

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/335612029>

# Approaching Sustainability: Generative Art, Complexity, and Systems Thinking

Conference Paper · September 2019

---

CITATION

1

---

READS

515

2 authors:



**Aleksandra Dulic**

University of British Columbia - Okanagan

22 PUBLICATIONS 166 CITATIONS

SEE PROFILE



**Miles Thorogood**

University of British Columbia - Okanagan

30 PUBLICATIONS 400 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



slidedeck.js [View project](#)



Future Delta [View project](#)

# Approaching Sustainability: Generative Art, Complexity, and Systems Thinking

**Alexandra Dulic, Miles Thorogood,**  
University of British Columbia  
Kelowna, British Columbia, Canada  
aleksandra.dulic@ubc.ca, miles.thorogood@ubc.ca

## Abstract

Generative art provides new opportunities for creating sustainable and resilient communities. We discuss three key elements important for the relationship between generative art and sustainability: Dynamic composition, Interdisciplinary development, and Community. Each of these elements is analyzed in relationship to exemplary artwork. We conclude with a discussion of the artwork *Journey of a Pod* that demonstrates how these three elements play a key role in the artwork development.

## Keywords

Generative Art, Sustainability, Dynamic Composition, Resilient Communities

## Introduction

Generative art and the fields of sustainability and resilient communities have the opportunity to become a reciprocal relationship of exchange, engagement and mutual benefit. Through collaboration and learning with communities about different ways of being that look at sustainability, generative art practitioners connect to new meaningful ideas that contribute to the algorithms and aesthetic details used in their work. Concurrently, communities and those individuals have access to the state of the art techniques and ways of understanding the world from generative art perspectives that bring value through the development of new media tools and new modes of public engagement.

Social change happens within a place we inhabit, incrementally, as things transform through practice. Social shifts evolve in the way we organize and relate to one another to build communities. Change processes that affect our collective and individual behaviours and worldviews have many influences. Some are explicit, and some are subtle. On a basic level, changes in our environmental conditions affect our behaviour. The question is how? How can we build resilient communities? The way that we see the world is shaped by our assumptions and metaphors we use to reconcile our experience. How does generative art add to themes of sustainable human living and reciprocity with nature to add to the transformative processes we need to engage in response to environmental crises we created?

As an artistic practice, generative art occupies a unique space in fine art. The reception of the artwork with fixed

form and content shifts when contexts and audiences change. In a generative artwork, the form and content continuously change. This inherent change has the potential to directly respond to different audiences and contexts in which the work is received. This is an important element that renders generative artwork categorically different than its non-generative relatives. The flexibility of presentation and consequently reception enables the artwork to be encoded in such a way to embody the space-time and context of the communities in which the work functions to provide the reflective space for building resilient sustainability practices. Generative art often surprises and some artists go as far as saying that a generative artwork is not successful unless this is the case [12, 14] and reveals new ways of seeing the day to day reality drawing from complex threads that can be weaved together in a coherent whole. This element of surprise indicates dynamic composition. It represents a shift in the nature of artwork-artist - audience relationship and creates new types of interactions between these four elements.

If we consider generative artwork to be a distinct type of media, we can follow in asking what is their message? What themes, what ideas, are built into generative art because of its very nature? How does generative art produce spaces for reflection, re-imagination, and grasping of the complexity of our place and the world? Can it reveal new relationships between seemingly disparate entities? Does it allow participants to experience new avenues for the understanding of socio-environmental relationships? How can dynamics in form and content contribute to the process of making meaning? We aim to elucidate what it is specifically about generative art that adds to sustainability discourse.

