# REDESIGN AS DEEP INDUSTRIAL ECOLOGY: LESSONS FROM ECOLOGICAL AGRICULTURE AND SOCIAL ECOLOGY

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The challenges ahead for industry are at the same time both formidable and potentially enlivening. The combination of increasing restrictions associated with inputs and outputs poses enormous threats to both contingency and recovery of investment on capital. These can be only partly and temporarily addressed by increases in **efficiency** of operations and **substitution** strategies, such as the use of alternative resources, including recycled stock and solar energy. Although we have still only scratched the surface in applying these two potentially valuable approaches, their limitations are such that without more fundamental changes in values and the design of systems, they can only delay the eventual reaching of critical thresholds relating to ecological collapse and associated cultural breakdown, including increased violence, war and personal degeneration. I believe, based partly on my familiarity with the history of soil degradation and associated cultural collapse (e.g., Hyams 1952), that such outcomes are inevitable if we continue to mainly focus on *status quo* maintaining, and problem-solving responses. However, if we take proactive, imaginative, fundamental **redesign** and transformative approaches to change, and are willing to learn from nature, and 'otherness' in general (Bhabha 1994; McClintock 1995), then numerous hopeful opportunities may be recognized and emerge (see also Nina-Marie Lister, Ch.2). I have called the approach that I will describe in this chapter **deep industrial ecology**. To realize the synergistic and synchronistic potential of this radical approach, we will need to more fully embrace an integrated, local-to-global, whole-of-society, long-term process of fundamental personal and cultural transformation. In this respect, I will be continuing the discussion on the 'human side of industrial ecology' advanced by Edward Cohen-Rosenthal (2000).

My aim in this chapter is to demonstrate that a **social ecology framework** (Hill 1999) has much to contribute to the discourse in industrial ecology, particularly by deepening the goals, working in integrated ways with complex contexts, and offering more effective means for bringing about progressive change. Because the redesign approach being advocated has a much longer history in agriculture than in industry, I will be drawing particularly upon relevant initiatives from **ecological agriculture** (Hill 1985, 1998, 2004), using a case study from Australia, noting especially the general lessons that can be learned and applied to other industries. My aim is to argue not only for the considerably expanded application of insights from ecology to design and redesign initiatives within industry, but also to the way we approach visioning, policy development, planning, deciding, implementing and all other forms of working and taking action.

## Some Key Assumptions

Based on nearly 60 years of experience and reflection, I have arrived at the following tentative conclusions, which are here reframed as the key assumptions that currently underpin my work, including the ideas presented in this chapter. I have grouped them under eight overlapping subheadings: humans, knowledge, communication, nature, sustainability, change, industry and redesign. What will be clear from reading them is that most are essentially the opposite of the dominant assumptions that guide most current industrial practice. As such they challenge much of our current thinking and action, and offer the possibility of radically different paths to sustainable futures. They also provide an 'alternative' approach for examining some of the limits to change highlighted in this volume by John Robinson and Asoka Mendis (Ch.14), James Tansey (Ch.10) and others.

**Humans** are not "good" or "evil"; rather they are potentially both. However, the life force within each of us, together with our social nature, biases us towards the **benign and relational** end of the spectrum, as evidenced by our passion for learning and improving, and caring and collaborating (Hill 2003; Josselson

1996; Shem and Surrey 1998). Contextual factors, particularly busyness, inappropriate reward systems, and lack of supports and regulations can be major barriers to the expression of these qualities.

**Spontaneity and being in the present** are the most reliable indicators of psychological and emotional wellbeing (Williamson and Pearse 1980), which are prerequisites to genuine progressive change. However, nearly all adults are significantly 'wounded', and are unaware of the extent and effects of this wounding, and are living in unsupportive and challenging conditions (deMause 1982; Hill 1991, 2003; Jackins 1997). As a consequence, most of us exhibit extensive 'compensatory' behaviors, including denial of this. We tend to construct deceptively simple assumptions about the world, and often interact with it in naive ways. One outcome is that the ways in which we explain our experiences, and the past in general, and plan for the future, often miss or downplay key factors that influence our thinking and action (such as the role of fear, particularly fear of loss of control, or conversely our largely untapped collaborative potential), and we tend to elevate minor concerns (such as short-term and superficial 'appearance' considerations). One framework for suggesting how such behaviors might become established involves adaptive processes that result in the construction of sub-personalities or multiple adaptive selves that exhibit broadly predictable (non-spontaneous) behaviors (Hill 2003). Each of these selves is likely to be triggered into action by environmental cues that are generically related to those responsible for the establishment of the original adaptation. Such adaptive processes commonly involve disempowerment, loss of awareness and psychic numbing (Macy 1983), and the development of related compensatory behaviors such as attraction to symbols of power, obsessive control, and distractive activities, along with defensiveness, denial, and underlying feelings of guilt and despair.

The immediate relevance of this to developments in industrial ecology is that unless we are aware of who the 'selves' are who are participating in any discussions and projects, then much energy can be wasted in negotiations with 'selves' who are currently incapable of making empowered and informed decisions. Only empowered, non-adaptive 'selves', ideally operating within supportive contexts, are likely to be able to fully engage in deep critical analysis and creative fundamental redesign initiatives. To achieve long-term success, it is essential that psychological recovery and the nurturing of human development be part of any integrated industrial ecology agendas; in the shorter term, if disempowerment is the limiting factor, it will be more effective to address this before (or at least at the same time as) focussing on other aspects of the change process (Hill 1991, 2001). In working with change, it has been my experience that this is the area that is most frequently neglected or dealt with by denial, yet it is also the area that has most to offer in terms of its potential contribution to sustainable progressive change.

