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Ecology good, Aut-ecology better; Improving the sustainability of designed plantings

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Abstract

This paper explores how contemporary ecological science, and aut-ecology in particular, can improve the sustainability of designed vegetation. It is proposed that ecological understanding can be applied to design at three levels: as representation, as process and as aut-ecology. These represent a gradient from the least to the most profound. Key ecological interactions that determine the success of designed plantings are explored via a review of relevant ecological research, challenging some widely held but unhelpful constructs about how both semi-natural and designed vegetation actually function. The paper concludes that there are real benefits to integrating autecological understanding in the design of vegetation at all scales, but that will require ecological theory to be taught as design toolkit rather than largely as descriptive knowledge.

Key words

Stability, disturbance, competition, diversity, aut-ecology, planting design

Introduction

Over the past forty years a search for “new” planting styles with relatively low maintenance costs has taken place. More recently, a similar process has taken place in search of higher ecological sustainability. In the rich nations of the west the goal has been to reduce financial and carbon expenditure, whilst still meeting public aspirations for colour, drama and seasonal change (Hitchmough 2004: 135-136). A recurrent theme in this approach has been to find ways to reduce more craft based, horticultural maintenance, traditionally used to maintain plantings in a relatively fixed, unchanging state. One of the approaches to achieve this has been through the design of ecologically-based plant communities. These new communities, be they native or non-native to the planting site, have often been inspired by the apparent stability of semi-natural vegetation such as meadows, prairies, heathlands and woodlands at low levels of maintenance (Robinson 1874; Hansen and Stahl 1993).

Since its emergence as an academic discipline in the late nineteenth century, ecology has had a significant influence on planting design. In Germany, Humboldts’ observations on biogeography (von Humboldt and Bonpland 1807) are still represented in some botanic gardens. Ecological underpinning of planting design is most developed in Northern and Central Europe, where plant phyto-sociology descriptions of spatial arrangement and successional change over time strongly informed, for example, the Hansen School of perennial planting in Germany (Hansen and Stahl 1993). Much of late nineteenth and twentieth century ecology followed a holist tradition of looking at semi-natural vegetation in the wild, describing and drawing inference about the ecological processes believed to be in operation. In landscape architecture as a whole, the use of ecology to inform landscape and planting design can be seen to operate at three distinctive levels: ecological ideas as representation, ecological ideas as process and ecological ideas as aut-ecology. These approaches represent a gradient from the application of ecology from the most superficial to the most profound, but are not mutually exclusive; in some cases all three might be involved in a design project.

Representation might involve the creation of facsimile plant communities without a detailed understanding of the species themselves and how these relate to the site in question; capturing the look, but not necessarily the desired functional properties. An example of this might be the sowing of generic native wildflower seed mixes specified by a planning authority on an infrastructure projects (compare Walker et al. 2004; Kühn 2011: 256). The list acts as a surrogate for the design process, the designer having little if any engagement with the individual species, nor whether they will be fit for the specific site conditions. Further examples might include designing a shrubby community without understanding the regeneration strategies of the individual species, or creating Prairie or Steppe meadows by standardized planting mixtures (see Kühn 2011: 244-245) that do not adequately consider ecological processes.

Figure 1. Standardised planting concepts: a prairie mixture as roadside vegetation

Ecology as process deals with understanding of systems and the associated ecological processes and has grown out of environmental-landscape planning (McHarg 1969), for example, urban watershed design in relation to pollution (Alberti et al. 2007) or habitat connectivity (Donald 2005). These approaches typically focus on the larger scale, and have strongly informed thought and practice within landscape architecture at a broad philosophical level. "Working with the existing", or adopting a relatively passive, less interventionist approach of just letting things happen to 'live lightly on the earth' (Dee 2012: 10) fit into this category, as do design interventions to allow access etc., into semi-natural vegetation where protection is paramount. When applied to planting design, process-based ecology is often expressed as habitat restoration, returning landscapes back to the "original", repairing "damage" and regaining ecological function, see Figure 2.

Figure 2. Ecologically oriented design: spontaneous vegetation in contemporary public park

design.