The dynamics of form and content within generative art enables meaning making that reflects our world, in which we are experiencing rapid changes in climate, technology, politics, and social norms. In representing the non-static and rapidly shifting nature of our world, we see generative art as opening new avenues for exploring sustainable socio-environmental living practices, responsible and reciprocal cohabitation of this planet. This dynamics in form and content provides fruitful grounds for the weaving of multiple voices and perspectives human and non-human. An encounter with multiplicity facilitates grasping and reflection on the complexity embedded in our current socio-environmental reality, opening new opportunities for integration of sensual experiences and ra-

tional thought. The analysis of media such as soundscape recordings, landscape documentation, and community voices as well as the design of algorithms within generative art systems can reveal relational characteristics within a given place and time. The algorithms that enable modelling of natural and community relations link media anthropology and big data with artistic expression that can make the knowledge embedded in these socio-environmental media accessible.

Doran et al. [4] propose a framework for generative art that focuses on form and mechanisms characteristics to be able to encompass its various complex forms. This framework, inclusive of the different type of media, time and physical manifestations, is structured within four primary elements: entities, processes, environmental interactions, and sensory outcomes each one focusing on fundamental aspects of the generative art form. Entities represent the smallest virtual or physical materials of the work, which are formed by various processes, digital, physical, or mechanical, into a work of art. Environmental interactions enable inputs and responses from the surroundings, while sensory outcomes refer to the experiential aspects of the artwork. The focus on formal structure within generative art allows Doran et al. to draw common features across a wide variety of generative systems including computational, physical, kinetic and virtual systems from the past, present, and future.

Conceptions of sustainability are primarily about change and involve imagining new ways that we can live and relate to each other and our environment. Kagan [10] writes about cultures of sustainability that reach across all areas of our being, knowing and doing. The change process entails identifying and developing cultural narratives of sustainability that are energizing and motivating [16] narratives that nurture human energy and promote activities that positively influence environmental and human health. Without new stories and visions of a relationship among people and the environment we risk failure in achieving sustainability [13]. Given the cultural roots of this crisis, its resolution requires new and renewed creative cultural approaches. In its role as catalyst, art and culture can significantly contribute to social transformation for a better quality of life [10].

From the perspective of sustainability practice, generative art offers tools for integrating various processes and media elements into a coherent whole. The dynamic processes that respond to the environment and each another in a correlated and co-dependent way, expressing equilibrium, is the most powerful narrative device that we aim to highlight in this discussion. The multiplicity of response and the possibility for exploration of a variety of relationships embedded in the dynamic art framework is a powerful instrument for exploring complexities embedded in the cultures of sustainability. However, given that the popularity of this term is rooted in the notions of techno-digital cultures its critique from the perspective of sustainable community practices lays in its preoccupation with pure form and coded abstractions removed from the body, place, stories, and community. What we aim to focus on locating the community context, space and time for generative art.

Generative work is in a constant process of self-reinvention, or what Maturana & Varela [11] call *autopoiesis*.

The continual shift of the work enables reflection as it changes, and new ideas about the meaning emerge. The constant re-exploration of the media materials within the work resonate with a culture of sustainability, where the set of social practices contribute to the community regeneration. Sustainable living practices require attention to relationships that are in flux, events that need re-imagining, and conditions that demand multiple responses and weaving of different perspectives, that benefits from visualizing the contradictions, competing interests and common ideas. As we address some facets of sustainability, we reflect on our practices in light of diverse points of view. Through the experience of generative art, perhaps we can learn what it means to re-imagine our actions and relationships in a continuous, critical manner.

The re-evaluation brings us to another aspect of the relationship between generative art and sustainability: the importance of interdisciplinary work. Generative art is almost always an interdisciplinary endeavor. Within the compositional form, such art must carry on complexity, variety, nuance and holistic representations that directly speak to the sensual, while developing new codes and models adopted from science and technology as part of their process. On the content level it bridges the sensual experience with traditional and scientific knowledge critical for understanding our environment. Galanter [6] argues that “generative art is uniquely positioned to negotiate between science and the humanities.” He defines generative art in terms of complexity theory, a branch of study that deals with “how relationships between parts give rise to the collective behaviors of a system, and how the system interacts and forms relationships with its environment.” He argues that, while science traditionally holds a modernist viewpoint and the humanities have tended towards post-modernism and an organizing worldview, complexity or *complexism* as a worldview is the synthesis of modern and postmodern modes of thinking indicating critical need to develop new language, metaphors and worldviews that can support us in addressing the environmental challenges we created. Complexity challenges the orthodoxies of both modernism and postmodernism and, in doing so, opens up a third space for scientific modelling, humanities, media anthropology and fine art to engage with each other through the world that they represent and make accessible for community reflection.

