From Atoms to Islands: Radiation Ecologies

Elizabeth DeLoughrey

Working draft

The Age of Ecology began on the desert outside Alamogordo, New Mexico on July 16, 1945, with a dazzling fireball of light and a swelling mushroom cloud of radioactive gases.
-Donald Worster, *Nature's Economy* (339)

While many scholars have explored the rise of ecological thought, few have traced the close relationship between the rise of the Age of Ecology and the Atomic Age, the mutually constitutive relationship between radioactive militarism and the study of the environment. Donald Worster's foundational book *Nature's Economy* suggests that nuclear weapon fallout catalyzed public consciousness about the pollution of the global environment.[1] In fact some have argued that the concept of globalism itself derives from the environmental consciousness created by radioactive fallout. [2] Worster's history of environmentalism gives us a vital starting point for assessing the paradox of how Cold War science was utilized to both destroy and conserve nature. Here I would like to delve deeper by examining how American ecosystem ecology, one of the most influential models of environmental thinking in history, was created by scientists funded by the Atomic Energy Commission, particularly in its surveys of the radioactive aftermath of its Pacific Island nuclear tests. Thus the ecosystem paradigm relies on the idea of a closed system, a concept that was constituted by the island laboratory and the irradiated—or pulverized-- atoll.

In 1947, David Lilienthal, head of the Atomic Energy Commission, declared that "The atom is center of reality at council tables… all over the world. No nation in the world can make decisions these days without thinking of the atom."[3] While a mere five atomic weapons had been detonated on earth by then, new uses of the atom were creating dramatic political, scientific, and environmental changes. Since the end of World War I nuclear physics grew exponentially; by the 1940s the field was being cultivated by the enormous budgets of the Manhattan Project (1942-46) and the Atomic Energy Commission (1946-74). Although it is not often recognized, these political shifts made a remarkable impact on studies of the environment, a field that was initially considered a "soft" science consisting of "butterfly chasers" (Bocking, 2004, 18) until it began to engage with a "big science" like physics. While nuclear physicists focus on the subatomic world, and ecologists privilege observable matter, the 20th-century crisis of nuclear fallout brought these disparate fields together. This is remarkable because the new field of quantum physics

determined that the subatomic world was not legible if one used the models and laws of classical matter. So while an emergent quantum physics was breaking away from its roots in natural history (we might remember the term *physis* means nature), ecologists sought to bring the fields together by using two key concepts: the island isolate and the flow of energy.

The concept of the island or isolate was vital to ecosystem ecology from the very beginning. In popularizing the new term "ecosystem" in 1935, the botanist Alfred George Tansley drew from the field of physics to describe the relationship between organisms and their habitat, arguing that one might conceptually isolate ecosystems as a model to study "the universe as a whole down to the atom" (2000, 64). He explained, "The point is to isolate ecosystems mentally for the purposes of study so that the series of *isolates* we make become the actual objects of our study, whether the isolate be a solar system, a planet…or an atom. The isolation is partially artificial, but it is the only possible way we can proceed" (64). Key to this new conceptual rubric was the theme of isolation, a model that reenergized the longstanding colonial understanding of the island as a laboratory. Tansley's invocation of atomic physics as a model for ecology was prescient; in less than twenty years the American militarization of science would usher in a new era of ecology modeled on isolated landscapes permeated with nuclear radiation.

I. Ecosystem Ecology

The theoretical connections made between physics and ecology were largely attributed to AEC-funded research during the Cold War. Joel Hagen has traced out what he calls the "symbiosis…between atomic energy and ecosystem ecology," particularly as it was organized by brothers Eugene and Tom Odum, the field's "founding father(s)" (1992, 101). It's important to note, as Stephen Bocking does, that it was not the AEC that pioneered this concern with ecology but rather public pressure on the agency to clean up their nuclear waste and particular AEC-funded scientists that shifted attention to radiation ecology. Atmospheric levels of military radiation (fallout) were alarming the public to such an extent that the field of "Health Physics" was created to determine the impact on human bodies (Bocking, 1995, 4), and secret AEC projects such as Operation Sunshine were established to collect cadavers around the world to measure radioactive traces in bone and tissue. The AEC was notoriously resistant to publically admitting any danger from nuclear tests—in fact the military head of the Manhattan Project, Lieutenant General Leslie Groves, lied to a Special Senate Committee on Atomic Energy in

1945, testifying in the wake of the radiation deaths of Nagasaki and Hiroshima that "they say it is a very pleasant way to die" (qtd in Welsome, 1999, 118). This was counter to the ample evidence of gruesome radiation deaths from the radium dial painters of the 1920s, nuclear accidents in AEC laboratories, and the military's study of post-atomic casualties in Japan. Although the AEC's stance was to publically deny any human or environmental impact from the nuclear tests, as early as 1952, two years before the first thermonuclear weapon, the head of Brookhaven Laboratory's Health Physics Division admitted that "the days of undisturbed natural background (radiation) are gone perhaps forever, as a result of the continuing detonations of atomic bombs" (Cowan, 1952, 14).

