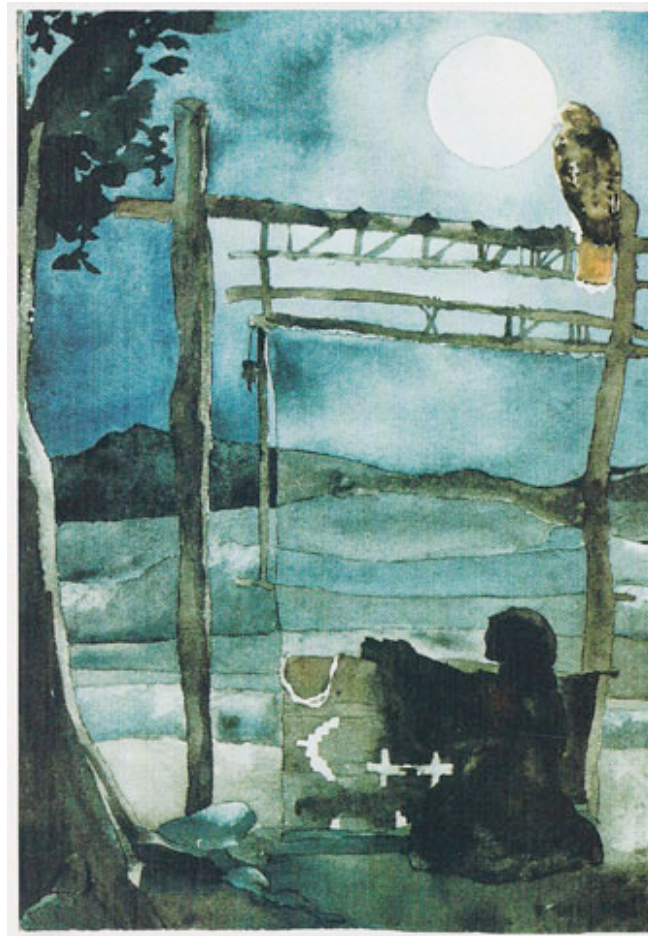# Compost, Blossom, Metamorph, Hurricane -
Complexity and Emergent Education Design: Regenerative Strategies for Transformational Learning and Innovation

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The conceptual foundation of ecotherapy and ecoeducation is a unified understanding of humans as holistic living organisms interacting with the world understood as a living organism.

    (Clinebell, 1996, p. 27.)

The emergent realm of complexity thinking answers questions [for which] one must "level-jump"—that is, simultaneously examine the phenomenon in its own right (for its particular coherence…) and pay attention to the conditions of its emergence.

    (Davis & Sumara, 2006, *Complexity and Education: Inquiries into Learning, Teaching, and Research*, p. xi.)

Abstract

This work proposes a novel theoretical framework for sustainability education and explores four possible applications of the framework. Insights from complexity and complexity education elide with patterns from nature to birth four patterns of regenerative, emergent education. In this work I explore these four natural systems models of emergence and apply them to education. For each of the four examples of emergent regeneration sourced in nature, I surface the dynamics of the pattern, explore the scholarship from multiple disciplines describing and detailing the pattern, including its invocation, process, and qualities, and provide an example of the pattern's application in education. Nature is replete with regenerative emergence. In the winter, the fallowing field is a haven for transformation; the compost bin is a small-scale example of this rich regeneration. In the spring, flowers emerge, bursting forth from closed buds. Summer brings the metamorphosis and emergence of moths and butterflies. Autumn's hurricanes are radical transformers. Applied in learning contexts, these ecologically complex and regenerative patterns promise to increase learning, leading, and innovation so that we can collaborate to restore the natural systems capacities of place, people, and planet.

At a time requiring regeneration of our capacities to learn and lead, emergent regenerative education approaches promise to restore us. These regenerative education systems liberate us from classrooms and programs stultified by over-planning and domination, hyper-technology, Cartesian separation and mechanization, disciplinary silos, and alienation from living systems, vibrant process, nature, body, interiority, and sense. Regenerative earth education reconnects us. Fallows learning can deepen us in emergent silence with sensory awakening, unstructured learning, imaginal depth, inner wilderness, and earthy groundedness. Bud burst can connect us like flowering trees in sensing networks and blossom us into learning collectivities. In diversity metamorphosis, we can weave safe havens of inner awareness and learner resonance, dissolve our resistance to difference, and renew our resilient capacities for change-making and beauty. We can create and support the conditions and processes for kicking off, amplifying, and nurturing hurricanes of learning in which flexibility and sensitivity catalyze creativity and flow. Nature can teach us to learn and lead as fertile listeners, collaborative networks, shamans, and creative storms. In this way, we can take the lead from nature in how to design transformational, emergent educational experiences that create sustainability, regeneration, and justice for learners and the world. With emergent regenerative education, we come to thrive as Earth.

Keywords

Introduction - Earth in Relationship: Gaian Templates for Learning and Leading

Nature is replete with regenerative emergence. In the winter, the fallowing field is a haven for transformation; the compost bin is a small-scale example of this rich regeneration. In the spring, flowers emerge, bursting forth from closed buds. Summer brings the metamorphosis and emergence of moths and butterflies. Autumn's hurricanes are radical transformers. Regenerative emergent education increases the weaving at the nonlinear bounds of levels of complex emergence, maximizing these transdisciplinary weaves and the fertility of learning edges and ecotones.

Models for regenerative education flourish when sourced in nature's templates of transformation. A shared theme of emergence in natural models parallels complexity theory's emergent properties. To birth educational models that are ecologically grounded and planetary in their effectiveness, emergent regeneration educators increase the number and depth of interactions and create conditions for emergence and complex interactions.

Curricular and program design for transformation and regeneration—which also can be called education for emergence—produces complex transformation in learners and in shared collaborative learning contexts, and also produces changes in the Earth system in which the emergent education is embedded. Multi-scale education design empowers the regeneration of learner, school/learning context, biotic communities, biocultures, ecoregions, world, and planet.

These emergent-educational (curricular and program) designs by their nature are transdisciplinary, provocative, and disruptive. They create mutualistic, positive feedback loops, catalyzing and synergizing the inherent growth processes of learners that further catalyze change. They are messy and sometimes painful, favoring darkness and mystery, requiring holistic approaches and left-right brain integration. They require us to re-adopt ancient, wisdom, and oral understandings and modes of inquiry, reconnecting and increasing coherence and trust. They nurture health and wholeness and promise to regenerate the living systems capacity of humanity and Gaia. Welcome to emergent regenerative education.

Context and Methods

This piece of theoretical scholarship represents the development of an initial framework for leveraging patterns from nature to inform education design. It heeds Ambrose's call that creative teaching involve actively exploring, adapting, and applying a wide variety of instructional models and strategies (2005, p. 288). It aligns with and extends Lee's systems-based educational research braiding human culture and biology, for adaptation through multiple pathways, with interdependence across levels of context (2010, p. 651). This work agrees with Falconer's proposal of supplanting linear change paradigms with patterns, pattern-sets, and pattern languages as systemic fabrics for epiphanies of change (2010, p. 147). The current work is sympathetic to the embodied integration of transformational sustainability learning (TSL), which "integrate[s] transdisciplinary study (head); practical skill sharing and development (hands); and translation of passion and values into behaviour (heart); … a unifying framework amongst related sustainability and transformative pedagogies that are inter/transdisciplinary, practical and/or place-based" (Sipos, Battisti, & Grimm, 2008, p. 68).
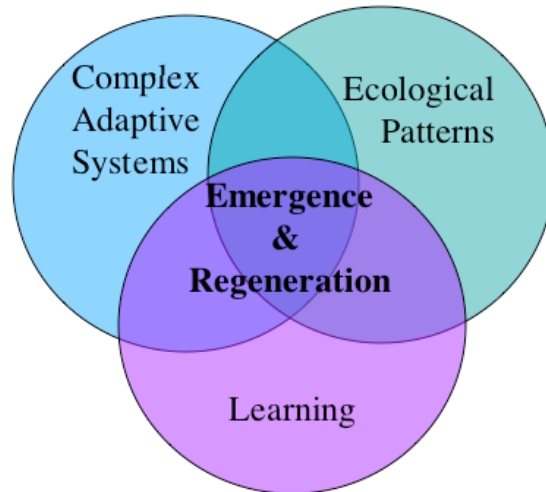
This research takes the general work of complexity education researchers such as Davis and Sumara (2006), and Luce-Kapler (2008), Mason (2008), and Doll (2008) and fuses it with trans-scale, biological, ecological, and ecosystem patterns. In this case, the insights from complexity and complexity education elide with patterns from nature to birth four patterns of regenerative, emergent education. In this work I explore these four natural systems models of emergence and apply them to education. For each of the four examples of emergent regeneration sourced in nature, I surface the dynamics of the pattern, explore the scholarship from multiple disciplines describing and detailing the pattern, including its invocation, process, and qualities, and provide an example of the pattern's application in education.

The work is meant to be suggestive rather than exhaustive. For example, my larger work of developing a model for ecological creativity suggests there are certainly more than four of these nature-sourced patterns of emergence, although they do fall into pattern sets and languages. However, I will reserve the exploration of ecological creativity generally or the larger pattern language of them for further work. This work is also suggestive rather than proscriptive due to the nature of complexity and emergence. Some teachers and administrators may find this essay a sufficient disturbance to provoke in their own professional creativity and work new patterns of regenerative collaboration, including directions which differ than those described here. I would consider this a second-order

Figure 1 Regeneration as an Emergent Property of Three Domains

success effect, along the lines of catalytic validity, in which "the research leads to creative, liberatory transformation" (Watkins & Shulman in Chalquist & Rankin, 2010, p. 321). This work assumes Ambrose's mandate for collaborative and dialogic reception of novel, big-picture frameworks (2009, p. 13).

