A functional habitat design technique for the linking of high detail development areas and open space

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INTRODUCTION

Need for and Values of Functional Habitat Design

"Design can be good only in so far as it does good." (Newton 1957). This thought must increasingly drive both landscape architecture and the habitat-creating professions. Doing good means that Functional Habitat Design (FHD) must be inextricably linked with the other design and management professions and their concerns with aesthetics, cost, and utility. It also means that more and better ecological goods and services must be delivered for less effort and at a lower cost to a wider range of animals and other species. These goods and services must be delivered both within natural systems and to the human systems on which natural systems are increasingly dependent.

The presence, diversity and abundance of higher animals are probably the most desirable end products of FHD. Consistently present diverse animal populations are a probable best indicator of the level of functioning of a natural system and provide a probable best set of circumstances for human enjoyment of natural systems. Animal guilds are the design process focal point for the presented technique. Animal guild selection determines the type of habitat functionality to be achieved. Guilding provides efficiency in design and efficacy in the end product.

Functional Habitat Design achieves the same human densities as conventional human development design approaches. Infrastructure and housing placement will vary only slightly from the usual pattern. It achieves a higher density of functional habitat decision units due to the vegetation species planted, habitat structural supplements, and higher vegetation planting densities associated with landscaping design. The FHD process extends habitat value over the pervious surface portion of the built environment.

The technique provides significant community and economic value. Housing associated with "green" typically sells for 10 to 30 percent more than the same house footprint and lot size located elsewhere. This is ecology positively merging with economy in the "Economy - Ecology – Community" management triad. It puts the "eco" in economy. This link, when coupled with understanding and participation in the program by residents, is one of the best means to assure continued propagation of ecosystem values through time. This approach adds an ecological capital component to the community capital contained within an economic system.

Functional Habitat Design has value because it is not based on and is missing in regulatory compliance. However, much if not all of the typically regulated area, and particularly wetlands, is contained within the functional habitat open space footprint. Contrasting a regulatory compliance overlay with the functional habitat design overlay typically suggests that regulatory processes promote fragmentation and isolation of areas whose physical and functional integrity is better determined and protected by a function based design approach. Regulatory intent often has a basis in function that is seldom met by the area-based end-product of the compliance process. The use of 5 to 8 guilds typically assures addition of additional or unplanned species, density of individuals and habitat.

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Design Process Summary

After the animal guilds are selected, FHD animal guild attributes are summarised in a Habitat Template. A Habitat Template is a tabular database that controls the spatial expression of habitat functional and behavioural attributes. It is a GIS compatible summarisation of design factors obtained from the literature and from expert opinion.

A vegetation plantings list or vegetation planting palette is produced. The vegetation species on the list must combine (1) high habitat function support values and (2) high horticultural value.

Plantings from this list, if used as the only portion of this technique, will add to community social and economic value by assuring an increase in habitat value to which people can and will relate. Use of this vegetation in conventional landscaping design and without consideration of habitat design factors will result in functionality increases and good juxtapositioning through what is essentially a random planting effort embedded in single and multiple landscaping projects. This unintended inclusion of "self-organised criticality" (SOC)(Bak 1997) in current landscaping and in areas where there is a failure to landscape is probably responsible for much of the current but unintended habitat value in the urban landscape.

Space Left after Planning (SLAP), the failure to either landscape or to manage, is another unintended, and valuable, high function habitat component of the urban fabric. SLAP is the unseen weedy component of urban natural areas. It is a dispersed, small sized set of features (Decision Units) having a significant aggregate area and set of functions. One common example of these functions is vegetation serving as a food source for butterfly larvae.

The FHD design process must end as area-based resource partitioning between humans and all other species. The partitioning occurs when a Boolean for Human Habitat generates a pattern that is used to decrease the habitat pattern created by the FHD Booleans for the "Tiny Twenty" animal guilds. This creates a land use pattern that is visually similar to conventional urban design processes. However, the design or pattern resulting from this technique is based on habitat function. It is based on planning or design as conventionally accomplished. Further, it is not a "regulatory" approach or an "opportunities and constraints" model. As a consequence, FHD provides more habitat utility and less fragmentation than conventional approaches. It retains in a single design process the aesthetic potential and the presence of higher animals that is readily achievable for the urban landscape.

