observed performance of anaerobic waste treatment systems.

Aerobic Waste Treatment. Aerobic waste treatment is also accomplished with microorganisms. However in this system, air is bubbled into the treatment process to ensure plenty of free oxygen. Aerobic organisms work about 20 times faster than anaerobic organisms. Since the process is so much faster, much less holding time is required and less treatment area is needed.

Aerobic waste treatment systems are reasonable to consider for all sizes of park and ecotourism developments, and because offensive gas odors are not normally produced, this type of system can be located close to occupied areas. The normal effluent quality of a properly designed and operated system meets most all secondary treatment standards. With a reasonably small filter, high quality effluent can be produced for irrigation and recycled toilet flushing water. With carefully planned effluent recycling and irrigation reuse, little or no effluent disposal would be required. If disposal is required, several options are possible.

There are several manufacturers of small aerobic treatment plants. The best plants for harsh environments and isolated areas are fabricated from durable, low maintenance materials, simple to operate and maintain, designed to use the fewest moving parts, and consistent in effluent quality. They are also quick to install and put in service, proven in similar installations, and completely assembled and warranted by one manufacturer. A good manufacturer also provides, at a reasonable cost, technical and monitoring services on the new plant for at least one year after initial startup.

The advantages of one particular system are that all materials in contact with liquids are noncorrosive (plastic, fiberglass, rubber, stainless steel) and can be buried or installed aboveground. The blower is the only moving part and requires only simple, routine maintenance. Effluent quality is consistently good. Excellent recycle and reuse options are available. The process easily handles surge loadings as well as underloaded periods. Land area required is about 0.1 acre per 10,000 gallons of rated capacity. Site installation and startup can usually be accomplished in five working days or less. Few spare parts are needed. Purchase costs are competitive with other similar-sized treatment units. Unskilled operators have successfully followed infrequent, telephoned system adjustment instructions to maintain top performance.

The disadvantages are that most components are fabricated, assembled, and shipped from Colorado — few local materials would be used. The blower, although small, needs to be run continuously. The noise would have to be muffled, and a constant power cost would be involved.

The National Park Service has five of these plants in service in four widely varying environmental areas. Three of these plants have been in service for several years.

Alternative Disinfection Methods

Traditionally, water from conventional treatment systems is disinfected with chlorine or chlorine compounds before being released back into the environment or reused. A side effect of this is that the chlorine or chlorine compounds are very reactive and sometimes produce highly persistent, toxic chemicals. Many environmentalists believe that there is no justification for use of chlorine and its compounds for disinfection.

Most public health codes call for disinfection with chlorine, and these codes would have to be changed to allow for either no disinfection or the use of other disinfectants. Less desirable possibilities include using less chlorine or removing the chlorine after the proper contact time. Dechlorination requires additional chemical feed and training.

The purpose of disinfection is to ensure that no virulent organisms are present after the water has been processed in one of the systems described earlier. The most common alternative disinfectants are ozone and ultraviolet light.

An entirely new treatment technology, introduced in September 1993, appears to provide excellent disinfection without the formation of environmentally harmful by-products. The National Park Service is arranging pilot studies at existing water and sewage treatment facilities to evaluate this emerging innovative technolgoy.

FACILITY MAINTENANCE AND OPERATIONS

FACILITY MAINTENANCE AND OPERATIONS

THE IMPORTANCE OF MAINTENANCE AND OPERATIONS IN SUSTAINABLE DEVELOPMENTS

Facility maintenance and operations should be part of an ongoing long-term management system that plans, guides, and supports visitor services, natural and cultural resource protection, and facility management. The purpose of the system is to provide guidelines that define acceptable maintenance and operational practices, employee training, and strategies for sustainably designed developments. The facility should operate and be maintained at the same or higher level as was designed and constructed, continuing the use of sustainable design concepts. The role of facility operations is to consistently maintain quality visitor experiences without the depletion of resources and to promote environmental and cultural resource awareness and education.