In the first part of this work, I establish the framework of emergent regenerative education by twinning the power of natural patterns with complex adaptive systems. In the second part of this work, I explore how four sample complex natural patterns— the compost pile, spring flowers, butterflies, and hurricanes — can all inspire transformational learning design. In the final section, I analyze and synthesize these findings and suggest future directions for research.

Natural Patterns, Ecological Systems, and Sustainability Education

Natural patterns inform sustainability education. Ecological systems design and regenerative ecological design inspire designs based on complex modeling and insights of ecological systems (Mollison, 1988). Traditional ecological knowledge in indigenous ways of knowing have innovated for millennia inspired by natural and ecological patterns (Cajete, 2000). Many other recent innovations from biomimicry (Benyus, 1997) to organizational development (Capra, 1996; Minati & Pessa, 2006) leverage systems understandings from the web of life to

inform design of human-nature collaborations. "A living system continually recreates itself" (Buckminster Fuller in Senge, 2005, p. 9).

Sustainability education has often erred in emphasizing learning about nature rather than leveraging design by nature (S. Sterling, 2001). Content and form cannot be separated. Increasingly, ecological and complexity systems models are informing educational design (e.g., Ausubel & Harpignies, 2004; Doll, Fleener, Trueit, & St. Julien, 2008). Examples from nature can inform the mirror twins of education in sustainability and education for sustainability. Education in natural principles and education is based on "a more holistic and ecological model that emphasizes the realization of human potential and interdependence of social, economic, and ecological wellbeing" (Medrick, 2009a). Regenerative earth education focuses on "working with others in community in a way that promotes collaboration, harmony, equality, and the common good" (2009b, p. 1). Some consider the possibility of managing, leading, and educating for self-organization and emergence as the most important international question of our time (Ison, 2001).

Embedding Humans and Ecologies

This research embeds co-researchers in the research and understands them as embedded social-ecological constructs. Humans are part of nature and ecology (Maffi, 2002, p. 22). Anytime in this work that nature or ecology is used as a term, it is used with a deep understanding and respect for the truth of the biocultural diversity movements' insights about the embeddedness of humans in ecologies and ecologies in humans. Models for systems are often most powerful when they do not unconsciously reinforce Cartesian distortions of separation of designer and system (human and nature) (e.g., Shotter, 2008, pp. 198-199; Fleener, 2008). Complexity in education generally and especially when applied to environmental education offers alternatives to Cartesian researcher separation and portends solutions that subvert "a material model of predatory relations within the environment" (Díaz, 2010, p. 53). So the models in this work assume and reinforce an embeddedness of researcher, educator, and learner within the frame of the examples of emergence. "Reconnecting us with a geometry of relationship, a poetry of connectedness, and an emergence of meaning," (Fleener, 2008, p. 10), this radical design strategy is an extension of the successes of experiential education and embodied learning. Embedded and embodied modeling qualify this work as a Gaian research methodology (Hauk, Landsman, Canty, & Caniglia, 2010).

Emergence

Each of the four patterns studied in this paper exemplify both ecological and complexity emergence. Emergence has confluent meanings in ecological and complexity contexts. Emergence generally expresses the concept of something coming out of being obscured and coming into awareness, something coming forth, with a hint of being birthed or coming into existence. Etymologically, emergence implies something rising from the depths (Oxford English Dictionary, 2010). For example, we might say the flower emerges from the bud casing or the butterfly emerges from the chrysalis. The sun emerges from the clouds.

Emergence also holds a particular meaning in complexity science. It indicates the point at which a complex construct arises synergistically from its comprising parts and which exhibits unique characteristics that are not exhibited by its constituent elements. Complex emergence is sometimes visualized as nested hierarchies. For example, each of these levels could be considered emergent inside of an ever-expanding set of levels of complexity: quantum particle,

atom, molecule, organelle, organ, organism, community, planet (Levin, 2005). However, many scholars object to this two-dimensional hierarchical modeling and inject overlapping and multidimensional emergents such as plant, guild, ecology, ecosystem, biome, planet or bioculturally-dense interdependencies between these simple models of emergence (Conger, 1925; Goldstein, 2009a and 2009b).

Needless to say, emergence is a critical concept of complex adaptive systems. The study of emergent properties and creating conditions for emergence is a key activity of complexity studies. In particular, complexity science is fascinated with the emergence of self-generation in processes or systems, often referred to as autopoiesis or autocatalysis. Another phrase for this phenomenon is self-organization. This topic is of particular interest as it relates to understanding the origin of life and the originating contexts for living systems. Complexity study includes the study of initial conditions and internal and external constraints cultivating emergence.

Regeneration

The compelling and dynamic area of study of complex emergence has relevance to the field of sustainability. In fact, Levin argues "understanding how complexity arises in ecosystems is the central and most exciting organizing theme in biological research" (2005, p. 1077). Complex adaptive system models including emergence are critically useful in designing social-ecological systems to build resilience and support change in increasingly complex contexts (Berkes, Colding, and Folke, 2003). And sustainability education itself benefits from understandings of complex emergence (Bawden, 2004; Hauk et al., 2010). In fact, Nolet (2009) identifies systems thinking and interdependence as well as nature as model and teacher as two of nine core sustainability education literacies.

In particular, this paper proposes the language of regeneration rather than sustainability. The extremity of our current circumstances calls us to go deeply beyond sustainability, beyond maintenance or sustaining the current levels of functioning, to focus on studying and learning from the capacity of the planetary systems themselves to regenerate. To learn how the earth regenerates and to use these models of regeneration for framing educational design is to engage in regenerative education.

Emergent Regenerative Education: The Framework

Because complexity and emergence teach about the generation (or regeneration) of living systems, the concepts of regenerativity and emergence have great kinship. In order to understand how to support and regenerate the living systems of the planet, we engage in emergent, regenerative education. The planetary systems and ecological patterns model and inform our teaching and learning so that we may embody and also effect planetary regeneration. This learning, as do complex emergence and regeneration, crosses scales and disciplines (Manuel-Navarrete, Kay, & Dolderman, 2004).

The Earth is our living campus, our self-organizing teacher. As educators and learners the more we embed in and the more we design for living processes rather than towards disciplinary specialization, static objectives, or facts, the more we can bring our learning processes into alignment with the great teacher—the planetary processes themselves. This effort is by definition transdisciplinary.

By crossing disciplinary bounds we are reweaving the world, defying the myopic reductionism that has split us apart, and reclaiming the finely tuned sensing capacity that is the fruit of reductionism's recent cultural misadventures. But now we can bring that sensory tuning

to the work of building bridges across levels of emergence. We can understand both the finely wrought details and dynamics within a certain level of emergent organization, and span across these emergents to understand how the world has woven itself. Transphenomenal hopping across nested systems, transdisciplinarity, and interdiscursivity, as well as knower-knowledge simultaneity, are vital to complexity education: "to cope with the task of educating, one must be able to jump fluidly among and across these levels of coherence" (Davis in *Complexity Theory and the Philosophy of Education*, 2008, pp. 49-50). "Just as transphenomenality entails a sort of level-jumping, transdisciplinarity compels a sort of border-crossing—a need to step outside the limiting frames and methods of phenomenon-specific disciplines" (Davis, 2008, p. 51).

Using complexity in sustainability education, we can find the most useful interdisciplinary discourse for a particular phenomenon. "Complexity thinking provides a means…by emphasizing the need to study phenomena at the levels of their emergence, oriented by the realizations that new stable patterns of activity arise and that those patterns embody emergent rules and laws that are native to the systems" to produce "a sort of interdiscourse" (Davis, 2008, p. 52). "Complexity helps here by pressing beyond the boundaries of intersubjective constructions, as it refuses to collapse phenomena with knowledge of phenomena" which are "inextricably entangled but not coterminous" (Davis, p. 53).

In regenerative emergent education, we build bridges, we weave and mend. We find similarities, we forge alliances. We become processual polyglots, able to translate across emergence-relevant discourse insights across widening spans of complexity. We can relate with and speak of a tree, forests, bioregions, or planetary systems with equal loquacity. We become part of the syncretic movement of the Earth itself to repair and regenerate. "The feel for life, the skills for creative interaction with the earth processes, these have been suppressed over a series of generations" (T. Berry, 1988, p. 96). Our sense of separation has become life-threatening. Our capacity to reconnect promises to be life-giving.

The Earth itself is a learning community, a leader and a teacher in regenerative processes continuously underway. As we deepen in our intimate connection with the Earth, as our lifework becomes the research, as we open to collaborations with others and the natural gyres of transformation available to us, great change unfolds. Our learning, teaching, and leadership become part of the continuing emergence of the universe itself.

As we embody connectedness, we collaborate in communities of practice with other sustainability educators in transdisciplinary alliances, we nurture collaborations and connections with colleagues and learners. Our work becomes the creative expression of the earth, that wide the breadth of our questions, that deep the solutions emerging.

Examples of Emergent Regeneration Applied to Education Systems Innovation

How do we know transformation is happening? How can we design educational experiences for emergence? If we are using complexity systems for transformation and eschewing flattened and linear models, how do we know when we are being effective? Particularly, due to including embedded and embodied systems understandings, how can we feel, savor, smell, and sense effective transformational systems?

Knowledge is within the student. The student potentiates and expresses naturally-occurring impetus and capacity for transformation and growth. Teachers cannot make students do anything or try to force or create change in students that would not otherwise happen. We

might be facilitating the emergence of what is already within; our role is to create conditions to nurture and catalyze capacity rather than controlling outcomes by instilling knowledge. The teacher activates and awakens. Davis, Kumara, and Luce-Kapler (2008) call this "nurture supporting nature" (p. 114).