FUNCTIONAL HABITAT DESIGN ATTRIBUTES

Functional Habitat Design Defined

Habitat is a very specific term. Habitat consists of "Feeding, Breeding, Nesting, Resting Opportunities Suitably Juxtaposed in Time and Space for All Life Stages" (USFWS, 1980). Functional Habitat Design (FHD) builds from this definitional base. It incorporates the use of assessment optima taken from the Habitat Suitability Index Models (HSI). The HSI optimal assessment condition is considered as a design optima when used as part of the FHD process. The vegetation cover types associated with habitat functions for assessment purposes are a core aspect of the Habitat Evaluation Procedure (HEP) of the U. S. Fish and Wildlife Service (USFWS 1980). In FHD, the association of cover type and habitat function is maintained but optimisation is improved by plantings for function and by structural supplements based on habitat requirements. These 2 procedural revisions are used to create vegetation cover type patterns that are guild habitat maps because of the linkage between vegetation cover types and life requisites of guilds or guild species. These habitat attributes, vegetation cover type relationships, are contained in the Habitat Templates. The Habitat Templates allow construction and testing of physically non-contiguous vegetation functional units or decision unit aggregates for functional habitat in value highly developed space.

These polygons or decision units within highly developed space, when functionally aggregated, either are or can be suitably attributed in functional values and spatial juxtapositioning to meet the provided definition of functional habitat. The functional and physical aggregation is achieved by (1) planting listed vegetation at natural or higher densities, (2) accepting the level of function that is associated with the attributes and values of naturally occurring vegetation cover types and densities and/or (3) adding habitat supplements such as cavities.

Functional Habitat Design Components and Process Sequence

<u>Select the Animal Guilds for Functional Habitat Design</u>

A guild is a group of animals making a similar use of a similar resource (Root, 1967), such as "canopy nesters" or "shallow water feeders." When selecting FHD guilds, create a strong association between (1) guild life requisites, (2) guild fidelity to particular vegetation cover and land use types, (3) habitat functions served by the vegetation cover type and (4) habituation potential of the guild to the site and the vicinity.

The habitat function must be closely linked with both the (1) guild and (2) the vegetation cover type. The vegetation planting list, in addition to its habitat functional support, is an attempt to improve this linkage within a range of species that can be managed by a commercial nursery.

Twenty design guilds are too many. Use of the term makes a point in Southern Africa to contrast this technique with those used to manage for the "Big Five." Five to 8 guilds are about enough. Consider urban habituation for the guild and its members when selecting guilds and be inclusive. Duiker (*Cephalophus* sp.) and many other small mammals are readily habituated. The usual list of "birds, bees, bats, bugs, and bunnies" always applies. But, Fish Eagles (*Haliaeetus vocifer*) and other larger high mobility species are easy to attract and add to habitat diversity and density of user organisms.

Select Vegetation Providing Both Habitat Support and Aesthetics

Combine indigenous and horticultural species in the Vegetation Planting Palette. The final set of listed species must have high to exceptional ratings for both habitat function support value and horticultural value. These plants will be grown in a nursery. A propagation requirement for 200 or more species is infeasible for most commercial nurseries. Therefore, select those plants best meeting (1) functional habitat needs, (2) landscaping aesthetics, and (3) horticultural requirements for the site or region.

Create Habitat Patterns

Habitat Templates are created following the selection of animal guilds. The vegetation cover type and land use portion of the Habitat Template is in expressing a Boolean that will propagate a habitat pattern in the landscape. Habitat Templates are also used in the last step in the design process to assist in confirming the reasonableness of the habitat patterns. They are used to test for contiguous polygon areal adequacy in open space design and for the aggregated value of the spatially disparate decision units contained within highly developed areas. Habitat Templates and associated Booleans and mapping unit criteria are easily revised to increase process and product efficacy.

The connection of isolated areas and widening of narrow connections are set arbitrarily based on animal acceptance of or habituation to disturbance. The criteria are then used to extend habitat areas. These connections are dependent on animal mobility and habituation to human activities rather than on making a "chlorophyll" connection. These extensions of habitat functions and consequent animal movement across conventional divisions between "developed" and "natural" or "open space" areas is a primary goal of FHD.

Simplification of Guild and Design Value

There will be a tendency to add specificity and detail to guild habitat templates. This increase in application of the knowledge base is probably unwarranted. It is much more important to (1) broaden the base of habitat requisites through the planting of more vegetation species, (2) provide closer juxtapositioning of those species, (3) increase the density of the planted vegetation and (4) add habitat structural supplements based on information in the Habitat Templates. Much of the value in the foregoing approach expected to occur from knowledge can be accomplished by adding another guild. Adding guilds that are kept basic and related to a set of vegetation features or cover types to which the guild responds for a portion of their life requisites adds design robustness and efficacy. Adding detail within the guild habitat template tends to merely meet needs of involved human experts and not the requirements of the animals.

