Biologically–Inspired Computing for the Arts: Scientific Data through Graphics

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Biologically-inspired computing for the arts: scientific data through graphics / Anna Ursyn, Editor.

Summary: "This book comprises a collection of authors’ individual approaches to the relationship between nature, science, and art created with the use of computers, discussing issues related to the use of visual language in communication about biologically-inspired scientific data, visual literacy in science, and application of practitioner’s approach”--Provided by publisher.


Library of Congress Cataloging-in-Publication Data
Biologically-inspired computing for the arts: scientific data through graphics / Anna Ursyn, Editor.
   p. cm.
   Includes bibliographical references and index.
   Summary: “This book comprises a collection of authors’ individual approaches to the relationship between nature, science, and art created with the use of computers, discussing issues related to the use of visual language in communication about biologically-inspired scientific data, visual literacy in science, and application of practitioner’s approach”--Provided by publisher.
   Q222.B56 2012
   006.6--dc23
   2011049596

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.
Chapter 6
Sustainable Cinema:
The Moving Image and the Forces of Nature

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ABSTRACT
While nature has often inspired art, a subset of artists has given the natural world an even more influential role in the outcome of their work. These artists have harnessed the physics, biology, and ecology of the natural environment as artistic tools and have used natural phenomena as a co-creator in the realization of their work. This use of natural force impacting the actual form of an artwork has also been explored in the kinetic and moving image arts. As one of several artists now working in sustainable energy, the author of this chapter has created a series of kinetic public sculptures that use natural power sources to create the moving image. These sculptures will be presented here as a case study for a larger perspective on the continuing relationship between the forces of nature and the materials of the moving image.

INTRODUCTION
The organic origins in art forms like painting and sculpture are easily recognized when one considers the ancient mixing of colored pigments found in nature, and the wood and stone chiseled by early sculptors. Musical forms, drawing and theatre share this foundation as many of their first materials came from plants and animals. The moving image, including the mediated versions of cinema and computer forms, also has traceable roots in the natural environment yet in a less obvious and inimitable way. Through tools and materials alone, nature has directly affected the outcome of nearly all creative expression.

Kinetic sculpture is a time-based, often narrative art form and its “moving image” is its changing shape, dimension, light, materiality, site, etc. As art forms that can be watched over time, cinema and kinetic sculpture share a unique perceptual connection. In addition, while all art forms reflect the society of their times, both the picture and the sculptural versions of the moving image are often used to directly comment on their context.
and physical presence. More than many other types of artistic expression, it seems cinema and moving three-dimensional art are by design highly self-aware of their contexts. Because of this, when one considers society’s changing views on nature over the past two hundred years, a thread of artworks becomes evident that shares and envisions those views.

This chapter presents a series of my sculptures that use natural power to generate the moving image. As background to these artworks, I will look at society’s changing relationship with forces in nature and how other artists have mirrored those relationships. These artists embraced the natural and organic beginnings of their mediums and allowed natural energy to write upon their works as a co-author. When placed parallel with the evolving global perspectives on the natural environment, a relationship emerges that creates a deeper context for the artworks and a clearer understanding of cultural views on nature.

BACKGROUND

Physics, biology, ecology and now sustainable design have all played into the moving image evolution. The optical illusions and electricity that led to the birth of the mediated moving image were seen as natural phenomena harnessed or recreated by man. Shadows plays, one of the earliest media presentation systems, were made from biological skins and fibers, and early moving images were often spoken of as being infused with a living force. The first screens were silk, celluloid itself was made from plants and animals. In the last mid-century, sculpture began to reflect and use the concepts of ecology that were emerging in society at the time by using natural systems integrally in their time-based, environmentally-conscious artworks.

Over the past two centuries, we have greatly advanced our comprehension of physics, biology and ecosystems. Now we hope use the forces found nature in ways that do not diminish them yet still benefit us. Once again the moving image
Sustainable Cinema will likely reflect society’s views on the environment, but this time with an emphasis on sustainability. The winds that blew Calder’s mobiles and changed their sculptural form are once again being considered as both a power source and a creative strategy. However, artists now are not limited to the direct elements of wind, water, light, and fire. Emerging sensing technologies are providing data that is being used to visualize hidden natural forces – and poetry – that we never knew was in the landscape around us.