Aut-ecology

Aut-ecology seeks to understand how an individual of a species interacts with other species, and the biotic and abiotic environment. Aut-ecology grows in prominence in the 1970's (Grime 1979; Ellenberg 1988), associated with reductionist experimentation, seeking cause and effect in plant communities (see for example Grime 2001). Aut-ecology argues that to understand the community, be it spontaneous or designed, you must first understand the component parts. These are the individual plant species, cogs with knowable properties, that when combined with other cogs of different species create a "machine" with broadly knowable properties and behaviours; the plant community. The properties of individual species are known as "traits" and represent behaviours acquired over long evolutionary histories. Species and sub-populations are what evolution in their habitats made them. This approach to ecological research has some parallels with how horticulturists understand plants through practice, and designers think about plants as "building blocks". There are also major differences. Horticultural approaches seek to identify the optimal conditions for that plant, which are then met by changing site conditions through cultivation and maintenance. The evolutionary traits of plants are often excluded from this conceptualisation. Aut-ecology offers a profound understanding of plants, derived from either investigation of the habitat, and plant behaviour in it, or experimentation to establish the tolerance of a species to given factors. This research can also be undertaken on designed communities, as has been demonstrated for example by research in the Department of Landscape, University of Sheffield (Hitchmough and de la Fleur 2006: 387-388; or at the Technical University Berlin, see Figure 3a/b (Kühn 2006).

Figure 3a. A field survey at the TU Berlin, Germany, where the biomass development of ornamental species is measured.

Figure 3b. Monarda fistulosa under the influence of the surrounding spontaneous vegetation.

The needs of a given species or cultivar in the horticultural literature are largely based on anecdotes of "what seems to work". Nearly all horticultural texts treat Kniphofia (approximately 70 species) as a uniform entity: all need well drained soils (for example; Rice 2006). All Kniphofia will potentially grow satisfactorily in well drained soils, but in actual fact, many Kniphofia are wetland species (for example; K. northiae, K. caulescens), others are highly xeric (K. hirsuta, K. stricta). Some are relatively short lived, others immortal (Codd 1968). Some species form vast colonies (K. caulesens, K. linearifolia) due to their competitive traits while others are always solitary (K. triangularis) and intolerant of competition. By emphasizing specific tolerances and behaviours, rather than generic horticultural anecdotes, an aut-ecological perspective shows which species can, and cannot be "stretched" to deal with specific stresses that are inherent in designed landscapes (for example a wet site), and how to predict much more accurately how species will perform and persist in the longer term.

Figure 4. It is apparent from the image of Kniphofia caulescens (colony forming monoculture) and K. northiae (individual giant) in a bog at 2800m in the Eastern Cape South Africa, that horticultural conceptualisations of the needs of plants fall well short of the understandings required for sustainable design.

Aut-ecology is extremely powerful, but unlike ecology as representation and process, is much less evident in landscape architectural discourse and practice, most probably because it requires the acquisition of more highly developed underpinning knowledge. The potential to converge design, ecological and horticultural thinking in an aut-ecology approach facilitates finding better answers to planting design questions. A key idea in ecology as representation or process is that ecology is largely (or entirely) a property of assemblages of native plants and animals, with humans a spoiling or corrupting influence (Eisenhardt et al 1995: 223). This limits the application of ecological ideas when dealing with very artificial environments such as an urban car park. This is not a problem with aut-ecological thinking, which is applicable to all situations, no matter how natural or unnatural. An impermeably surfaced car park has no obvious natural analogue, and therefore no obvious link to representation or process. Trees that have evolved to grow on flood plains, where low soil oxygen is a recurrent experience (Kabrick et al. 2012), will however be far more tolerant of such sites than will trees selected at random on appearance, or locally native species associated with well drained soils.

Planting design and its passion for stability

Planting designers have a vested interest in plantings persisting to continue to deliver the benefits species were originally selected for, stability promises lower maintenance levels. In addition to its use in an ecological context, stability has a long history as political, economic and social metaphor (Rousseau 1762). Human beings value the idea of the world not oscillating too dramatically between different states. Stability is however a temporal illusion in the human realm, and even more so in the ecological realm. Fairbrother (1974) explicitly recognizes the ephemeral nature even of planting that in practice we implicitly imagine to be almost permanent. Our short life span, a high capacity to forget what we have experienced and constantly create new narratives about our relationship with the ecological world, appears to compel us to believe that the latter is intrinsically stable (Ladle and Gillson 2009: 234-239).

We often describe this as “the balance of nature”, an idea that begins to appear widely in human discourse from the late nineteenth century, in response to the observed and imagined perils of industrialization (Naylor 1980) and new views of the world arising from the anthroposophic philosophy of Steiner (Moore 1992).