**Knowledge**. Despite the extent of our accumulated knowledge and technological power, our species has still only scratched the surface of its potential in terms of personal and cultural development, and of our understanding of the workings of nature. **Most of what is remains unknown** (see, for example, Voisin 1959, especially Figure 1, p.3), and, in any event, because all knowledge is constructed, it can never be absolute or complete and must always be regarded as open to revision, refutation and elaboration. Paradoxically this is cause for hope, because the opportunities for improvement and progress are enormous. This will be realized, however, only if we are willing to become much less arrogant about our 'knowing', and much more creatively proactive in our psychosocial and cultural evolution, and in our learning from and working with nature. In particular, this will require us to courageously let go of dysfunctional and life-threatening assumptions, biases, visions, preoccupations, designs and practices. Common biases and barriers to creative thinking include our frequent privileging of science, males, specialists, and a symptom-based problem-solving emphasis. Consequently, the untapped knowledge base for developments in industrial ecology is extensive, and until it is accessed in unbiased ways its neglect will remain as a major barrier to progress (this will be discussed further under "Nature" below).

**Communication.** Because of the factors referred to above under "Humans", most communication about change is predictably relatively shallow and ineffective. Feelings of really being listened to are rare and **misunderstanding is widespread**. Effective communication is made particularly challenging as a result of our enormous individual variability. This may be related to differences in personality (Keirsey 1997), gender (Tannen 1986), age, cultural background, lifestyle preference, knowledge, skills, and psychosocial development (Josselson 1996; Lauer 1983; Beck and Cowan 1996; Wilber 1998), as well as past

experiences, including both those that were liberating and developmental, and those that were wounding (Hill 1991, 2003). As a consequence, much communication is adaptive and is concerned with negativity (or with ungrounded and 'patterned' positiveness), trivia, tiptoeing around issues, rather than dealing with them (and other postponing strategies), and reactive defensiveness and power games. Dysfunctional communication is, in my experience, a much more common barrier to making progress in most areas of industrial ecology than is the need for technological innovation. Because of this, it is imperative that much greater attention be paid to improving communication. To be open to learning from nature, for example, one has to be aware and paying deep attention. It is important to realise that the developments in information technology are similarly subject to all of the distortions noted above and, as such, their contributions will also be limited by our ability to address these underlying issues.

**Nature** functions according to **ecological 'laws'** and processes that involve limits and opportunities, cycles, non-linear and threshold relationships, complexity and high functional biodiversity, and widespread mutualism, with competition usually being a last resort, and most resources being used for maintenance (sustainability) and regulatory processes, with 'production' being a by-product of this (Commoner 1970; Hill 1991). **There can never be a non-ecological long-term future** for our species, including our industries. Because we are products of nature, we are subject to her limits and opportunities. This is discussed in more detail below under "Sustainability" and "Redesign". The sooner we develop psychosocially (Huxley 1952), in ways that enable us to live according to this ecological reality, the sooner we are likely to experience love, purpose, wellbeing, sense of community and place, peace, social justice, and ecological sustainability (deMause 1982). Gregory Bateson (Harries-Jones 1995) has provided an epistemological basis for such reasoning, and others have documented the rich history and implications for choosing our way of life based on ecological thinking (e.g., Hay 2002; Mulligan and Hill 2001; Orr 1992, 1994, 2002; Worster 1994).

Deep industrial ecology is concerned with finding creative and sustainable ways to integrate nature's wisdom into the design and management of all industrial operations. In this process, the opportunities for applying insights from ecology and nature to industry should be regarded as infinite. Immediate areas for reflection and application, in addition to those mentioned above, include: limiting factors and their substitutes; microhabitats, niches and territoriality; guilds, roles and keystone species; system maintenance and service functions; resilience and ecosystem resistance; succession, and developmental and intergenerational change; feedback loops, co-evolutionary processes, altruism and group selection; edge effect and boundary phenomena; functional diversity, system stability and homeostasis; specialists and generalists (eurytypic and stenotypic expressions), and r and K strategists; entropy and negentropy; specific indicators and integrator indicators; time and space specificity; synergy and mutualism; catalysis and amplification; non-linearity and threshold relationships; integrated web-like relationships; self-regulative and regenerative processes; numbers, biomass, energy flow, and the specifics of resource partitioning and budgeting; and hierarchical and systems phenomena at every level. Information about these and other related phenomena may be found in most major ecology textbooks (e.g., Andrewartha and Birch 1984; Begon et al. 1996; Krebs 2001; Odum and Barrett 2004; Smith 2001), and also in dictionaries of ecology (e.g., Allaby 1998; Lincoln et al. 1998). It is clear from even such a preliminary list of ecological concepts that present approaches in industrial ecology are still at a very early stage in their development.

**Sustainability** is concerned with the **long-term regeneration and maintenance of living systems**. It has a paradoxical relationship with progressive change and personal and ecosystem development, for which it is a co-requisite. Ecological sustainability affects the survival and wellbeing of all life. Social and cultural sustainability relates only to human groups, and personal sustainability to individual wellbeing. Because money and economic systems, like politics, technology and even religion, are human constructions (in a sense, merely 'tools') that enable us to act on our values, they should not be accorded similar status to the environment or personal wellbeing when considering sustainability. Like all tools, they must be regarded as subject to being changed as needed, and their appropriateness must be judged against a broad range of life-affirming values. To allow any of them to assume the role of a higher value, as we have for growth, wealth, ownership and global trade, is paradoxically an indicator of our collective disempowerment (it is a predictable, associated compensatory behavior), and loss of our humanness.

