Resource-Balance Design and Monitoring: Assessing Sustainability of FSEEC-LandLab as BSU's First Sustainable Built-site

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Abstract—*This paper addresses the change from earth as self-managing ecosystem operating within local limits and natural laws, to a human-dominated ecosystem where people falsely believe they live outside natural limits and laws. It reviews the shift from low-technology and regional-economics to advanced technologies and globalization whose impacts exceed nature's ability to regenerate and that render the earth incapable of self-management. It calls for a shift from the present source-to-waste paradigm to one that promotes system regeneration; and for environmental management essential to a sustainable future.*

The paper reviews major built-environment impacts; and the absence in the planning and design professions of defensible processes that interconnect decisions to the health and sustainability of local and contextual ecosystems. It also addresses the lack of recognized methodologies to assess whether "sustainable" planning and design decisions facilitate ecosystem regeneration or, conversely, degrade contextual ecosystems.

This paper presents a model for designing built-sites that seek to sustain ecobalance; and for monitoring ecosystem indicators to assess whether decisions achieve this goal. It reviews application of this model to the site of Ball State University's proposed environmental education building and landlab green technology demonstration site (FSEEC-LandLab) as the university's first proposed green built-site. This application includes: 1) resource-balance as an initial site decision management tool, 2) GIS database development to facilitate design that sustains resource-balance, 3) proposed management systems for the overall site and its built-zone, 4) a decision framework of built-site goals, objectives, and guidelines, 5) a proposed feedback system of ecological indicators, baselines, benchmarks, and monitoring to determine the degree to which site-based management, planning, and design sustain resource-balance, 6) initial indicators, monitoring hierarchy, and monitoring station locations, and 7) proposed initial resource-balancing projects to build and monitor.

Systemic Shifts

Diverse global systems are degrading. Capra (1981) suggests that parallel degradation in diverse systems is symptomatic of a metacrisis; and that this degradation indicates the Earth is at a turning point that will profoundly affect human survival. Managing Human Dominated Ecosystems (Hollowell 2001) explored the recent shift of Earth from a self-managing ecosystem to a human-dominated one, where humankind decides whether the Earth is managed in sustainable ways.

Humankind arrived at this turning point due to social, economic and technological shifts from people living largely within local economies and using relatively low-impact technologies to a global economy and high-impact technologies. Unfortunately, these shifts were accompanied by a paradigm shift to a false belief that humankind operates outside local limits and natural laws (Quinn 1995). These shifts replaced production and infrastructural systems that were, in many cases, interconnected with local and regional systems; with disconnected production and infrastructural systems that overpowered the regenerative capacity of natural systems. They degraded resources (air, land, water), reduced local and global capacity to sustain life and build natural capital, triggered decline in every living system on Earth (Brown 2003), and turned Earth from a self-managing global ecosystem to one that can no longer self-manage.

Needed Shifts

There is a profound need to co-manage natural and human systems for sustainable health and production, and for human survival. This includes a need to shift technology, production, and infrastructure from systems that consume and degrade resources to ones that sustain and help regenerate resources. There is a need to manage human impacts within the limits of natural system regeneration, and co-manage natural and human systems to produce a just world that enhances living standards for all. Global societies need to shift from economic systems that mine and consume resources to ones that harvest and sustain resources (Quinn 1995); and from economies that degrade to those that facilitate regeneration. Global societies need to embrace an eco-economy that uses principles of ecology to integrate decisions with resource life-cycle flows and sustains ecobalance so that environmental potential after intervention is at least as great as potential prior to intervention. Survival requires that we sustain environmental resources and the ability of living systems to regenerate the natural capital (Hawken and others 1999) upon which we ultimately rely.

Needed Built-Environment Shifts

Natural systems sustain themselves through regeneration and cyclical life-cycle resource flows. Elements partner to regenerate system health and capacity. Outputs from one process are inputs to another, and the system regenerates its capacity and self-manages its health and productivity. People intervene in these systems to use natural capital to address human needs, often through manufacturing and the provision of infrastructure, buildings, and cities. The way human and natural systems interconnect profoundly affects natural system capacity to address human needs and sustain the natural capital upon which people depend. In a sustainable world, human systems augment natural system regeneration, health and sustained productivity. In our present unsustainable world, human systems fail to support regeneration and excessively convert resources to waste.

Like other professions, physical planners and designers urgently need to shift from waste-producing paradigms to regenerative ones. They need to implement processes and integrate decisions to produce sustainable local and contextual ecosystems; and to monitor whether planning and design facilitate regeneration or, conversely, degrade ecosystems. They need to embrace regenerative design (Lyle 1994) so that products, infrastructure, buildings, and cities function as appreciative systems (Jantsch 1975) that help regenerate natural system health and productivity. Planners and designers need to pursue a positive ecobalance between pre- and post-intervention system health and productivity. They need to replace decisions that mine resources in consumptive, waste-producing, chemically dependent ways; with decisions that promote sustainable harvesting, integration with resource life-cycle flows and regenerative dynamics, and impact mitigation.

Resource-Balancing Design for the FSEEC-LandLab

Methods, tools and datasets have been developed to integrate design decisions with resource flows (Odum, H. T. 1994; Peterson 1972; Fisk 1989) and to pursue ecobalance (Fisk 1997). Motloch reviewed some of these, the lack of integration of these tools into mainstream planning and design processes, and the need to implement design for regeneration and ecobalance (2001). Based on Fisk's work, he proposed the Eco-balancing Design Model to integrate ecobalancing methods into physical planning and design (fig. 1). This model sought to extend conventional GIS databases and data analysis to inform land management, use, and planning decisions based on the ecobalance implications of decisions. The model includes GIS life-cycle data-maps and productivity maps, and eco-balancing processes (balancing upstream and downstream productive potential). It includes a feedback system of ecological baselines (existing conditions or performance levels), benchmarks (targeted conditions or performance levels), and monitoring of sustainability indicators to assess the degree to which interventions promote change toward benchmarks. This model was proposed as an information-flow system for confirming and evolving the degree to which planning and design decisions promote sustainability.