With the rapid expansion of nuclear testing in the Cold War and the subsequent radiological contamination of the planet, the AEC contracted a number of biologists to study the radioactive fallout from the newly acquired American territories in the Marshall Islands (Micronesia).[4] Annexed under the unprecedented concept of the "Trust Territory" (Article 82 under the UN Charter), Micronesia became a U.S. nuclear colony under President Truman's doctrine of oceanic colonialism. In claiming Micronesia and expanding the U.S. EEZ, Truman tripled the territorial size of the United States.[5] Although the land-base of the islands of Micronesia represented only 846 square miles, the oceanic territory, vital to both naval and airforce transit, represented three million square miles (Margolis 630). By 1946, the AEC began relocating islanders in order to detonate atomic and hydrogen weapons in the atolls, turning the Marshall Islands into a "Proving Ground." By 1954 the AEC had cordoned off an enormous area of the Pacific, banning the passage of ships or planes for 400,000 square miles (Margolis 631). This was in direct contradiction to the Freedom of the Seas, which ensured unrestricted international access for navigation, fisheries, submarine cables, and flight above the high seas (Margolis 634).

Tom and Eugene Odum were sent to Enewetak Atoll in 1955, and thus the field of what they termed "radiation ecology" began in the Pacific with their study of a chain of islands that functioned, literally, as an AEC laboratory for nearly fifty nuclear weapons tests between 1948 to 1958. So irradiated was the marine life in Bikini Atoll that the fish produced auto-radiographs; impressing their own images onto photographic plates and film (Boyer, 1994 92). By the time the Odums arrived for their 6-week study, eighteen nuclear weapons had been detonated at Enewetak and Bikini Atolls. This began with Operation Crossroads, tests *Able* and *Baker* at

Bikini Atoll in 1946. These tests so irradiated the islands that the Bikinians, originally asked to vacate for a few weeks, are permanently displaced from their homeland. The extensive radioactive fallout from the *Baker* shot became a scandal and caused President Truman to cancel the third test of the operation. According to Paul Boyer, "it was Bikini, rather than Hiroshima and Nagasaki, which first brought the issue of radioactivity compellingly to the nation's consciousness" (90).[6] Operation Sandstone was staged in 1948 and Operation Greenhouse, a series of four nuclear explosions, was executed in 1951. The name of this particular operation overtly labeled the islands as a contained ecological space, a "greenhouse" for experiments in nature/physics; although surveillance photos of the period demonstrate that the islands are paved over for military transport and are anything but green.

The Odums arrived shortly after Operation Ivy (another naturalizing "green" title), a test known for the world's first thermonuclear (hydrogen weapon) explosion called *Mike*, a 12-megaton device that produced a mushroom cloud 25 miles high and 100 miles wide. *Mike* blew the island of Elugelab out of existence, leaving a 6,200 foot wide crater, giving new meaning to the term (ground) "zero island." In the words of the AEC film *Operation Ivy*, "in the early months, Elugelab was just another small naked island of the atoll but by midsummer, it began to look like the thing it was selected for, a shot island." As such, the repeated production of island craters suggests the AEC's nuclear testing program was dependent on an island laboratory that then became its opposite—in the words of E.B. White in the *New Yorker*, the "laboratory was a paradise" and they conducted "an experiment in befouling the laboratory itself" (qtd in Boyer, 1994, 91). The visibility of the tests was vital to U.S. Cold War strategy, in which their spectacular effects were caught on film and then distributed widely. Yet audiences had to be created and coached as to how to witness a nuclear test, and to appreciate its production of a new sense of time and space, apparent in the AEC film *Operation Ivy*:

> "You have a grandstand seat here to one of the most momentous events of the history of science. In less than a minute, you will see the most powerful explosion ever witnessed by human eyes. The blast will come out of the horizon just about there, and this is the significance of the moment. This is the first full-scale test of a hydrogen device. If the reaction goes, we're in the thermonuclear era. For the sake of all of us, and for the sake of our country, I know that all of you join me in wishing this expedition well." (1952)