Natural Phenomena: The Moving Image and Physics

For centuries, civilizations have looked at the stars and ascribed characters, connections and stories to them. These myths and narratives were not groundless flights of imagination, but a complex merging of science, art, and culture. Nearly every civilization has considered nature as a proactive character integrated into a complex pattern of belief. More than just giving human characteristics to natural phenomena, it is the recognition of both force and intent in the environment.

Early moving image media had their origins in scientific experimentation in physics. Early optics was viewed as occurring outside of the body, images were ‘projected’ onto our eyes by invisible natural phenomena. Optics follows a heritage spanning Aristotle, Bacon and Da Vinci that involved research in light, lenses, shadow and reflection. Combining these elements into the principles of mediated projection appeared as early as Ars Magna Lucis et Umbrae written by Athanasius Kircher in 1645 (Gorman, 2001). The scholar explored the creation of images by sunlight, mirrors and lenticular lenses and his catotrophic lamp made advances in the emerging technology of magic lanterns.

In her book on 19th century electric communications, Caroline Marvin (1998, p. 120) explains that electricity was first thought of as “the production of lightning,” a creation of an anti-nature that caused consternation in a divided society. Nature was viewed as in battle with man-made nature and would proactively respond. “Recurring in all these expressions of popular concern was the fear that man was throwing nature wildly out of balance in his manufacture of electricity, and that nature would sooner or later redress that balance” (Marvin, p. 121).

When wireless technologies were first introduced, nature was considered a conduit. The popular idea in 19th century physics was that a natural ‘luminiferous aether’ served as a ubiquitous but invisible transmitter of electricity and communication waves through space. The metaphors that helped society understand the emerging technologies were often tied to a proactive, engaged nature. “Not only did the metaphor of the ‘etheric ocean’ encourage the idea that one could become ‘lost at sea,’ but it also implied that, as with oceans of the earth, unknown creatures might stalk this electronic sea’s invisible depths” (Sconce, 2000, p. 69).

Several artists explored physics as a force to affect the moving image. In 1976, Mary Lucier (1975/1993) allowed for direct environmental impact when she created “Dawn Burn” by aiming a camera at the morning sun as it rose. Slowly, the direct sunlight damaged the camera’s tube, leaving a dark, arcing scar on the video image. Her video’s confrontational face-off with natural force and its eventual pounding into submission is still one of the most poignant examples of the moving image being directly modified by nature at the behest of the artist. As part of an installation that included video, Doug Hall’s (2009) “The Terrible Uncertainty of the Thing Described” makes a direct association between nature and technology by using a Tesla coil to transmit huge electrical bursts between two steel chairs. “Inspired by ideas related to the sublime, the video shows scenes of intense weather...which it compares to extreme technological and industrial situations that replicate, or are modeled after, natural phenomena” (Hall, 2009).
Natural Processes: The Moving Image and Biology

As mentioned earlier, biological materials and early moving image systems have been intertwined through design for centuries. In a sense, Plato’s cave was an organic system – the wood fire, the silhouettes. Dried translucent animal skins and local woods were used in the shadow puppet plays of Asia (Groenendael, 1987). In the early days of the cinema industry, the name ‘silver screen’ came from the embedding of silver into woven silk. As mobile media evolves today, media archeologists are also considering 18th century formal garden designs, framed panoramas explored by strolling, as part of moving image history.

The biological ancestry of moving image materials did not end as distantly as one would expect. Celluloid resulted from the mix of natural and organic materials. The Book of Film Care (Gordon, 1983), a publication by Kodak, boasted that their film was ‘animal, vegetable, and mineral’ – bragging how all the materials used to make the celluloid of the movie industry came from the natural world. It is easy to forget that the first century of cinema was completely founded on a stock made from wood pulp and a coating of boiled cattle bones and cartilage.

Several artists and filmmakers have acknowledged the forces of biology in their work through direct application of natural materials onto the film stock. Both the Structuralists and the Expanded Cinema movement explored this relationship. In 1966, George Landow embraced the dirt that appeared on the material in his “Film in Which there Appear Sprocket Holes, Edge Lettering, Dirt Particles, Etc.” and Nam June Paik’s “Zen for Film” (1962-1964) was one hour of dust particles on unprocessed celluloid. However, the most direct application of nature onto the materials of the medium is likely Stan Brakhage’s (1963) experimental silent film “Mothlight.” A film with no camera, he pressed moth wings, flower petals and blades of grass between two sheets of mylar. Both a lyrical and literal imprinting of nature onto the moving image, Brakhage successfully invented a new film process that used “real world elements” (Elder, 1998, p. 389).