Each guild contains a habitat function in the name. This function is linked to a vegetation cover type or land use where the function can be met for the guild. A Boolean expression is used to propagate the habitat map pattern in conventional open space based on these linked relationships expressed as vegetation cover types and land uses. The resulting habitat pattern for the guild is tested against spatial and behavioural criteria in the Habitat Template. Spatial adequacy for habitat composed of conventional open space vegetation cover type mapping units presumes an adequacy of life requisites and their juxtapositioning in time and space within the aggregated cover type units.

Because this design occurs within a managed environment having public and private funding sources, vegetation plantings, habitat supplements and infrastructure modifications can be used to exceed minimum habitat requirements and consequently increase and modify or redirect the habitat composition and value. The technique should supplant and consolidate many urban open space management programs and budgets while providing both lower costs and improved natural system values.

This design base condition changes for developed areas. The size of Decision Units decreases to essentially detailed landscaping design level in developed areas. These units are disparate and typically created for their visual appeal to humans. They are almost never created for their functional habitat value to animals. They can be aggregated and tested against the Habitat Template criteria for functional adequacy. The landscaping plan should assure their aesthetic value.

Notice the potential for structural and functional overlap among the guilds. This factor is significant and adds materially to the robustness of the end product. Other species, guilds, and individuals are carried by this design factor.

Guilding, and adding of guilds results in many additional habitat features that are valuable but are not part of a deliberate design. This indicates why the guilding approach to design and the use of several guilds for design provides habitat for many species other than those considered and why animal "species packing" can occur. It also suggests (1) why design professionals without environmental expertise can produce successful habitat designs using Functional Habitat Design, and (2) why use of proper vegetation plantings alone can be a significant inducement for increased habitat function.

Adaptation and Use of Standard Techniques

The Habitat Evaluation Procedure (HEP) (USFWS 1980) uses a maximum value obtained from the Habitat Suitability Index (HSI) models. This HSI maximum score becomes a design optimum in FHD. About 273 refereed HSI models are available and are good analogues for many species around the world (USFWS 1980). This approach and these models increase affordability and initial utility. The compression of HSI habitat criteria into a vegetation cover type increases simplicity, affordability, and utility.

The "Flux" (FLUCFCS) code mapping system allows easy changes in mapping unit size and detail based on level of use selected (FLDOT 1985). The technique was developed by the United States Geological Survey and is a standard (Anderson, Hardy, and Roach 1976) numerical system allowing subsetting of polygon attributes. It works well with HEP and the associated HSI models. Its nomenclature was expanded to include guild and species habitat design attributes. Consequently, both guild and species habitat maps could be produced.

Booleans are used to produce guild habitat maps. They link the vegetation cover types, whether natural or designed and planted, that contain habitat life requisites for the design guild. Aggregation of these guild related-function based vegetation cover types produces an animal guild habitat map for the Open Space areas. Competition with a Human Guild Boolean results in area-based resource partitioning and an Urban Development Pattern.

After final area-based resource "partitioning" to establish the development pattern, extension of habitat functionality into the high-density development area occurs. A different design approach is needed for these areas. High habitat support vegetation, standard landscaping design practices, and Self-Organised Criticality (Bak 1997) result in habitat creation in intensely developed areas. Vegetation coding and habitat functionality testing differs for this use.

A Habitat Template is a table of temporal, spatial and functional habitat attributes against which habitat designs are tested. Lack of conventional vegetation cover types and the small "grain size" of decision units in developed areas requires a test of disaggregated and functionally disparate "decision units" against habitat thresholds.

Simplified Application Using Partial Technique – Reverse Design Sequence

Suburbia is one of the largest and fastest growing ecosystems in the United States (McKibben 1995). Furthermore, it is stable, gaining in maturity, and has public and private funding and management sources. It is essentially one of the worlds least managed ecosystems. It is also highly resistant to change because of the restrictive planning, zoning, development and other regulations affecting its options and values. However, it offers exceptional potential habitat value across scale ranges from micro to intercontinental.

Creating and applying only the listed vegetation portion of the technique to the urban system will materially affect land values and habitat value. Addition of essentially self-maintaining habitat functions to the system in patterns and sizes customarily produced by humans adequately provides for the needs of many species. The "species packing" that results from this provision of function in the absence of any habitat design results in a very high number of decision units within the urban fabric and a consequent increase in the number and types of using organisms.

Adding a minimal consideration of guilds adds a spatial planning component. This adds value to the vegetation list alone by assuring enough of the vegetation to meet guild life requisites at a larger scale of guild utility. This increases the likelihood of incorporating population scale management possibilities without increasing human effort for design or management.

While this "Bottom Up" approach is desirable for retrofitting habitat into urbia, the "Top Down" design is the only way to knowingly achieve effects at the scale of source populations across urban infrastructure gradients and impediments. This scale of action is particularly necessary if the Environmental Wealth of cities is to be achieved.