The most controversial test of all, the reason why the AEC started to increase its funding to field of radioecology, was Operation Castle, a series of 6 nuclear explosions at Enewetak and Bikini Atolls in 1954 that featured the notorious 15-megaton thermonuclear weapon *Bravo*, which left a crater (or "anti-island") 6,500 feet wide & 250 feet deep. Hydrogen weapons are some of the radioactively "dirtiest" of nuclear devices due to their outercasing of uranium-^{238}, which has a half-life of over two hundred thousand years (Stephenson and Weal 79, Jungk 1958, 310). *Bravo* covered the surrounding islands with radioactive strontium, cesium, and iodine, and became an ecological and political relations disaster. In addition to exposing a Japanese fishing vessel to lethal levels of radiation that killed its crew and created a transpacific ban on consuming fish, *Bravo*'s fallout exposed hundreds of Marshall Islanders to nuclear radiation, contributing to countless miscarriages, leukemia deaths, thyroid cancers, and the kind of chromosome damage which knows no temporal or genealogical limit. It covered the neighboring island of Rongelap with "radioactive snow" and permanently displaced its residents due to continuing lethal levels of cesium^{137}, even 40 years later.[7] The 1954 "Petition from the Marshallese People Concerning the Pacific Islands: Complaint Regarding Explosions of Lethal Weapons within Our Home Islands," an "urgent plea" to the U.N. to cease the tests due to extreme radiogenic illness and land displacement, went unheeded. In the clinical words of the AEC film *Operation Castle*: "These islands, functioning as *accidental total fallout collectors*, gave us our first real clues to the vast area affected by contamination from a high yield surface burst" (1954, my emphasis).

Estimated at one thousand times the force of the bombs dropped on Hiroshima and Nagasaki, *Bravo* has been called the worst radiological disaster in history. In addition to spreading lethal levels of radiation over 7,000 miles of the Pacific,[8] *Bravo*'s fallout was detected in the rain over Japan, in lubricating oil of Indian aircraft, in winds over Australia, and in the sky over the United States and Europe (Jungk, 1958, 310). It caused the radiogenic illness to the crew of a Japanese freighter 1,200 miles away (Margolis 637). Designed as a weapon of radiological warfare, *Bravo* catalyzed a worldwide outcry against the H-bomb and forced the AEC to more thoroughly assess the radiation impact of its weapons testing program (Kwa, 1993, 215). As such, the island became a world--the irradiated atoll, as and anti- or zero-island--became a catalyst and signifier for a global consciousness about our increasingly militarized environment.

Since tropical islands were already associated with the contained space of a laboratory, which is to say they were erased of history and indigenous presence, this generation of ecologists embraced nuclear testing as creating a "novel" opportunity to study a complete ecosystem through the trace of radiation. As the Odums remarked, "Since nuclear explosion tests are being conducted in the vicinity of these inherently stable reef communities, a unique opportunity is provided for critical assays of the effects of radiations due to fission products *on whole populations and entire ecological systems* in the field" (my emphasis, Odum and Odum, 1955, 291).[9] Although Enewetak and Bikini were already heavily irradiated, the Odums injected additional radioactive isotopes in order to study ecological metabolism. Although many have commented on the paradox of ecologists celebrating the opportunities provided by irradiated landscapes, Frank Benjamin Golley, one of Odum's colleagues, remarks that they all "seemed oblivious to the connection between ecosystem research and the military activity of the U.S." (1993, 105)

While AEC-funded ecologists were also studying the radioactive impact of non-island sites, such as nuclear power plants, nuclear dumps, and the impact of weapons tests in the continental U.S., I want to underline the importance of the island as a conceptual rubric and literal laboratory. Understood as a "landmark in ecological research" (Hagen, 1992, 105), the Odums' work on the irradiation of Enewetak's coral reefs provided ecologists with a model of a structured, self-regulating ecosystem (1955, 105) and the first theorization of shared resource relationships in nature which they termed "mutualism" (104). As such, "systems ecology" emerged from the field of "radiation ecology" (Kwa, 1993, 213). After his research at Enewetak and publishing work on the "strontium ecosystem," Tom Odum coordinated a research grant from the AEC to irradiate El Verde, a tropical rainforest in Puerto Rico, killing various plants, trees, animals and birds. Describing a project that irradiated the forest with cesium^{137} and strontium ^{85}, Odum, senior researcher at the University of Puerto Rico's AEC-run Nuclear Center, concluded the El Verde forest was an ideal "teaching laboratory" (Odum x). One of the major catalysts for the study was the discovery in 1962 of high fallout levels in the El Verde mountains from the atmospheric testing of nuclear weapons in the Pacific Islands (Odum 1970, C-17).

