Introduction

EcoBalance™ is a sustainable land use planning and design method that employs the principle of life cycles as a framework for sustaining basic life supporting systems. It was developed by the Center for Maximum Potential Building Systems as a means to address the need for planning of physical space – both within buildings as well as surrounding land area - that surpasses the conservation-based planning and design methods of the past and moves towards procedures more in sympathy with sustained and balanced use of resources. The EcoBalance™ method is based on the understanding that sustainability is measurable by the degree to which human needs are balanced with our ability to adroitly manage the environment through adoption of nature augmenting technologies that support a positive relationship between human activity and natural resources.

During the EcoBalance™ planning process space uses are determined and analyzed according to the footprints that are necessary to supply the basic human life support requirements of air, water, food, energy and materials in a generative fashion. The framework for EcoBalance planning remains essentially the same regardless of project scale, with the process typically directed towards the building, site, and master planning scales.

The objective during the planning process is to understand the parameters, or limits, on human activities by carefully managing their resource use. In addition, the degree to which limits are exceeded is shared within the next scalar boundary, either on or off the building boundary or site. Measurement of sustainability is an integral part of the planning and design process, and is illustrated in multiple forms, such as:

1) the ratio between the amount of life support supplied vs. the amount of life support needed by humans,
2) The ratio of the sourcing requirements of physical space verses the re-sourcing capacity in space,
3) the ratio of on-site supplied life support needs vs. off-site supply.

Most of these relationships are summarized in the Venn diagrams below. The objective is to understand the parameters, or limits, on human activities by carefully managing their resource use, and to share the degree they go beyond these limits to the next scalar boundary either on or off the building boundary or site. This paper is an introduction on how this method can be applied both at the building, building site and master planning level.
Background

Over the last 25 or so years, a gradual conceptual evolution has occurred, shifting the focus of design and planning from conservation, or more efficient use of non-renewable resources, to sustainability. “Sustainable design,” as it is often practiced, however, simply expands the concept of conservation to include more resources, such as water, to what was once simply an energy conservation program. Few, if any, land use planning methods incorporate sustainability principles in a manner that attempts to plan a sustainable community in a truly resource balanced fashion.

The pro-active concept of “balancing” is not new, yet it has only barely been recognized by the planning and design professions, primarily catalyzed by the development of a new method of working with industry referred to as industrial ecology. Many disciplines (including those without an obvious environmental focus) make use of either the concept of ‘balancing’ resources or are actively involved with balance as a fundamental performance metric. In the case of planning, a significant shift in focus must be made due to the fact that – even in cases where exceptional sustainability work and policies are in practice - the ecological impacts of human activity continue to grow rapidly due to increases in both population and per capita resource use reflected in our various standards of living. In these cases the purely conservation ethic is in serious jeopardy.

A case in point is the City of Austin Texas’ renowned Green Builder Program. A detailed critique of the program found that although improvements in residential energy efficiency have decreased consumption per square foot by 29%, per capita residential energy consumption in this same time period has increased by 13%. This reflects two major trends: over the past 30 years, the average number of persons per household decreased by 32% and the average size of new residences increased by 47%. This reflects two major trends: over the past 30 years, the average number of persons per household decreased by 32% and the average size of new residences increased by 47%. In addition, since 1985, most of these new residences are built in areas characterized by urban sprawl increasing urbanized land in the county by 28%. Consequently, transportation energy consumption has also increased. Thus, when the whole system is critiqued, what looks good using one method of measurement does not actually accomplish much.

It can be argued that planning approaches in general, whether site planning, master planning or city/regional, will fall short of addressing the incredible challenges facing our future unless increased attention is placed on measurement that actually addresses resource balance or imbalance. Land use planning implications for this method are great, especially if one were to look closely at international agreements such as the Kyoto Protocol, as establishing limits on greenhouse gas emissions is virtually impossible to achieve using the standard palette of purely conservation based practices that exemplify linear non cyclical resource use thus stringing out a line of never ending responsibility verses setting boundaries of performance.