This section considers the implication of sustainable development on postconstruction responsibilities. Although many of the principles are applicable to any well-operated facility, they take on significant importance with sustainable developments in order to meet the purpose and demands of sustainability.

GENERAL CONSIDERATIONS

Since planning, design, and construction of a facility affects its operation and maintenance, these needs and concerns must be incorporated into the planning, design, and construction efforts. Facilities (primary and support) should be designed using appropriate technology necessary to meet their functional needs. Simplicity of design and construction will reduce maintenance costs and maximize operational efficiency for the staff. Materials chosen should meet all local and national occupational safety and public health service guidelines for health and toxicity standards. Toxic materials should be avoided or their use drastically reduced to prevent pollution of the resource. Adherence to safety and accessibility considerations is of particular importance in sustainable design to avoid postconstruction redesign to correct deficiencies or improve standards. For example, nonskid surfaces in wet areas and access for those with physical and sensory impairments are issues that need to be resolved in the planning stage, thereby eliminating later reconstruction that wastes materials and energy and disrupts natural environments.

The use of new technology as a management tool for operations and maintenance (e.g., geographical information systems (GIS), computer assisted drafting and design (CADD), maintenance management systems) is of special importance with sustainable developments. The goal is to design correctly the first time to avoid unnecessary maintenance and replacement at a later date.

Ongoing communication between facility operators and cultural and natural resource personnel should be continued to ensure design intentions and operational quality are maintained following initial construction.

An awards program is recommended to recognize excellence and use of sustainability and nontoxic principles in facility operation and maintenance. Such programs could be developed on industrywide and local levels.

GENERAL MAINTENANCE

The planning, design, and construction of a sustainable development is based on sound engineering and ecological practices. When construction is completed, the designers and construction contractors should critique and fine-tune the final product for environmental sensitivity before the site is turned over to a facility manager for maintenance. During the life of a park or ecotourism development, designers rarely have the opportunity to revisit the site to provide direction for maintenance activities. Over time, the collective and cumulative effects of maintenance and operations may diminish the environmental soundness and sensitivity of the development unless appropriate maintenance practices are defined before facilities are opened for use.

From a maintenance standpoint, the differences between sustainable design and nonsustainable design can be compared (see table 5).

TABLE 5: SUSTAINABLE VS. NONSUSTAINABLE DESIGN MAINTENANCE

Sustainable Design	Nonsustainable Design
Durable material from natural, renewable, or recyclable sources (stone, fly-ash concrete, recycled aluminum)	High-energy/high-resource impact material selection with short life expectancy (synthetic carpeting, hydrocarbon-based plastics)
Lower energy consumption and resource demands (use of recycled wastewater, low-volume plumbing fixtures, and energy-efficient equipment)	High utility cost (unrestricted water use, uncontrolled energy use, discharge of waste without reuse/recycling)
Operational mandate and direction (experienced management with appropriate resource and climate background, commitment to sustainable design)	Lack of operational manuals and direction (no waste management manual or long-term maintenance plan)
Helps promote:	Leads to:
lower operational costs (better training, warehousing)	high operational costs
high visitor satisfaction (local materials, appearance harmonious with environment)	low visitor satisfaction
reduced maintenance staff with higher morale (pride in facility, easier to maintain)	large maintenance staff
little redesign or rehabilitation	frequent rehabilitation and/or replacement
maximum return on embodied energy	lower standards accepted to lower costs; higher user costs

Maintenance facilities must be an integral part of the design of a development. The aesthetic and environmental value of a development can be severely compromised by a maintenance site that appears to be badly designed or added as an afterthought.

Maintenance access to the development should limit vehicular use and travel, minimize environmental impacts on the site, and be nondisruptive to the functional operation of the development.

For the original design to retain its high quality, facility maintenance must have the highest quality standards. The true test of a successful maintenance program is through the perceptions and reactions of the users.