Generative art encourages interdisciplinary engagement, not only by often bringing people from different disciplines together to work on a project. The art itself opens spaces for interdisciplinary dialogue because of its dynamic and uncertain nature. By drawing on many ways of knowing in the creative process, the result often opens up different entry points to the work itself, thus encouraging a disciplinarily-diverse audience to engage with it. These types of collaborations and dialogical spaces are essential resources for addressing sustainability. Just as generative art is complex practice, transformation toward sustainable, reciprocal and responsible relationships with the natural world that supports us is a complex problem. It has many interconnecting and often competing facets. The problem can and should be understood in many different ways. Understanding the problem in this multiplicity of ways means that it is critical to have interdisciplinary

perspectives when attempting to address sustainability and other complex problems. Generative art can represent the complexity and fluidity of the problem, open spaces for interdisciplinary dialogue and indicate synergies across diverse viewpoints.

Interdisciplinarity is recognizing that there are many simultaneous, complementary, and contradictory worldviews and that each of these lenses is both valuable and incomplete. These multiple viewpoints and disciplinary perspectives give rise to further diversity of values, beliefs, and needs. It informs how we understand our world in the context of the whole, to diverse communities of practice as well as how we interact with each other (and other species). Interdisciplinary art through creativity and sensual experiences provide a ground for meeting and grasping those diverse worldviews simultaneously, which can inform our place in the world and enable us to position our actions cognizant and compassionate for the diversity that surrounds us.

Interdisciplinarity is an essential aspect of approaching sustainability, but the term still implies a relationship between individuals with different backgrounds. However, the sustainability of individuals despite what “green” industries attempt to espouse makes little sense in isolation. Civilizations and species live and die as groups, and so the formation of “cultures of sustainability” [10] are essential in any formulation of sustainable futures. Giddens’s [8] structuration theory posits that agents (individual people) and structures (communities and organizations) interact in a recursive (complex) manner, with each affecting the other and neither agents nor structures dominating the relationship. From that perspective, the change process needs to address agents and structures, which can be represented through generative art. The distributed nature of this form binds individual experience to a larger community of practice and begins to create a social context for approaching the complex question of sustainability.

Community, along with interdisciplinarity and dynamism are critical components of the generative art form. We propose that they are not only essential to the form but that they also contribute to the natural fit between the generative art and the topic of sustainability. The sustainability that we address moves beyond simple material actions such as recycling or being energy conscious though these are essential components of such sustainability and towards a mindset, lifestyles and relationships that are reciprocal and responsible. We see sustainability as a holistic idea that is itself constantly shifting to accommodate new understandings of the mutual impacts between our surroundings and ourselves. In the remainder of this work, we explore the notion of dynamics, interdisciplinarity, and community and as we do so, we will position them concerning the notions of sustainability.

## Dynamics

“Cultures of sustainability may inspire hope, but their strength is also their vulnerability. As soon as they crystallize into fixed states, closing their boundaries and fixing their borders, they risk losing their elasticity and porosity, down the path of *autopoiesis*. Cultures of sustainability are a matter of dynamic self-critical exploration. They require a continuous re-actualization of reflexive competencies. For this reason,

they demand an artful practice of life.” - Kagan, 2010 [9], a dynamics of becoming. The process-driven generative art also emerges through the constant state of becoming. Often interactive, generative work can provide conceptual framework to engage with the dynamic socio-environmental inputs, which act a endless source for varied artwork representations. When artwork is interactive the work moves from a single creator and a single viewer to being to directly responding to its environment and enabling a multifaceted conversation within given environment.