Ecobalance Planning

A planning approach is needed that is applicable to scales ranging from individual buildings to communities of all sizes. Application of this consecutive Russian Matryoshka doll type of performance boundary framework is a necessary reprogramming of objective towards balancing human consumption with available resources at given levels and intensities of resource use. In industrialized nations, the ability to determine what can and cannot be balanced within the confines of a particular site is difficult. Therefore, carefully defining topic areas are essential for this type of planning to work. This is accomplished by defining key categories of life support: air, potable water, food, energy, (both passive climatic and electric power), and materials (both biological and inert) for shelter. These life support topics are placed in a framework that represents any product by its full lifecycle and in which by-products (intentional or unintentional, benign or toxic) are viewed as resources. Figure 3 represents the Ecobalance systemic which shows how the Life Cycle Principles: source, process, use, and resource are derived from the six life cycle stages:

1) resource extraction
2) transport
3) processing/ manufacturing,
4) distribution
5) installation, use, and maintenance
6) reuse, recycling, or disposal

These stages are classified into two main Life-cycle Balance activities: Source & Re-source. All these segments of life support systems and lifecycle principles can be summarized into a single diagram: the Ecobalance square or Ecobalance circle.

Ecobalance Planning can now be defined as the principal of balancing life support systems between Source (Upstream) and Re-Source (Downstream) lifecycle activities. A set of terms and definitions must be stated and agreed upon by the users of this approach, to be used as guidelines for Ecobalance decisions. A set of these terms is presented below:

Figure 2: Ecobalance systemics

Figure 3: Ecobalance footprint
Ecobalance Footprint

The Ecobalance footprint corresponds to the immediate physical land/space that contribute to human life support activities or in the case of a calculation of only in-home utilities, the capacity of these utilities to work together to perform balancing functions. These life support activities can be given a range of approximate physical dimensions or footprints in English units, for both the Source and Re-source ends of the life cycle to show balancing as demonstrated in Figure 4. For the purpose of clarity, the author selected extremely simplified systems as examples – assessment of more complex systems requires other tools including IO/ LCA methods (see Baseline Green and GreenBalance on the CMPBS web site www. cmpbs.org). These tools include in-depth life cycle analysis beyond the boundaries of the immediate site but this paper demonstrates that the same methodology can be incorporated within the boundary of an individual building.

Hierarchy of Scales

Hierarchy of Scales refers to the varying generic boundaries within which life cycles need to be performed to achieve balance: i.e. building, lot, site, neighborhood, community, or town, up to the metropolitan region, bioregion, or country if needed. Many commonly used technologies have extensive footprints needing very robust tools for inquiry. This would not be problematic except that the array of the hundreds of life cycle steps that go into the construction and operation of those technologies are generally poorly understood relative to their environmental impact, as is the spatial understanding relative to the land area committed to support them.

In the case of the building being the boundary in a LCA, one measures the source and resource needs of the building’s utilities (the hot water heater, the sink, the shower—and possibly the dimensions of those utilities) rather than the building’s spatial footprint or plan area. Therefore, to understand the relationship between the footprints of lifecycles a hierarchy of orders is required. Most of these relationships are summarized in the Venn diagrams in Figure 4. The objective is to understand the parameters, or limits, on human activity by carefully managing their resource use, and to share the degree they go beyond these limits to the next scalar boundary.

Order of Footprints

Depending on the life support category being considered, these conversion processes have different relationships at the source and re-
Lifecycle Balancing

Lifecycle Balancing refers to the actual process or physical accounting for both the sourcing and re-sourcing land areas. The process of balancing can be graphically explained by either the EcoBalance square or EcoBalance circle. The life support topics are represented by five different colors and the lifecycle processes are represented by the four sides of the square or four quadrants of the circle. The Lifecycle technologies are either represented by icons or numbers. The physical EcoBalance mapping can be done based on two criteria: number of people or land area. When the number of people on a given site is known (already developed or planned site), the land area required to support them is calculated. It is then divided into different hierarchy of scales based on suitability. For example, water can be sourced on building scale, but can more effectively be re-sourced on a site scale by forest wastewater treatment. Since the site area is limited, those sustainable technologies are chosen which can integrate more than one life support needs. When the site area is exhausted, the deficit area is calculated for the life support needs that need to be balanced off-site. Sustainable technologies which do more in a lesser footprint area like intensive farming and megafauna plantation can be used off-site to balance all the needs of people within the site in as minimal an area as possible. In the case of undeveloped land where the land area is known, the carrying capacity of site is calculated to find how many people can be sustainably balanced within the site and the program is developed accordingly. This approach has been used for the Peaceable Kingdom project explained below.