As a step toward campus design for ecobalance, Motloch (2002) conducted a Ball State University (BSU) CERES Fellowship to: 1) develop an integrated environmental management system for the University's field sites, 2) generate a resource-balancing model adaptable to each site, 3) recommend a field site for the FSEEC-LandLab environmental education building and green technology demonstration lab, 4) adapt the resource-balancing model into a decision management tool for the site, 5) develop a GIS database to facilitate analysis and decision-making, 6) recommend locations for the education building and green technology demonstrations, 7) propose a conceptual management system for the overall site and developed management system for its FSEEC-LandLab zone, 8) generate a decision framework

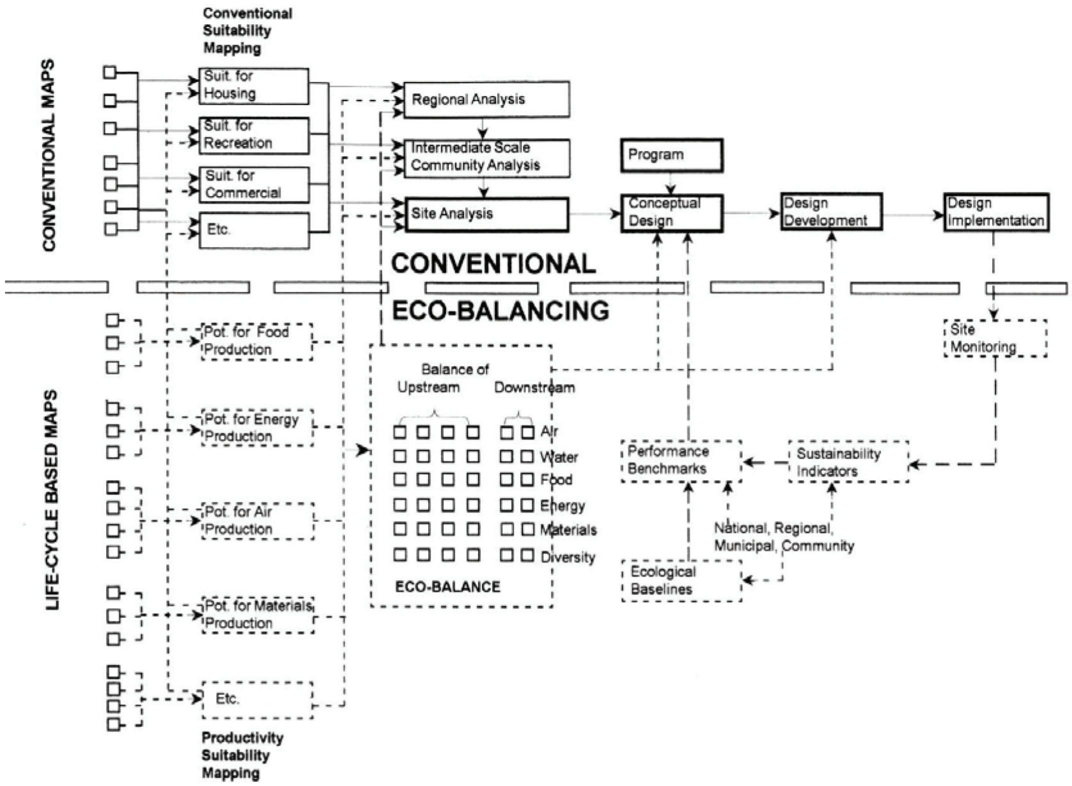

Figure 1. Eco-balancing Design Model (Introduction to Landscape Design, ed 2, J. Motloch, 2001, based on the Eco-balance GameTM and work of the Center for Maximum Potential Building Systems).

of planning and design goals, objectives, and guidelines for the FSEEC-LandLab and its environmental education building and site technology demonstration components, 9) propose a network of environmental Indicators and stations to baseline, benchmark, and monitor to determine how site management, planning, and design move Indicators in relation to benchmarks, 10) propose an initial program of site-based demonstration and resource-balancing projects to build and monitor, and 11) develop proposals for initial projects including designing, building, and monitoring the effects of interventions on site environmental health and productivity.

Integrated Property Management System

The study explored the BSU Field Station and its field sites as a single integrated education, research, demonstration, and outreach resource. It saw each site as an integral Field Station component as well as an individual resource. It sought to help the university manage each site for its value as an individual resource, contribution to the field station, and potential to enhance understanding of natural and human-dominated ecosystem regeneration and management. The Integrated Environmental Management System (IEMS) was proposed in this study to promote understanding of the potentials and management needs of each site based on its contextual relationships (urban to rural), site characteristics, land use needs, and allowable uses based on legal or other restrictions (fig. 2). The study also recommended baselining, benchmarking and monitoring environmental indicators based on site context, internal relationships, desired integration, and intended contribution to the University's

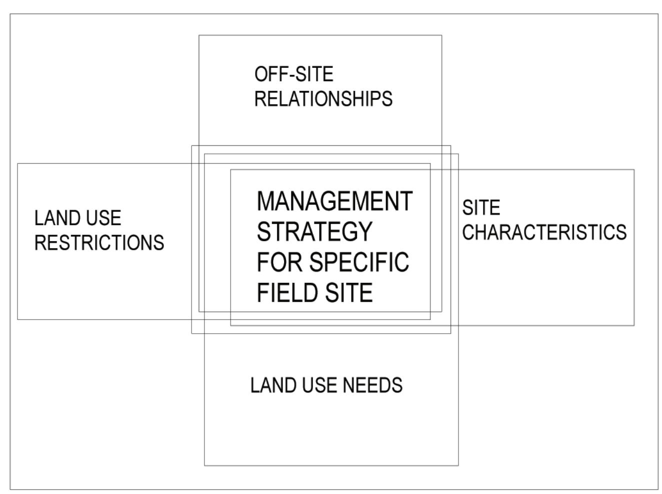

Figure 2. Integrated Environmental Management System (IEMS).

educational, research, demonstration, and outreach missions. It sought to facilitate monitoring to inform the University whether decisions sustain resource-balance. As better data and analysis techniques are developed, it will facilitate a shift from resource-balancing to eco-balancing decisions.

Resource-balancing Model as Site Decision Management Tool

The Resource-Balancing Model for BSU field sites (fig. 3) was evolved from the Ecobalancing Design Model (Motloch 2001, based on the Eco-balance GameTM and work of the Center for Maximum Potential Building Systems). The model integrates physical maps, productivity maps, and resource-balancing methods to facilitate sustainable decisions. It includes a feedback system of ecological baselines, performance benchmarks, and monitoring of environmental indicators to assess changes in Indicator performance in relation to benchmarks. This model is adaptable for each field site, in response to location, surrounding land uses, land use constraints, desired use, and site role in the IEMS. The Resource-balancing Model was recommended to predict outcomes of different alternatives, help the University make decisions and manage its field sites, and evolve future field site decisions based on Indicator feedback.