Welsby’s [17] work *Tree Studies*, a single channel weather driven video installation, explores ideas of collaborating with nature as a process for art-making enabled by generative art. The installation view shows an image of a tree against the stormy winter sky. Recalling the cubist image with multiple points of view, Welsby shoots the tree from three different angles 20 degrees apart centering on the tree using multiple single frame exposure. The sound included people in the distance, voices of starling and raven, wind sounds, footsteps from nearby gravel pathway and a computer-simulated harmonics of the Aeolian harp. Wind sensors positioned at the roof of the gallery space provide the dynamic input from the outside world to work inside the gallery. The system translates data captured from the wind sensor to compositional decisions that coordinated frame rate, picture and sound components of the work. The display of the weather sensor capture information is as another element of the work.

The changes in weather captured by the sensor provide core compositional element that weaves the recorded media, providing the multiple renderings of the work. This work visualizes the dynamics of interactions and co-dependencies among people, nature, and technology. It works highlights the social collaboration with the dynamic natural phenomenon as a critical component of our survival. Changing flickering winter light and sweeping clouds that paint the scenery animates the bare tree that dominates the installation. This composition alludes to melancholic and somber feelings that reflect transitory nature of life.

In this example, the dynamics within the generative art system acts as narrative devices for meaning-making. Artistic technique and system have a purpose of illuminating the dynamic co-dependence on with our natural environment. As such it provides a link for thoughts and feelings in a coherent experience that engages the viewers in the processes of reflection on dynamic co-existence and interrelationship between people, technology and nature that sustain us. This interrelationship is at the base of art and sustainability practices pointing to the significance of sensual understanding of the human effect on the global changes in the earth’s climate.

## Interdisciplinarity

Sustainability as complex problem benefits from an interdisciplinary approach, which can extend the individual point of view and facilitate new ways of approaching problems that consider a full range of goals and targets instead of focusing on a narrow set of objectives. Complex, generative artwork can be thought of as one possible forum for rendering such concepts in their near-infinite dimensionality. The

work is necessarily interdisciplinary, often exploring the liminal spaces between and around fields. As a gathering point for people with diverse backgrounds, the processes behind the creation of elaborate generative artwork can provide valuable proving grounds for models of working across and between disciplines. Successful artwork created in this mode often requires that the work consists of an ongoing dialogue between the parties involved in its creation. Some of the most compelling works in this have come from deep collaborations between the diverse people involved in a given project.

Installations by Brigny et al. [2] *Reefs on the Edge*, 2012 and *InterANTARCTICA*, 2010 are interdisciplinary artworks that experiment with scientific data, photography, video, sound, and tangible user interfaces to provide educational space for reflection on climate change challenges. These two works are examples of the use of interactive and generative processes in education surrounding climate change. Both installations use tangible user interfaces and generative processes to shape interaction that invites viewers to engage with scientific measurements of climate change effects through embodied, visceral and aesthetic experience. These strategies allow the message of the effects of rising sea surface temperatures on young corals and melting ice in Antarctica to be translated seamlessly across multiple media platforms, creating a perceptible experience that integrates full body. In both of these works, de Brigny works with a team of interdisciplinary professionals to bring the science art together into an integrated interactive experience that engages an audience on an embodied, emotional and intellectual levels in the exploration of the challenging topic of natural degradation that unfolds because of climate change. These examples point to the importance of an interdisciplinary team approach in addressing complex problems that face humanity today.

## Community

Place and communities shape sustainability, providing a way of moving from individual experience to community to societal change and back again in his formulation of structuration theory. Structuration theory emerged as a response to objectivism and subjectivism, as a synthesis of the two perspectives that acknowledges that the relationships between agents and structures are fluid and cyclical. Structures affect agents, which affect structures and so forth. In the context of sustainability, this provides a pathway from individual learning and action to community development to the forms of profound structural change that are necessary to address questions of sustainability.