Consequently, for me, any **triple bottom line must relate to ecological, personal (including "spiritual") and social (including economics, politics, etc.) sustainability**. Until economics is removed from its primary position in decision-making frameworks, we will continue to be ruled and directed by distressed and disempowered individuals who are attracted to external symbols of power (in this case, money) to compensate for their internal lack of power and purpose. We should also not be shocked to discover that such disempowered individuals and groups are likely (mostly unknowingly) to be slaves to symbolically powerful tools. They are also likely to frequently remain silent in the face of obviously ridiculous, morally indefensible and unsustainable ways of living, and systems of production, consumption and waste management, oppressive relationships, widespread fear, violence, and other compensatory behaviors. A provisional set of testing questions relating to the above view of sustainability and to personal, social and ecological wellbeing is provided in Table 1. I am suggesting that the kind of questions in this table be applied to all industrial ecology initiatives, including all of the suggestions and implications raised in this volume.

The goal of sustainable design and management must be to build up and maintain natural, cultural and personal capital, and to use the interest from this, rather than the capital, to support wellbeing in each of these areas (Hill 2005). This will require distinguishing between needs and greeds, keeping population activities (numbers, distribution and impacts) below carrying capacity (Wackernagel and Rees 1996), the support of biodiversity, natural cycles, and other ecosystem maintenance processes (thereby enabling the renewal of renewables), and the conservation, recycling and prioritized use of non-renewables. It may seem that my lack of emphasis on an 'economic bottom line' is naive and unrealistic. In fact, I am arguing that the converse is true. If money and economics are tools, as I am suggesting, then it is imperative, that as with any other tools, rather than being used as blunt instruments, as is so common, they be used with much greater wisdom and skill. Thus, rather than advocating that we neglect economics, I am arguing that we develop more appropriate and profound relationships with it (Nina-Marie Lister in Ch 2 and Walters [1986] have advocated adaptive approaches to management as a solution, but observations in the health field that adaptation can lead to addiction, allergy and system degeneration should alert us to being cautious in using this term uncritically; see Randolph and Moss 1980). Environmental accounting and total cost accounting are early expressions of positive steps in this direction. Reframing and redesigning our relationships with these tools will enable us to develop more appropriate institutional structures and processes, which in turn will enable money and economics to serve us better. It is likely that with such changes, much creativity and innovation will be released and genuine sustainable progress can be made. Although this is a formidable challenge, progress is already well underway, as reflected in the growing body of literature on alternative and ecological economics and politics (Daly 1996; Hawken et al. 1999; Henderson 1991; Hill and Henning 1992; Martinez-Alier 1987; Millani 2000), on the need to examine underlying values and assumptions when making proposals (e.g., Cohen-Rosenthal 2000; Ehrenfeld 2000; Norgaard 1994; Trainer 1995), and on visioning significant increases in the efficient use of resources (e.g., Weizsacker et al. 1997; Hawken et al. 1999).

**Change** is a natural **whole-system process** that in nature mostly occurs gradually (with occasional bursts) in a highly integrated way that is co-evolutionary (Norgaard 1994). Effective sustainable and psychosocial co-evolutionary change in human societies is supported by being based on this awareness, by having shared emergent and contextually appropriate goals and agendas, being clear (not naïve) about the contexts within which one is operating, and having the knowledge, skills and psychosocial maturity to collaboratively implement our visions and bring about desired changes. We must constantly be open to change in direction (including paradigm shifts; Kuhn 1970) as we sensitively learn our way into the future. One key to effective change is to focus on **small meaningful initiatives** that can be accomplished with the widest possible sense of ownership, and to publicly **celebrate progress** (to acknowledge achievements and facilitate copying by others). The importance of this approach to change cannot be overemphasized. Mega-projects 'owned' by experts and those with positional power are the least likely to succeed, and the most likely to experience low compliance and, over time, lead to unexpected negative outcomes, and be ultimately unsustainable (Hill 2001). I have found that co-operative inquiry (Heron 1996) and action research (Reason and Bradbury 2001) provide the most powerful frameworks for working with change at the 'small meaningful' level within a research context.

Rachel Lauer (1983) has argued that all fields of understanding seem to commonly evolve in ways that reflect the following overlapping and inclusive stages or 'epistemes':

1. initial recognition of the thing or concept (in this case, industrial ecology);
2. its definition, classification and measurement (the stage to avoid getting stuck in);
3. understanding its relationships with other things and phenomena (e.g., sustainability);
4. critical reflection on its meaning (hence my proposal for a 'deep industrial ecology'); and
5. recognizing its unifying and core qualities, while also acknowledging its vast unknown (and even 'mystical') and paradoxical qualities.

**To what extent does any industrial ecology initiative (policies, programs, plans, regulations, decisions, actions, etc.) support or undermine each of the following qualities:**

**Personal Area**

1. empowerment, awareness, creative visioning, values and worldview clarification, acquisition of essential literacies and competencies, responsibility, wellbeing and health maintenance practices, vitality and ***spontaneity*** (building and maintaining personal capital – personal sustainability)?
2. caring, loving, responsible, mutualistic, ***negentropic relationships*** with diverse others (valuing equity and social justice), other species, place and planet (home and ecosystem maintenance)?
3. positive total life-cycle ***personal development*** (lifelong learning) and 'progressive' change?