An American empire of islands, from the Pacific to the Caribbean, became vital spaces of military experimentation and the production of knowledges like ecosystem theory. The

militarization of the atom created the new availability of radioactive isotopes, allowing the Odums and their contemporaries to study nuclear fallout and waste sites as well as to introduce radioactive tracers into the environment to determine how energy was transformed in a contained system. By comparing Enewetak and Puerto Rico, Tom Odum hoped to use the concept of *energy* as a "universal principle" of any ecosystem (Taylor, 1998, 229). Thus we have a tension between the ways in which the island contains and concentrates space and the concept of energy which allows for mobility and transmission. Their support by the Atomic Energy Commission must be considered influential to their theories of both energy and space, particularly the islands that were subjected to extreme Cold War militarization. The enormous energy released by the splitting of the nucleus of an atom suddenly became a universal framework for understanding any isolated system. This model of how energy moves between elements of nature the Odums hoped would "revolutionize" ecology (Kwa, 1993, 213). Since to revolutionize is to break from institutional models rather than to assimilate them into a military state, one could not really say the Odums' work "revolutionized" ecology, but it certainly catalyzed remarkable institutional expansion. AEC-funded research laboratories and over fifty programs in radiation ecology (radioecology) were organized in universities and at nuclear power sites all over the United States, creating an "invisible college" (Golley, 1993, 74) and catapulting ecosystem ecology into a veritable institution (Hagen, 1992, 112).

From our contemporary viewpoint, the ecologists' obliviousness to the militarization of their research may seem incredulous. Yet this militarization of space also permeated in the grammar of ecosystem ecology. For instance, Eugene Odum's 1957 article, "Ecology and the Atomic Age," argued that "science advances on a *broad front*…It is analogous to the advance *of an army*; a breakthrough may occur anywhere, and when one does it will not *penetrate* far until the *whole front* moves up. Thus, ecologists need not feel bashful about *attacking ecosystems* so long as they observe the rules of good science" (my emphasis 28). Although Eugene Odum is considered an inspiration to the environmental movement because his theories integrated humans into natural systems (Kingsland, 2005, 185), his Cold War writing demonstrates the mutual permeability of the militarization of the island laboratory, science, and the language of ecosystems. In bracketing off ethics in this war for knowledge, Odum's model of the ecosystem positions laboratory space outside history and accountability, encouraging scientists to "attack" environments already devastated by nuclearization. This grammar of assault is possible because

of an American empire sustained by the concept of an isolated and ultimately disposable laboratory and its human subjects for experimentation.

II. The Laboratory

I'd like to turn more closely to how islands were conceived in order to tease out this relationship between the concept of the island laboratory and the ecosystem. Ecosystem ecology is modeled on the concept of a closed system, so it's not a coincidence that island colonies were chosen for nuclear tests and their radioactive surveys. While often deemed peripheral to modernity, we know that islands have in fact been at the center of the development of modern ecological thought. Richard Grove has demonstrated how tropical island colonies all over the globe served as vital laboratories and spaces of social, botanical, and industrial experiment in ways that informed 17th- and 18th-century modernity and the conservation movement. I would like to propose a similar relationship between the American island colonies of Micronesia and their constitution of both atomic modernity and the field of ecosystem ecology.

Just as the AEC manipulated landscapes in an era of what Ward Churchill calls "radioactive colonialism," the new field of ecosystem ecology emphasized the management of the environment in a way that could be extended to social relations. Thus the ecosystem is based on the concepts of the closed system, stabilization, and control. In the words of historian Gregg Mitman:

> "Ecology not only appropriated military funds, it also appropriated the cybernetics narrative that emerged from military research on aircraft-missile guidance systems. The ecosystem blurred the distinction between inorganic and organic by reducing everything to energy as the common denominator. Nature had become a system of components that could be managed, manipulated, and controlled." (1993, 209)

The conversion of populated islands into ahistorical laboratories of radiological experiment is particularly visible in AEC films of the 1950s, newsreels that were released to American audiences that utilized aerial surveillance as vital to the scientific and military control of the Marshall Island atolls. While some have argued that the expansion of the aerial view could lead to the blurring of the boundaries between nations, Gillian Beer points out that the aerial view of an island reinscribes the concept of boundedness, since "centrality is emphasized and the enclosure of land within surrounding shores is the controlling meaning" (265). In foregrounding

the importance of military aircraft, the 1948 AEC film *Special Delivery* glorifies the bombing of the Pacific Islands as a demonstration of air force flexibility and "peace power." It opens:

> "Special delivery, Army Air Forces-style, is designed for a particular function…During times of war, air power is war power: as destructive as is necessary to destroy the enemy. But Army Air Force planes large and small have more than destructive power: they have constructive power greatly beneficial to the nation. Thus in times of peace, air power is peace power."