With a design based on sustainable technological systems and material selections, an acceptable facility maintenance program should center on the

- understanding and interpretation of original design elements that must be repaired on replaced over the life of the facility
- development of a maintenance management system for daily and long-term operations that minimizes environmental impacts
- training and development of a local work force
- use of skilled artisans who provide, or instruct maintenance employees in, traditional methods of construction to reflect and enhance local cultural values

Construction Materials

Maintenance implications for commonly used construction materials are indicated in table 6.

Maintenance Management

Facility managers must be encouraged and trained to look beyond daily maintenance operations, particularly in remote park and ecotourism developments. For example, managers must anticipate and accurately predict component replacements, since shipping and delivery of small orders are subject to delays, consume energy, and disrupt operations.

A maintenance management system must be developed that includes

- an inventory of elements to be maintained
  Examples:
  - number of picnic tables, signs, campsites, rooms, food service seats, number and type of docks, etc.
  - square footage of building space, miles of road, length of trails, etc.

- maintenance standards based on use and environmental/climatic conditions (tropical area used as illustration)
  Examples:
  - frequent pruning of trails due to year-round plant growth in a tropical climate (pruned vegetation may be placed in a composting pile for use later as soil enhancer or fuels)
  - numerous daily cleanings of restrooms due to tropical sands and warm, moist weather conditions
  - frequent cleaning, waxing, and lubrication of vehicles and mechanical equipment to prevent rust and early mechanical failure due to salt spray and sand
  - frequent repair of signs due to intense sun and wind

- work schedules
  Examples:
  - daily, weekly, monthly, and seasonal schedules
  - long-range goals to determine future direction and cyclical needs

- work implementation and direction
  Examples:
  - work crews assigned duties with environmental standards
  - field inspections for quality control
  - assurance that tasks meet environmental and operational objectives

- plan for logistical services
  Examples:
  - planning and scheduling work material orders with energy-efficient transportation systems
  - reducing energy requirements for transportation
  - promoting local economy and using locally available equipment and supplies
  - meeting preventive maintenance scheduling
  - using a warehouse operation, maintenance contracts, and local technical support services to reduce energy inefficiencies and avoid delays normally found in remote areas

- realistic budgets, both long and short range
  Examples:
  - setting annual and quarterly budgets
  - including preventive maintenance in budget
  - including full salary costs, benefits
  - generating budget cash flow that develops an account to cover major replacement costs

TABLE 6: MAINTENANCE IMPLICATIONS FOR COMMON CONSTRUCTION MATERIALS

Construction Material	Material Longevity	Cycle Frequency	Specialized Training	Specialized Equipment	Employee Health Hazard	Renewable Resource Requirement	Maintenance Costs	Disposal Problems
ROADS								
Gravel	3	3	1	1	1	3	3	1
Asphalt	1	1	2	2	1	2	1	2
Concrete	1	1	2	2	1	2	1	2
Special Treatments	V*	V	V	V	V	V	V	V
* Varies								
TRAILS								
Gravel	2	3	1	1	1	3	3	1
Stone Chips	1	2	1	1	1	3	3	1
Bark	3	3	1	1	1	3	3	1
Native Soil	3	3	1	1	1	3	3	1
Wooden Boardwalk	2	2	2	2	1	1	2	3
Concrete	1	1	3	2	1	2	1	2
Asphalt	1	1	3	2	1	2	1	2
BUILDING MATERIALS								
Foundations								
Concrete	1	1	2	3	1	2	2	2
Block	1	1	2	2	1	2	3	2
Treated Plywood	3	2	2	1	2	1	2	3
Exterior Walls								
Wood	2	2	1	1	2		2	2
Plaster	1	1	2	1	1		3	1
Concrete	1	1	2	2	1		2	1
Block	1	1	2	1	1		2	2
Vinyl	3	3	2	2	1		3	1
Stone	1	1	1	2	1		3	1