Planned Environmental Monitoring

The site recommended in the study for locating the FSEEC-LandLab includes diverse zones appropriate for its proposed environmental education building and green technology demonstrations. The site also offers opportunities for hands-on environmental education, research, demonstration, and outreach; and for integrated monitoring and management.

Previously planned monitoring

The site was selected, in part, to facilitate monitoring of environmental effects of several activities previously planned for the site including drainage improvements, creation of a wetland meadow, revegetation projects, and enhancement of regional biodiversity as part of the Field Station's restoration and environmental education programs. The study sought to help the University achieve permanent monitoring stations for biotic and abiotic components of its field site ecosystems, for its monitoring education activities, and for environmental research (FSEEC 2002). It also addressed University plans for monitoring plots to facilitate study of successional changes within the site's forested areas, monitoring of prairie plots to facilitate learning and research of different treatments in prairie restoration (for example, controlled burns, herbicide applications, machine treatments), and other site monitoring.

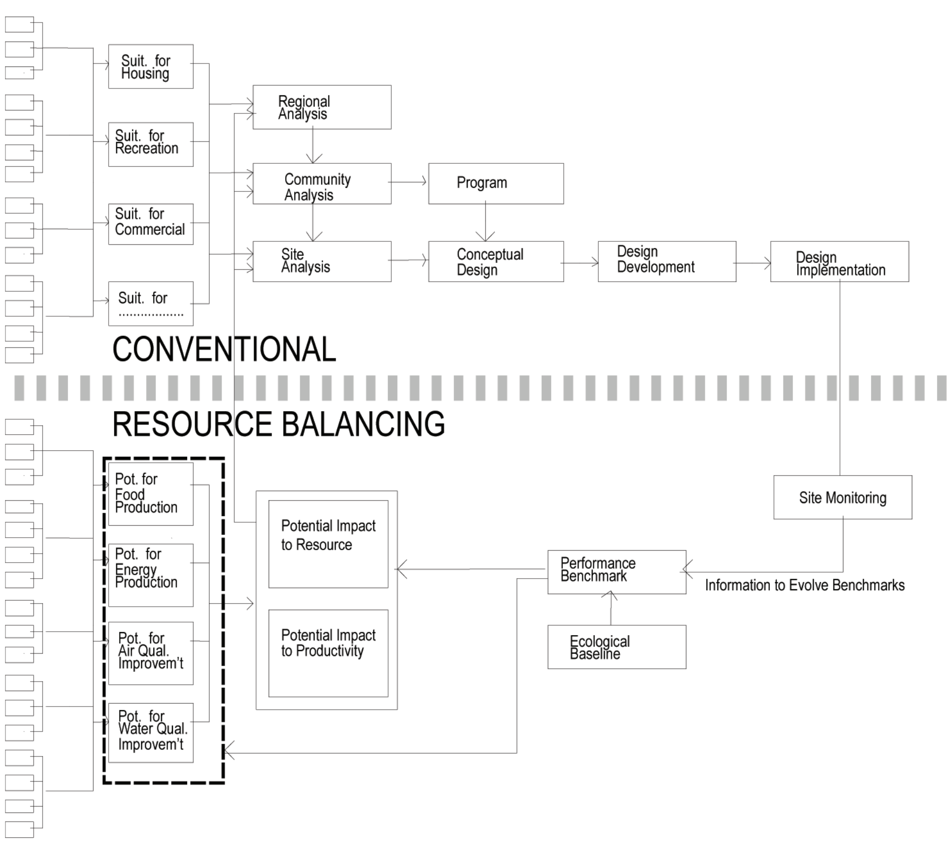

Figure 3. Resource-Balancing Model for BSU Field Sites (Evolved from Ecobalancing Design Model in Introduction to Landscape Design, ed2, J. Motloch, 2001, based on the Eco-balance GameTM and work of the Center for Maximum Potential Building Systems).

Proposed additional monitoring

The project recommended additional site improvements and associated resource-balance monitoring. This included changing site landform to isolate on- and off-site runoff; and monitoring site hydrology in relation to changes in landform, off-site land use (including change from rural to suburban), and off-site hydrology. In the area of the proposed environmental education building and green technology demonstrations, it included landform changes to redirect off-site water around watersheds proposed for monitoring site-generated impacts; and recommendations for designing the built-site as an intervention, monitoring, management, and educational resource. It suggested placing the proposed building and site developments within the watershed of a proposed lake for fisheries research; and monitoring the ability of the built-site to be designed, built, and operated so its runoff helps sustain the health and productivity of the pond ecosystem.

Resource-balance assessment

The project recommended monitoring of environmental indicator performance before and after site adaptations including building and green technology construction and operation. It recommended simultaneously monitoring of changes in site- and context-generated impacts, and comparing on- and off-site changes over time as feedback to the environmental management system. It included recommendations for monitoring building and technology demonstration effects on existing and proposed wetlands and ponds, and the ability of wetlands and ponds to balance building- and technology-induced impacts.

GIS Database Development

Development of the site's resource-balancing database began by integrating existing GIS datasets into a single geo-referenced database. This database was then extended to include additional data-maps (for example, wind and solar energy) and productivity suitability maps (for example, suitability for biomass productivity). The study proposed later addition of ecobalancing suitability maps (for example, suitability for carbon-balance considering O2 production and CO2 sequestering) subject to future funding.

Site Management

The project recommended the site be managed at two levels: overall-site and built-site. For the overall-site, the study recommended monitoring and mitigating the impacts of near-site changes, including changes from rural to suburban land use; and comparison of the impacts of on-site and off-site changes as the site undergoes sustainable development and near-site areas undergo conventional suburban development. It recommended integrated monitoring of Environmental Indicators before and after building and site interventions, to measure the effectiveness of the resource-balancing management system.

The study recommended that the area proposed to include the environmental education building, associated site development, and integrated building-site sustainable technologies be managed as a built-site. It recommended this built-site be managed for integrated research, education, and demonstration. It conceptualized an integrated built-site water-wastewater-energy-landscape system that would facilitate integrated management of resource harvesting, processing, use, reuse, regeneration and balancing.

Management Zones

Based upon contextual-landform and site-landform, and relative ability to isolate site areas from off-site water-borne pollution, the study structured the overall-site into seven management zones (fig. 4). It identified the ability of each zone to be isolated, managed, and monitored independently from off-site runoff for controlled research, education, and demonstration. Within each zone it identified drainage units and their opportunities for isolation from other drainage units for management and controlled monitoring purposes.