This leads to the construct that nature is stable until human beings interfere with it. Although this view of human interaction with the natural world appears to be very widely held (Worster 1985: 341; Budiansky 1995: 23; Thompson 2000: 144), it is no longer held by most ecological scientists (Wu and Loucks 1995: 459, 460). Vegetation that looks unchanging (and hence stable) to the casual observer will show dramatic change to the knowledgeable long-term observer (Dunnett and Willis 2000: 47-50). “Natural vegetation”, like designed vegetation, is always changing. .This is not to say that semi-natural “wild” vegetation changes as rapidly as vegetation in a garden might, once management ceases. In the latter, fertilisation and watering drives change at rates that are impossible in the less productive conditions of most semi-natural habitats.

Most of our understanding of these ecological phenomena are derived from semi-natural vegetation; what sort of change can be expected to occur in designed plantings and why? Firstly, change may occur at the level of individual species and the aggregated number of species present (the community). Change may be driven by planted, or incoming weedy species that produce large biomasses causing the loss of other planted species. The latter often arise from vegetative fragments of previous site occupants not completely extirpated by site preparation protocols, from seedlings recruited from the soil seed bank, or from seed transported by vectors such as wind, water, and animals.

In practice, change in designed vegetation may be minor, the planted community acquiring new species as described, whilst at the same time retaining many of the planted species. Alternatively, new colonists may lead to the elimination of the planted species. This is common in landscape plantings where either weeding or mulching is insufficient in the first few years.

The planted species are not passive bystanders in the process of acquisition/loss. Depending upon their degree of fitness and growth traits, they may either eliminate planted neighbours, co-exist with them, be outcompeted by incomers or actively exclude the latter. In some cases, a notionally stable outcome might entail a gross reduction in diversity of the initially planted species as a few (sometimes one) of the most robust or competitive planted species eliminate both their planted neighbours and check invasion from outside (Hitchmough and Wagner 2013: 130). Avoiding species with the traits that lead to this situation (rapid growth rate; tall, leafy stems spreading rhizomes (in herbaceous plants)) plus highly productive soils, substantially reduces post-planting instability.

Key-processes of stability

Assuming for a moment that designed and semi-natural plant communities can reach an equilibrium point, which are the species or community properties that facilitate or undermine this stability?

Many scientific studies have tried to answer this question but have often been frustrated as to what precisely stability means (Odenbaugh 2001: 494-498), and how to meaningfully measure it (Christianou and Kokkoris 2008: 162). Species diversity i.e. the number of species per unit area has dominated research into stability over the past decade.because it is currently a politically important currency and relatively easy to measure (Ives and Carpenter 2007: 58).

MacArthur (1955) and Elton (1958) proposed that diverse systems should better resist change, return to their original state following disturbance (Tilman and Downing 1994: 364) and be more resistant to invasion (Levine and D'Antonio 1999: 16).

Two key processes that underpin stable plant communities are i) response to disturbance, and ii) response to invasion. The specific ecological meaning of disturbance is: an 'externally imposed factor that temporarily restricts or perturbs the production of biomass' (Grime 2001: 83). Common disturbance factors include grazing, trampling, soil cultivation, cutting, burning, drought and so on. Disturbance factors are at work in all natural and semi-natural vegetation, sometimes obviously human imposed (as in alpine hay meadows), sometimes imposed by wild herbivores and sometimes by the abiotic environment, as in the case of fire or drought. Designed vegetation is subject to both intentional (cutting, surface cultivation, etc.) and unintentional disturbance (vandalism, trafficking, de-icing salts, etc.). Understanding plant and community response to disturbance is therefore a pre-requisite to creating more sustainable designed landscapes. If not understood during the plant selection and design process, it is unlikely that plantings will be manageable in the longer term. How common is it for landscape architects to select shrubby plants for urban plantings on the basis of their capacity to respond satisfactory to management disturbances such as coppicing?

The literature shows that at best the evidence for plant diversity increasing positive responses to disturbance is either weak (Tilman and Downing 1994; 599; Kahmen et al. 2005: 599; Wang et al. 2010:110), or negative, i.e. that increasing plant diversity reduces recovery post disturbance (Kennedy et al. 2003; Pfisterer et al. 2004).

This suggests that whatever the perceived aesthetic richness, by itself increasing plant diversity is unreliable as a means of improving designed plantings response to disturbance. Relatively stable plant communities might thus be based on few or many species, depending on specific environmental conditions and the aut-ecological traits of individual species. No matter how many species of non-resprouting dwarf shrubs are present in a designed ground cover planting, return to the previous state post disturbance (for example canopy removal by coppicing) will be poor compared to a monoculture of a resprouting species. Aut-ecology rather than diversity determines the outcome.