Each of the four ecological system sections that follow explores how to apply a pattern from nature through the lens of complex emergence to an educational experience. In each case, the resulting educational experience has regenerative qualities emerge. Each sample transformational system offers methods, skills, and approaches for provoking and nourishing the type of change experience. It suggests the role of the educator-facilitator-provocateur in supporting the type of transformation described. I conclude by savoring differences and resonances across the patterns and by suggesting descriptions of the learner experience embedded within the regenerative educational pattern.
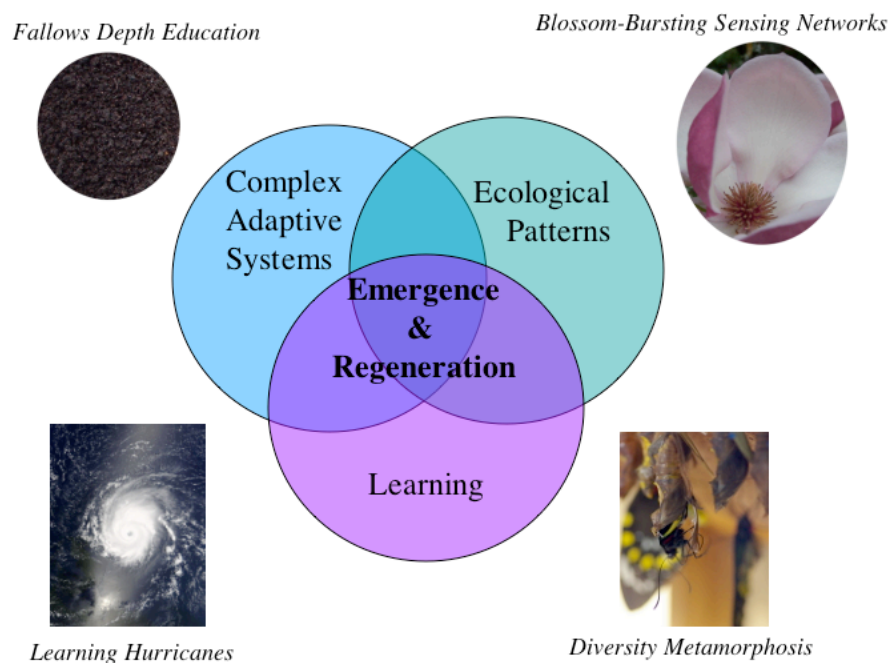
Figure 2 Regenerative Educational Framework

Change and transformation in education create new solutions that are world-healing. These solutions are available across scales of complexity. Silence and fallow walking can bring about new insights in connectedness that heal our relationship with the more-than-human world. Sharing results across remote sensing networks on ecological phenomena can surface trends across geographies. Being willing to be liquefied by the turbulence of diversity can support the formation of stronger, more just forms. Riding the whirlwind of learning collaborations can focus our creativity in earth-enhancing innovation. "When disturbance is at its greatest, change is at hand" (Wheatley, 2007, p. 105). When we feel knocked off-kilter, we might actually be in the midst of radical and constructive change. Rather than feel threatened, we are invited to feel alive.

Transformational System Type 1: Compost and Winter Fallows
LISTENING, DISSOLVING, AND DEEPENING

The fallowing winter field and the compost bin model a pattern of regeneration that can be applied to educational contexts. Fallowing is the period when the activity is deep in the soil but the surface seems inactive. It is when rotting and the activity of worms break down old growth and transform what has died into new fertility. Nature models these characteristics of depth, stillness, and the transformation of rotting and remaking. We can model educational experiences on this emergent stillness with sensory awakening, unstructured learning, imaginal depth, biophilic groundedness, and surrender. Walking in nature in darkness is an applied example of fallows learning.

Figure 3 Worm Casts (2009)

Being Watchful *(excerpt)*

As soon as I felt a necessity to learn about the non-human world,
I wished to learn about it in a hurry.
And then I began to learn perhaps
the most important lesson that nature had to reach me:
that I could not learn about her in a hurry.
…
Hurry is beside the point, useless, an obstruction.
The thing is to be attentively present.
To sit and wait is as important as to move.
Patience is as valuable as industry.
What is to be known is
always there.
When it reveals itself to you, or when you come upon it,
it is by chance.
The only condition is your being there and being
watchful.

Wendell Berry

Berry in "Being Watchful" confirms attentive presence as a primary means to learning from nature. In fact, listening and sensing are regenerative education skills from the fallows and the compost. The hyperactive focus on structured learning, standardized testing, computers, and control in today's classrooms are choking the wildness out of young learners. Regenerative education transforms through supporting the emergence of wildernesses of learning. Whether through actual encounters with wilderness, in an attempt to counter nature deficit disorder (Louv, 2005), or through the cultivation of internal wilds, regenerative education requires fallow time. This includes using silence (Baetz, 1997, p. 57-76) as a way toward learning. What seemed wasted, a wasteland, is really fallowing earth. Untamed "wasted" time for the imagination to run amok is a requisite of a regenerative classroom where intelligence and learning emerge. The fallows foster primary perception, "the freedom to explore sensitively and to learn from exploration" (Brooks, Laeng-Gilliatt, Lowe, & Selver, 2007, p. 18 in "Nature and 'Second Nature'").

Underneath the land, in the fallows of winter, the earth is in transformation. The unseen activity and unstructured rebuilding flourish. Leaves compost to humus. Deep soil earthworms bring minerals to the surface through the highway systems of the intact roots of harvested top plants (Hazelip, 1995). Lowell Monke affirms this need for unstructured, unsupervised activity and learning, including the merits of recess. He points out that by 2000 over 40% of schools had entirely eliminated recess, and during the same time spending on computer systems in U.S. classrooms had increased by more than 300% (2005). He is concerned that in the changeover from studying *Charlotte's Web* to Charlotte's webpage, our hyperfocus on technology is taking our attention away from

> …something that is increasingly rare in schools: **the wonder of ordinary processes of nature**, which grows mainly through direct contact with the real world.... Substituting the excitement of virtual connections for the deep fulfillment of firsthand engagement is like mistaking a map of a country for the land itself." (2005)

Another aspect of how the fallowing earth nurtures emergent education is the cultivation of liminal and imaginal knowledge realms from the unseen dimensions into the classroom. "The ultimate purpose of the dark is to bring healing and renewal into our lives" (George, 1992, p. 265). Ecotherapy, dreams, and poetry nurture regenerative imagination. Educational experiences that increase grounding and ecobonding are crucial. Clinebell, one of the innovators of the eco-education movement, describes how earthly rootedness opens us to being nourished by nature:

> A missing dimension of most theories is that healthy identity includes a strong sense of being firmly grounded. This means discovering the reality of our body-mind-spirit self being deeply, securely rooted in the biosphere.... Such grounded identity has an anchored awareness of organic relatedness with one's body, with the earth, and with the other living creatures that share the biosphere with us. This ecobonding influences, if not determines, how open we are as adults to intimate interaction with nature. Having a solidly grounded identity enables us to become maximally receptive to daily experiences of being nurtured by nature... (1996, p. 33)

In terms of designing curricula for Earth connection, Gaian Methodologies (deChambeau, Hauk, & Landsman, 2010) and Earth Empathy (Hauk, 2010) are deeply relevant to fallows learning (e.g., Gaian Methodologies website, http://www.earthregenerative.org/gaiamethods and the website on Earth Empathy, http://www.earthregenerative.org/earth-empathy/homepage.html). The work of Andrea Olsen and her month-long embodied exercises bring together the bodily experience of place, ecology, and planet in *Body/Earth: An Experiential Guide* (2002). Additionally, the Gaian connection strategies of Stephen Harding in *Animate Earth* (2006) are particularly useful in educational contexts cultivating an emerging sense of firm grounding.

Our sense of goal-direction dominant in formal teaching programs is transformed in regenerative education as an exercise in surrender. Perhaps the fallows offer new ecological models of education: vermicultural education where we design for compost, breakdown, and transformation to fertile tilth. One of C. Dillard's five guiding principles of an endarkened epistemology involves looking and listening deeply resulting in a surrender of our sense of separateness (2008, pp. 287-288). Thomas Moore refers to this surrender as "the collapse of the goal" in teaching:

A sense of home, intimacy, stillness, adventure without experience, the dance of relationship—these are the ingredients of an education in the soul. Setting goals in education should be a playful setting up for disaster, failure, and disillusionment. The collapse of the goal allows for learning to take place (2009, p. 13).

Complex emergent fallowing, thus, can include releasing expectations of rigidly pre-organized lesson plans as well as eschewing lesson plans altogether for primary experiential learning; it can also include actively studying the unknown and unknowable. A teaching time of fallowing encourages connection with the unknown and the mystery, with allowing. The depths of Earth connect us to primary regenerative powers (Gimbutas, 1989, pp. 316-317).

Recursive, self-generating, self-evolving, and re-enlivening, emergent education includes becoming grounding as well as learning about the ground. Clinebell notes that biophilia and ecobonding are the rich tilth of earth-inspired regenerative education that connects learners and biosphere; lack of this learning promotes the dangers of ecoalienation and ecophobia:

Discovering, befriending, and intentionally developing one's profound rootedness in the life-giving biosphere is the process that produces what is called healthy biophilia and ecobonding. Ignoring, denying, or rejecting this inherent earth-rootedness is called ecophobia and ecoalienation. Ecobonding involves claiming and enjoying one's nurturing, energizing, life-enhancing connectedness with nature. Ecophilia is the love of life associated with this bonding with the Earth. Ecoalienation involves seeking to distance oneself from our inescapable life-giving dependence on nature. Ecophobia is the fear of claiming one's dependence and bonding intimately with nature. (1996, p. 26)

Fallowing includes cultivating a sense of groundedness and earthly belonging in learners as prerequisites for growth. This sense must go beyond accepting dependency to understanding how learners can be nurtured by intimate nature bonding (Clinebell, 1996, p. 33).