In the film *Operation Greenhouse* (1951), the AEC employs an aerial view to juxtapose the modernity of American science—the master lab at Los Alamos-- against the purportedly ahistorical and depopulated Marshall Islands, which are viewed with detachment from a military plane. As such modernity is seen to be exported from the U.S. to "distant and primitive" yet vitally important "test islands…a giant lab in the middle of an ocean." To quote from this Hollywood-produced film:

> "One of the proving grounds is an outdoor laboratory: Enewetak Atoll in the Pacific. This Trust Territory of the United States has been used before as a testing ground for Operation Sandstone (1948). But three years have passed, three years to bring new and improved atomic weapons to this secluded equatorial land. This island, like spaced beads of a necklace […] .Since Enewetak is a distant and primitive area, men have to leave their stateside laboratories and homes for a period of months. Now the proving grounds come alive like a university campus when students return from a summer holiday…these are the dormitories of "Enewetak university"…individual test islands, seemingly like so many science buildings on college grounds."

In its persistent references to flight and aerial images of the islands, this film harnesses what Denis Cosgrove has termed the "Apollonian eye" that is "a synoptic and omniscient, intellectually detached" (2001, 2) as it surveys a colonial island laboratory and presents it as an extension of the long reach of the arm of the American Air Force. As Cosgrove and Fox point out, "widespread familiarity with the aerial view in the post-war years came not only from actual flights, but also – for most people – from photographs… newsreels and movies" (59).

It's no coincidence that the first ICBM developed in subsequent years was called "Atlas"--aerial vision has long been tied to conceptualizations of the globe, and often territorial claims over it (Cosgrove). The airplane radically changed the perception of space and time, producing

an “aerial subjectivity” (Waldheim 1999), a “cosmic view” (Kaplan 2006) or “aerial gaze” (Adey 2010, 116) born out of colonial mapping practices and tied to the often violent geopolitics of knowledge accumulation (Adey 2010, Kaplan 2006). “The airman’s vision evolved into a powerful trope not only for military strategy in a war of fighter plans, massed bombers, and parachute invasion but also for political shaping of the postwar global order” (Cosgrove 242-3). This was particularly important for the large oceanic spaces of the Pacific, which were inconceivably large in terms of a horizontal view but understood aerially, where the term “island hopping” was coined by the U.S. military to describe the system of runways and military service stations installed across the region for an expanding US empire. Released in 1951, *Operation Greenhouse* predates the *Apollo* space mission photographs of the earth (1969-71) so a photographic global vision had not yet become possible, but it is prefigured in these U.S. military surveillance films in which the island is a world, a microcosm of the potential global destruction that would be unleashed should this nuclear warfare be expanded to other targets outside the Pacific island colonies.

While “vision has been the privileged sense in Western science” for centuries (Cosgrove 26) it was through airplane technologies since WWI that new ideas of space, vision, photography, and patriotic nationalism came together (236). Flight and cinematic photography emerged nearly simultaneously and are constitutive of modern war (242). Ernst Junger has argued that “war making and picture taking are congruent” (qtd in Sontag, 2003, 66). That was certainly the case in the Pacific Proving Grounds, where the 1946 Operation Crossroads test at Bikini Atoll was recorded by 1,500,000 feet of film and over 1 million still pictures.[10] Paul Virilio has argued that “if you can see a target you can destroy it” (1989, 4) and this seems to be confirmed by the American nuclear tests in the Marshall Islands, where islands become, in Godfrey Baldacchino’s words, “tabulae rasae, potential labs for any conceivable human project” (2006). As Baldacchino and others have argued, the Pacific Islands have long been fashioned as laboratories for western colonial interests, from the botanical collecting of James Cook’s voyages to Darwin’s theories of evolution to structural anthropology. In fact functionalism, which is based on studying how individual parts fit the body of the whole community, is tied very closely to the bounded island concept and ecosystem ecology.[11]

Ecosystems ecology drew from the grammar of the AEC and its nuclear tests and therefore it’s not surprising that it focused on energy as a universal means of exchange and that it

upheld the concept of isolated spaces. While *Operation Greenhouse* juxtaposes the complex laboratories and lives of Los Alamos with the depopulated and defoliated Enewetak Atoll in ways that emphasize that they are bringing "new and improved atomic weapons to this equatorial land"—that is to say civilization to the savages, an old colonial trope--- we see the ways in which space is not, as Johannes Fabian might say, coeval. In this narrative, modernity emanates from the American colonial center, visible in the way in which the camera lingers on the uniformed officers, airplanes, and laboratory space, and is being imported to the tropical island, bereft of history and indigenous inhabitants. Thus it produces a paradox, a "distant and primitive area" yet at the same time a place of "individual test islands" much like the "science buildings on college grounds." In positioning Los Alamos as a "modern pueblo" as much as an "atomic city" and "isolated mesa," the film unwittingly suggests the ways in which indigenous appropriation and erasure in both the American west and its new frontier, the Marshall Islands, are constitutive in visualizing and creating the concept of the isolated laboratory.