One of the most striking uses of biology directly influencing the materials of cinema is Australia’s Bio-Kino project that produced a collection of screen/organism hybrids. “The Living Screen” 2005, is a series of screens grown or scavenged from living organisms including skin tissue and blood, sperm, or cornea cells. As the specially made ‘nano-movies’ (only 25 microns in size and shown through a modified microscope) are projected onto the living screens, the surfaces change, respond, and die. The artists explain that “in overlaying digital pixels over biological pixels we intend to explore the tension between the inanimate and the animate and the digital versus the biological” (BioKino, 2011).

Natural Systems: The Moving Image and Ecology

Although not considered moving image artworks per se, the Land Art sculptures of the 1960’s and 1970’s were often both programmatic and time-based. As temporal forms that changed ‘image’ as part of their design, they can be included in discussions here. Robert Smithson’s (1995-2011) “Spiral Jetty,” 1970 has ominously, grandly re-surfaced in the Great Salt Lake, once again changing color, form, aesthetic, and meaning. “Spiral Jetty” is becoming one of the century’s great artistic narratives. In a broad sense, Earthworks (and later Environmental Art) were moving images in that each work had its own lifespan and presented itself to a viewer in stages. Sculptor Robert Morris explained, “What art now has in its hands is mutable stuff which need not arrive at a point of being finalized with respect to time or space. The notion that work is an irreversible process ending in a static icon-object no longer has much relevance” (Morris, 1969/1998, p. 231).
The emphasis on time and process was directly tied to dynamics in the environment for these artists. The sculptures were interactive through contextuality—the artist interacted with the landscape, the user interacted with the artwork as a space, the environment interacted with the work by actively changing its form. It was “a programmatic approach to the work and advocates sculpture which experiences, reacts to its environment, changes, is non-stable... art is gradually entering into a more significant relationship with the viewer and the component parts of his environment” (Sharp, 1970/1998, p. 200). Nature was chisel, paintbrush, pen.

“During the period, many artists worked with natural materials, often fascinated by their evolution and their organic decomposition. To better observe this process, the artist became almost a laboratory assistant, engaging in artistic experiences” (Tiberghien, 1993/1996, p. 14). Robert Smithson wrote, “by excluding technological processes from the making of art, we began to discover other processes of a more fundamental order” (Smithson, 1968/1998, p. 213).

A curator familiar with kinetic art, Guy Brett explains that art began to open up in the 1960’s and allow for a greater direct impact of nature on the form and narrative of an artwork. “We begin to see that ‘natural phenomenon’ and ‘aesthetic decision’ were at this time in a shifting and reciprocal relationship to one another. The working-out of natural processes was allowed to change the conception of the beautiful; artists ceded their ‘will to form’ to certain degrees and in certain ways, and allowed natural events to prevail, which was seen as an emancipatory process, and to offer deeper insight into reality” (Brett, 2000, p. 31).

Many examples of artworks partially controlled by eco-systems surfaced in this period—each containing a very direct environmental agency with the sculpture. Some were created to specifically react to natural systems, for example Hans Haacke’s “Fog, Flooding, Erosion” (1969) and Robert Smithson’s “Asphalt Rundown” (1969). Others mimicked natural systems. Haacke’s “Rhine Water Purification Plant” (1972) paired an artificial ecosystem with an endangered one, Agnes Denes harvested wheat in lower Manhattan (‘Wheatfield: A Confrontation,” 1982), Helen and Newton Harrison researched land use and ecosystems (“The Lagoon Cycle,” 1972-1982), and Mel Chin used plants as remediation tools (“Revival Field,” 1990-present). As Don Krug explained, “the artists are doing cultural work, through art, in relation to the systemic characteristics of human, plant, and animal interactions within particular geographic locations” (Krug, 2011). Artist and nature had joined forces to create temporal, changing image sculptures.