Orr believes the abstraction and rigidity of disciplinary thinking compounds this ecoalienation, "a deeper failure to join intellect with affection and loyalty to the ecologies of particular places…a failure to bond minds and nature" (2004, p. 95). Cultivating an intimate sense of place nurtures holistic learning capacity, while increasing and earlier onset exposure to computers in education can alienate learners: "As the computer has amplified our youths' ability to virtually 'go anywhere, at any time,' it has eroded their sense of belonging anywhere, at any time, to anybody, or for any reason" (Monke, 2005). Primary spacious contact avoids the dangers of abstracted environmental facts and statistics that overwhelm and actually increase biophobia (Sobel, 1996). Harmonizing with Earth increases our intelligence and intelligent capacity to harmonize (Berry, 1983 in Orr 2004, p. 50). Freya Mathews finds that "this kind of gestaltic intuition, informed with the inner organisational dynamics of nature, will… provide a … reliable source of understanding" (2007, p. 56). It regenerates the capacity for biophilia. It catalyzes learners to connect which, in turn, in emergent synergy, creates more connection.

One example of the regenerative transformation of the fallows or compost pattern is the night walk. Patricia Damery describes an experience of camping with her family. Inspired by Wendell Berry's exhortation "to know the dark, go dark," she took a night walk, barefoot and lightless in a redwood grove with her young sons (2010). "And yet for me this 'going dark' underscored a way of perceiving in the world that felt ever more alive than my usual mode,

bringing an awareness of my body and relying on senses that normally remain eclipsed by the light, and day consciousness." She parallels this night walk with traditional Irish night visiting, *cuairds* (Lenihan & Green, 2004). Some researchers treat silence as an emergent property of communication systems (Penna, Mocci, & Sechi, 2009). By relieving our verbal selves, other aspects of our embodied aliveness and intelligence surface insights from our depths.

Regenerative education, by welcoming learners to the wilderness of their own senses, their deepening sense of place and grounded connection with the Earth, and their creative interiority, nurtures the tilth of holistic learning capacity. Annie Dillard describes a fallows experience in which deep, still attention brings aliveness and restorative connection with the humming silence of the living earth:

> Now I am ready. Now I will stop and be wholly attentive. You empty yourself and wait, listening. After a time you hear it…. There is nothing but those things only, those created objects, discrete, growing or holding, or swaying, being rained on or raining, held, flooding or ebbing, standing, or spread. You feel the world's word as a tension, a hum, a single chorused note everywhere the same. This is it: this hum is the silence. Nature does utter a peep—just this one. The birds and insects, the meadows and swamps and rivers and stones and mountains and clouds: they all do it; they all don't do it. There is a vibrancy to this silence... it is all there is. (1982, p. 90)

These rich wintry fallows birth spring's budburst, summer's butterflies, and autumn's hurricane of emergent learning.

Transformational System Type 2: Bud Burst - Emergence of Flowers on Angiosperms
POSITIVE PRESSURE- BURSTS OF CHANGE

Figure 4 Magnolia Blossom (2010)

Springtime blossoms bursting from bud casings offers an explosive counterpoint to fallows learning's depth and silence. The nature pattern of bud burst operates at two levels of emergence. First, the potential of the fruit and seed has over-wintered and grown, until it breaks through the bud casing and the flower emerges. Secondly, it is not one flower that emerges, but the entire tree that flowers. So bud burst applied to regenerative education involves both creating individual but also collective learning networks where new connections blossom and grow.

What is bud burst? Bud burst occurs when the biological process of the flowering overpowers the bud coat. What had protected becomes constraining. Our former safety keeps us small; we break through. The double emergence in learning systems (classrooms) of individual and collective, decentralized and shared, results in the flowering of the entire tree. When planning, sustainability educators can relinquish control and take up the constant need to

restructure structures (Davis & Sumara, p. 151). The expressive urge of the project/team/class to share findings or participate in larger learning networks is the hallmark of bud burst. The emergent properties of inspiration, awe, and wonder are the fragrant flowers of the experience of regenerative bud burst.

From a level-hopping, emergent point of view, bud burst happens not only for one bud on a tree, but often for many buds on a tree at once. In this manner, bud burst is a truly emergent emergence, an eloquent expressiveness of the living Earth. David Abram recounts an experience with this emergent phenomenon:

> Meaningful speech cannot even be restricted to the audible dimension of sounds and sighs. The animate earth expresses itself in so many other ways. Last night while I lay sleeping the old apple tree in front of the house quietly broke into blossom, and so when, in the morning and still unaware, I stepped outside to stretch my limbs, I was stunned into silence by the sudden resplendence. The old tree was speaking to the space around it. Expressing itself, yes, and in the most persuasive of languages. The whole yard was listening, transformed by the satin eloquence of the petals. The spell quietly cast by the uttering forth of white blossoms was irrefutable and irresistible. (2010, pp. 171-172).

Just as many buds can open at once, the focus of learning can be the whole classroom community rather than the solitary learning. The expression of the bud bursting tree can be understood in ecological complexity education terms. "This condition of complex emergence compels us to question an assumption that underlies both teacher/researcher-centered and student/participant-centered arguments—namely, that the locus of learning is the individual" (Davis & Sumara, 2006, p. 144). Like an apple tree, the classroom itself is an emergent learning collectivity, what Minati and Pessa (2006) term a collective being. In complexity education, "Learning occurs on other levels as well…the nature of complex unities… are shared ideas, insights, projects, concepts, and understandings that collectively constitute a group's *body* of knowledge… The goal is not interpersonal collectivity, but collective knowing… consensual domains of authority" (Davis & Sumara, pp. 144-145).

Regenerative education mandates that lesson plans—perhaps best re-rendered as "chaos paths"—refocus learning design for decentralized/shared collectivities, where knowledge is action and system. Regenerative education grounded in complexity theory challenges the individualism of constructivism and instead leverages a nuanced balance of randomness and coherence (as in Davis & Sumara, pp. 147-150) to provoke collective knowledge systems.

Designing educational experiences to extend across scales increases collaboration and produces earth regenerative educational emergence. Watching buds burst to flowers literally informs planetary insights. Project BudBurst, a national phenology and climate change field campaign for citizen scientists (2010, http://budburst.ucar.edu/), offers both learners and educators ways to learn about plant life cycles and record key detailed observations of phenomena, and share them across diverse regions, using a form of participatory embedded networked sensing. Learners hone their primary scientific observation skills of local plants (aided by friendly cartoons such as those at http://www.budburst.ucar.edu/buddies/index.php). Data accumulated across diverse and large regions on key plants at seasonally significant plant changes (phenology is the timing of life cycle events like leafing, budding, and blooming in plants) helps bust open and map emerging patterns of phenomena across scales of location and

time, demonstrating climate change (Project BudBurst, 2010). The amounts of information involved provide a positive pressure so that whole new levels of insight blossom.

A collaboration between UCLA, CalTech, USC, and other schools produces the Center for Embedded Networked Sensing. CENS's Terrestrial Ecology Observing Systems and Participatory Sensing (PART) Research offer beacons of insight into how to study multi-scale ecological phenomena (2010). Their Project BudBurst is a prime example of how collaborations across classrooms and regions can provide emergent multi-scalar information and education that are highly relevant and that model embedded, multi-scale intelligence.

The transformation pattern of bud burst requires growth until bursting through constraints, for individual learners and their learning collectivities. Inspiration, wonder, and enthusiasm while sharing information in flowering networks of remote sensors allow larger patterns of knowledge to emerge. Bud burst as a regenerative education practice involves emergent phenomena for both learner blossoming and the blossoming of extending learning networks. These blossoms represent the flowering of extended intelligence and insight far surpassing single contributor expertise. Project BudBurst is one example of this emergent regenerative education system.

Transformational System Type 3: Metamorphosis and Emergence of Butterflies and Moths
WEAVING EMERGENTS – LEARNING AND LEADING FOR DIVERSITY AND SOCIAL JUSTICE

A cocoon in some ways is similar to a bud casing on a flower. Both create positive containment and constraint for transformation waiting to emerge. Thomas Berry calls this "the curvature of the emergent universe, sufficiently closed to hold all things within an ordered pattern, while... sufficiently open to enable the creative process itself to continue" (1988, p. 213).

The concept of the formation, transformation, and release from the cocoon (for moths) and the chrysalis (for butterflies) can be applied to emergent educational design; in both cases, certain patterns apply: (1) the development of an enclosed space in which (2) dramatic transformation occurs and from which (3) the transformed, winged being then emerges. This biological process pattern can help regenerative educators create weaves of safety so that diversity and wondering can proliferate, liquefying oppressions and forming new and stronger forms which then break free into new scholarly collaborations. Shorb's multidimensional Butterfly Curriculum is one example of diversity metamorphosis in motion.

Figure 5 Butterfly emerging from chrysalis (Husvedt,

Weaving Chrysalis Learning Contexts

Regenerative educators can "teach like a butterfly" first by designing chrysalis learning contexts. Chrysalis and cocoon are formed by weaving. And in emergent education, it is the lithe jumping back and forth between complex levels of emergents that spins the new classroom nooks for learning. Transdisciplinary approaches across topics of interest, the creativity at the frothing ecotone, at the highly productive edge (in permaculture) weave nests of learning. Context dependence and personally

relevant learning weave safe containers for deep educational transformation. Skills that empower students to become emergence-weavers include permission to connect across usual disciplinary lines. This capacity, in fact, is part of the Gaian research method of "connect and collaborate" (Hauk, Landsman, Canty, & Cox Caniglia, 2010, pp. 10-11).

> Instead of reducing things down, our research expands and spans across. The point is collaboration: how to look for similarity; in effect, the convergent evolution of insights flourishes across disciplines, similar to symbiogenesis: evolutionary advancement through the collaboration of living forms to create novel, more complex life. How can our research build on and interrelate with other research? How can the active thriving and creativity of participants and co-researchers generate greater wisdom? How can we design research so that it can be highly useful and designed to work across disciplines?