The resistance of natural and designed plant communities to invasion is derived from the aut-ecological traits of the resident species (Baez and Collins 2008: 4-5). The major factor driving invasion is competition for light, space, water and nutrients (Thompson et al. 2005: 357). Under productive site conditions (abundant light, water, and nutrients) competition is mainly between leaves and shoots, i.e. for light.

Under unproductive conditions, for example in poor, dry soil, competition is largely for water and nutrients (Weiner et al. 2001) as it is not possible to produce enough leafage to shade other plants.

These competitive processes are ongoing in designed plantings just as in naturally occurring vegetation. Un-exploited light, nutrients and water is an “open gate” to establishment within the community (Weiner et al 2001: 788-789). Community “invasibility” depends on the traits of the resident species to monopolize all the available resources to “close the gate”. Resistance to invasion is not reliably correlated to plant diversity (Crawley et al. 1999: 145). Highly resistant communities can contain few or many species (Kennedy et al. 2003: 138-139), depending on the characteristics of these species and the site conditions, with invasion taking place when the community is most open (Grigulis et al. 2001: 288), typically in winter-spring.

Transferring these ideas to planting design; aut-ecology as the toolkit

In naturally occurring communities the individual species have been co-evolving with one another for centuries, or much longer to arrive at compatible aut-ecological strategies for that particular environment. Species with incompatible traits will have been eliminated long ago.

In contrast to this, most designed plant communities are based on species whose aut-ecological traits are either unknown to the designers, and hence simply on the basis of chance alone. There is likely to be a large degree of incompatibility (fast growing species mixed with slow, shade tolerant with intolerant, competitive with uncompetitive) between species, and hence stability is likely to be lower. The more experienced the designer, and paradoxically the more restricted their plant palette, fewer species are likely to be outcompeted and the greater the stability is to be. All designers can use aut-ecological thinking to increase stability of mixed plantings by selecting species with similar key traits (growth rate, for example). In essence every planting design is at some point an unintentional experiment into the affect of traits of the individual species interacting with one another and the environment, leading to winners and losers.

This raises an interesting question; if we only use native species would stability automatically be better captured irrespective of the degree of understanding of the plant material? The difficulty in this is that by definition newly created communities (no matter where the species come from) cannot initially be at equilibrium with the environment, and since on a given site only some of the species will find themselves well-fitted, there is still likely to be as much instability as with species of eclectic origin. The establishment period is often a barrier preventing species and communities that are capable of achieving some degree of stability from being able to do so.

Barriers to incorporating Aut-ecological approaches

All landscape architecture students receive tuition in plant ecology, but this does not mean that they are able to use ecological understanding with confidence in practice, as part of their core design toolkit. In many cases this is because how ecological understanding feeds into creative design practice has not been adequately resolved at the curriculum level. Ecology is largely taught as description of either communities or processes, with only a limited understanding considered of the traits of individual species under different design scenarios. One of the characteristics of ecology at the representational and process level is that it is based on broad, almost philosophical, theoretical positions..

To reference aut-ecology, requires access to information on the traits of individual species, such as are presented in ‘Comparative Plant Ecology’ (Grime et al. 1988) for common Western European species. The concept was originally developed for native species, but has increasingly been applied to cultivated species (Sayuti and Hitchmough 2013) used in landscape architecture. Currently however there is no convenient equivalent to ‘Comparative Plant Ecology’ for less common native and non-native species. It is possible to assemble proxy information of this nature from either observation of plants in their habitat or by reading the ecological and botanical literature. There is a pressing need for a new horticultural/ecological literature on plants that brings this information together. Typically this commences by screening individual species for aut-ecological characteristics such as tolerance of shade, moisture stress (Bartlett et al., 2012), temperature extremes, palatability, and growth rate. This is then applied to long term testing in microcosm (miniaturised real world) experiments to see how the traits of individual species affects their capacity to persist over long periods of time. Figure 5 shows a microcosm experiment over a 3 year period, designed to identify the critical threshold densities for long term survival of 10 low canopy, 10 medium canopy, and 10 tall canopy species. The species in each canopy layer have different aut-ecological traits.

This research tests both the performance of individual species and the designed community as a whole, vital information to create new plant communities in landscape practice.