**Socio-Political Area**

4. trust, accessible, collaborative, responsible, creative, celebrational**, *life-promoting community and political structures and processes*** (building and maintaining social capital – cultural [including economic] sustainability)?
5. the valuing of 'functional' high ***cultural diversity*** and mutualistic relationships?
6. positive ***cultural development*** and co-evolutionary change?

**Environmental Area**

7. effective ***ecosystems functioning*** (building and maintaining natural capital – ecological sustainability)?
8. 'functional' high ***biodiversity***, and prioritised use and conservation of resources?
9. positive ***ecosystem development*** and co-evolutionary change?

**General Area**

10. **proactive** (*vs* reactive), **design/redesign** (*vs* just efficiency and substitution) and **small meaningful collaborative and individual initiatives** that can be achieved (*vs* heroic, Olympic-scale, exclusive, high risk ones) and their **public celebration** at each stage – to facilitate the spread of concern for wellbeing and environmental responsibility?
11. focusing on key opportunities and **windows for change** (pre-existing and contextually unique change 'moments' and places)?
12. effective monitoring and evaluation of progress (broad, long-term, as well as specific and short-term) by identifying and using **integrator indicators** and **testing questions**, and by being attentive to all **feedback and outcomes** (and redesigning future actions and initiatives accordingly)?

Table 1. Twelve social ecology testing questions for evaluating industrial ecology design initiatives, processes and outcomes (all may be evaluated qualitatively and quantitatively).

This latter stage is the one most likely to be associated with paradigm shifts and radical changes in worldviews, both of which are needed if the full benefits of concepts such as deep industrial ecology are

to be realized. Such a 'progressive' view is paralleled by the ideas of Clare W. Graves (popularised by Beck and Cowan [1996] as 'Spiral Dynamics'), Ken Wilber's (1998) levels of being, Ruthellen Josselson's (1996) stages in the development of relational competence (Hill 2003), and Lloyd deMause's (1982) stages in the psychosocial evolution of child rearing. I believe that although these ideas are themselves very preliminary, they have much to contribute to the ongoing co-evolution of industrial ecology, which is still to some extent stuck in Lauer's early stages of development.

Based on my change work, I have found that the following overlapping stages are also commonly experienced:

1. ignorance and denial;
2. awareness and acknowledgement;
3. understanding and competence;
4. effective action and initiatives; and
5. ongoing responsible practice.

Because different barriers are associated with each transition, to be effective in working with change, it is necessary to ask 'strategic questions' (Peavey 1994) that are fine-tuned to the stage that is most dominant in the particular context.

**Industry**, like economics, politics and religion, is a social construct. **Designed and used appropriately, industry can serve us in supporting the wellbeing of both people and the planet**. Conversely, with personal disempowerment, lack of awareness and vision, undeveloped worldviews and confused values, we are susceptible to being enslaved by industry (as we are by any of our other social constructs). The more powerful the social construct, the more powerful and clear we need to be to not become victims of such enslavement. In this regard, for industrial ecology initiatives to achieve their full potential, they must focus on fundamental whole-system eco-design and redesign, and not be regarded as add-on or fine-tuning preoccupations. What we are concerned with here is not just the redesign of industry but, even more importantly, the fundamental redesign of our relationships with it (see also John Robinson & Asoka Mendis, Ch.14, and James Tansey, Ch.10). As other chapters in this book review the literature relating to current theory and practice in industrial ecology, this will not be repeated here.

**Redesign.** All existing systems can benefit from fundamental redesign based on the creative application of our understandings of life, particularly in relation to ecology and psychology. An initial list of such understandings in ecology with some of their social implications is provided in Table 2.

This deep approach to industrial ecology, natural resource management and change is profoundly different from the more usual tinkering approaches that aim to improve efficiency within flawed designs (such as monocultures in agriculture, forestry and fisheries), substitute inputs (such as renewables and biologicals for non-renewables and synthetics), and that focus on problem solving and symptoms (usually regarded as 'enemies' instead of feedback from poor designs). Rather, deep redesign initiatives **aim to use ecological insights to create self-maintaining and self-regulating optimally productive healthy systems** (see also Nina-Marie Lister, Ch.2). This is, I believe, a significantly different objective than that promoted by those promoting resource use efficiency (von Weizsacker et al. 1997), 'biomimicry' (Benyus 1997) and 'natural capitalism' (Hawken et al. 1999).

An example of this redesign approach in agriculture (pasture management in Australia) is provided below to illustrate the potential gains that may be made as a result of engaging in this fundamentally different way of thinking. Whereas efficiency and substitution approaches may serve as stepping-stones towards such redesign approaches, they may also act as barriers to the latter if they are regarded as endpoints. It is important to realize that the social change being advocated here is partly associated with a shift from a focus on products (particularly those used as curative solutions to problems and as distracters from psychological distress) to services (using our knowledge and skills for the design and management of sustainable systems and activities). In agriculture, this whole-systems approach to change requires a critical review of purpose (why), strategies (how), of where to do things, when to do things and what to do. When such an approach is applied to all industrial activities, it soon becomes evident that the

opportunities for improvement are extensive, and that the main barriers to their achievement are largely psychosocial and a result of our ignorance of ecological and psychological processes, together with the lack of appropriate institutional **supports, rewards and penalties**. Areas where initiatives need to be taken in relation to the latter are listed in Table 3.