Fitting life cycle balancing into the land planning process

Part of the purpose of EcoBalance™ planning is to utilize existing ecological land planning techniques as much as possible. The following description places the life-cycle balancing framework within a well known sequence of

a) inventory mapping,
 b) suitability maps,
c) composite maps,
d) synthesis maps and
e) master plan.

Base/Inventory Maps

The base map inventory is essentially a graphic summary of the various topics of the site analysis data. It covers five different base data conditions:

1) Ecosystem identification
2) physiographic features
3) Vegetative area
4) Human basic life support needs
5) Legal issues as they effect sustainable master plan needs.

The first step in preparing these data is the collection of site data in the form of site maps at a scale that relates to participant needs and the site size. These are inventories of site characteristics and resources such as topography, soil types, geology, hydrology, vegetation, site improvements, and special features. Each base map topic may include sub-topics such as digital elevation model, slope, and aspect. Each Base Map is a separate document that can be overlaid in various sequences with other Base Maps.

Suitability Maps

In various combinations, the many Base/Inventory Maps form “Suitability Maps” illustrating
five human life support themes - Air, Water, Food, Energy, and Materials— as well as the site conditions defined by Ecosystems and Hazards. For each life support theme the amount of land available to fulfill both sourcing and re-sourcing is determined. Then, using figures for the minimum amount of land required to support one person (a per capita life cycle footprint), the carrying capacity of the site is determined for each of the five life support themes.

For example, the composite map for the life support theme “Food Production” includes the amount of land area suitable for vegetable gardens, orchards, cropland, and grazing land (source) as well as composting of food wastes (re-source). Similarly, for “Water Availability” water harvesting areas (source) are balanced with the area required for ecological treatment of wastewater (re-source, e.g. wetlands, forest mantle etc.). The amount of land within the site boundaries that is suitable for each life support need is divided by the per capita ecological footprint for that need, resulting in a site population total representing the carrying capacity of the site for each life support need. Each of the five life support needs will likely result in a different site carrying capacity total population number.

Proposed land uses can be represented on these maps with icon tiles showing per capita needs that correlate in scale to the base map. The goal in using the icon tiles is to visually represent the balance of proposed land uses with site carrying capacity.

**Composite Maps**

The next step in preparing the master plan is to create four “Composite Maps.” These are composites of the five life support theme maps plus the Ecosystem and Hazards maps. The planning process works on the premise that all land types can be divided into four basic types: natural, productive, built (or developed land) and infrastructure. Natural land includes those uses that preserve, protect, and regenerate ecosystems. Productive land includes all uses appropriated for human needs such as...
agriculture, forestry, and fisheries. Built land includes the actual footprint of land development including buildings, and facilities (e.g., athletic fields). Infrastructure land is the footprint of all human infrastructure activities: water, wastewater, transportation, power, etc. Each Composite Map is a separate document that can be overlaid on the site and on other Composite Maps. These Maps comprise basis for decision making in the EcoBalance Planning process. In short, the composite map is a graphic summary of all the previous maps—the Base/Inventory Maps and the Suitability Maps—organized according to the three main land use topics. EcoBalance™ planning is a graphic representation of inherent site characteristics that indicate the carrying capacity of the land under the land-uses defined by planning participants.

Composite Synthesis, Priorities, Principles and Patterns

The following explanation of infrastructure uses a particular project referred to as Peaceable Kingdom to help in defining the mapping aspect of the EcoBalance™ planning process. The description is placed in a narrative format that follows the discoveries made by the group client. This stage synthesizes all previous mapping into a whole that utilizes nature in a sustainable manner in order to establish human habitat. The composite synthesis stage reflects back to the original priorities and confirms that the program is really reflecting these priorities.