Figure 5a,b,c. Change in designed South African Altimontane grassland in Sheffield over a three year period, driven by aut-ecological trait differences in relation to varying ratios of low to tall species. (a) Year 2011; (b) Year 2012 and (c) Year 2013

“Fitness” of plant species in relation to the planting site is a major determinant of success in planting, and is often based on the similarity of the environment of the habitats in which plants have evolved in relation to the planting site. Key ecological factors affecting this “fitness” are air temperature, precipitation/evapotranspiration, solar radiation levels, and soil fertility-productivity. With herbaceous planting, slug and snail density is also of critical importance (Hitchmough and Wagner 2011: 281). The interactions generated from within the designed community, substantially the product of the traits of the species, include: how tall, how shade tolerant, how palatable, how fast growing, leaf canopy position in space and the means of reproduction. The importance of these factors are more widely appreciated in some landscape architecture cultures than others; there is a long tradition of this in German landscape architecture (Hansen and Stahl 1993).

Advantages of simple mono-specific planting?

The search for urban vegetation that is relatively stable and cheaper to maintain has led to strongly contrasting planting styles. Historically, modernism and economic rationalisation independently led to monocultures of low evergreen shrubs such as Lonicera pileata, that after an intensive establishment period could be maintained at extremely low resource levels. Although there is no published trait data on this species it is clear that it tolerates sun to moderately dense shade; high levels of moisture stress but not anaerobic soil; is able to initiate roots in moderately compacted soil; is tolerant of pH extremes; long lived, highly unpalatable, suffers some loss of leaf density with aging (leading to gradual invasion by tree seedlings) but retains viable vegetative buds in the old tissues (see Warda 2002: 365). It is a re-sprouting species that can be regenerated by severe coppicing. Once its leaf canopy has fused, light, water and nutrients are very effectively utilised, keeping the “invasion gate” closed, and stability is high. After 20-40 years in the absence of maintenance (i.e. managed disturbance) tree seedlings eventually colonise these plantings. Although their horticultural origin, mono-specific composition and simple mono-layer structure positions this planting genre outside current conceptions of the ecological, it is an impressive ecological application of high dominance potential. These aut-ecological traits allow such shrubs to dominate in the same way that native clone-forming graminoids such as Phragmites communis and Typha latifolia do in wetlands.

When disturbances such as cyclic “coppicing off” the canopy to ground level and returning it to the site as a chipped mulch are applied to monocultural shrub plantings, this dominance appears to be maintainable almost indefinitely for species with the capacity to “resprout” from basal buds (La Dell 2004).

Figure 6. Most temperate shrubs maintain viable buds in the basal bark. With global warming/urban heat islands more Mediterranean, fire ecosystem species are being used in plantings. Many of these species do not maintain basal buds and die after fire (or severe pruning).

Leucadendron spissifolium, a resprouter, is here shown four weeks post an intense fire

Advantages of naturalistic planting?

In Northern Europe the current fashion is to design more species-rich plantings which borrow the appearance, and in some cases the structural and spatial organisation of wild occurring vegetation such as North American prairie or Eurasian steppe and meadow (Kühn 2011: 244). Much of this work in practice operates at the level of ecology as representation; and as a result offers few guarantees that the vegetation will be more stable in the long term than horticultural monocultures (Kühn 2011: 273).

These caveats aside, one of the advantages of naturalistic design form, when aut-ecological understanding is well represented in the design process, is potentially high self-regulation at the community level. This is due to plants often being organised into multiple canopy layers, and spatially distributed on a repeating basis.

By organising plants into two or three overlapping layers, see Figure 7, with the most shade tolerant species at the ground level and the most shade intolerant in the upper, the capacity for near complete utilisation of resources that check plant invasion is increased (Davis et al. 2000). The spatially more complex structures that result support more invertebrate biodiversity (Morris 2000: 140) and also potentially more aesthetically pleasing seasonal change events, that are important for landscape users (Özgüner and Kendle 2006: 152), than single layers are able to provide.

Figure 7.Herbaceous planting in different layers. Aegopodium is set as ground layer and is overgrown by taller species of Euphorbia and Epilobium.

Conventional single layer landscape plantings nearly always involve mono-specific blocks or patches that are only as stable as the traits of individual species allows. Once a patch declines only weedy colonists are left.