| Ecological understandings | Prevailing assumptions/practices |
|---|---|
| • Responsive to early indicators | • Wait for crises |
| • Cyclical, regenerative relationships | • Linear material flows |
| • Growth subject to limiting factors | • Unlimited growth (unsustainable) |
| • Most resources used for maintenance | • Production overemphasized |
| • Based on solar and renewable energy | • Reliant on fossil fuels and nuclear power |
| • Mutualism favored | • Competition emphasized |
| • Functional diversity and complexity confer stability | • Simplified, highly controlled systems (dependant and unstable) |
| • Rich diversity of specialists, generalists, roles and niches within communities | • Few specialists and roles valued |
| • Uniqueness of time and place (reflected in all structures and processes) | • Structures and processes universalized (everything the same, everywhere, all the time) |
| • Gradual co-evolutionary structural change, with occasional bursts of creativity | • Rapid, forced change with few beneficiaries and many 'casualties' |
| **Cultural and personal imperatives** | |
| • Building personal, social and ecological capital and well-being, and a sense of enough; and living off the interest | • Inequitable and accumulating personal wealth (unsatisfiable and unsustainable); and living off the capital |
| • 'Conserver Society' (equitably meeting basic and aesthetic needs) | • Growing consumption (increasingly emphasizing compensatory wants) |
| • Appropriate scale, resource efficient (solar, renewables); structures processes and technologies minimizing waste and impact | • Mega, powerful resource consuming; structures process and technologies waste producing and impacting |
| • Values-based decision making by an informed, participatory population (public education, access, transparency and inclusion) – for the greatest good (social justice) | • Market forces (political and consumer manipulation through advertising and exclusion; short-term narrow focus, with neglect of externalities) – monetary system of values (economic rationalism) |
| • Regional self-reliance, shared leadership and responsibility; and context sensitive and specific designs, products and services | • Transglobal corporate managerialism and hierarchical control; homogenized designs, products and services |
| • Right to meaningful work (sense of purpose, place and valued roles within vibrant communities) | • Mobile, disposable workforce (loss of sense of purpose, meaning, connection to place and community) |
| • 'Understanding', creative, and design focused science, technology and arts, and their integration | • Controlling and problem solving, specialized science and technology (understanding science and arts as disposable luxuries) |

Table 2. Comparison of ecological understandings and prevailing assumptions and practices within industrial societies.

In the absence of such understanding and support, it is not surprising that denial, ridicule, isolation, procrastination and other distractive, compensatory and addictive behaviours are so widespread. One of the most disturbing postponing tactics, given our resource limitations and the urgency of confronting the

problems, is the usual demand for further research before action can be taken, and the channelling of most resources into the endless measurement and monitoring of obvious problems, including those listed above, rather than their avoidance through redesign strategies. This is particularly exacerbated by the current tendency of governments to channel most developmental research dollars into matching funding projects with industry, and industry's tendency to only support projects associated with product development, growing consumption and the justification of present practices. The potential of redesign research to reduce or eliminate dependence on curative and compensatory products is understandably regarded by most in industry as a threat to short-term profits. **It is imperative that governments directly fund redesign research and prioritize such research when awarding matching funding with industry**, thereby helping to facilitate the needed shift from products to services, and reducing our compensatory consumptive and impacting lifestyles.

**FORM OF POLITICAL ACTION**

Supports

- Education, demonstration, and models
- Extension and other services
- Research and development
- Legislation and regulation

Rewards
(only available during a transition period to prevent the development of dependence)

- Tax incentives
- Subsidies
- Low interest loans

Penalties
(for those who act irresponsibly)

- Monitoring programs
- Legislation

Table 3. Political strategies for supporting change.

## Yeomans Keyline: An Example of the Application of Our Ecological Understanding to Design/Redesign in Agriculture

Percival Alfred Yeomans (1905-84), or PA as he preferred to be known, was an exemplary deep design/redesign thinker and practitioner. Although the importance of his contributions to agriculture are yet to be fully appreciated and applied (Mulligan and Hill 2001), he was a major source of inspiration for the development of Permaculture (Mollison and Holmgren 1978), and his 'Keyline' system of landscape management is familiar to many who are at the cutting edge of applying our ecological understanding to design and management in agriculture. David Holmgren (1999, personal communication) put it succinctly when he stated, "Yeomans has made Australia's greatest contribution to sustainable land use, because he introduced the practice of design to what previously had been just husbandry and cultivation".

PA had extraordinary observational powers. He read widely, loved to experiment, was pragmatic, and persisted where others might have given up. Before purchasing his first farm in 1943 (1000 acres of poor, unproductive land near Richmond in New South Wales), he had developed a deep understanding of landscape as an assayer and valuer of gold and tin mining projects throughout eastern Australia and New Guinea, and a fascination with water conservation and management. After becoming disappointed with

the results of applying the latest soil conservation strategies, he started to develop and apply his own ideas. His years of experience observing landscapes had included seeing how immigrant Chinese miners had stored water in arid environments in temporary dams and directed it across slopes to where it was needed. He also had experience working with chisel plows, which he had introduced into Australia, and he read widely, becoming familiar with the literature on organic farming, much of which is devoted to the creation of a healthy soil. But more important than this, he was driven by a deep desire to transform Australia from an arid landscape to one where water is universally available. This was initially triggered by a frightening experience, when his three-year-old son Neville wandered off into the bush during a camping trip. As time went by, PA feared that Neville would surely die for lack of water. Happily, a local aborigine who knew where to obtain water found Neville and returned him to his family. PA's growing concern for water was reinforced a year after purchasing his farm when his brother-in-law, who managed the farm, tragically perished in a grass fire that got out of control.