Creative approaches support analogy and metaphorical thinking to learn to see parallels across dimensions of phenomena. Chrysalis-forming education weaves connections. Poetry, autoethnography, and integration of personal meaning and symbiotic synthesis threads the loom of emergence. Cultivating and inviting this type of cross-weaving perception into the living archetypes and symbols that source from and span cultures is poetic and archaeomythological – and effective (Gimbutas & Dexter, 1999). Further, as hooks (1994) suggests, "any radical pedagogy must insist that everyone's presence is acknowledged… demonstrated through pedagogical practices" through "an ongoing recognition that everyone influences the classroom dynamic, that everyone contributes" (p. 8). Bawden confirms that engaging with 'lay' knowledge and ways of knowing "in deliberative democratic discourses…allow[s] a synergy to develop" to achieve the complex emergence of sustainability in higher education (2004, p. 29). Reeder also includes everyone in "Classroom Dynamics and Emergent Curriculum": "Teachers can develop space in the classrooms in which students are invited to be co-creators of and participants in curriculum as conversation may emerge" (2008, p. 251). The weaving of the classroom chrysalis, the cauldron of transformation connects not only content but also people—people as individuals and people as agents in emergent learning collectivities. Complexity educators describe these chrysalis-producing incubators for change as "enabling constraints for developing knowledge" (Davis & Sumara, 2006, p. 150).

The fact that the chrysalis or cocoon is extruded out of the pupa/caterpillar's own body (via silk or goo) parallels the fact that this entire process can be self-provisioning. The learners, or deep co-researchers (or in complexity terms, agents), can help provision and build the safety space for change from the fiber of their own experience and being. There is nothing magical or externally necessary other than openness, including greater engagement on the part of the students, helped by "some deconstruction of the traditional notion that only the professor is responsible for the class dynamics" (hooks, 1994, p. 8) and the positive invitation/provocation of the facilitator. "Seeing the classroom as a communal place enhances the likelihood of collective effort in creating and sustaining a learning community" (p. 8). Davis and Sumara (2006) suggest that focused projects with a balance of enabling constraints – proscriptive instead of prescriptive – help create the container for complexity education: "'everyone participates in a joint project'" (pp. 148-149).

Liquefying and Reforming: Diversity Builds Resilience

Next, just as the organs of the pupa are liquefied and re-formed into a new organism, regenerative educators promote conditions for intense transformation. hooks (1994) describes organ-liquefying educational skills for both teachers and learners in *Teaching to Transgress: Education as the Practice of Freedom* (1994). "From the mutually illuminating interplay of anticolonial, critical, and feminist pedagogies," "pedagogical practices have emerged…expanding beyond boundaries…[to] engage directly both the concern for interrogating biases in curricula…while simultaneously providing new ways to teach diverse groups of students" (p. 10).

hooks argues for a flexible approach, requiring moving beyond accepted boundaries [dissolving], generating excitement for learning –which is in itself transgressive—and which "had to allow for spontaneous shifts in direction" to see the particularity in the students as individuals while understanding their learning needs (p. 7). Aal and Adair describe the social permaculture principle of diversity bringing resilience (2008, p. 2). Davis and Sumara characterize diversity as one of the six conditions of emergence in complexity education (2006, p. 151). Difference bridges to relationality (Riley-Taylor, 2002, p. 127), increasing part-to-whole relationship with larger learning groups and the world (pp. 139-140). hooks affirms:

> Multiculturalism compels educators to recognize the narrow boundaries that have shaped the way knowledge is shared in the classroom. It forces us all to recognize our complicity in accepting and perpetuating biases of any kind. Students are eager to break through barriers to knowing. They are willing to surrender to the wonder of re-learning and learning ways of knowing that go against the grain. When we, as educators, allow our pedagogy to be radically changed by our recognition of a multicultural world, we can give students the education they desire and deserve. We can teach in ways that transform consciousness, creating a climate of free expression that is the essence of a truly liberatory liberal arts education. (p. 44).

The time of transformation is a time of taking in diverse understandings and knitting something new. It requires permeability to discomfort [dissolving] and the willingness to regenerate. To be effective, leadership in transformative sustainability learning brings about perspective shift (Sipos, Battisti, & Grimm, 2008, p. 71):

> Transformative learning in the context of higher education requires major shifts in university structures to enable such critically reflective, inter/transdisciplinary, experiential and place-based learning to emerge; and also for university educators to better prepare for the disorientation and other unexpected potential outcomes that may arise through this type of learning.

In the emergent learning chrysalis, people interact, open to difference, weave together new understandings, and emerge transformed.

Akin to a focus on cultivating the sharing of diverse insights and cultural perspectives, the transformation in the chrysalis can include the furnace of social activism to fuel the metamorphosis. *Learning as a Way of Leading: Lessons from the Struggle for Social Justice* (Brookfield & Preskill, 2009) offers a model of nine learning tasks of leadership (for all involved, "student" and "teacher" alike), including several that are resonant with this chrysalis

process: learning how to be open to the contributions of others; learning how to reflect critically on one's practice; learning how to support the growth of others, learning how to develop collective leadership, learning how to question oneself and others, learning to sustain hope in the face of struggle, and learning to create community. (pp. 15-18). One of the critical aspects of learning how to question oneself and others includes inviting people to wonder:

> Asking these questions can be an unsettling, even rebellious act. It disturbs both those being asked…and those in power. The edge, daring side of questioning can also be an antidote to routine, to convention… Questioning can stir people up in creative ways, tapping into unrealized passions for the novel and innovative. Questioning can also take us to the verge of recreating our world. (p. 128)

Asking questions, inspiring wonder, and provoking creativity teach to transgress and create new forms. This second phase of metamorphosis is when the forms melt and new forms are generated. It is heated, creative, chaotic, terrifying, and productive.

The critical need for openness to the spontaneous unfoldment of the learning process, the emphasis on participatory learning community, and the willingness to change are critical to mention in an age of *in loco parentis* which extends in deep, unexamined habits across educational approaches. Learners increasingly find themselves hour upon hour in adult-controlled and adult-designed contexts or highly structured or manicured learning situations. By contrast, a certain amount of growing pain and pressure to change and learn are critical for teachers to allow. The dynamic tensions and full range of experience characteristic of regenerative education also surprise or perplex parents, administrators, peers, or educators if they have internalized educational domestication. Yet this smiley-faced, illusion of control, middle class, educational domestication must be liquefied to support the emergence of change, transformation, new direction, and wildness. Inner learner wilderness and liberatory educational praxis can then "bear witness to education as the practice of freedom" (hooks, p. 11).

Creating a learning community involves attending to how experiences interrelate. In fact, Bache suggests that living classrooms display qualities of experiential resonance (2008). He explores collective "Aha" experiences across communities of learners (whether students or teachers), and thereby describes a form of emergence in the classroom: "these resonances of living experience would occur …drawing the students into heightened states of awareness" (p. 29). The classroom can become a cocoon for collective change. He emphasizes the need for the facilitator of learning to themselves live in a way deeply aware of their own unfolding process. "The expansive states of conscious[ness] that were emerging in my private life seemed to be triggering incidents of sympathetic resonance in my public life" (p. 31).

Bache discovered that "these synchronicities became particularly pronounced… when… undergoing a series of powerful inner experiences in my spiritual practice that were breaking me down at very deep levels" (p. 31). Their dissolving quality also provoked a dissolving of limiting structures and a reformation in learning context. In the latter part of the following description, he eloquently describes the process of emergence that takes place in the educational chrysalis:

> All spiritual traditions describe a phase of inner work that involves dissolving the boundary between self and other. They describe a membrane that marks the boundary between the individual and the surrounding universe, the interface of the personal and the transpersonal psyche. On the near side of this membrane, the world appears to be

composed of separate beings, each with their own private existence. On the far side of the membrane, the world appears as an integrated whole, a continuum of energy that shows itself to be a massive, unfathomably complex, extravagantly beautiful, single organism. Here is the domain of "death and rebirth," death to the world of the private self and rebirth into a larger transcendental order of wholeness that underlies and saturates life's diversity. When a practitioner is transitioning through this territory… powerful synchronicities with other persons sometimes manifest. (pp. 31-32)

One of Bache's points is the critical role of the educator in being aware of, open to, and clear with the work beckoning from the personal/transpersonal deep. Sustainability educators in this way are like shamans; Thomas Berry in *The Dream of the Earth* notes that "we are supported by the ultimate powers of the universe as they make themselves present to us through the spontaneities within our own beings" (1988, p. 211). He suggests that

We need only become sensitized to these spontaneities, not with a naïve simplicity, but with critical appreciation. This intimacy… with the larger cosmic process is not primarily the role of the philosopher, priest, prophet, or professor. It is the role of the shamanic personality, a type that is emerging once again into our society." (p. 211).

Berry believes that in times such as now of "significant cultural creativity, this [shamanic] aspect of the psyche takes on a pervasive role throughout the society and shows up in all the basic institutions and professions" (p. 212). The teacher-shaman senses "the deep, hidden structure behind things and the sacred patterns to which shamans in all cultures attune themselves….the continuous regenerative power that is at the root of all female shamanism" (Noble, 1993, pp. ix-x). bell hooks describes this as teacher as healer, willing to be vulnerable, with an engaged pedagogy, her teaching emphasizing wholeness (1994, pp. 13-22). Utilizing earth regenerative process templates for educational design is an example of heeding Berry's call for us as teacher-shamans to "the supreme need of our times [which] is to bring about a healing of the earth through this mutually enhancing human presence to the earth community" (1988, p. 212). He describes the "supreme disaster…our present closing down of the major life systems of the planet" as exactly the necessary "mode of pressure" to birth "a new sensitivity that comprehends the larger patterns of nature, its severe demands as well as its delightful aspects…so that other life forms might flourish" (p. 212).