Construction Material	Material Longevity	Cycle Frequency	Specialized Training	Specialized Equipment	Employee Health Hazard	Renewable Resource Requirement	Maintenance Costs	Disposal Problems
Roofing								
Tile	1	1	2	2	1	2	1	1
Roll Roofing	3	3	1	1	1	1	3	3
Asphalt Shingles	2	2	1	1	1	1	2	3
Sheet Metal	2	2	2	2	2	2	1	2
Interior Walls								
Sheet Rock	3	3	2	1	1	3	2	2
Plaster	1	1	2	1	1	3	2	2
Tile	1	1	3	2	1	2	1	2
Treated Plywood	2	2	1	1	2	1	2	3
Flooring								
Slate	1	1	2	2	1		1	1
Linoleum	1	1	1	1	1		3	3
Tile	1	1	2	2	1		1	1
Vinyl	2	3	2	1	1		3	3
Carpet	3	3	1	1	1		2	3
Wood	2	2	1	1	2		2	2
Key to ratings:	1 = long	1 = low longevity	1 = little training replacement	1 = general required	1 = low health equipment	1 = minimizes use of nonrenewable resources	1 = low cost of nonrenewable resources	1 = low
	3 = low life expectancy	3 = high cycle replacement	3 = high degree of training	3 = specialized equipment	3 = high health hazard	3 = requires high degree of nonrenewable resources	3 = high costs	3 = high

Maintenance Employee Selection, Training, and Development

An essential goal of a quality, well-maintained sustainable development should be the hiring and training of the local population. During design and construction, individuals who excel in local artisan skills and show leadership potential should be identified. Upon completion of initial construction, the most qualified local artisans should be recruited and trained for future maintenance manager positions. The concept of total absorption of individuals into the design, construction, and maintenance steps constitutes sustainable personnel use, which complements sustainable development. A maintenance employee who was involved in initial design and construction would be likely to show a high level of pride in maintaining the facilities to the highest possible levels of quality.

The maintenance personnel training program should include exposure to the environmental features and constraints, development concept, and design philosophy of the park or ecotourism area.

Each employee should be cross-trained in major maintenance categories. The stratification of specialist employees should be avoided. Maintenance employees should be trained in interpretive skills and present demonstrations that reflect their skills. Maintenance uniforms should reflect use of cultural clothing.

Families of maintenance personnel should be encouraged to visit the workplace to develop a sense of pride in "ownership" and workmanship. Parents should be encouraged to pass along artisan skills to children, who in turn would eventually become multiskilled.

Technical training should begin in the early phases of design and construction, and product manufacturers should provide hands-on training in preventive and cyclic maintenance before the park or ecotourism area is opened.

CHECKLIST OF SPECIFIC MAINTENANCE ELEMENTS

Building Materials

- Use quality materials compatible with sustainable design to provide environmentally sensitive, yet easily maintained facilities (quality materials provide durability and reduce life-cycle resource and maintenance costs, thereby enhancing sustainability and visitor appreciation).

Site Architecture

- Use low-maintenance native vegetation for landscaping and incorporate natural features (rocks, trees, etc.) for defining paths, walkways, etc.

- Use hardened trails, boardwalks, rope or wood railings, tent pads, designated boat moorings, etc. when intensive visitor use threatens to degrade the site and subsequently increase maintenance and operational costs.

- Limit use of signs to minimize visual clutter.

Recycling

- Make visitors and operators aware of recycling opportunities and environmental benefits.

- Provide programs to recycle glass, plastic, paper, aluminum/tin, oils, etc., for both visitors and staff (this includes providing separate bins for recycling materials and using generators that recycle their own waste oils).

- Recycle appropriate building materials resulting from construction, rehabilitation, and demolition activities.

- Search out and retain markets for recyclable materials — a problem in many rural, remote locations (if recycling markets are distant, additional storage space should be provided onsite for short-term storage of recyclable materials awaiting efficient means of transport; or alternate products and materials should be considered that have longer life spans or can be recycled locally).

Waste Management

- Separate composting materials from other trash for soil enhancement (the main maintenance facility should include composting facilities for a vegetative material generated by pruning or storm damage).