Where large patches are replaced by a diversity of individual species or small groups that repeat across a planting, community self-regulation (i.e. gaps resulting from plant failure are likely to be utilised by adjacent planted plants) is facilitated. As an example of this, in planted urban drainage swales, marked gradients of soil wetness occur over quite short distances: a wet central swale channel, wet to drier lower slopes and dry upper slopes. The actual wetness-dryness status of a swale profile is almost impossible to know at the time of designing the planting. By including wet species in at least the lower slope as well as the channel, and dry species in the lower slope as well as the upper slopes, the vegetation is better able to self-organise in response to the environmental conditions as found, even without self-seeding occurring. To do this requires the use of mixes of repeating species (see Figure 8). The consequence of this however is that some planted individuals will inevitably be poorly fitted to their micro-site and will be lost from the community; this must be seen as normal rather than a calamity.

Figure 8. Naturalistic planting where similar groups of species are repeated distributed over the planting site and are allowed to spread and establish at the suitable micro-sites.

These processes work best as the density of planting increases, as this increases the likelihood of individuals finding locations or “niches” in which they are well fitted, and minimises the visual impact of the loss of species. This type of ecological planting is essentially an “active skin” that can respond to changing conditions and “fix” itself.

By embracing fluctuating species numbers and spatial distributions, suitable species are able to spread to close down remaining open spaces. This process works most effectively under low-moderate productivity conditions. On highly productive soils the speed of change is accelerated, and gaps either fill up quickly with growth from planted neighbours or weedy invading colonists. Low productivity approaches challenge traditional landscape architectural specifications that value high productivity substrates (such as agricultural quality topsoil) over low. In most cases the most significant restrictions on achieving these more sustainable types of plant communities can be the difficulties of finding unproductive soil substrates and secondly convincing sceptical clients who see topsoil as a fundamental “good”, of the value of doing this.

There is however a negative aspect to using low productivity conditions, as this inevitably means the community will be “open” for longer. Adequate resource consumption will rarely be achieved by the planted species over this timescale and hence even if invaders are individually small (due to the low productivity), invasion from outside will take place, leading in spring to plantings in which many of the spaces are occupied by thousands of nutrient stressed weed seedlings, which even if they do not outcompete the planted species, create a sense of failure in the minds of the public. The design of planting must therefore be informed by estimated site productivity; high productivity sites require high productivity vegetation with a closed canopy, low productivity sites allow the use of more open low productivity vegetation types such as xeric steppe (Hitchmough 2004). On a highly productive soil, low open communities such as xeric steppe can never consume sufficient quantities of the spare resources (light, water and nutrients), to be stable and low maintenance. Traditionally we get around this ecological restriction by applying a highly selective ecological disturbance known as weeding. Where this can not be afforded, the only option is to apply less selective disturbance treatments to disadvantage the colonizing species. In meadow-like communities this involves cutting and removal of biomass at the most harmful times for tall invaders, frequently July. In prairie or steppe communities burning over in spring with a flame gun or applying vinegar based herbicides (acetic acid) post removal of the dead canopy, to kill seedlings of species that have invaded over the leafless winter months (Hitchmough and de la Fleur 2006: 387-388). This can however only work when species are selected on the basis of their aut-ecological traits to ensure that they can respond positively to the intended management regime.

Conclusions

At the outset of writing this paper we asked ourselves was it likely that landscape architects whose primary focus was not planting design should see these issues as important? Given the broad church that is landscape architecture, perhaps it is unrealistic to ask designers to apply ecological theory at a deeper, aut-ecological level?

Such an approach would in time, potentially bring benefits. It would for example help more clearly distinguish the contribution of landscape architecture from architecture in the design of more sustainable landscapes in the built environment. There are many challenges in doing this, not least finding space in the curriculum and the aut-ecological skills to teach this to students who in many cases diverged from the biological sciences relatively early in high school. Few landscape architecture departments are large enough to have a “publishing” ecological science researcher on staff, and even if they do, the chances they will also be a designer is relatively remote. A review of the worlds published research literature in landscape architecture suggests there are few who can confidently integrate these contrasting traditions, especially at the aut-ecological level. Professional ecologists are often brought in to teach descriptive ecology and students learn background ecological principles such as food webs, plant succession, important native plant communities and how to do a basic habitat survey. These are all important and useful understandings but generally will not equip students to “use” ecological theory as a creative and practical tool in designing sustainable landscape vegetation. Without this ability, the capacity of landscape architecture to develop plantings that can be sustainably managed in the long term is significantly compromised. In practice, an alternative to re-thinking how ecology is taught in conjunction with design is for landscape architecture to work more closely with ecologists and ecologically informed horticulturists. This is possible on prestige projects that are well funded, but unless ecologists who are supportive of design can be found, the result can be schizophrenic, a rather unsatisfactory compromise between two competing world-views rather than a true, creative integration of design and ecology.

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