Generative artwork *Becoming World* by Aleksandra Dulic and Kenneth Newby [5] explores the idea of community by bridging two key ideas: that of cultural and ecological health both images of diversity. This exploration of the community expands the multicultural fabric with complementary ecological characteristics of complexity, biodiversity, and variety in balance. This dynamic artwork imbues the Canadian ethnocultural diversity with an ecological perspective. *Becoming World* engages in reconciling the culture-nature divide through a composition process that merges the images

of beauty within natural environments with the overconsumption and environmental degradation. *Becoming World* is a work of generative art that produces transforming images of the human body embedded or extended by Nature. A generative collage system composes from an extensive database of images of people, our actions and Nature.

Meaning, both broad and focused, is drawn out of the work by including, in the compositing process, layers of human portraiture and acts drawn from the diverse community characteristic of Canada. The natural images function to reorganize and enhance the body becoming skins and spaces making of each a merging of the human and the world we inhabit. As an experience, the work situates itself around the boundary between knowledge, grief, hope, and memory. People, their faces and bodies emerge and are torn apart by images of sustainable and unsustainable human activities. The work reflects a state in which we at once carry an image of the world within us while, at the same time, are subject to the changes wrought on our selves by the external forces of an enveloping world. In this way *Becoming World* attempts to show an interpenetration of the human with the world an interpenetration that might hopefully enter into a discourse on a transpersonal state of being conducive to a rethinking of our place in the world as continuous, cohabitant, participatory and fundamentally resonant with the world.

The image of a community emerges through the dynamic representations of human and nature. The continues, slow transformation from one superimposed image to another, shift the viewers' attention to the multiplicity of relationship that we carry on and create as species. The works represent hybrid culture between nature, people and their technologies using hybrid media and generative art techniques to evoke an emotional engagement with a place. The dynamic juxtaposition among the human body, body of nature and our actions that exhibit the careless approach to nature human and more than human slowly shifts viewer's attention to multiple relationships and points of view we inhabit at once. The moving image transforms so slowly that is almost imperceptible to enable the audience's spaces in-between the states critical for reflections.

## Bringing the Threads Together

How does generative art communicate sustainability?

In an attempt to answer this question, we will describe our recent work *Journey of a Pod* [7] that brings Dynamics, Interdisciplinarity, and Community together. Presented at the Kelowna Art Gallery and curated by Laura Jane Ritchie, the work is the union of objects from the creek, digital media, and encoded environment that connects the audience with an ecological cycle and highlights a reciprocal relationship with the earth. In this interactive and immersive installation, the artists invite visitors to engage with the wandering of a seed pod within Okanagan creek systems. Expressed through the interplay of image, sound, and object, the cycle of seasons guides the journey.

This communal experience of passage through waterways is rooted in these artists' love for nature and represents the fundamental relationship between humans and the ecosystem. The experience opens the ephemeral aperture between the



Figure 1: *Journey of a Pod* Installation view



Figure 3: *Journey of a Pod* Installation view



Figure 2: *Journey of a Pod* Installation view

tangible and intangible, earth and sky while balancing the female and male present in Mother Earth and Father Sky, fused as the pod. The metaphor of the pod, seeding of a partnership with nature, animates a pattern that connects living things in the environment [1].

### Dynamics

The Journey of the Pod system is made up of different software for the audio spatialization, video mapping, and motor controllers. A conductor program coordinates these discrete modules and manages the timing and media selection. We encoded the conductor with a cyclic pattern that internally represents the four seasons. A timing parameter tuned to the installation requirements sets the duration of the cycle.

### Installation

The installation of *Journey of a Pod* includes a 21' by 8' platform shaped to reflect the curve of a stream that tapers to a point at either end. Roughly two metric tons of river

stones and gravel cover and surround the platform. Stones, sourced from the Okanagan, measure 1' in diameter and descend in size around the perimeter of the platform to flow into the exhibition space. Along one side of this sculptural form is a path that has a fluid shape following the curvature of the platform. On the other side, an area covered in gravel and stepping stones encourage the playful experience of rock hopping. The surface of the elevated platform is the central



Figure 4: *Journey of a Pod* Installation view

visual media scene. This space embraces 12 video channels mapped to different objects and artifacts created by the artists. The main video channel is a 6' circular projection surrounded by 12 medium sized river stones. The remaining channels are mapped to project to the inside of ceramic chalices created by the artists. These chalices are filled with salt to form the projection surface. Another video channel projects onto an

importantly shaped stone sitting outside the centre circle. The final channel projects onto a simple flat stone carving of the great father. Contrasting the great father at the opposite end of the platform is an urn depicting the female form to indicate the great mother.