- Consider conventional underground and spray irrigation systems for wastewater.

- Use discharge of gray water for irrigation purposes and avoid discharge into lakes or streams.

- Develop waste management systems within the capabilities of operators.

Animal Control
- Provide animal-proof storage boxes for food items.

- Develop systems to prevent conflicts between feral animals and the visitors and employees in developed sites.

Toxic Waste
- Substitute nontoxic materials (numerous nontoxic building materials, household cleaners, and water-based paints are widely available — e.g., substitute hydrogen peroxide for hypochlorite as a disinfectant; substitute solar battery rechargers and rechargeable batteries for disposable batteries, which accelerate placement of toxic compounds into the waste stream).
  - avoid use of toxic materials as a substitute for elbow grease or when required maintenance of equipment has been omitted

- Use minimum amount of nontoxic materials to accomplish task.

- Plan to avoid wasted materials.

- Use care in handling to avoid spillage.

- Train all workers about safe use.

- Find opportunities for offsite recycling (many toxic materials can be recovered and re-refined for future use, including automobile oil, car batteries, lead storage batteries, and tires).

- Provide onsite control.
  - design handling area for spill control and recovery
  - pave and dike all areas to ensure that spilled toxic materials do not enter the environment
  - build enclosures to prevent runoff

- Collect and segregate remaining toxic waste for offsite disposal (a small accumulation of toxic waste that cannot be reused or recycled can be caused by limits in product availability and lack of control over materials brought in by visitors and employees — e.g., batteries, photographic products, pest repellents, fuel products, light bulbs, degreasers).
  - keep in aboveground storage to prevent undetected release into the environment
  - ship to offsite facility for disposal (landfill or incinerator)

Pest Control
- Conduct complete survey of wildlife and vegetation prior to construction.

- Avoid sites that contain large populations of noxious insects, organisms that serve as disease vectors, spiny and poisonous plants, etc. (when these are natural inhabitants at a site, they must remain at the site).

- If a particular site must be used, do not control or eradicate naturally occurring organisms.
  - isolate humans from interaction with pests (this must be both site and organism specific)
  - use window screens and nets to keep out mosquitoes (these may keep out small insects, but may be counterproductive if they cut down on breezes that blow small insects away)

- Provide education and interpretation for visitors before or at arrival onsite.
  - instruct visitors on how to live most comfortably with the plants and animals who have priority over them in this particular habitat
  - make visitors aware of any risks

- Recognize that organisms that are present, or in extremely elevated populations, are likely due to the intervention of man (these problems might be the result of alteration of the landscape or from more generic problems related to the development).

Examples of organisms that are or have become pests due to man's intervention:

- exotic mammals — humans have often inadvertently (and sometimes deliberately) introduced exotic mammals in places where they have prospered and become destructive to native wildlife (e.g., Norway rat, mongoose, mice, rabbits, burros, horses, beaver, goats, dogs, and cats)

- disease organisms — humans have brought various diseases into new locations that have become epidemic, wiping out entire populations, or have become lingering debilitating problems, as with malaria

- increased populations of existing species — mosquitoes and other insects that are attracted or given more breeding opportunities due to the development

- exotic insects — many nuisance insects have been introduced (e.g., the German cockroach and the Formosa termite)

- marine organisms — ballast water carried by ships has introduced various organisms into tropical and temperate waters (e.g., the Crown of Thorns starfish)

- birds — exotic bird species are often introduced by man and cause extensive damage; they are also responsible for diseases and destruction of native birds

- weeds — much native vegetation has been lost worldwide due to man's activities; even in seemingly wild places there are nonnative plants, and these new arrivals are often more robust and choke out native vegetation

■ Select building materials and climatic/miniclimatic building factors to reduce or eliminate breeding grounds for pests whenever practicable.

■ Develop a pest control management program that uses nonchemical means to the degree possible (different strategies would be required for different pests in different habitats; the following list is illustrative of some choices available).