In other words, the transformation cooked within the bounded container of the educational chrysalis requires the pressure of the necessity of our situation; and this chrysalis is synecdoche or emblematic of the entire effort of regenerative education: "in this context all our professions and institutions must be judged primarily by the extent to which they foster this mutually enhancing human-earth relationship" and based on "the larger patterns of nature" (p. 212).

Flying from the Chrysalis, Transformed

To teach for metamorphosis, first the educator creates a safe container for mutually meaningful exploration on topics of personal interest and invites the respectful dialogue for co-research (Rosenburg, 2003). Then the teacher-shaman stays attuned to deep pattern—ecological, mythological, transpersonal—and creates a context where the students' limiting beliefs and ideas can liquefy and dissolve and reform into earth-informed insights. Finally, regenerative educators

support the emergence of the transformed being, a butterfly emerging from the chrysalis. Note that in nature, it is essential for the smooth filling of fluid across the wings for the butterfly to struggle out of a tight aperture. If the teacher or other learners attempt to "make it easier" by opening the breakthrough space for the emerging creature, the wings of the transformation will fail and the change will die. In this sense, this third phase of chrysalis emergence parallels Bud Burst (Type Two Emergent Education System, see Section 2, pages 17-19). A certain amount of pressure is actually life-giving. The being must become too large for the previously supportive self-containing structures.

In this third phase of Type 3 Regenerative Education, Metamorphosis, things burst open. What was a safe container becomes (by necessity) a restriction and the organism (or, metaphorically, some aspect of our consciousness) dissolves and reforms. We emerge too large and must fly free. Liberation is the positive result of the discomfort of struggles for ecojustice or the uncomfortable work of becoming aware of and dissolving our racist behavior and assumptions. The exposure to new and diverse ways of perceiving can feel threatening or exhausting. But in chrysalis education, we learn to stay open, to transform and emerge. Note that the goal here in Teach Like a Butterfly is liberation. An example of chrysalis liberation learning is Terril Shorb's four-winged Butterfly Curriculum for Sustainable Community Development (2008, 2009). This integrative approach braids together realms of natural history, human footprint, socio-spiritual community, and celebration into the central being of the just sustainability learner. This complex model empowers multivalent dissolving and reformation of the learner into a liberated form who is able to integrate many dimensions of diversity to flourish and liberate others. Through the chrysalis of transformation, regenerative education takes flight. The liberation urge in sustainability education indicates the restoration of the inner rhythm, cadence, capacity, and wilderness of the learner to "celebrate teaching that enables transgressions—a movement against and beyond boundaries. It is this movement which makes education a practice of freedom" (hooks, p. 12).

Transformational System Type 4: Teach Like a Hurricane
CREATING CONDITIONS FOR TRANSFORMATIONAL CREATIVITY

Hurricanes are turbulent and volatile, nature's great change-makers: "one of nature's most impressive and massive self-organized forms" (Briggs & Peat, 1999, p. 18). A hurricane is a three-dimensional vortex, a living being with self-transforming properties and powerful inner dynamics. Welcome to the drama of how the vortex emerges. We cannot cause a hurricane to happen in the classroom, our focus is on creating conditions that can nurture its likelihood. In *Complexity and Education: Inquiries Into Learning, Teaching, and Research*, Davis and Sumara (2006) explore how the dynamism of complexity and chaos can inform education, and how the role of the teacher is to create conditions:

We understand knowledge in terms of potential to action—necessarily dynamic, even volatile, subject to continuous revisions as the knowing agent integrates/embodies new experiences. The principle that we are developing here is more

Figure 6 - NASA - Hurricane Frances

about the importance of activating these potentials in the hope that they might trigger others and, in the process, be blended into more sophisticated possibilities. (p. 142)

A hurricane, like all vortices, requires certain initial conditions, a state of turbulence and the bifurcation point. Conducive interrelating conditions kick off both negative and positive feedback loops that sustain the process-structure through which energy then must flow to sustain the pattern. This pattern during the course of energy flowing through becomes a living system, powerful and with a structural stability. It rips things up and makes things new. Hurricanes and vortices are powerful bringers of change. How enlivening to be tasked as a teacher to provoke hurricanes of creative learning, to be given permission to let the classroom make huge movement and change, unleashing the creativity of collectivities of life in service to Gaian thriving.

One of the critical differences between conventional educational approaches and complexity-informed education is that the primary role of the teacher is to create conditions for change to occur rather than trying to control change throughout or to hold and enforce a particular script for change. "One must relinquish any desire to control the structure and outcomes of the collective. Consistent with such unities as brains, anthills, cities, and ecosystems, control in a knowledge-producing collective must be understood as decentralized, arising in localized activities." (Davis & Sumara, 2006, p. 144).

Phase 1: Turbulence

How can we teach like a hurricane? Briggs and Peat describe three phases or aspects of vortices of creativity: turbulence, bifurcation-amplification, and open flow (1999, pp. 22-28). In the turbulence phase, the system explores its maximal "degrees of freedom." Turbulence requires we become open to being shocked, being doubtful, holding multiple truths, and sensing through to deep truth; we must cultivate what researchers have found to be common, cultivated traits of highly creative people: "a high tolerance for ambiguity, ambivalence, and a tendency to think in opposites" (p. 23). Briggs and Peat describe "the many faces of creative chaos" as including "sensations of 'knowing but not knowing,' inadequacy, uncertainty, awkwardness, awe, joy, horror, being out of control, and appreciating the nonlinear, metamorphosing features of reality and their own thought processes" (p. 24).

These characteristics are increasingly rare in "right answer" and "right method," test-based contexts. It will often be the outcasts and renegades of hyper-controlled schooling who have the natural knack for shit-disturbing and chaotic potential. As a culture we often ostracize and suppress raw creative and chaotic power; in regenerative classrooms, these potentials are critically necessary for us to access and cultivate, similar to bell hooks' insights in *Teaching to Transgress*. Fortunately, our learning communities have hidden resilience and creative habits we can cultivate instead of suppress in order to access transformational learning power. Allowing and cultivating learning-turbulence, the creation of conditions for insight, are the premiere hallmarks of a regenerative educator.

Phase 2: Bifurcation and Amplification

Chaotic systems spring forth from sensitive-dependence on initial conditions. This is one way that chaotic systems can be understood as a subset of complexity, for all complex systems do not have sensitive-dependence as a trait (Goldstein, 2009a). Hurricanes and vortices, however, do require particular initial conditions. Once the first condition of turbulence is

sufficiently met, bifurcation and amplification are critical to formation of the creative learning hurricane. Complexity educators speak about the need for creating interactions with a high density of interacting, trans-level neighbors, not only neighbors such as students or classes but also neighbors such as "ideas, hunches, queries" that can interact by "bumping colliding, and juxtaposition" (Davis & Sumara, 2006, pp. 142-143). Similar to the emergence of the other types of regenerative education patterns—fallowing, bud burst, and metamorphosis— the hurricane requires dense interactions, preferably of attentive and self-reflective, communicative collective beings. In this case, the bifurcation point is the moment when the system begins to self-organize. In dense interactions of hunches, questions, and ideas, the birfurcation point and amplification can be a slip of the chisel or a mistake or the offense which are perceived by the flexible and creative mind not as a failure, but as an opening: the "aha" –"moments of insight when we see or hear something that would be meaningless, nonsensical or trivial" in other contexts "but which seem to set in motion a significant change in our perception, to get to the 'truth' of our perception, the authenticity of our experience of life" (pp. 24-25). Allowing existence at far-from-equilibrium states (FFES), deferring closure, suspending judgment and cultivating a greater tolerance for ambiguity, sensitivity to nuance and creative connections all increase the complex creativity of groups (A. Sterling, 2003, p. 154). In project teams, it is an emergent property of the team. Things click and gel. As facilitators, we can't control that happening, but we can create conditions conducive to a learning team self-organizing.

> The structures that define complex social systems, in contrast, maintain a delicate balance between sufficient coherence to orient agents' actions and sufficient randomness to allow for flexible and varied response…. 'everyone participates in a joint project.'" (Davis & Sumara, 2006, pp. 148-149)

Phase 3: Open Flow

Once the bifurcation point and amplification kick in, then the open flow is required to sustain the complex pattern of the learning hurricane (see Figure). Dense interactions continue, and the teacher can continue to support the flow-through, supporting the delicate balance between coherence and flow. At this point, the hurricane holds the structure through which the creativity flows. Learning hurricanes are creative autopoeisis, the generation of a living system:

> Systems that self-organize out of chaos survive only by staying open to constant flow-through of energy and material. Vortices in rivers and streams typically emerge out of the swirls of turbulence produced downstream from obstructions in a fast, deep current. Each vortex has a definite shape, but is in reality composed of the material flowing through it… These vortices remain stable as long as the conditions out of which they were created are kept within certain limits. (Briggs & Peat, pp. 16-17).
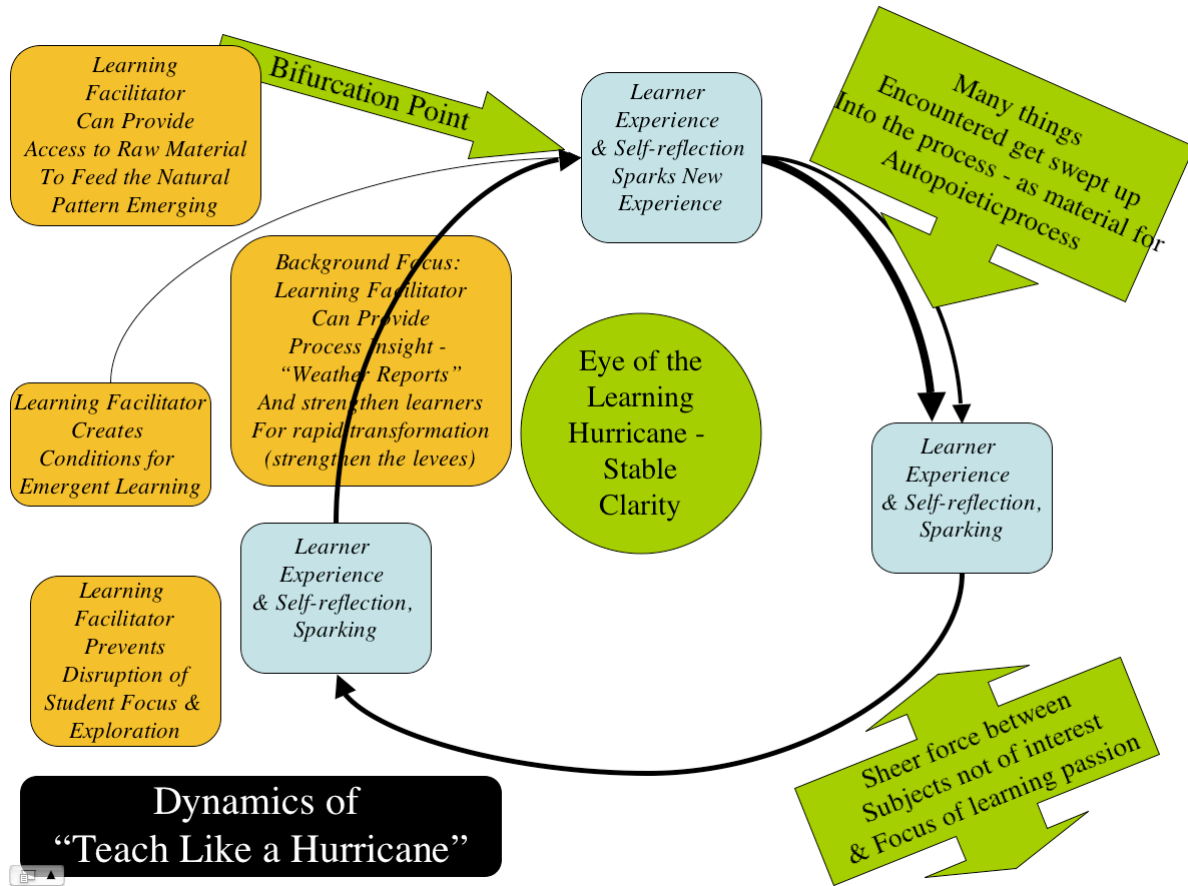
Figure 7. Dynamics of Teaching Like a Hurricane

To be clear, the learners and teachers (co-learners) facilitate the creation of conditions, including cultivation of loose, creative, possibility-oriented thinking. Respectful shit-disturbing is welcome because mistakes, conflict, and misunderstanding can all produce bifurcation and amplify resulting processes. As self-organization emerges, learners' own self-reflection and group synergy continue to feed the flow-through of the learning vortex. Many things encountered are swept up into the process and at the same time the consistency of the self-organizing structure also maintains focus and repels distraction. The calm eye of the storm is an emergent clarity from the creative synergies. Teachers and learning facilitators can provide weather reports, but mostly are present to the vitalizing process.

Emerging participative exploration (Christensen, 2005) observes and reflects, "it moves one from thinking of consultation as an outside intervention into a system of thinking in terms of participative self-organizing processes and transformation as a participant in human relating" which offers an

> emergent understanding of research…no ambition to implement anything or to control a series of steps to reach an end game…I do not formulate working hypotheses or set up a research plan in advance. I do not use organizational diagnoses, models, or methods for gathering data…. I use the opportunities I have in daily work, in ordinary meetings…taking part in different conversations. During these conversations, or sometimes after them, I reflect and make notes on how I have conducted my work and

how I have understood especially what I have experienced as striking moments….This means I write from within my own experiences and invite other participants to do the same…. (p. 87).

Christensen focuses on J. Shotter's writing "from within 'living moments' or 'witness-writing' rather than 'aboutness writing.'" Systems understandings reject the inadequacy of models based on external observer view and require locality-based embedded or internal observers to shed light on emergent systems (Penna, Mocci, & Sechi, 2009. p. 34; See Table 2). Their observations can include microlevel (singular experience, particular conversation) and macrolevel (buzz of the crowd) observations (Minati & Pessa, 2006; Penna et al., 2009).

"I am trying to catch these moments of becoming, the aesthetic moments of new insight in which I feel that I understand something that might change my identity, who I am and what I am doing" (Christensen, p. 87).

Embedded researchers engaging reflexively is a way to navigate complexity research, including in education (Taylor, 2005).

In this regard, the learners themselves become the embedded, self-aware researcher-observers and moreover the class or project team becomes self-aware as an emergent organism of its knowing-as-action at an emergent organismic level. This self-reflective emergent understanding and processing flow-through continues to fuel the highly productive system of transformational learning. This learning, as described earlier, from a complexity education point of view can be understood to be shared and decentralized, but nevertheless coherent (Davis & Sumara, 2006, p 145).

Regenerative education resonates with insights from ecological postmodernism. In ecological postmodernism, the approach is processual (ecological postmodern) rather than socially engineered (modern) or fragmented (postmodern) (Spretnak, 1999, p. 73). The science is complexity instead of reductionism or narrative, and ecology is the key metaphor instead of mechanics or signs/coding (p. 73, the last resonant with S. Sterling, 2001, p. 73). In *The Resurgence of the Real: Body, Nature, and Place in a Postmodern World*, Spretnak proposes an ecological postmodernism model, her articulation of an alternative to modern or deconstructionist postmodern modalities (p. 73). Spretnak's model is more nuanced than the contrasting paradigms of Sterling's Mechanistic versus Ecological Views (2001, pp. 58-59).

The cultivation of initial conditions for learning hurricanes leverages the process of ecological complexity to redesign the learning experience. In regenerative education, if there are still classrooms, they become living vitality zones where learners have permission and are invited to think flexibly and nimbly. Dense interactions and intense creativity generate powerful new insights. The hurricane is kept in motion by the interest of the students.

Researchers such as Slattery and Selig, articulated by Aizenstat, describe this hurricane developing from flow, creativity, and student engagement as education that is soul-centered:

In a soul-centered classroom, students are so interested and involved in the subject matter that the test is the last thing they are thinking about. They're captivated by imagination, participating….[W]hat's going on… invites their involvement and excitement…fully engaged…Everyone brings his or her life experience into conversation with one another…. The classroom revolves around the students' experiences as well as their

ability to share and interact with one another…. The moment students walk into a soul-centered classroom, they're walking into a realm of stimulation, imagination, new discovery, excitement, and engagement. Their senses are touched and activated, and their life experience is evoked and appreciated. (Aizenstat & Galindo, 2009, pp. 81-85)

Fox affirms that "creativity and imagination are not frosting on a cake: They are integral to our sustainability. They are survival mechanisms. They are of the essence of who we are. They constitute our deepest empowerment" (2002, p. 31)

Hurricanes are examples of dissipative structures (or networks) maintaining their energy states far from equilibrium. One of the advantages of creating the conditions for learning hurricanes is that the potential transformation is enormous. The benefits are disproportionately high in relationship to the initial inputs. Smitherman in *Chaos, Complexity, Curriculum, and Culture* (2008) describes it as: "Students can play around with ideas, concepts, and information, and interrogate underlying assumptions associated with knowledge" within "a curriculum that rigorously challenges students as they recursively reflect on their connectedness and express their creativity" (p. 171). Doll clarifies: "Another way to say it is that the *problematics, perturbation, and possibilities* inherent in a curriculum are what give the curriculum…its richness" (in Smitherman, p. 171). The three phases of learning hurricanes—turbulence, bifurcation and amplification, and open flow—are enabled by these dense interactions and perturbations. These scholars express how living networks that are open and transformative can be provoked in the classroom:

The network of relations that occur within this dance functions in a feedback loop so as to continually move, change, and develop in relation to an even greater context (or whole)….Perspectives of curriculum that stem from nonlinear dynamics [complexity] spark new notions of epistemology and pedagogy. Working with bounded infinity and reciprocity in respect to knowledge acquisition, a teacher can create a chaotic learning environment, where open and divergent ideas are generated…. Negotiating knowledge and interacting as co-contributors to the conversation contribute to changing perceptions as well. What will be produced, opened up, generated, is unpredictable. How exciting! (Smitherman, pp. 175-177)

Synthesis and Conclusion

Nature is in a state of continuous change and flux. Transformation, in nature best termed regeneration, is the pace of the day. As we are part of nature, enmeshed in her wild, wide rhythms of transformation and renewal, we are ourselves evidencing patterns of transformation and regeneration across the emergent levels of complexity of natural phenomena. We live in a time desiring to molt the recent three to five thousand years of cultural suppression and the five hundred years of devotional practice to linearity. So we design educational systems that generate transformational experience as a key to creating new options for human thriving with Gaia.

How can we design education for regeneration? Four patterns that hold promise include the fallowing of the winter earth, blossoming from the flower bud casing, the metamorphosis of the caterpillar, and the ferocious turbulence of a hurricane. The four different systems of transformation each have different features and foci. The summary chart highlights the major

movements, characteristics, and skills of each of the four: fallows and compost, bud burst, chrysalis metamorphosis, and hurricane (see Table 1).