Rethinking the ways in which science used the isolated island concept to produce some of the most apocalyptic technologies on earth challenges both the assumption of the primitive ahistorical island and what constitutes the laboratory itself. For instance, David Livingstone's *Putting Science in its Place* argues that there are four distinct spaces of science: The space of manipulation (the lab); the space of expedition (the field); the space of presentation (museum); and the space of circulation (the archive) (2003, 180). *Operation Greenhouse* suggests that these spaces were condensed in the Pacific Proving Ground. The space of expedition, signaled by the Los Alamos scientist leaving his boy and dog to travel to the Pacific, is not a field so much as "a giant lab in the middle of an ocean." The excessive photographic documentation of the Pacific nuclear tests, where the high speed camera and color film were developed, suggests that the "field" is also the space of presentation and of circulation, in which one tropical island stands in for the next, a virtual archive of nuclear irradiation, and a virtual island laboratory.

III. Metaphor

Metaphor moves from one object to another—in this case, island to laboratory—in a way that foregrounds resemblance and renders what might be invisible visible (Ricoeur, 2003, 34). But metaphor is equally about displacement, subsuming other possible modes of relation between objects and suppressing the ways in which the island is not a laboratory and vice versa.

(Ricoeur, 2003, 110). Metaphor is how nonhuman nature is rendered knowable and, following Girard Genette, the way that "language spatializes itself" so that space becomes language and thus articulates itself to us (Ricoeur, 2003, 147). Thus remote islands of the Pacific, for American viewers, become legible by likening them to island laboratories. The glaring displacement of course is the erasure of the inhabitants of these islands who must be suppressed in order to naturalize the islands as nuclear testing zones and laboratories, bereft of human history or cultural significance. Thus in the aerial surveillance of the islands, images of the Marshall Islanders have been removed, their housing and cemeteries plowed down, even the foliage has been bulldozed "for elbow room," as one AEC film declares, fashioning a laboratory but also a tropical playground for soldiers to play volleyball and sunbathe. Thus islanders rarely appear in these films, except a brief appearance of displaced Bikinians where the narrator declares, ''the islanders are a nomadic group, and are well pleased that the Yanks are going to add a little variety to their lives." Generally speaking the human subjects who appear in these films are American scientists at work, generals explaining the exercises, and servicemen—future Atomic Veterans-- at leisure on the beach. Such images anticipate what Teresia Teaiwa terms "militourism," the mutual constitution of the tourist and military industry in the Pacific Islands. In erasing the presence of the islanders, AEC newsreels instead celebrate the collection of scientific data, the nuclear yield, and the size of craters, zero islands, left behind. Employing an Apollonian eye, the films encourage the American audience to become vicarious masters of all they surveyed.

This "aerial gaze" displaces the horizontal island stories—the complex social and historical relations between the islands, the creation of nuclear nomads, and the collection of the islanders' biomaterial without consent for decades after the tests. Still displaced from their lands, many of the islanders have died of leukemia, thyroid cancer, and other radiogenic illnesses. The island as laboratory metaphor—and the aerial gaze--displace the most criminally and ethically negligent results of these 67 nuclear tests in the Marshall Islands, such as the occupation and illegal contamination of the western Pacific and its people and the denial of their well-being which was assured under UN Article 73. Moreover the AEC medical experiments conducted on the Marshallese are in violation of the 1949 Geneva Convention and the 1998 Rome Statute of the International Criminal Court (Johnston and Barker 197). Since the Rongelap islanders were covered in radioactive fallout and not evacuated for 3 days after the *Bravo* test (even though

local US servicemen were removed), many believe that the islanders were used as guinea pigs, which has been confirmed by recently declassified documents that show the Navy knew about the wind shift towards Rongelap hours before the test (Johnston and Barker). The boundedness of this chain of islands was thought to allow the division of “test” and “control” groups, but as recent work demonstrates, all 28 Marshall Islands were seriously and lethally contaminated with fallout, not merely the four islands indicated by the AEC (Johnston and Barker 2008, 28). In fact, one of the northern Marshall Islands has been declared by the AEC as uninhabitable for 25,000 years.

The declassification of a 1957 memo from Brookhaven National Laboratory's medical researcher Dr. Robert Conard, the doctor in charge of testing and caring for the hundreds of Marshallese exposed to radiation, has confirmed suspicions that it was the islanders as much as the environment that were subject to a terrible AEC experiment. To his colleagues he wrote, "The habitation of these people on the island will afford most valuable ecological radiation data on human beings." Arguments like this are pervasive throughout the AEC records. The director of the AEC Health and Safely Laboratory described neighboring Utirik Atoll in 1956 as “by far the most contaminated place in the world” but that it will be “very interesting” to get data from the environment and islanders when they are returned there. “Now, data of this type has never been available,” he argued. Referring to genetic tests about the impact of radiation on fruit flies and mice, he continued to observe of the Marshall Islanders, “While it is true that these people do not live, I would say, the way Westerners do, civilized people, it is nevertheless also true that these people are more like us than mice.” (Qtd in Johnston 25).