**Natural Forces: The Moving Image and Sustainable Energy**

If ecology was the recognition of the relational systems in nature and their fragility, sustainability is partially how those systems can healthily survive and endure without diminishing over time, in a sense, empowering natural systems. The Earthworks emphasis on complex organic and natural relations has shifted towards an emphasis how an environment can keep those relations running through its own natural forces and our respectful interaction. Sustainable design often includes a direct agency with environmental forces—wind power, water currents, sunlight, etc.

These sustainable forces of nature being used as a formal property in art making has some precedent in art history. If nature is perceived as an energy force, artists have used it to power kinesis in their work. Alexander Calder’s mobiles alluded to the movements of nature—leaves rustling, insects and birds fluttering—but also used those forces to change their form. When describing his early mobiles, Calder wrote, “I have made a number of things for the open air: all of them react to the wind, and are like a sailing vessel in that they
react best to one kind of breeze” (Calder, 1937). His simple description of his mobiles conceals their revolutionary break from sculptural traditions. “He introduced an intricate dynamic of dispersed and reciprocal forces that took the notion of sculptural mass beyond the uni-directional force of gravity, and he opened it up to outside influences” (Brett, 2000, p. 15). This direct impact of wind on sculpture continues today with the kinetic works of Theo Jansen (Frazier, 2011), whose wind-powered skeletal ‘strandbeests’ lope across the Dutch beaches.

The mutating form of kinetic art and sculpture ties directly to energy. In the *Artforum* review of “Force Fields: Phases of the Kinetic,” an exhibition of kinetic art in Barcelona, Yve-Alain Bois (2000) emphasized curator Guy Brett’s interest in the natural power sources inherent in the works:

It should be noted here that what’s at stake for Brett is less “movement” per se than “energy”--the specific desire of a tremendous number of artists in the twentieth century to materialize energy, to give form to something that is eminently nonvisual. Movement, in this account, is only one of several formal possibilities in this quest, but a particularly efficient solution; no matter how concrete, movement can always be expressed as an equation, like energy itself. The qualities that define movement (slow/fast; continuous/discontinuous; regular/irregular; accelerating/decelerating; etc.) are shared by every object or being that produces and expends energy. This very universality, which is an abstract quality, makes of movement an ideal metaphoric switchboard: Every work exhibited in “Force Fields” alludes to either the organic, the mechanic, or the cosmic--in all cases concepts of energy that we, as human beings, have learned to apply in our daily life without a second thought (Bois, 2000).

A year earlier, a 1999 exhibition at the Hudson River Museum called *Drip, Blow, Burn: Forces of Nature in Contemporary Art* presented artworks that used wind, water, and fire as integral components to shape the materials of the artworks. The artists employed these elements as power to animate, alter, or destroy their creations. The curator, Thomas Weaver (1999) observed how using natural process as a material in art allows for a unique dual transformation:

*It manipulates structures of mediation and representation, and shifts the viewer’s awareness of nature, space, time, and movement. This dual process is reciprocal, with modes of signification affecting referents and referents affecting modes of representation...The natural here is not just a subject, and certainly not just a material...moving natural elements are primal elements that, by rupturing the boundaries that govern the significations of visual art, embody the power of art to wrestle with the world* (Weaver, 1999, p. 24).

**SUSTAINABLE CINEMA: CREATING THE MOVING IMAGE WITH NATURAL POWER**

I am working with natural energy in my own artworks. Sustainable Cinema is a series of kinetic public sculptures I am fabricating that harness natural forces in the environment to power a perceptual illusion of a moving image. Large-scale and made from steel or wood, the artworks reference early optical illusion toys that were part of the history of cinema as well as early energy sources that are now experiencing a revival. By examining the concurrent histories of film and industrialization, they are meant to trigger consideration of environmentally sustainable media. In many respects, sustainable energy is a re-imagining of the oldest energy forms like wind and water and these sculptures do the same with the moving image.