Table 1 – Attributes across Types of Transformational System

| Attributes	The Transformational System Patterns			
	Type 1: Fallows	Type 2: Bud Burst	Type 3: Metamorphosis	Type 4: Hurricane
Season	Winter	Spring	Summer	Autumn
General Description & Directionality	Downward Quiet, Stillness, Inner Activity	Moving outward from center	Into a contained space, liquefying, forming new organs, transforming form, flying free	Creating conditions - vortical motion around a central peace
Transformation Characteristics	Nurturing, Rehabilitating	Pressure to Change from Within	Flexibility, Learners step out, Safety	Learning community
Major Skills	Listening Depth/ Deepening Ecobonding, Earthly grounding Surrendering goals and structure Rewilding the senses	Create networks and share information across large and distributed groups Stay open to unusual or surprising perceptions Designing for learning collectivities	Safety, listening, collaboration and connection Depth experiences in resonance with the learning community Cultivating diversity and multicultural learning and leading Liberation approach	Creativity, openness to disruption, being unsure, holding two things at once, willingness to collaborate and focus Letting the energy flow through, stay open to large currents of creativity
Major Activities	Depth Presence Ground Immerse Surrender	Pressure Building; Breaking Open	Chrysalis Formation; Liquefying and Regenerating; Emerging to Fly	Turbulence; Bifurcation Point and Amplification; Open Flow
Example	Night walk Eco-education	Project BudBurst	Butterfly Curriculum	Creative participative collaboration
Qualities	Patient, Sensing, Numinous	Connecting, Observing, Courageous	Inspiring, Communicating, Diverse,	Ambiguity-Positive, Creative,

Attributes	The Transformational System Patterns			
	Type 1: Fallows	Type 2: Bud Burst	Type 3: Metamorphosis	Type 4: Hurricane
			Compassionate	Outrageous, Focused
Educator Role Parallels	Worm	Network	Shaman	Change Agent or Storm

Some of the regenerative education transformation systems model very different movements; for example in budburst and chrysalis, change emerges outward from inside a boundaried container; in the hurricane, change from the outside creates a boundaried center. Meanwhile, the fallows have fewer distinct boundaries or structures; change is ubiquitous (see Figure 8). As we explore these four examples of types of regenerative education, they also connect with one another and interrelate. Christopher Bache's description of dissolving and learner resonance connects the chthonic quality of Phase 2 Type 3 metamorphosis educational regeneration with Type 1 compost/fallows regeneration processes. Bache further likens this process of deep transformation to a vortex (2008, p. 32), resonating with the dramatic changes available from the learning hurricane (Type 4 vortical, creative educational regeneration).

Whether through descent and transformation in earthly fallowing, pressure to grow in bud burst, the

Figure 8. Contrasting Movements in Regenerative Designs

liquefying and reforming crucible of the chrysalis, or through the chaotic order of a hurricane, emergence in nature can provide patterns for regenerative education.

Sparked by complexity insights about the embedded point of view of co-researchers and the emphasis on participatory exploration, the final table provides sample descriptions of the experience of each of the four regenerative education processes from the point of view of the learner-co-researcher-participant (see Table 2). Further, future explorations could include having co-researchers themselves generate these embedded process narratives. Along the same lines, through the use of Brand's resonance and efficacy validations (Chalquist & Rankin, 2010, p. 320), I could apply, test, and extend this four-fold emergence framework in the future.
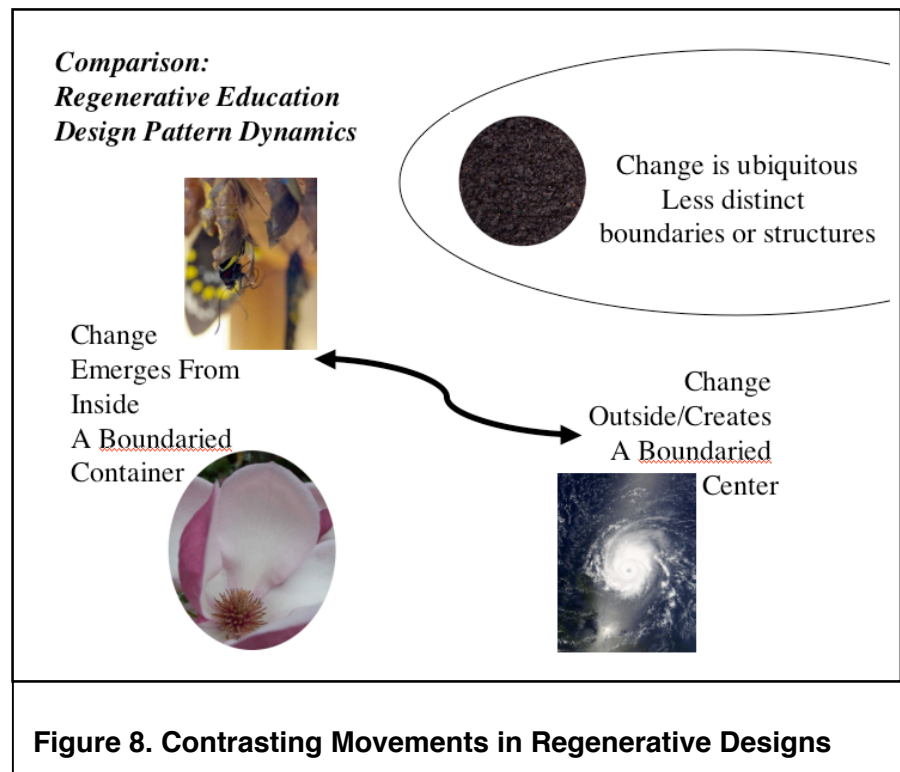
At a time requiring regeneration of our capacities to learn and lead, emergent regenerative education approaches promise to restore us. These regenerative education systems liberate us from classrooms and programs stultified by over-planning and domination, hyper-technology, Cartesian separation and mechanization, disciplinary silos, and alienation from living systems, vibrant process, nature, body, interiority, and sense. Regenerative earth education reconnects and awakens us. Fallows learning can deepen us in emergent silence with sensory awakening, unstructured learning, imaginal depth, inner wilderness, and earthy groundedness. Bud burst can connect us like flowering trees in sensing networks and blossom us into learning collectivities. In diversity metamorphosis, we can weave safe havens of inner awareness and learner resonance, dissolve our resistance to difference, and renew our resilient capacities for change-making and beauty. We can create and support the conditions and processes for kicking off, amplifying, and nurturing hurricanes of learning in which flexibility and sensitivity catalyze creativity and flow. Nature can teach us to learn and lead as fertile listeners, collaborative networks, shamans, and creative storms. With emergent regenerative education, we come to thrive as Earth.

In all four examples, there are both processes and points of change, both particle and wave, in regenerative education. For each system-pattern, we notice both the creation of conditions for and the epiphanic systems of change. We explore applications of each in educational design. We discover how truly transdisciplinary learning leads by weaving and leaping across multi-scales of emergence, across the portalways of coherence generated by the phenomena termed emergent weaving. And these four systems and strategies can be applied at many levels of emergence in living systems, from individual curricula or classes to programs and institutions. In this way, we can take the lead from nature in how to design transformational, emergent educational experiences that create sustainability, regeneration, and justice for learners and the world.

> To educate as the practice of freedom is a way of teaching that anyone can learn. That learning process comes easiest to those of us who teach who also believe that there is an aspect of our vocation that is sacred; who believe that our work is not merely to share information but to share in the intellectual growth of our students. To teach in a manner that respects and cares for the souls of our students is essential if we are to provide the necessary conditions where learning can most deeply and intimately begin. (hooks, 1994, p. 13).

Applied in learning contexts, these ecologically complex and regenerative patterns promise to increase learning, leading, and innovation so that we can collaborate to restore the adaptive and regenerative capacities of place, people, and planet.

Table 2 – Description of experience throughout the process of change from the perspective of the learner-participant-co-researcher

Fallow, Compost:	**Bud Burst, Snake Shed:**
I am feeling like I'm being digested, my thinking is floating. I feel like I'm going deeper, taking tatters and making something new. I feel close to the Earth. The deeper I go, the clearer I become. I'm being emptied out, coming true to inner space. I feel companioned in my process. What I thought I understood has fallen apart. Clarity deepens within me. I am being made whole. I can see how decisions that I made years ago that I always thought of as terrible mistakes are actually bringing me to a perfect now place (Stuckey, 2010, private conversation). My judgment and perfectionism are lifting. I feel my fertility as a learner, accessing the stuff of life. My roots go deep. I feel how the past and the future connect.	*I am feeling tight and compressed, lots of pressure. There is not enough space in this context for all of me. Why do I have to work within all these teacher defined constraints? I feel pushed upon on all sides. I feel like I'm bursting with ideas/ insights/ connections. Suddenly I'm bursting forth, I feel a whole new life within me. It's like I'm vibrating with energy, feeling vibrant and alive. I can see and sense my beauty. Colors are brighter. I feel an increased sensuousness. I have new capacities for collaboration. I feel limitless capacity for growth. I feel the pressure lifting. I experience expressive flowering and spaciousness.*
Chrysalis or Cocoon:	**Vortex:**
I am feeling like I'm being liquefied. New capacities are beginning to make themselves felt. (Later) Suddenly, I feel like I'm pulling myself out of a long sleep. Things that seemed nonsensical before have all come together in a new form. I am lifted up and transported. I can see from a whole new perspective, I can move more freely. This learning is making my life larger, more spacious, lighter, more easy. I had to think about everything for a long time, now it's happening effortlessly. I know where I need to go to get the educational nourishment I need. I am reborn. I have been released from some prison and now my learning can move freely, lightly, on new adventures. Colors are brighter.	*I am densely connected in a learning community. Ideas are flying. I stay open to impossible possibilities, keep my options open. I make a mistake, but see how I can use it creatively. "A-ha!" I am suddenly galvanized, sparked by one thing into a whole new form. Things are accelerating rapidly. There is a central principle/ insight/ concept around which my learning is rotating. In the center of me, I feel calm and aligned, but the changes are streaming out from me in all directions. I feel ferocious and powerful, what I'm studying is creating huge winds of change in my thinking. One idea has kicked off a whole new life path. I am being moved rapidly to a new place. My entire orientation has changed. I feel the pointless eddies change into a stable form of powerful change.*

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