- trapping of individuals — this is appropriate for rodents or for relocating

- proper cleaning — pests are indicators of improper sanitation and storage of materials; visitors and staff must store food properly and keep all areas of a facility clean

- natural predators — natural predators must be able to live in the development and prey on the target pest population; lizards and spiders are particularly important for this purpose

- regular removal of attractants — some products should be avoided such as certain perfumes and colors of clothing

- habitat control — inadvertent changes in habitat can create new breeding areas for pest species; e.g., standing water in otherwise dry areas

- hand removal — it is sometimes possible to control nuisance organisms by capturing them by hand; large caterpillars and beetles can be removed by hand from individual plants

- use of natural means — many naturally occurring materials have pesticidal properties; as these materials are found in nature and created by living biochemical processes, they can be handled by the environment with less drastic results than is the case with introduced chemicals.

■ Initiate method of preventing introduction of new organisms into facility.

■ Know cradle-to-grave implications of using any treated materials or chemical treatments.

FACILITY OPERATIONS

A sustainable development provides opportunities for sharing sustainable design values with the visitors and staff. Development operations should help impart to both visitors and staff an enhanced set of values supporting sustainable human behavior towards the earth. This should be a primary focus in the staffing, staff training, and interpretive efforts, as well as in the actual design and use of the facilities and services.

Staffing

Operations and maintenance staffs should have a sense of commitment to sustainable design and operations and pride in the facility and services offered. These values are dependent on guidance and leadership of the managers.

The staff (operations and maintenance) must be trained to understand and communicate sustainability principles to visitors and other staff members. They will teach by example as well by answering questions. The maintenance staff must also be trained in preventive maintenance procedures rather than just replacement procedures.

Education and Interpretation

Sustainability must be visible in all aspects of the operation, including utilities, waste handling, maintenance, retail operations, and visitor services. The development should share sustainable design, maintenance and operational problems, and solutions with visitors, and actively demonstrate solutions and new technology. Through information signs and brochures and items sold in shops, the visitor can become informed about environmentally responsible design, operational procedures, materials, and equipment. They can learn how to adapt some of the methods to their personal lifestyles. For further information, see the "Interpretation" section.

Visitor Facilities and Services

Facilities should complement both the natural and cultural environment. If local renewable materials or crafts are used, they should be interpreted so as to ensure their sustainability. Colors, wall hangings, and furnishings can add to or detract from the visitor's experience, and to the extent possible, furniture should reflect environmental concerns and local cultural sensitivity. For example, furniture should not be made of woods such as teak, rosewood, or ebony that encourage rain forest depletion, and furnishings should not reflect colors or subject matter that may be culturally offensive.

Food service, merchandising, and other services should contribute directly to an increased understanding and appreciation for environmental and cultural awareness, as well as sustainable design. Menus could feature local fare and include information on local food customs and the area in general. Shops provide a means for visitors to take something of their experience away with them. Gifts and souvenirs should have a direct relationship to the area's natural and cultural values or other related environmental topics, including sustainable design. The development should use the most sensitive packaging for sales items and food items.

Environmental Action Checklist

Each park and ecotourist development should have an environmental action checklist that will provide ideas on good environmental practices. The list should be reviewed periodically for additions and changes. It can include maintenance actions, utilities, specific operational activities, antipollution measures, and interpretive activities. The accompanying list is provided as an example of items that could be included. It is modeled after a list prepared by Development Counselors International for the U.S. Virgin Islands, and included resort activities as well as general concerns. Each park or ecotourism area must customize its list to include all specific concerns and provide examples where appropriate.

ENVIRONMENTAL ACTION IDEAS
(Sample)

MANAGEMENT

- Staff meetings to educate staff about environmental concerns.
- Establish no-smoking sections.
- Do not purchase furniture made of teak, mahogany, rosewood, ebony, iroko, or other tropical timbers that encourage rain forest depletion. Instead, use oak, pine, cherry, birch, or maple.
- Conduct an environmental audit.
- Plant trees for cooling, using native trees.
- Discourage feral animal populations (examples)
- Encourage indigenous wildlife (examples). Work with nearby parks.
- Plant some attractive local species of plants and trees on property to maintain local biodiversity. Work with nearby parks, arboretums, etc.