Overall site management and monitoring system

The study proposed environmental indicators within these management units. It proposed the Modified Resource-Balancing Model (fig. 5) as a conceptual management system for the overall site, with monitoring of general and habitat-specific indicators within each zone to assess the impact of decisions on resource-balance.

Resource-Balancing Management System for FSEEC-Lanllab Built-Site

The study recommended that the environmental education building be built within the drainage unit of the existing pond used by the University's fisheries group (fig. 6). It recommended that off-site runoff be redirected around this unit. It recommended that the area below the existing pond be managed as a second drainage unit for integrated built-site water-wastewater-energy-landscape research, education, and demonstration. These decisions sought to optimize opportunities for integrated knowledge-based management informed by monitoring the changes induced by prior interventions.

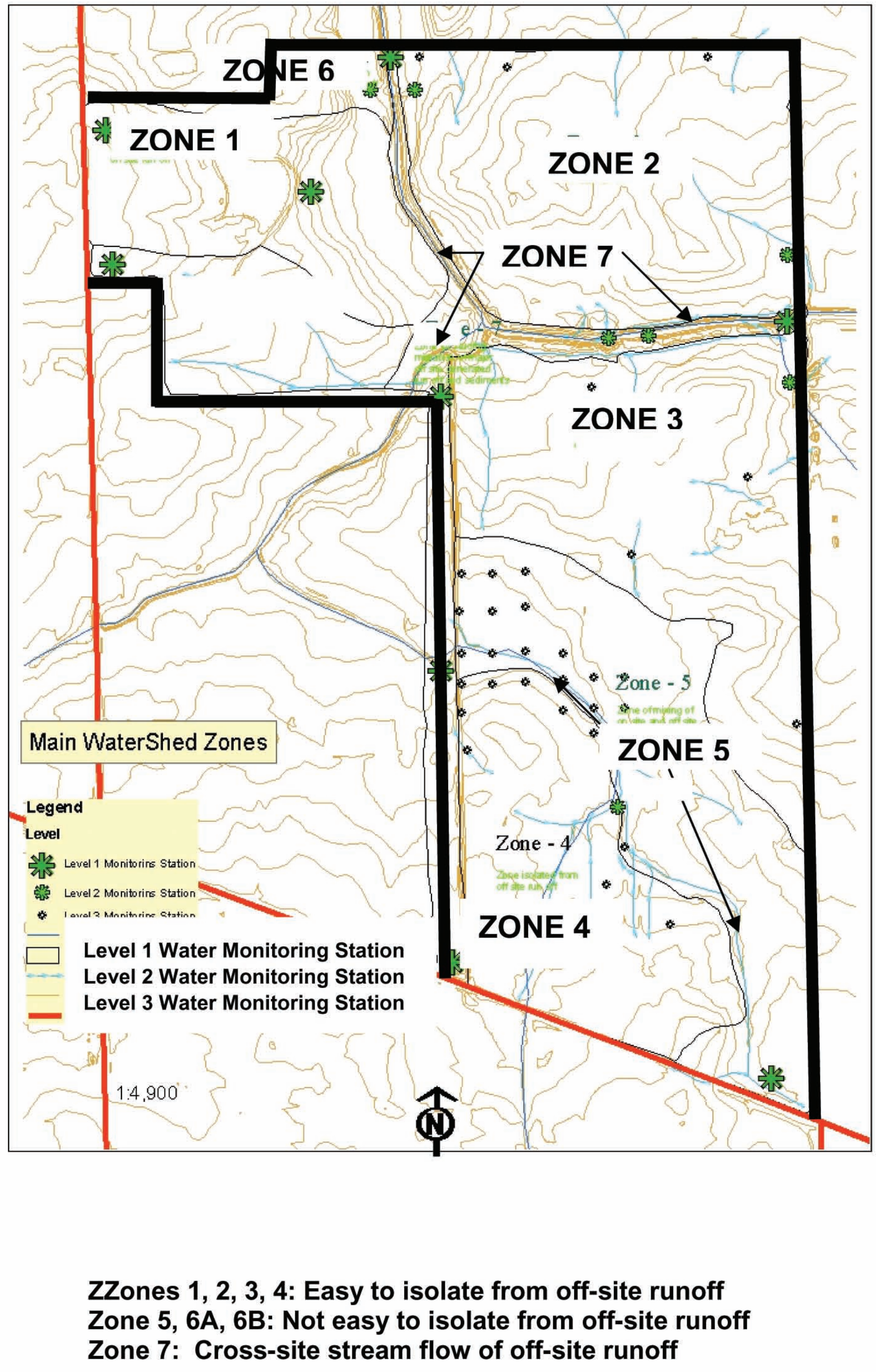

Figure 4. Site Management Zones and Hierarchical Water Monitoring Stations.

The Resource-Balancing Management System for the FSEEC-LandLab Built-Site Zone (fig. 7) recommended that Stella system dynamic modeling software (ISEE SystemsTM 2004) be used to predict Incubator performance. It recommended that once the University decides what areas, Indicators, and stations to monitor, that Stella be used to model anticipated Indicator performance under alternative management scenarios. It recommended monitoring of Indicators and comparison of monitored results to Stella-predicted performance to assess and evolve the design of the model and its dynamics (equations and performance curves), and to identify whether decisions to sustain resource-balance achieved this goal. It recommended fine-tuning the model and future management decisions based on monitored movement of environmental Indicators in relation to benchmarks, and based on insight provided by comparing monitored changes in Indicators to changes predicted by the model.