Because of his fascination with water, PA had the habit of going out in the rain to observe the movement of water across the landscape. On one of these occasions, when it was raining heavily, he had noticed a reflective band running across some of the hillsides at the point where they change from being convex above to concave below. He reasoned that on sloping land this is where the water table is most near the surface, this being the highest point on the slope where a dam can most easily collect water and be used to irrigate the land below. He later called this line the **Keyline**, and the points where it crosses the drainage lines within primary valleys the **Key Points**. PA was also quite stubborn and persistent, and he had little time for those with less inquiring minds. Although this enabled him to continue to experiment and implement his ideas, it also made him unpopular with some in government and university, some of whom actively opposed him. This, together with the fact that the time when he developed his more complex, integrated, whole-system approach coincided with the introduction of deceptively simple management tools to agriculture, such as superphosphate, was probably responsible for his approach not receiving the attention it deserved. It remains, however, as an exemplary model of the deep design/redesign approach being advocated here.

Faced with an eroded and degrading landscape, he set out to fundamentally redesign it so that it could recover, build natural capital, come alive and be sustainably productive. He had the novel idea that perhaps rather than just trying to conserve soil, he might actually be able to create it (in fact, he was able to create 10 cm of topsoil in three years, whereas previously it was assumed that this would take several hundred to several thousand years!). He reasoned that because soil is a decomposer system, its development is likely to be limited by inputs of dead organic matter, which can most readily be added *in situ* in the form of dead plant roots. Furthermore, he reasoned that all processes in soil are, in turn, limited by the suitability of the prevailing conditions (particularly access to air, water, and potentially limiting nutrients). This he was able to transform through his system of plowing (across the slope, veering slightly down from the Keyline, using his Keyline plow), periodic flood irrigation (from his redesigned Key Point dams, with their irrigation channels; note, we could improve on this today), and a single 'priming' application of limiting nutrients. Plowing across the slope was repeated annually, ideally when the weather is warm and rain is expected, for just three years at increasing depths (e.g., 20cm, 30cm and 40cm or more, depending on the particular conditions and depth of the existing soil). This enabled the roots of pasture plants to penetrate progressively deeper into the soil, and the channels running across the slopes enabled the irrigation water to flow out to the ridges.

By practising rotational grazing (Voisin and Lecomte 1962; see also Savory and Butterfield 1999), he found that enormous amounts of organic matter can be added to the soil – when the top is browsed off by livestock (or, less ideally, is mowed), an equivalent amount of roots die and add fibre to the soil. Together, these practices enabled the soil to retain enormous amounts of water. The plow that PA used was also redesigned to create aeration and drainage channels in the soil, break any hardpans, and shatter the clods, thereby permitting better root penetration and ideal conditions for soil life and soil formation. His **Keyline plow**, which was then marketed as the "Bunyip Slipper Imp with Shakerator", was in 1974 awarded the "Prince Philip Prize for Australian Design" by the Industrial Design Council of Australia. By attaching a vibration device to the plow, besides helping to break up the soil, he was able to reduce resistance and so enable the plow to be pulled by a lower horsepower tractor, thereby saving energy and

environmental impact. All of this was just part of a larger redesign approach that involved arranging the various features of the farm in a **Hierarchy of Permanence**, recognizing that different strategies are required for working with features exhibiting different levels of permanence. Climate, landshape and water supply he called the 'inseparable trinity of landscape design', with roads, trees, farm buildings, subdivision (fences) and soil being the more negotiable remainder of the hierarchy. In his book *The Challenge of Landscape* Yeomans (1958) examined each of these in detail. Windbreaks, fences, roads and buildings were all placed at specific locations (attention to place) and all operations were carried out at optimal times (attention to time). Records were kept so that he could learn from his experience. The various features of Yeomans' approach to sustainable landscape management described above are summarized in Table 4.

**Conceptual**

- Learn from nature, others and one's own experiences (indigenous, immigrant and organic farming cultures)
- Create, as well as conserve, soil (and natural capital in general)
- 'Hierarchy of Permanence' as basis for strategic decision making
- Support and effective use of ecosystem processes and 'services' (through careful choice of the nature, time and place of all structures and processes, eg., Keylines and Key Points)
- Use of inputs and processes to build natural capital and 'prime' systems

**Structural**

- Keyline plow (modified chisel plow with vibrator)
- Keyline dams and irrigation channels
- Nature and placement of all structures

**Procedural**

- Timing of all operations (plowing, irrigation, rotational grazing)
- Keyline pattern of plowing
- Rotational grazing

Table 4. Key features of Yeomans' Keyline design/redesign initiatives.

Sir C. Stanton Hicks (1955), who was Professor of Human Physiology and Pharmacology at the University of Adelaide and one of the few who recognized Yeomans' genius, wrote:

> " The bare ridges became covered with lush pasture. Erosion in the valleys ceased. Earthworms, which had never been seen, appeared in their myriads. Soon bare loose red shale became submerged in rich black soil.… In three years he has produced four inches of friable black soil where bare weathered shale or sandstone so recently comprised the barren soil….
>
> The Keyline Plan is simple to put into effect. It is inexpensive. Results are rapidly produced and the land values improve quickly.… It is a complete plan [that] … deals with … water and air in the soil. It places the dams in the most effective situations and constructs these by the cheapest technique…. The plan appeals to me as the basis for renaissance in Australian land use. Through its application we may well hope for the much needed extension of rural population in Australia, that will rapidly become profitable even if poor to begin with.