Nine video channels project to the chalices that display moments of experience encountered along the creek system during the year. Examples of the videos included water over stones, balsamroot flowers in the breeze, and ice flows. The video clips range in duration from 10 seconds to 1 minute and are periodically switched with other videos from the same season by the conductor to produce a stochastic cycle that changes not to repeat a particular motif of experiences. The conductor synchronizes video with a generative audio sequencing and spatialization module. The audio module, developed in Super Collider, outputs to an array of six speakers spaced equidistantly along the gallery wall. A motif of water represents each season with corresponding sounds such as birds and insects, and voices from the community to emphasize the importance of water to the landscape and people.

At the point of transition between seasons, the core audio-visual composition explores concepts of varied human relationships with Nature:

Spring to summer: "Light dark" is a piece that includes male and female voices, images and sounds of water, earth and rocks, to highlight the relationship created between opposing concepts in nature - calling attention to the foundation of the space between things.

Summer to autumn: Focusing on the partnership with nature, "Thank you for sharing" includes male and female voices, and images and sounds of an insect that emphasizes how in nature the environment and its creatures come together and share experiences and relationships that form the tapestry of the soul in this world.

Autumn to winter: "War" is a piece that stresses escalating destruction and domination over the natural environment, moving between the development of forests, water pollution, oil industry, to landscape desolation.

Winter to spring: "Time to move on" reflects how the situation human-caused environmental damage is a space providing opportunities to reintegrate with more positive ways of coexisting nature.

## Interdisciplinarity

*Journey of a Pod* is a part of a larger project funded by the Social Sciences and Humanities Research Council, entitled Water Ways - the Past, Present, and Future of Okanagan Waterscape. The Water Ways project is a four-year undertaking to research and create a community-based interactive media exhibition that explores the nature of human-water relationships in the Okanagan Valley, British Columbia. The artworks created in the exhibition employ creative and innovative uses of interactive media and artistic software design to present a platform for dialogue across diverse community-based, poetic, traditional and scientific water knowledge. These artworks synthesize diverse water knowledge of the past and present and use community-engaged research to envision multiple sustainable water futures of the Okanagan

Valley. The exhibition will encapsulate the different meanings that water holds for many communities, cultures and interest groups in the valley, including Indigenous Okanagan (Syilx) communities, environmentalists, artists, agricultural, forest and tourist industries.

Water Ways is an interdisciplinary undertaking between UBC Okanagan researchers from Fine Arts (the authors), Traditional Ecological Knowledge (Dr. Jeannette Armstrong), Environmental Anthropology (Dr. John Wagner), Environmental Science (Dr. Lael Parrott) and Indigenous Scholarship (Dr. Marlowe Sam). We collaboratively research, design, implement and evaluate an artwork that draws from a rich history of participatory sustainability research and media for social change. This type of research-creation can lead to widely applicable approaches of engaging Canadians on local environmental sustainability in new and fruitful ways, fostering better citizenship and dialogical engagement on issues crucial to community resilience and well-being.

## Community

Inspired by the artists' experiences within the environment and communities along the creek systems of the Okanagan, *Journey of a Pod* brings together a sculptural form, system design, and audio-visual media. We recorded audio and video media for 12 months exploring the seasonal episodes and shifts of death and rebirth. At a conceptual level, the work investigates the oppositions of domination versus partnership with the environment. The media representing the spring season includes recordings of the creek systems as they refresh the landscape with life-giving forces such as the incredible power of water overwhelming the creek banks. Events of drumming and children activities at the Salmon Release Ceremony at the Penticton Indian Band accompany the environmental pieces. Summer season features Okanagan sunflowers, bees, birds, sunlight refracting onto the underwater stones. The voices in this section were taken from Columbia River Treaty Workshop organized by John Wagner and the focus group led by Jeanette Armstrong at the Enowkin Centre.