MAINTENANCE/JANITORIAL

- Minimize the use of nonbiodegradable cleaning products.
- Keep air-conditioner filters clear.
- Fix leaks promptly.
- Buy unbleached paper towels, toilet paper, coffee filters, etc.
- Post anti-litter signs around the grounds.
- Adopt area for cleanup.
- Donate waste to charity program (left-over room items, shampoo, etc.)

ENERGY/RECYCLING/WATER CONSERVATION

- Use gas rather than electric clothes dryer.
- Install water saving faucets and showerheads.
- If using regular toilets, put bottle in the toilet to conserve water.
- Bike to work program (possible tee shirt: "I Biked to Work at the (name of property)").
- Caulk windows to eliminate cooling loss. Use shades, drapes, shutters, etc. on sunny side.
- Practice good vehicle maintenance:
  - buy light-colored cars with tinted glass (need less A/C)
  - keep engine filters clean
  - use the gas octane and oil grade recommended
  - check tire pressure regularly
- Program for wastewater recycling.
- Employ computer controls for energy use – off when not needed.
- Work with natural resource department to maximize the use of solar energy (sun, wind, etc.).
- Help initiate a recycling program for the area.

POLLUTION/BEAUTIFICATION

- Ventilate areas where smoking is permitted.
- Control mold and mildew on carpets, drapes, etc.
- Do not use construction materials or adhesives made with formaldehyde
- Take waste motor oil to a recycle center.
- Do not use Halon fire extinguishers.
- Get involved in beautification programs in residential areas around the resort – house painting, landscaping, power cleaning, litter control, garbage cans, etc.

RESTAURANT/COFFEE SHOP/SNACK BAR

- Eliminate the use of beverage containers with detachable flip-top lids.
- Minimize the use of throw-away plastic cups, plates, and bowls.
- Minimize the use of nonbiodegradable cleaning products.
- Purchase in bulk such items as sugar, jellies, butter, and eggs to reduce packaging and waste.
- Consolidate ordering of supplies to reduce traffic and fuel consumption from delivery trucks.
- Establish no-smoking sections.
- Offer vegetarian meals to encourage visitors to eat lower in the food chain.

- Use sensible dress code (no jacket) to save cooling.
- Check that shrimp being purchased are caught by fleets using turtle-release devices.
- Check that tuna are caught by means that protect dolphins.
- Use cans instead of bottles to reduce landfill until glass can be recycled.
- Use boric acid for roach control instead of poisons.
- Encourage less beef to protect rain forests.
- Offer food waste to farmers for animal food.

SHOPS/DRUGSTORE/GIFT SHOPS/ETC.

- Minimize aerosols that contain fluorocarbons.
- Minimize polystyrene foam products.
- Minimize the use of plastic bags where possible.
- Purchase items with sensible packaging.
- Purchase bulk items where possible.
- Consolidate ordering of supplies to reduce traffic and fuel consumption from delivery trucks.
- Offer healthful snacks.
- Print anti-litter and conservation slogans on paper grocery and shopping bags.
- Print anti-litter and conservation slogans on clothing and tee shirts sold in shops.
- Eliminate products from endangered plants and animals (ivory, tortoise shell, etc.)
- Install can crushers to recycle aluminum cans and receptacles to place them in.
- Recycle newspapers – take them to the Humane Society for use in cages.

INTERPRETIVE AND PROMOTIONAL IDEAS

- Publish a conservation newsletter on subjects such as don't waste (take home partially used bathroom articles), support nearby parks, pick up litter, be nice.
- Use conservation posters.
- Print save the planet or environmental destination notes on menus, tee shirts, anti-litter garbage cans, and at the waterfront, spa, and health activities.

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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