Yeomans recorded his ideas and experiences in several books, the most accessible being *The Challenge of Landscape* (1958), *Water for Every Farm Using the Keyline Plan* (revised edition 1978) and *The City Forest, the Keyline Plan for the Human Environment Revolution* (1971). PA's youngest son, Ken Yeomans, has revised and republished his 1978 book as *Water for Every Farm: Yeomans Keyline Plan* (2002). In 1960 Professor J. Macdonald Holmes, who was then Head of Geography at Sydney University, and who had spent some time working with Yeomans on his ideas, published a small booklet entitled *The Geographical Basis of Keyline*. Ken Yeomans continues to work as a Keyline consultant and has placed several articles about Keyline on his website (http://www.keyline.com.au). PA's middle son, Allan, continues to market an improved version of the Keyline plow. He has a draft manuscript on the Web about the broader implications of his father's

discoveries (http://www.yeomansplow.com.au), including an extensive argument concerning the ability of the Keyline system of landscape management to effectively fix carbon dioxide and so address the threat of global warming. According to his calculations, this would be much more effective than through the planting trees, and so should be appropriately acknowledged though the awarding of 'carbon credits'.

Although it is tragic that Yeomans' ideas have not been more widely adopted or further investigated and developed, his Keyline system remains an outstanding model of the kind of integrated design/redesign approach that is desperately needed in all of our productive endeavors. Compatible initiatives in agriculture can be found in the extensive literature on organic, ecological and 'Natural' farming (Altieri 1987; Fukuoka 1985; Hill 1985, 1991, 1998; Hill and MacRae 1992, 1995; Hill and Ott 1982; Lamkin 1990), Biodynamics (Koepf 1989), Permaculture (Mollison 1988; Holmgren 2002), rotational grazing (Voisin and Lecomte 1962), Holistic Resource Management (Savory and Butterfield 1999), and the related habitat eco-design literature (Aberley 1994; Alexander 2002; Alexander et al 1977; Glickson and Mumford 1971; Papanek 1995; Todd and Todd 1984; Van der Ryn and Cowan 1996). For a more extensive discussion of such ecological thinking, including further details of Yeoman's contributions, see Mulligan and Hill's (2001*) Ecological Pioneers: A Social History of Australian Ecological Thought and Action*, and for the application of such ideas to pest control see Hill (2004). Lister (Ch.x) reviews the broader field of design, and particularly landscape design.

**Industrial Keyline: Lessons for Industry from Yeomans' Approach to Landscape Design/Redesign**

It may be helpful to reflect, using Lewin's (1935) 'force-field analysis', on the strengths and weaknesses, and driving forces and restraining forces (barriers) that may have affected the outcomes of Yeomans' initiatives. Although there can be no neat formulae for effective change, and many cases exist where despite conditions being ideal change did not occur, and where change did occur within unsupportive conditions, much can be learned from such retrospective analyses.

**Personal**

- Exceptional powers of observation (especially of water movement across the landscape) and creativity
- Deep and broad interests, commitment, rebelliousness, 'drivenness' re water, soil and pasture management (near loss of son to desiccation, loss of brother-in-law in a grass fire), and 'stickability'
- Diverse complementary enabling experiences and competencies (mining assayer, seeing mining dams, and aboriginal knowledge, earth moving, time with nature and extensive reading)
- Cross-boundary (applying water management in mining to agriculture) and integrative thinking (Hierarchy of Permanence, Keyline as a whole design system)
- Lateral and paradoxical thinking (creating vs just conserving soil)
- Ongoing experimentation and careful record keeping
- Implementation of small, meaningful initiatives (including small risks) that could contribute to larger, longer-term plans (initial dam construction etc.)

**Social**

- Post-war programs/tax benefits facilitated farm purchase
- Importation of initial chisel plow from USA
- Involvement of others with complimentary qualities and competencies (aboriginal influence, Holmes, Hicks, children etc.)
- Communication of findings and ideas (open days, training sessions, talks, articles, books, a journal, media)
- Commercialization of products (Keyline plow) and services (Keyline consulting, dam construction, self-publishing)

**Ecological**

- Capitalizing on forces and 'services' of nature (natural water flows, gravity, carbon capture, soil formation, windbreaks, grazing management, working with place and time)
- Using nature as a model and source of inspiration

Table 5. Strengths and driving forces affecting Yeomans' Keyline initiative.

Strengths and driving forces for Yeomans' initiative are listed in Table 5, and weaknesses and restraining forces in Table 6. Lewin (1935) argued that change may be facilitated by strengthening and adding to the driving forces and by weakening and removing the restraining forces. Because of the frequent overlap of these strategies, suggestions concerning them have been presented in a single table (Table 7).

**Personal**

- Personality and psychological problems (somewhat intolerant, low level of patience, isolated in some ways, some difficulties with collaboration, and a challenging writing style)

**Social**

- Most of society was in a relatively uncritical phase of fascination with deceptively simple 'magic bullet', technocentric solutions (superphosphate, conventional irrigation) to complex ecological, social and personal problems (sustainable landscape and lifestyle design and management)
- Unavailability of affordable enabling technologies (e.g., mobile electric fencing for rotational grazing)
- Lack of access to long-term funding for on-farm, design focused, participatory, transdisciplinary, action research and development (still a major barrier to progress)
- Lack of supportive government policies and programs and interest by researchers in universities and government laboratories (and even ridicule by some of these individuals)
- Lack of consumer demand and markets for 'green' produce, and low public awareness of ecological imperatives

**Ecological**

- Still a fairly limited and rudimentary understanding of nature and ecology, soil ecology, plant nutrition and ecology, ecological services, livestock behavior and ecology, including optimization of rotational grazing and pasture management

Table 6. Weaknesses and restraining forces affecting Yeomans' Keyline initiative.