**Mediated Earthworks**

Natural energies are often invisible, often indiscernible. To be able to read and design artworks that utilize the environment’s invisible dynamics,
computational sensing technologies come into play. Sensing allows for a new form of interplay with nature. As changes in motion, light, sound, and temperature can now be measured with great computational detail, our modern surveillance technologies are no longer dedicated to watching people—they are now reading the environment as well and offering unique information about the shifts and patterns in our world. Hewlett-Packard’s “Central Nervous System for the Earth” is a corporate initiative to deploy a trillion sensors into the natural and built environments (Sutter, 2011). A global swarm of miniature wireless devices would observe ecological systems, seismic vibration, natural energy activity, etc. Computers are about to take over the role as explorer and revealer of essential truths in our world.

I’ve experimented with this type of sensor-driven environmental agency in two cinema projects. “Brakelights” (2004) is a real-time computer system that uses changing color information in the environment by reading the RGB levels of every pixel in every frame coming into a camera. The program analyzes the color levels and then selects elements from a visual database, in this case two hundred pre-shot scenes between man and woman delineated into five distinct emotions. When the camera was placed on a Los Angeles traffic jam at night, the red brakelights controlled the narrative. When traffic jammed, the red became brighter, the system pulled shots from the ‘anger’ database, the couple fought; when traffic flowed, fewer red brakelights, they spoke of their love. Designed as a live cinema-making machine, the artwork makes a film that is directed by the environment. The ebb and flow of my daily traffic jam, something I did not even realize had existed, became a powerful narrative generator. While I used a completely non-natural phenomenon in this piece, automobile brakelights, the system was originally designed to read color changes in nature like clouds in the sky or the wind on leaves.

2005’s “Mulholland Drive” was a mediated earthwork I created with programming by Michael Chu and sound design by Martin Bonadeo. Together, we drove the length of Los Angeles’ famous Mulholland Drive with five types of sensors—computationally measuring the tilt, direction, altitude, speed and engine sound of the car. The precise captured data was then used to create an exact 3-D path in a computer, duplicating every curve and pothole of the journey. That computer path was then used to control two robotic lights in a dark room filled with fog. Two beams of light and the processed sound of the engine recreated the journey of driving the road. The road’s topography creates a new form of visual experience and sculpture. In a sense, the artwork is cinema without an image.

**Media Archeology**

While this paper focuses on natural environmental agency, my sculptures cannot be separated from their debt to media archeology and the popular 19th century optical toys. I am one of several artists who are currently exploring this history in their new media art practice. In a forthcoming paper, media archeologist and scholar Erkki Huhtamo considers the trend:

*There seems to be a parallel between the emergence of the archeological art and some changes taking place in the cultural and intellectual ambience. The general framework seems to be the gradual displacement of the 1980’s postmodernist discourse in favour of an approach which once again seeks foothold in “real” space and time….I see the activity of this gaze as an attempt to go beyond postmodernism, to initiate a dialogue with the past with the aim of countering the constant blurring of boundaries and definitions which is characteristic of the “postmodern condition” and largely a product of the spreading of audiovisuality (Huhtamo, in press).*
In many ways postmodernism has muddied the waters. By mixing everything and anything, we may have created some unnecessary complication and possibly lost touch with the purity of the individual elements. The simplicity of these sculptures in creating a moving image offers a glimpse into the mystery of cinema; they are simple illusions made with simple energy. By doing this, I hope to initiate a conversation about our distancing from the sources of power, both literal and sociological, in our world. They are meant to be a primal media experience; in the age of rapid technological development, this is no longer an oxymoron. This theme of demystifying invisible power has surfaced in several of my works, notably the dome visualizations I created of the increasingly dense aerial technologies above us in my planetarium artwork “Celestial Mechanics” (2005).

Referencing the early optical toys served another purpose. Their inherent interactivity, a dialogue between man and illusion machine, were part of a historical trajectory of recognizing that systems could be art. Duchamp made it official, but the distancing from a static art object had begun. In media, we watch machines to watch the moving images. The Sustainable Cinema sculptures are meant to simultaneously create and break the illusion by revealing the machinery of cinema. The tools of the mediated moving image are inherent in the sculptures’ materiality, and because of this, the images shown in them serve a dual purpose of proscenium art and abstraction of the machines’ own narrative.