Once the core material for the process is established, it is "use forever," as is, or with continual improvement. Upon achieving this point in the utilisation process, design professionals with no environmental training can produce high value habitat integrated with their disciplines. This is very good news. But, how will people and old practices survive in this New World?

The environmental expertise used for the initial effort is free to become really good and productive with totally different requirements for performance. Experts and professionals are no longer required to repeatedly give the same basic advice. The advice need no longer be superficial and surficial. Emphasis can shift to providing benefit that the natural and human systems and their components require for added value in urban environments and elsewhere. Management efforts can shift to the creation of "institutional memory" and development of "intellectual capital." This capital can be distributed for increased social and environmental benefit with very limited costs.

Functional Habitat Design and all ancillary processes are contained in ArcView, which is widely distributed and relatively affordable.

RESULTS

<u>Overview of the Project Site and Application of Functional Habitat Design</u>

The study area is located to the north of Durban, South Africa, and is predominately sugarcane fields. It covers over 26 000 ha extending along the coast of the Indian Ocean and inland about 20 km. The developed area design and test occurred on the 200 ha Mount Edgecombe Country Club Estate in the southern portion of the study area. Limited efforts were also conducted in the Zimbali Coastal Forest Development.

An analysis to determine the pre-alteration vegetation cover types suggests the site was once coastal lowland forest subject to fire and grazing. Relictual vegetation cover types remaining in the area were useful in the simulated regeneration of the pre-alteration vegetation cover types likely to dominate in developed areas following buildout and the consequent restriction of perturbations such as fire and grazing.

The northward moving development front provided an unusual opportunity to design and practice at the scale of the city's development front that occupied a several kilometre wide corridor. This contrasts strongly with the typical infill development pattern. Experience gained from this application suggested that the technique would be successful when used on a typical infill project. Opportunities presented along the development front for the study area, such as cross-basin connections and habitat extensions, would occur with less frequency under infill conditions.

The developers are the current human controllers for this habitat creation and management effort. They are conveyors of this knowledge base to the final landowners. This transfer is necessary for the accumulated intellectual and economic capital to become institutional memory that can be applied by residents in a simple, successful, and enjoyable manner.

Cultural incorporation and acceptance is necessary for this or any similar technique to work. Bringing the process within the economic system gains one type of acceptance, and possible perpetuation because of this linkage. Ultimate success at the "homeowner as a species" level is probably best measured by their slower restful breathing and the slightly, just slightly, upturned corners of their mouths. This socio-psychological acceptance must be accomplished for success to occur.

FINDINGS

The open space design technique and the developed area design technique conformed within developed space. The Developed Area Open Space was also designed independently of this study technique and for development using conventional planning techniques. Linkages indicated by the technique between these 2 approaches were both obvious and counter intuitive.

Aggregation of isolated decision units within developed space allowed testing for compliance with life requisites contained within the Habitat Templates. Utilisation of these isolated units suggested that self-organised criticality may be responsible for the unintended habitat quality occurring within developed space. Over 200,000 decision units occurred within about 60 ha of the developed space without inclusion of the golf course acreage.

Selection of vegetation species having both high habitat support value and high horticultural value was desirable and possible. The visual effect was softer than conventional landscaping, colourful when colour was a design factor, and allowed roadside maintenance by Duiker to be significant.

FHD within highly developed space requires a Decision Unit aggregation technique derived from the same theoretical base and Habitat Template. The fit of the Decision Units and the larger areas determined by the Functional Habitat design Technique for Developed Area Open Space and their conformance in turn to a conventional design by planners and engineers suggests the process is reasonable.

This spatial conformance allowed further design extension for functional habitat at a much finer grain size for design Decision Units. This extended habitat space by (1) improving linkages between habitat fragments and (2) using the vegetation list to extend function within traditional landscape design. Self-Organised Criticality substituted for human determined habitat design at this level of detail. The same concept incorporated functional values in Space Left after Planning (SLAP).

Humans are a necessary component of urban ecosystem design and maintenance. It is fine to design, but habitat has to be functional. It has to work. It has to work well and it can't work without its human inhabitants. They must become knowledgeable ecosystem components with responsibilities for its economic, ecological and social success.

This technique when located in the urban environment offers an excellent opportunity to (1) link the economic power of developed areas to ecosystem sustainability, and (2) to generation of additional economic capital and ecological capital. It can be used to decrease landscaping and maintenance costs while gaining habitat value within an increasing but unmanaged ecosystem type.

Within 15 months into construction of the project 85 percent of the bird species possibly occupying the site had been identified on the site. This contrasted with sites within suburban Durban where at 20 to 40 years of maturity about 20 percent of the possible bird species occur.

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