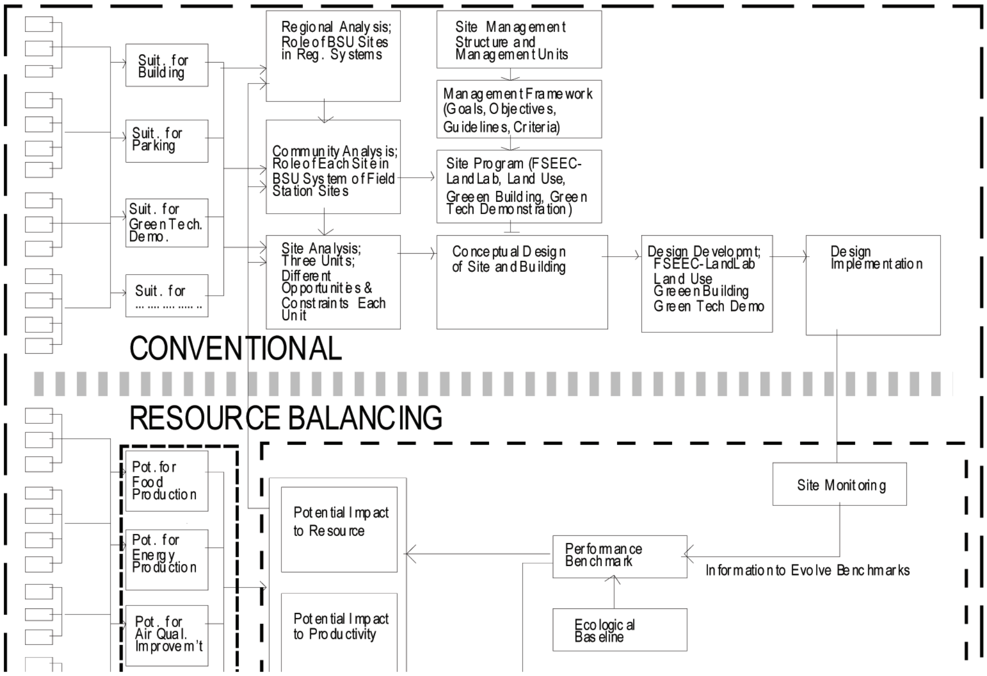

Figure 5. Modified Resource-Balancing Model for FSEEC-Landlab Site.

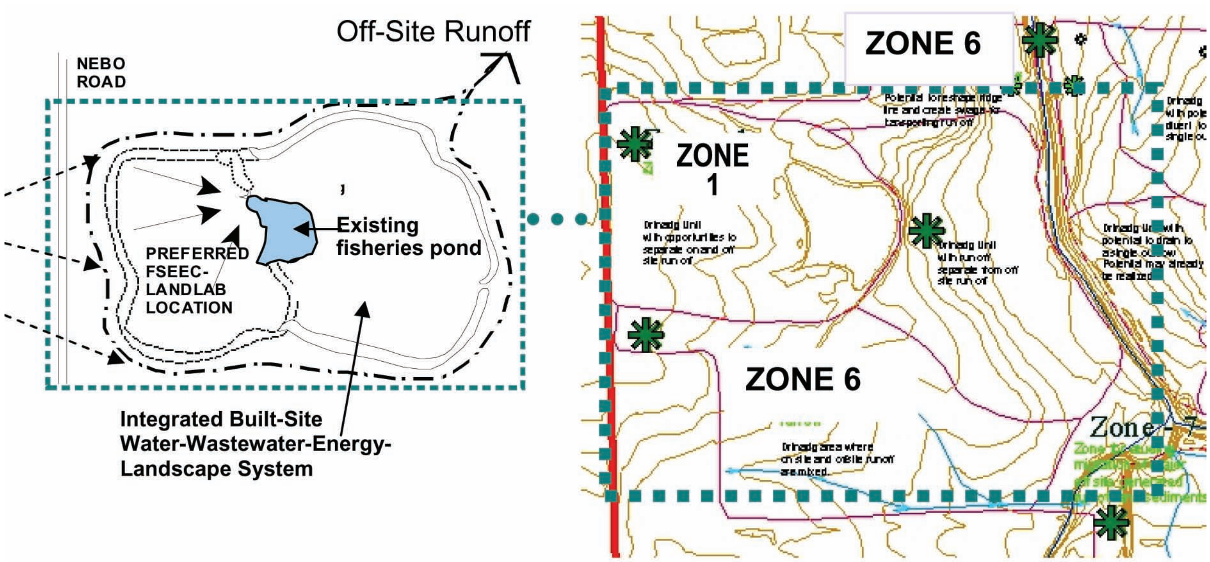

Figure 6. Environmental Education Building Location and Drainage Units.

Built-Site Framework

The built-site planning/design framework—including goals, objectives, concepts, guidelines and standards—grew from the missions of the Field Station and Environmental Education Council (FSEEC) and the Land Design Institute (LDI). The framework grew within the context of the integrated environmental management system (IEMS) described above, and with an understanding of desired land uses and management. This framework pursued four goals. The first goal was multi-disciplined environmental education in natural and built settings for students of all ages. The second was to increase understanding of regional resources and human impacts. The third goal was to help lead society to a sustainable future; and the fourth was to optimize short-term and long-term potentials. The built-site framework sought to guide the planning and design of buildings, infrastructure, and demonstration projects and to integrate diverse activities, participants, and timeframes.

Zoned Green Technology Demonstration

The study recommended site demonstration structured into two zones (fig. 8). The Near-Zone included integrated water-wastewater-energy-landscape systems (buildings,