Themes about the culture and landscape as related to water and spoken by Indigenous and non-Indigenous scholars and community members represent the diverse perspectives centered on waterways of the Okanagan. It is essential for us to recognize the depth of the words shared here by Syilx knowledge keeper Richard Armstrong. Canada Research Chair and UBC professor Dr. Jeannette Armstrong shared with us that the words spoken have been passed down in the traditional Syilx family from Uncle, and Mother, and teachings of family elders. It is a long line of teachings that are carried by this generation of knowledge keepers. The words are exact but are treated differently than direct quotation in the academic sense - for the Syilx knowledge keepers become owners of the exact wording and are to use it in the same way for the same purpose while acknowledging that they are words passed down from the relative that gave it.

"Tell me about water is that even though it's soft to the touch, it's not hard it's something soft. Yet as soft as it is it can wear away the hardest material like solid rock wall, it will wear that away."



“Water is so sacred that where it comes from never empties and where it goes never fills up.”

Richard Armstrong

Dr. Marlowe Sam’s interviewed Richard Armstrong for the 2008 research entitled *Okanagan Water Systems: An Historical Retrospect of Control, Domination, and Change* [15]

The re-combinatory poetics in generative art brings together communal diversity with knowledge about the environment into the experience unified by the artistic whole. The artwork becomes the mechanism to achieve balance in diversity - negotiating across multiple perspectives, complexity, and ecological resilience - using experience design as a way to provide public access to complex ideas produced as a reciprocal relationship between the generative system and the artist/interactor forming an ecosystem with the expression of thoughts and feelings.

## Discussion

The contribution of generative arts to sustainability discourse lays in its powers as a means of inquiry, as a way of knowing, understanding and representing the world we live. Generative arts practices provide awareness that reaches beyond the conceptual framework, building on the capacity to know the world, which exceeds the capacity to categorize the world. The epistemological dimensions of arts have the capacity to present realities as constructed, rather than fixed, in order to invite new cultural dialogues, construct new cultural narratives and develop new forms of creativity. In that regard, generative arts inherits a language of fine arts to create an embodied experience that enables reception of ideas in a fluid cycle across the sensual and conceptual, facilitating a space for ontological reflexivity [3]. We approach generative art as a source of ontological reflexivity and an agent of transformation and social change, where foundational knowledge of how humans connect with the more than the human world is brought into play through multi-sensory experience that activates lateral thinking and an intuitive grasp of concepts.

The digital characteristics of generative art enable the expressions that are dynamic, flexible and responsive to its environment. The dynamic feature embedded in generative art provides fruitful ground for engaging with complex problems. The artistic representation formed through an equilibrium across multiple elements within the system that act together in a co-dependent yet flexible way. This characteristic of generative art is a crucial narrative device that can enable an imaginative space of engagement and reflection on the multiple realities embedded in our place: geopolitical issues, histories, futures, resource availability, conflicts, demography, biodiversity, and beauty. The renderings of multiple relationships across its components within generative art provide a unique conversational space for a creative engagement with sustainability thinking and practices.

Generative art, and its unique language that spans across fine arts, technology, and scientific modelling, draws pathways for creative actions that can span across the world of politics, economics, and science while maintaining and leveraging transformational power of fine arts that can directly speak to our hearts. This interdisciplinary relationship between artistic and scientific inquiry can only be successful

when the integrity of sensual processes within ontological reflexivity is in equilibrium with rational and technical. Fine arts and the power of persuasive aesthetic experience cannot be placed in service of representing the world through the lens of deductive, rational knowledge or financial gains. Instead, the artistic experience must be drawn from the way we perceive and engage with the world directly with our hearts and our minds. The integrity of artistic understanding as both process and outcome for enabling ontological reflexivity lay in its ability to affect the perception through creative engagement, for which the relationship between how we perceive, represent, know and change nature is firmly linked.