At Peaceable Kingdom (a particular project contracted by a Texas client) it was evident that this property’s lush, plant-oriented characteristics needed to be emphasized and made into a special and permanent attribute as far into the future as possible. Overlay maps of all composites were created so that we could look at what the land was telling us. Patterns were found within the overlay map information, and we were tested according to the original program goals. Out of this re-synthesis we found that certain attributes of soil, vegetation, microclimate, and the relationship to natural and agricultural areas indicated different solutions from different land areas. Agriculture in one area, for example, was prairie oriented while in another the hydrology and soils showed a wetter environment. Woodlands dominated some areas of the site, while other areas contained extensively refurbished soils. The special qualities differentiating these

Figure 10: Ecobalance planning maps combined into a masterplan for the Peaceable Kingdom project
areas led to natural delineation of settlements that could cooperatively share their products and resources amongst themselves. As these settlements together increased productivity, they could then also afford to supply others outside Peaceable Kingdom.

To describe the settlements more specifically, the West Settlement was larger in terms of contiguous area for human habitation and was dominated by a restored prairie site. The area known as the South Settlement was cloistered with a large woodland that left it visually and spatially separated from the others, with a high potential for forest-based habitation. To the East we found a large contiguous area of habitable land surrounding a pond. This was the lowest area of the site and had natural conditions for high soil moisture crops. Reeds of a wide variety of types – including sugar cane - began to make sense and led to development of a concept for a reed based micro economy. To the north, which became known as the North Settlement, there had already been established a very productive intensive gardening operation with emphasis on flowering plants. The pattern of habitation determined for this area was quite different from the others, due to the land features in that area indicating suitability for small separated plots of land with separate building structures. Coincidentally, this was the development pattern of buildings already established in this area.

Each settlement possessed very different relationships to the infrastructure zone of land that wound its way throughout the community. Various technology/land scenarios developed, leading us to established flow diagrams of how the infrastructure zone served each settlement. The infrastructure became a resource flow integrator between land use types, and in doing so, was a mark of resource management that maximized the use of resources in each settlement when combined with the solar constant.

Settlements became working entities functioning together in resource terms within a single community, each one serving the others to some degree, by representing unique resource integrations.

Example: The cane based East Settlement could export epoxy glue derived from the sugar cane crops grown in the wet zone. The forested South Settlement could supply Chestnut wood, the material of choice for the post and beam building system planned for the site. In this case, since Chestnut trees have been long vacant from Texas forests, hybrid species of American and Chinese chestnut would be re-introduced. The pegs for putting the post and beam system together would be sourced from...
either an oak wood plantation area that also acts as a mushroom farm, or from the existing productive zone forest. The chip wood panels would be derived from a planted Southern Yellow Pine bound together with the sugar-based glue from the Southern Settlement. When exports from between Settlements exceeded the needs of the Peaceable Kingdom community, they could then be sold. Many of these goods would be value-added products in that they combine multiple resources to form a unique product type. For example, selling bread made from amaranth grown onsite, or sugar based epoxy instead of the sugar. Other resources produced within the Peaceable Kingdom settlements were special enough that they could be sold with little extra work, such as flowers grown in the North Settlement.

Master Plan

The master plan was the final reflection of how the Peaceable Kingdom Settlements would work together. A transportation system was established that both defined each Settlement and connected each to the others within the community as a whole. A community entrance separated the public from the private, and two commercial export areas were established that connected Peaceable Kingdom to transport routes on the east and on the west of the site. Higher canopy vegetation was planted at the breaks between land use types. This was done to establish spatial definition and define the territory for each settlement. All transport routes were coordinated to be along as many of these vegetative edges as possible. The approach on the master plan is to offer incentive and guidelines for future land use development. Buildings were not placed by the master plan but instead the criteria for building placement was established.