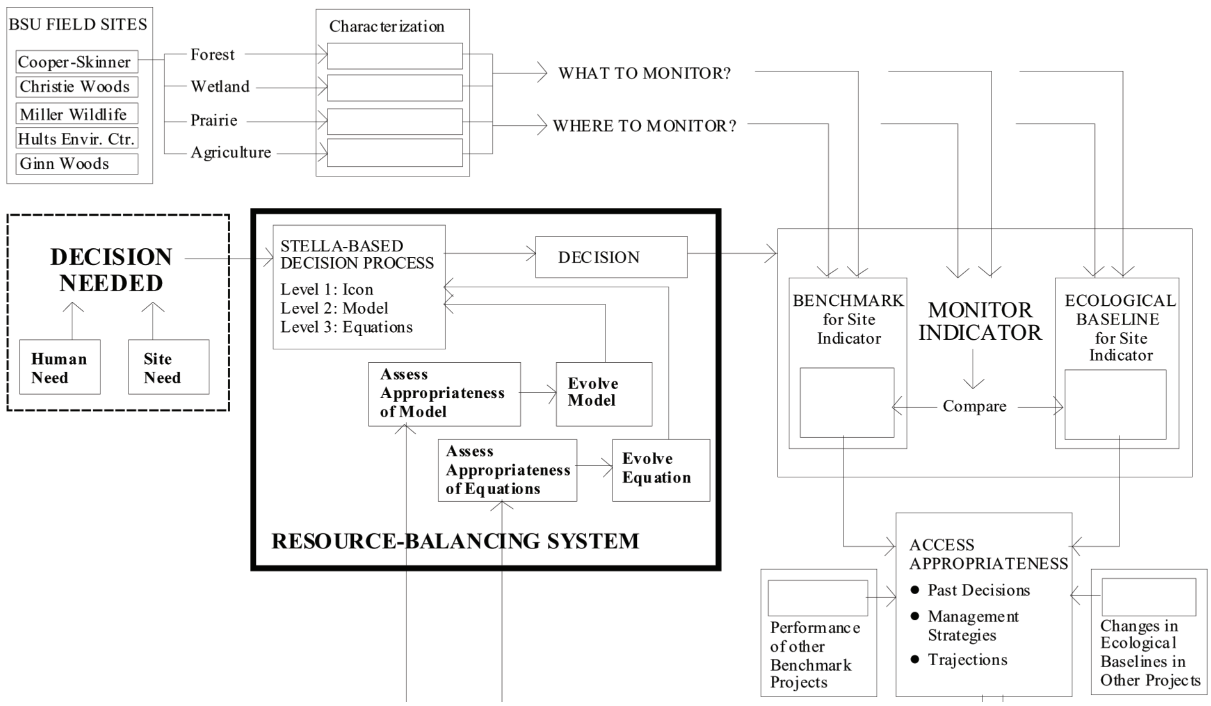

Figure 7. Resource-Balancing Management System for Landlab Built-Site Zone.

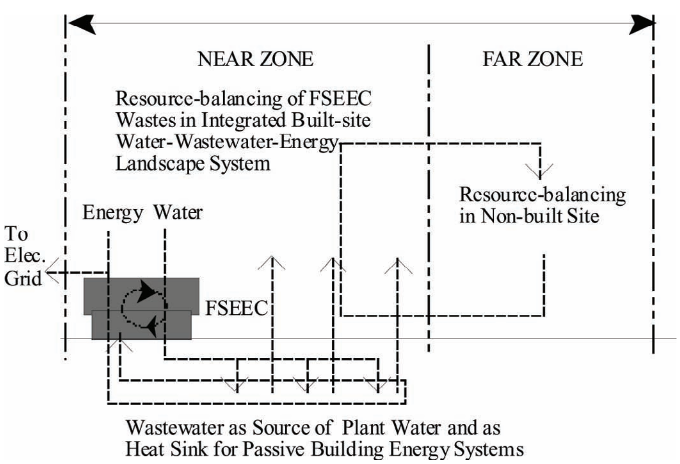

Figure 8: Zoned Green Demonstration.

shade structures, water walls, building extensions, living fences, landscape elements) with energy harvested by roof surfaces and water harvested by building and site surfaces. It included demonstration of biologic wastewater systems that restore water quality, and provide this restored water to landscapes that enhance performance of building and site passive energy systems. The study recommended that larger demonstrations (constructed wetlands, wet and dry prairies, agro-forestry) be located in the Far Zone.

Integrated Water-Wastewater-Energy-Landscape System (IWWELS)

The study recommended demonstration of built-site integrated water-wastewater-energy-landscape systems that harvest, distribute, use, reuse, and return resources to the site. It recommended that the system's *Water-Wastewater Component* (fig. 9) demonstrate how built-site systems can harvest, store, and distribute water for building and site use and reuse; collect wastewater and biologically restore water quality (living machines, rock-reed systems, constructed wetlands), and deliver restored water to the root zone of landscape components. It conceptually designed the *Energy-Landscape Component* (fig. 10) to demonstrate solar energy harvesting for building and site use, building bioclimatic benefits of soil saturated by restored water, and potentials to contribute harvested energy to the web. It recommended that the *Landscape Component* (fig. 11) demonstrate how built-site systems can provide habitat for wastewater treating organisms, maintain desired soil conditions, convert nutrients in effluent

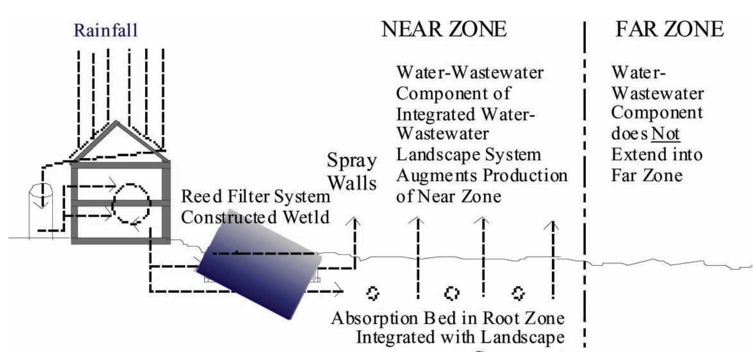

Figure 9. Water - Wastewater Component of IWWELS.

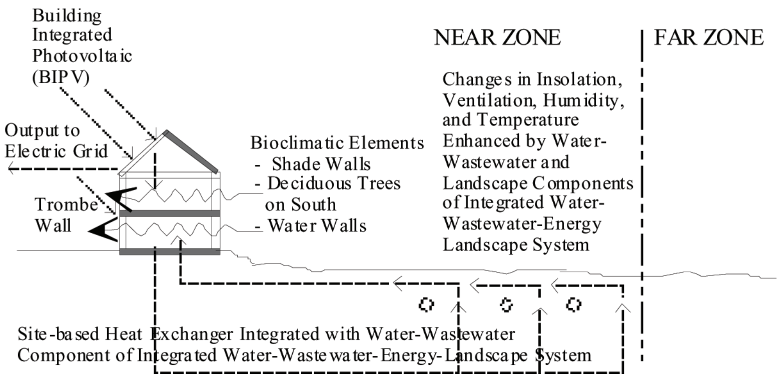

Figure 10. Energy - Landscape Component of IWWELS.

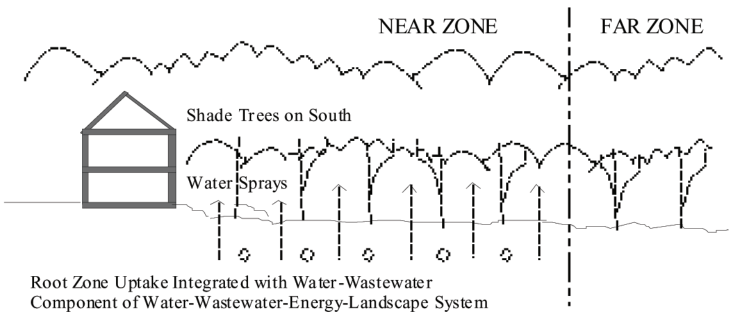

Figure 11. Landscape Component of IWWELS.