The recent work of Barbara Rose Johnston and Holly Barker has brought to light some very disturbing evidence about the extent to which the Marshall Islands were used as living ecological laboratories and the islanders for human subject research for four decades, without their knowledge or consent. From 1954 until their removal by Greenpeace from contaminated Rongelap in 1985, the islanders were studied by AEC scientists but rarely treated or informed about the nature of their illnesses. For instance, when the Rongelapese were first exposed to *Bravo* fallout, some with radioactive burns over 90% of their bodies and causing skin to peel down to the bone, not one of the islanders was given pain medication. With the declassification of “Project 4.1,” evidence has come forward that AEC scientists collected blood, tissue, bone marrow and teeth samples for decades—extracting even perfectly healthy teeth (156)—to

measure bioaccumulation without consent. When Rongelapese women began giving birth to babies without skulls, without skeletons ("jellyfish babies" and "grape babies"), and with severe retardation and missing limbs, the AEC informed them that these miscarriages and defects, never before experienced, were normal for a small island population (24). Although scientists from the AEC Division of Biology and Medicine had ample evidence of the extensive radiological contamination of Rongelap, they allowed the islanders to return in order to deflect criticism of the AEC's atmospheric testing program, and thus exposed the islanders to another twenty-two nuclear tests on Enewetak alone. Moreover, they did not warn the islanders to avoid eating certain plants, animals, and fish that bioaccumulate and concentrate deadly levels of cesium^{137}, strontium ^{90}, and iodine ^{131}, the most lethal isotopes to humans. Over the course of 67 nuclear tests, many of which were designed to spread deadly radioactive isotopes, the Marshall Islanders were exposed to over 8 billion curies of iodine-^{131}. Comparatively, the Chernobyl accident, widely known as one of the worst radiological accidents, released 50 million curies (J&B 2008, 19). As a result, their return to Rongelap exposed the islanders to another three decades' worth of additional radiological contamination, for which they were not provided medical support, except for the annual visit for sampling bones and tissues by the AEC director Robert Conard. Even more disturbingly, this population, the most radiogenically exposed and studied people on earth, was subjected to the injection of radioactive isotopes without their knowledge or consent by AEC scientists. Despite this extreme attention to their radiogenic illnesses, to this day the vast majority of affected islanders have been refused access to their medical records and adequate medical treatment.

After decades of suffering in a radiological laboratory, the Rongelapese magistrate Nelson Anjain had this to say in an April 1975 letter to Conard:

> "Your entire career is based on our illness. We are far more valuable to you than you are to us. You have never really cared about us as people—only as a group of guinea pigs for your government's bomb research effort. For me and for other people on Rongelap, it is life which matters most. For you it is facts and figures. There is no question about your technical competence, but we often wonder about your humanity…We want medical care from doctors who care about us, not about collecting information for the US government's war makers…America has been trying to Americanize us by flying flags

and using cast-off textbooks. It's about time America gave us the kind of medical care it gives its own citizens….We no longer want you to come to Rongelap." (2008, 139).

While ecosystem ecology did not catalyze the AEC's decision to detonate 67 nuclear weapons in the Marshall Islands and to expose and then study radiological data on humans, we must raise the vital question as to how, as a methodology and system of thought, it sustained the concept of isolation, despite all evidence to the contrary. Elsewhere AEC studies of the same era were experimenting with radioactive isotopes on indigenous peoples in the Amazon and Alaska based on a similar concept of the "biologically discrete" (see Johnston 2007). This model of isolation perpetuates the neat division of "test" and "control" groups, and the presumed isolation of the Marshall Island colonies from the continental US and its responsibility to the rule of law. As I've argued elsewhere, the colonial concept of island isolation has worked---too effectively—to suppress the ongoing history of military expansion and new forms of colonialism.

Ecosystem ecology, with its emphasis on closed systems, management, control, and equilibrium, drew tremendous support because it was appealing to the military, which sought to expand its weapons testing program, and to industry, which began working with the AEC to capitalize on the opportunity to build more nuclear plants (Golley, 1993, 3). Although it was discarded as a scientific model in the 1960s for more dynamic approaches to the environment, as late as 1968 Glenn Seaborg, the Chairman of the AEC, had this to say in a press release:

> "While Bikini is best known as a weapons testing site, it has also contributed significantly to man's knowledge of the long term effects of radiation on an environment. During the years when radiation levels were too high for people to live there permanently, the AEC sponsored several scientific studies on the atoll. In fact, Bikini truly served as a living ecological laboratory."