Ecobalance at the building level

The EcoBalance methodology can be applied equally well using the building itself as the boundary. In order to keep this explanation relatively simple, only key life support topics related to building level (i.e. energy, water and food) are considered. Figure 15 illustrates each part of a lifecycle process in the building plan of a dwelling unit in Peaceable Kingdom project. Energy is sourced from solar PV’s, processed using an AC/DC converter and used as well as conserved within the building envelope. Water is sourced from rooftop rainwater harvesting, stored in cisterns, used for toilet, kitchen and other standard domestic uses and re-sourced using on-site wetlands. Food is sourced from on-site vegetable garden, processed in the kitchen area, eaten in the dining area and re-sourced as compost either in a composting toilet or a composting pile.
1.5 Ecobalance Planning and Design

Figure 15: Integrated system design diagram showing ecobalancing at the building level
These building metabolics are further elaborated in a representative building section in Figure 15 where each life support topic is converted into flows. Using this technique, specific building components can be identified and more complex lifecycle processes and integrations can be showcased. For example, energy can be divided into four flows: electricity (from renewable sources like sun and wind), thermal energy in form of hot water, waste heat from appliances which can be captured and re-circulated, and Biomass energy from onsite vegetation which can be used in a flex fuel stove for cooking to produce ‘biochar’ as a resource which when added to soil increases its fertility and carbon sequestering capability. In addition to flows, it is also possible to include other aspects of energy such as solar passive heating/cooling techniques, high thermal mass walls, shade, natural lighting and ventilation, heat gain from electric appliances and energy conserved by LED lights, ceiling fans and ice battery dehumidifier. These system diagrams can be used to calculate the actual energy/water needed to sustain one person or one household, roof area needed for PV’s or rainwater harvesting, determine the amount of waste heat output, size of cisterns and wetlands.

Integrated system design approach, illustrated in Figure 15, is needed for maximizing the potential of the building to balance as many life support needs as possible within its boundary. It also helps to identify multiple uses of various components, for example, a fruit tree represents all three life support topics. It is a source of biomass and shade, it can be irrigated by wastewater, nurtured by compost (food re-source) and provides fruits. For simplicity’s sake, the building components which represent more than one life support topic have been colored according to the major topic. Integrated system design approach demonstrates the synergy between the natural and built environment and how both are required to complete all the four lifecycle processes, namely source, process, use and re-source.

Conclusion
Ecobalancing requires technical sophistication rooted within the ecological potential of a particular place. Connecting life-supporting technologies to the land from which our resources originate is the core of the EcoBalance process. We chose to move from this level inward to make sure that the building itself entailed as much balance as possible reversed before going to the entire site although could have easily been reversed. The particular technologies represented for our demonstration are a small sampling of what is needed to EcoBalance a site or a building. It is important to understand in all cases that nature is doing the work for us. For example, forests give us oxygen, while also serving as a carbon sink. It seems that we need a major re-evaluation of what is technology and what is nature. We cannot start the planning process with the assumption that we know what technology a culture may or may not relate to nor whether what we are proposing is politically correct. We cannot afford to say that because the technology is old that it is good, nor vice versa. At this point in the development of any project, we must understand as professionals and as users that we are in the midst of an evolutionary change in human development that must borrow from the best of human experience in general as to what might or might not adapt to a place. The care and management of the natural life support system itself will become an important community enterprise and must be reflected in planning and economics. Therefore, in planning we need to be as clear as possible within any proposed land to people (technology) relationship as to the degree of responsibility people will have, and their time commitment to making this relationship work. This human factor is one of the biggest unknowns that must be dealt with in planning.

Resources


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Figures

All figures courtesy of Pliny Fisk and CMPBS

Biography

Pliny Fisk co-founded the Center for Maximum Potential Building Systems in 1975, and currently serves as Co-Director. The Center is recognized as the oldest architecture and planning 501C3 non-profit in the U.S. focused on sustainable design. In addition, Pliny also serves as Fellow in Sustainable Urbanism and Fellow in Health Systems Design at Texas A&M University where he holds a joint position as signature faculty in Architecture, Landscape Architecture and Planning. In 2002, Pliny was awarded the U.S. Green Building Council’s first Sacred Tree Award in the public sector category. He is also recipient of the Passive Solar Pioneer Award from the American Solar Energy Society, the Herrin Distinguished Fellow from Mississippi State University, the Presidential Team Award for the sustainable relocation of towns displaced by the Mississippi Flood, and the National Center for Appropriate Technology’s 15th Year Distinguished Appropriate Technology Award, recognizing significant work in the field of environmental protection.