Sustainable futures have ethical implications regarding how to conduct life that is political, socially just and socially conciseness act, transcending our understanding through the process of perceiving positioned itself as an interactive performance of the agency. The artwork creates an experiential journey that transcends our personal and socio-cultural norms to reach beyond our normative structures to new creative territories through the sensual process of listening, looking, touching, tasting and smelling. This transcendence through a process of perception means co-evolving with social and personal structures as a result of improvisations within the experiences enabled by the artistic system. This form of communication enables the space for ontological reflexivity, compelling creative engagement from the participants to reach perceptual transcendence through the act of engagement with the artistic system. Artist, participants, digital media, and computer software all have equal status in the collaborative performance, and the improvisational interaction among them nurtures insights.

## Conclusion

The discussion in this paper has been a team effort. The discussion of the dynamics that we see in complex systems was in many ways a reflection of dialogues we had over the years at the Centre for Culture and Technology at the University of British Columbia how does complex art reveal to us as the dynamic, fluctuating and co-dependent nature of our world? While one is often between disciplines oneself, an interdisciplinary practice usually involves working with groups comprised of people from different disciplinary backgrounds. As a team, we came together in our interest in the more profound understanding of intertwining art, science, technology, and nature. Building on the current work of the Waterways project we are integrating scientific modelling explaining species and land distribution and Indigenous knowledge for embedding generative artworks in the environment through locative media technology. This work aims to bring opportunities for imagining sustainable living solutions into the experiences of people situated in the environment.

## References

- [1] Bateson, G. 1979. *Mind and nature: A necessary unity*, volume 255. Bantam Books New York.
- [2] de Bérigny, C.; Gough, P.; Faleh, M.; and Woolsey, E. 2014. Tangible user interface design for climate



- change education in interactive installation art. *Leonardo* 47(5):451–456.
- [3] Dieleman, H. 2008. Sustainability, art and reflexivity. *Sustainability: A new frontier for the arts and cultures* 108:146.
- [4] Dorin, A.; McCabe, J.; McCormack, J.; Monro, G.; and Whitelaw, M. 2012. A framework for understanding generative art. *Digital Creativity* 23(3-4):239–259.
- [5] Dulic, A., and Newby, K. 2016. 17 generative approaches for meaning making in art. *Intersecting Art and Technology in Practice: Techne/Technique/Technology* 207.
- [6] Galanter, P. 2008. Complexism and the role of evolutionary art. In *The Art of Artificial Evolution*. Springer. 311–332.
- [7] Gallery, K. A. 2018. Journey of a pod.
- [8] Giddens, A. 1984. The constitution of society: Outline of the structuration theory. *Cambridge: Polity*.
- [9] Kagan, S. 2010. Cultures of sustainability and the aesthetics of the pattern that connects. *Futures* 42(10):1094–1101.
- [10] Kagan, S. 2014. *Art and sustainability: Connecting patterns for a culture of complexity*, volume 25. transcript Verlag.
- [11] Maturana, H. R., and Varela, F. J. 1980. Problems in the neurophysiology of cognition. In *Autopoiesis and cognition*. Springer. 41–47.
- [12] McCormack, J., and Dorin, A. 2001. Art, emergence and the computational sublime. In *Proceedings of Second Iteration: A Conference on Generative Systems in the Electronic Arts*. Melbourne: CEMA, 67–81.
- [13] Robinson, J., and Cole, R. J. 2015. Theoretical underpinnings of regenerative sustainability. *Building Research & Information* 43(2):133–143.
- [14] Rokeby, D. 1990. The harmonics of interaction. *Musicworks 46: Sound and Movement*.
- [15] Sam, M. 2008. *Okanagan water systems: an historical retrospect of control, domination and change*. Ph.D. Dissertation, University of British Columbia.
- [16] Talks, T. Sustainability: Are we the monsters?: John robinson at tedxstanleypark.
- [17] Welsby, C. 2011. Technology, nature, software and networks: Materializing the post-romantic landscape. *Leonardo* 44(2):101–106.