**Personal**

- Personal development work (recovery, therapy, self-knowledge, relationship counseling, group support)
- Collaborating more widely to achieve shared ownership and enrichment of the project (with those in the region and beyond, those in university and government, public interest and consumer groups)
- Linking Keyline to superphosphate use as a short-term strategy for adoption (capitalizing on the existing trends)
- Working with a smaller part of the property as a more intensively managed experiment (with controls for comparison), and so generate better data
- Working with others with better communication skills (possible use of signage on the property, well-written pamphlets, articles, books, grant proposals and submissions to government)

**Social**

- Seeking access to all of the resources listed as limiting factors in Table 5
- Greater effort to form alliances and linkages with others to achieve shared sense of ownership and collaboration in achievement of aims
- Greater use of the media for public education and for influencing political and cultural change

| **Ecological** |
| --- |
| • Going further in mimicking and working with nature<br>• Being willing to 'become the other' as a strategy for deepening understanding of limiting factors, influencing variables, relationships and opportunities |

Table 7. Suggestions for improving Yeomans' chances of success

The late Neville Yeomans, PA Yeomans' eldest son, whom I interviewed in 1998, was the inspiration for labelling this section 'Industrial Keyline'. He was an innovative psychiatrist, which included applying his father's ideas to the field of social psychology, labelling his approach 'Cultural Keyline" (see his website: http://www.laceweb.org.au). This willingness to apply insights and wisdom gained in one area to another apparently quite different area is a key recommendation of this chapter. I believe that the kind of analysis provided above might usefully be used as a model for analysing other initiatives in industrial ecology with the aim of better understanding their nature and importance, and identifying ways to improve their effectiveness.

## Conclusions and Guidelines

The message here for those involved in industrial ecology initiatives is that to achieve sustainable progress we must pay much more attention to the factors that are most commonly neglected when working with change. Key among these are the broad range of personal and psychosocial limiting factors, whole-system design/redesign approaches, cross-boundary thinking and ways of working with the unknown, and the full spectrum of co-factors involved in change, including the need to simultaneously work with others to facilitate fundamental structural and institutional transformation, based on the kinds of assumptions discussed above. Below I provide a preliminary set of guidelines to keep in mind when endeavouring to engage in deep industrial ecology initiatives. If we are willing to risk doing this (and I acknowledge that for many it will involve risk), then I believe that significant progress can be made. If we persist in denial, postponement, and in focussing on narrow approaches (e.g., just efficiency and substitution strategies), rather than on broad, integrated, whole-system, deep design/redesign approaches, grounded in our understanding of nature, ecology, psychology and culture, then progress will remain slow and much of the change will be counter-productive. The choice is ours. Because effective change is limited by our awareness, empowerment, vision, values and worldviews, and by the contexts within which we are operating, these are the areas where most attention will need to be applied.

### Provisional guidelines for engendering the frame-of-mind needed to engage in 'deep industrial ecology'

1. **Don't be blinded by what you think you know** – especially by 'deceptive naïve simplicities' – the future has always had its roots largely in the 'unknown' – so the challenge is to **be open to engaging with the unknown**, and with the known in radically new ways. Also, resist letting your 'successes' carry you back into the blind-knowing loop – be willing to stay humble, confused, and open to seeking new understandings. Also, **resist all attempts to impose order on the 'unknown'** – this prevents both discovery and our psychosocial evolution.

**2. Science and technology (like money) are definitely part of the solution**, **but** they can be really effective and reach their potential **only** when they are regarded as 'tools' that are to be used '**in the service of higher values and goals',** and the design/redesign and management of whole systems to meet such goals. **To make clear decisions about such issues, we need better 'indicators' and 'testing questions'** re our values, goals, actions and outcomes (feedback) -- money and power are poor measures of ecological, social and personal success. **Use 'back-end', single issue, symptom-based 'solutions' only in emergencies and to buy time to find 'front-end', whole-system, design and management strategies;** and use integrated change strategies for improving situations**.**

3. **Use all of nature for everything** – and remember that you are part of nature – as models, and for services, products and inspiration – and do this in sustainable ways and ways that support nature.

4. Be aware that if you are not yet open to **thinking paradoxically and radically**, you are not yet ready to discover the profound answers.

5. **Become all 'others'**, and experience the world from their perspective, to gain fresh thinking.

6. Know that no psychosocial problems can be completely solved by science, technology and social engineering – strategies must **include integrated psychosocial initiatives**. Also, know that our species is continuing to co-evolve psychosocially, and that all 'sustainable' solutions must include integrated, co-evolutionary, psychosocial components. Choosing solutions from earlier stages in our evolution will drag us back to those stages, and will deprive us of the benefits associated with later stages.

7. **Use areas of profound understanding** to ask the key questions and gain insights in areas of naïve understanding and ignorance. Remember, however, that non-living models (e.g., fractals, chaos and complexity theories, quantum physics, entropy/negentropy etc.) can never adequately explain living systems, which need to be understood as living systems.

8. **Use collaborative processes** to engage the understanding, experience and wisdom of the greatest diversity of people.

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