Using natural energy to power these cinema-generating machines adds an additional layer of meaning to the sculptures. These hulking steel artworks are not powered conventionally. We have come to equate media with electricity and by changing the source of power in creating the moving image, the sculptures very clearly capture the energy of the earth. The animations seem to be part of a life force continuum. They are animated in the mediated sense, but also animated in a way associated with living nature. We see a

*Figure 2. Scott Hessels, “The Image Mill” during ArtPrize, Gerald R. Ford Presidential Museum, Grand Rapids, Michigan. (© 2009, Scott Hessels. Used with permission).*
Sustainable Cinema

natural energy captured by a machine, injected into a representation, and come alive.

**Sustainable Cinema No. 1: The Image Mill**

The first completed sculpture was installed at The Gerald R. Ford Presidential Museum in Grand Rapids, Michigan in 2009. “The Image Mill” is a rotating steel machine that uses the force and beauty of falling water as the energy to create a moving picture. As water falls over the 4-meter-tall wheel, a transmission assembly causes two disks to spin in opposite directions. On the interior wheel are a series of animation frames painted onto plexiglass; on the black outside wheel, rotating in the opposite direction, are cut slits. As the two wheels spin, the slits act as a shutter and the animation becomes visible; a movie plays in the falling water.

The site of the work in the heart of America’s ‘rust belt’ determined the content for the sculpture. One of the first movies created was a galloping horse and this sculpture also uses it as a metaphor for the struggling Michigan automobile industry; the animation is part Muybridge, part Ford Mustang. As the waterwheel spins, the pony stumbles, but continues on. This 32-frame narrative suggests that the ‘horsepower’ that drove the state’s industrial age is at a transition to a new age of alternative energy. This theme was also revealed in the fabrication. Made by Michigan metal workers, the artwork was meant to be an optimistic hope that the skills of industrial-era tradesmen could be tapped as a valuable resource now that the region is considering new sustainable directions.

*Figure 3. Scott Hessels, Design rendering of “Rickshaw Cinema” (© 2010, Scott Hessels. Used with permission).*
Sustainable Cinema No. 2: Rickshaw Cinema

Although not an energy source created by the natural environment, pedal power is often considered in sustainable design. The recycling and redesign of bicycles to build simple systems to help facilitate the work of small-scale, self-sustaining projects is receiving global attention. This sculpture explores regional bicycle traditions as a starting point for a greener future.

The crudely chopped bikes seen throughout Southeast Asia combine found metals, recycled wood, concrete and other cheap materials to create a hybrid ‘hack’ that assists a struggling family to better their lives. Inspired by this heritage, this sculpture is a mechanically re-engineered regional bicycle. In the artwork, the pedals both generate the electricity and advance the celluloid film to project a film on a coarsely made screen that folds up in front of the handlebars. The sculpture references the vernacular of Asian mobile small-scale businesses to celebrate the folk beauty, ingenuity and compelling history of these machines.

Sustainable Cinema No. 3: The Praxinoscope Windmill

The third sculpture uses mirrors similar to the design of another early animation device called a Praxinoscope. A windmill at the top turns a gear system that powers the spinning of a beveled, diamond-shaped mirror at the base that reflects two disks of animation frames rotating directly above and below it. Using wind as the energy and...
a tower structure that references futuristic 19th century innovation and design (the Praxinoscope and the Eiffel Tower occurred at nearly the same time in history), the simple animation is completely controlled by the speed and direction of the wind.

**Sustainable Cinema No. 4: Shadow Play Windmill**

In this wind-powered shadow puppet show, the silhouettes are also achieved by light penetrating a translucent screen. The rotation of the windmill powers the backlight for the shadows as well as turns a series of gears and plates that animate the puppets and move a background diorama. Unlike the other sculptures which function as ‘players’ for animation content that can be easily changed, “Shadow Play” required the content to be created in tandem with the overall design. Instead of a machine that plays an animation, this sculpture is an animation that determines the structural design of the machine.

**Sustainable Cinema No. 5: The Phenakistoscope Windmill**

Figure 6. Scott Hessels, Model of “Phenakistoscope Windmill.” (© 2010, Scott Hessels. Used with permission).

As with the “Image Mill”, the phenakistoscope was the foundation for the fifth sculpture. This windmill uses a dual-blade system where one fan acts as a shutter by overlapping another fan that contains the animation frames. In this artwork, the front windmill fan is black, the rear contains fifteen frames of animation. As the wind spins the two blades, the moving image is visible in the intersection of the two fans.