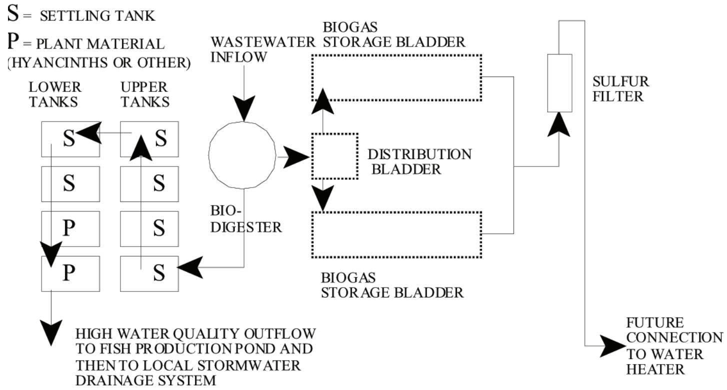

Figure 12. Biogas - Energy Landcape Component of IWWEL.

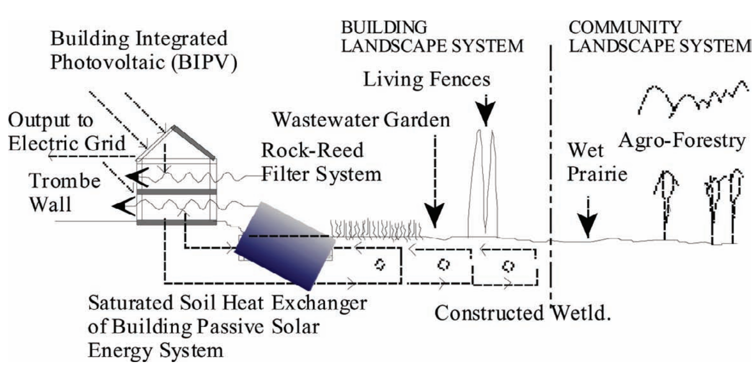

Figure 13. Solar Energy - Landcape Component of IWWEL.

into plant biomass, reduce building energy demands, and enhance building and site bioclimatic comfort. The *Bio-energy-Landscape Component* was conceptually designed to demonstrate how built-site systems can harvest biogas from human wastes while regenerating water quality (fig. 12). Recommendations for this component included a biogas harvesting system, biologic wastewater treatment system, and pond ecosystems that together harvest biogas, treat wastewater, and produce fish. The *Solar Energy-Landscape Component* (fig. 13) was conceptually designed to demonstrate landscape harvesting and use of solar energy. It also demonstrated how plants can contribute energy to building energy systems and the grid while producing functional, aesthetic landscapes. Integrated monitoring of the IWWELS was proposed as a means to assess performance of each component, to assess benefits that accrue to individual components and systems, to evaluate benefits due to the integrated nature of the systems, and to assess the value of integrated technologies to reconnect people to nature's integrated systems.

Monitoring Within Management System

The proposed management system included recommendations for baselining, benchmarking, and monitoring overall and habitat-specific Environmental Indicators for the overall site and the LandLab Zone to assess whether site management sustains resource-balance. It recommended a hierarchical system of water monitoring stations, and station locations in relation to water management zones and drainage units (fig. 4). It recommended that monitoring be integrated into academic, research, and demonstration programs; and that dynamic modeling software be used to model performance. It recommended that environmental Indicators be monitored and compared to baselines, benchmarks, and modeled performance to assess and evolve the model and to propose future land use and management decisions.

Monitoring of Habitat-Specific Indicators

The project included recommendations for monitoring habitat-specific Environmental Indicators. Recommended indicators were identified based on habitat types, typical Indicators for those habitat types, site conditions, and University land use and management needs. In recommending Environmental Indicators, this study benefited from an earlier report (FSEEC 2002) that assessed site habitat and potential Indicators.

Habitat Benefits, Ecological Considerations, Recommended Indicators

The property recommended in this study for the FSEEC-LandLab includes a range of micro-environments and habitat. Each offers habitat-specific opportunities for hands-on environmental education, research, and demonstration. Each also provides management opportunities and constraints. For each habitat, this project recommended Indicators with potential to be monitored to assess change in relation to baselines and benchmarks. Interventions that result in Indicator movement toward benchmarks were deemed to be desired actions that help the university realize the educational, research, and demonstration potentials of site habitats, while sustaining these habitat.

Based on available information (FSEEC 2002), the study identified site habitat types, benefits of those types of habitat, and ecological considerations in managing those habitat types. Based on the FSEEC report, the study also identified development activities generally seen to adversely affect that habitat type's health and to offer challenges to effective management of that habitat type. For example, *benefits* in <u>wooded areas</u> are generally understood to include carbon sequestering, nutrient recycling, reduced runoff, nutrient filtering from runoff, improved water quality, increased infiltration, sustained groundwater resources, stabilized soil, and wildlife habitat. Ecological considerations are generally seen to include successional increases in the interrelatedness of vegetation associations with climate, landform, soil, hydrologic regime, disturbance regime, and land use. These benefits are usually seen to be affected by the size and number of canopy layers; and by disturbances that affect ecological function (for example, fire, wind-throw, adverse changes in water regime, grazing, and pest outbreaks). Pressures that are usually expected as a result of development include forest fragmentation, increases in diseases and pests, atmospheric and runoff pollution, introduction of exotic species, and landscape disturbance by foot and motorized traffic.

Typical *habitat-specific Indicators* in wooded areas are usually understood (FSEEC 2002) to include Indicators of Fragmentation (ratio of woodland interior to total woodland area; indices of landscape fragmentation and connectivity), Biological Pressures (spatial extent of exotic species, pests, and diseases; population of grazers), Plant Community Health (extent and distribution of vegetative associations; density of snags and woody debris; extent and distribution of key plant species; ratio of vulnerable species to total forest dependent species), Atmospheric and Water Pollution (changes in sensitive species), Productivity (rate of tree growth indicated by number, volume, or diameter; population of key animal species in each tropic level), Nutrient Cycling (spatial extent of land with significant erosion; changes in soil thickness, compaction, density, structure), Hydrology (amount of storm runoff; time of concentration of runoff, percentage of stream length with vegetative barriers, width of barriers), and Disturbance (frequency of pest/disease outbreak).