**CONCLUSION**

The history of the moving image has rode astride culture’s views of nature. Society’s perceptions of physics, biology, ecology and sustainability have all surfaced in artworks and media theory over the past two centuries. We’ve journeyed from phenomena to organism to system to force. In each case, the direct integration of the natural environment into an artwork has generated a reconsideration of both nature and culture. With the Sustainable Cinema series of sculptures, natural and sustainable energy is used in a visible, understandable and startling way, to generate the moving image. As with other artists who have worked with natural forces, I hope these works will lead to enduring conversations about the environment.

**REFERENCES**


**ADDITIONAL READING**


KEY TERMS AND DEFINITIONS

**Biology:** Broadly, the branch of natural sciences that includes living organisms, used here interchangeably with ‘organic’ (Audesirk, Audesirk, & Byers, 2010).

**Earthworks:** Although usually used interchangeably with Land Art and Environmental Art, the phrase coined by Robert Smithson is usually applied to artworks that involved a sculptural gesture that involved direct manipulation of the soil and terrain (Boettger, 2002).

**Environmental Art:** Also used interchangeably with Land Art and Earthworks, this term appeared later and includes work that is usually more direct in its support of eco-friendly practices. Many of the Land Art works were systems that mimicked natural processes and Environmental Art became the term that encompassed a type of ‘stewardship’ towards the earth that many of these artists supported (Kastner, 1998).

**Kinetic Art:** Artworks, usually three-dimensional sculptures, that use real movement. Often powered by motors, environmental forces (e.g. wind) or human interactivity (Popper, 1968).

**Land Art:** Also used interchangeably with Earthworks and Environmental Art, it often includes a broader range of sculptures beyond the soil-specific pieces associated with Earthworks. Here, the sites, materials and gestures are more diverse yet still include physical (and usually non-representational) interactions with the natural environment (Tufnell, 2006).

**Luminiferous Aether:** One of several ‘ethers’ that were falsely considered as mediums for a wide range of movement in space; a way to explain the invisible including conduits for magnetics, planetary movement, and electricity (Hecht, 1987).

**Optics:** A branch of physics that studies the properties of light and vision, as well as other radiations that cannot be seen by man (Freeman, 1990).

**Phenakistoscope:** A 19th century optical illusion toy that simulated movement through the use of two disks—one with slits, the other with frames of animation. When spun in different directions, the illusion of movement appears, usually presented in a rotating mirror (“Phenakistoscope”, 2011).

**Physics:** The study of natural phenomena and the patterns and principles found there; the search for fundamental properties in physical phenomena (Wilson, 1977).

**Praxinoscope:** Another 19th century animation device where a strip of animation cells is reflected off a rotating ring of beveled mirrors creating the illusion of movement (Greenslade, 2011).

**Rickshaw:** Invented in Japan in 1869, the man-powered carriage quickly spread throughout Asia in a variety of forms well into the 20th century. Today, they exist as transportation novelties but have influenced a mobile culture where bicycles are converted into shops, entertainment, and a host of other functions (Warren, 2003).

**Shadow Play:** One of the oldest art forms and possibly the first moving image system, several ancient cultures developed variations of presenting cut, usually flat characters made from woods or skins against a cloth or hide screen, backlit by fire, oil or kerosene lamps to create the shadows. The players usually performed dual roles, moving the puppets and vocalizing the dialogue and effects (Tilakasiri, 1968).

**Sustainability:** Sustainability is the ability to endure and has been applied to a wide range of fields. It is used here more specifically as the potential of a biological system or ecosystem to subsist and remain productive over time (Riboratti 1999).
**Sustainable Design:** Although first used in connection with architecture (notable ‘green’ buildings), the definition can now include several other design fields that involve fabrication. The approach attempts to use resources fairly and efficiently so that substances from the earth do not increase in the ecosphere (*e.g.* oil, coal), substances made by man do not increase in the ecosphere, and the productivity and diversity of nature is not be systematically diminished (Robert, K.H., Daly, H., Hawken, P., Holmberg, J., 1996).

**Sustainable Development:** Although the term is also applied to a wide range of beliefs and approaches, it is used here in a multidimensional point of view, beginning with ecosystem integrity. From there it recognizes that human society and economics are closely tied and cannot grow faster than the consumption of the resources (Ratner, 2004).