Through discussions with University faculty and field station managers, the study identified *Environmental Indicators to baseline, benchmark, and monitor* on the project site. These included overall-site and habitat-specific Indicators. Recommended Indicators were those seen as most likely to provide opportunities for monitoring to support management, educational programs, research, and demonstration of environmental change with alternative management. For example, in the site's wooded areas, key site Indicators identified for baselining, benchmarking and monitoring included water quality, turbidity, BOD, and key chemical constituents (pH, nitrogen, salt) of runoff.

Initial Phased Demonstration and Monitoring

The study included a LandLab program for integrated technology demonstration to be implemented in phases. This program was designed to begin with low-investment ecological restoration and resource-balancing constructions and experiments. The study recommended phasing to more costly, complex and sophisticated hybrid technologies and systems. These more complex systems are anticipated to provide opportunities to harvest resources more efficiently, provide more sophisticated environments with greater control, promote positive resource-balance, and serve as benchmark projects.

Phased Construction of FSEEC-LandLab

Proposed *Phase One* education, research, and demonstration projects included establishing the site management system; initiating the program of baselining, benchmarking and monitoring at key Indicator stations; implementing low-cost ecological restoration projects; and implementing key design, build and monitoring projects. For example, the "FSEEC-LandLab Test Module" was designed to develop insight for future planning, design, management, and monitoring of FSEEC-LandLab facilities. *Phase Two* included design and construction of FSEEC-LandLab Core Facilities including the Environmental Education Building and the Green Technologies Demonstration site. *Phase Three* included design and implementation of other buildings and site demonstrations (caretaker residence, dormitories, ancillary structures, and infrastructure) as a monitored resource-balancing FSEEC-LandLab demonstration campus. The study proposed integrated monitoring of the LandLab's integrated water-wastewater-energy-landscape system (buildings, infrastructure, other interventions), monitoring of built-site harvesting of resources (energy and water), monitoring of building performance, monitoring of site conversion of built-site wastes to resources (including soil and biomass), and monitoring site Environmental Indicators to assess resource-balance. The proposed integrated monitoring and demonstration projects were intended to raise understanding and awareness of the resource-balancing potentials of integrated built-site systems and regenerative technologies (greenhouses, rock-reed filter systems, wetlands, wastewater and washwater gardens, and so on).

Phased Monitoring, Baselining and Benchmarking

The study recommended that, as soon as possible, the University baseline and benchmark the most crucially-needed Environmental Indicators and stations. It recommended water quantity and quality as the first variables to be monitored. It recommended that the University implement its initial Environmental Indicator monitoring program and extend the site database through periodic mapping of Indicator performance.

Phased monitoring recommendation

The study recognized that monitoring can be costly and time-consuming. To help control costs, it included a hierarchical system of water monitoring stations (fig. 7) with essential and less-costly monitoring to begin pending more substantial institutional investment. It identified urgently-needed stations and recommended that these stations be immediately baselined, benchmarked, and monitored. These included stations for monitoring runoff entering and leaving the site and its major drainage areas, and runoff from the area planned for the environmental education building, green technology demonstration, and other areas of on-going and impending habitat establishment and ecological restoration projects. Since planning, design and construction of the building might take several years, it proposed designing and building a module for testing green building and site materials, technologies, and monitoring. This test module was proposed as a Self-contained Workstation and Toilet with resource-balancing integrated systems (water-wastewater-energy-landscape) for research, education, and demonstration purposes. The study recommended monitoring performance of this test module in the drainage unit that will later receive the environmental education building and associated site development.

Implementing baselining

The project recommended that baselining of site areas be achieved prior to activities that induce landscape change. Since changes, in many cases, were already occurring or anticipated in the near future, it recommended baselining begin immediately on Level One water monitoring stations. It identified these baselines as highest priority due to on-going and planned changes in land cover and use, and the need to compare on- and off-site trends as these changes occur. It recommended the University commit to a location for the environmental education building and areas for major green technology demonstration. It recommended that the University determine baselines for key areas (including drainage units of planned buildings, and areas of on-going or planned habitat establishment and ecological restoration) to enable the university to monitor changes that occur in relation to building and landscape establishment and restoration.

Implementing benchmarking

The study recommended that the University benchmark Indicator performance at each monitoring station; and that these benchmarks be used to assess appropriateness of past site intervention decisions. It proposed that this feedback system also be used to inform future site activities. It recommended that processes for establishing benchmarks be participatory to promote broad understanding and attachment to these benchmarks as goals.

Implementing monitoring

Since monitoring of environmental indicators is a long-term, time-consuming, and costly venture, and competition for resources is severe, the study recommended the University identify concurrences between what can be monitored to enhance education (academic degrees, K-12 support, Globe International) and research programs; and what needs to be monitored to promote resource-balance. It recommended the University initiate a process to assess its educational programs (degree and non-degree) and research programs to identify potential synergies and associated monitoring. It recommended results of this process be used to design a sustainable monitoring program that facilitates resource-balancing site management while enhancing the quality of educational and research programs.

Benefits of Monitoring

The study identified benefits of monitoring to include *Curricular Benefits* of hands-on learning including monitoring of environmental Indicators to assess change over time and to predict the outcome of anticipated interventions. It suggested that the activity of monitoring environmental Indicators can enhance curricula in various disciplines and different types of learners. It identified benefits of monitoring activities as a means of connecting university students, K-12 students, and adult and community learners to sustainability. It also suggested *Benefits to Research* by strategically integrating the monitoring of research projects (including narrowly-focused ones) into this broader system of baselining, benchmarking, and monitoring Environmental Indicators. It suggested that this integration would allow focused research projects to assess performance at a deeper level based on better existing data, while allowing these projects to contribute to the ability of future research to do the same.

Integration of Monitoring, Research, Demonstration, Academic Programs

The study recommended that the university initiate an integrated study of the potential to implement the resource-balancing model on the proposed site. It recommended that this study integrate: 1) the ability of baselining, benchmarking, and monitoring of Environmental Indicators to enrich the University's academic programs in various disciplines and audiences, 2) the potential for University classes, public school programs, and adult and community education to contribute to baselining, benchmarking, and monitoring in cost-effective ways that enhance learning, 3) the ways in which the system of baselined, benchmarked and monitored Indicators could enhance the potential, ability to implement, and benefits of research to various audiences; and 4) potentials of specific research projects to contribute to baselining, benchmarking, monitoring, and integrated resource-balancing. Completion of this integrated study will allow the University to develop a program for integrating its field site management, education, research, demonstration, monitoring and resource-balancing programs.

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