Metaphor not only connects two disparate entities but validates and naturalizes this new relationship and thus is crucial to constructing new paradigms of knowledge.[12] This has not been lost on theorists such as Bruno Latour, who has long argued against the concept of the bounded laboratory, and Isabelle Stengers, who argues "isolation is a dangerous game, and those who can purify their objects in fact intervene actively in the significance of the object they observe" (1983, 17). Clifford Geertz has observed that the "the natural laboratory notion has been…pernicious, not only because the analogy is false" since parameters are always porous, but

because the data is no more pure or fundamental (1973, 22). In *Nuclear Playground* Stewart Firth deconstructs the island laboratory metaphor, arguing "The nuclear bomb men have always assumed that atolls and deserts are a long way from anywhere. But they are wrong. Nuclear explosions in the atmosphere, which occurred frequently in the Pacific Islands between 1946 and 1975, were global in effect…In preparing for war we were poisoning our planet and going into battle against nature itself" (1987, 3; see also Howe).

The lie of isolation has indeed been a dangerous game, to the Marshall Islanders especially, and beyond. Due to these thermonuclear weapons, the entire planet is permeated with militarized radiation. *Bravo* and the subsequent 2,000 or so nuclear tests on this planet, Eileen Welsome observes, "split the world into 'preatomic' and 'postatomic' species" (1999, 299). Radioactive elements produced by these weapons were spread through the atmosphere, deposited into water supplies and soils, absorbed by plants and thus into the bone tissue of humans all over the globe. The body of every human on the planet now contains strontium^{90}, a man-made byproduct of nuclear detonations (Caufield, 1990, 132) and forensic scientists use the traces of militarized radioactive carbon in our teeth to date human remains (as before or after the 1954 *Bravo* shot).[13] At very conservative estimates, these nuclear weapons tests have produced 400,000 cancer deaths worldwide (Masco, 2006, 27).

As a transoceanic culture, Pacific Islanders have not traditionally harbored a division between land and sea nor have they conceived of their islands, before colonialism, as peripheral to an American metropolitan center. With this horizontal view, we might say that many in the region might wish for *more isolation* from the United States and its expanding military (especially due to the recent buildup in Hawai`i and Guam). For better or worse, this desire for isolation is not possible given what we know about globalization and complex ecologies. Thus we might agree with the late Tongan anthropologist Epeli Hau`ofa who argued against the concept of isolated islands and brought our attention to a "sea of islands" long connected by histories of migration, diaspora, nuclear colonialism and globalization. A world of islands. Thanks to their irradiation, we all carry a small piece of that island world in our bones.

Endnotes

[1] Worster *Nature's Economy* 339.
[2] See Weart *Nuclear Fear.*
[3] Qtd in Daniel Lang *From Hiroshima to the Moon,* 89.
[4] See Klingle "Plying Atomic Waters," 1998.
[5] Explored in DeLoughrey *Routes and Roots*.
[6] See Boyer, *Radio Bikini,* Weart, Weisgall, and Barker.
[7] See Dibblin, Firth, *Half-Life,* and Teaiwa.
[8] *Operation Castle Commander's Report* film
[9] Donaldson "an unparalleled opportunity to study the role of trace elements" in the environment (Klingle 11).
[10] *Hollywood's Top Secret Film Studio, Radio Bikini*. As one AEC film observed, "one of the most important and dramatic elements in the dropping of the bomb is the photographic element" (qtd in *Radio Bikini).*
[11] Kirch points out that 'their very boundedness seems to make them almost the perfect unit for the 'structural-functionist' approach to ethnographic description and analysis, (1)" and shows that Marshall Sahlins found the island topos as "enticing in developing his theory of social stratification in relation to the distribution of resources (3)."
[12] See Boyd "Metaphor and Theory Change" and Kuhn "Metaphor in Science" in Ortony, *Metaphor and Thought,* Cambridge UP, 1979.
[13] See "Forensics: Age Written in Teeth by Nuclear Tests."

Works Cited

Baldacchino G, 2006, "Islands, Island Studies." *Island Studies Journal* **1.1** May, 3-18

Barker H, 2004 *Bravo for the Marshallese: Regaining control in a Post-Nuclear, Post Colonial World.* (Wadsworth, Belmont, CA)

Bocking S, 1995, "Ecosystems, Ecologists, and the Atom: Environmental Research at Oak Ridge National Laboratory" *Journal of the History of Biology* **28** 1-47

Boyd R, 1979, "Metaphor and Theory Change: What is 'Metaphor' a Metaphor for?", in *Metaphor and Thought* Ed. A Ortony (Cambridge UP, Cambridge) pp 356-408

Boyer P, 1994 *By The Bomb's Early Light American Thought and Culture at the Dawn of the Atomic Age* (U of North Carolina Press, Chapel Hill, NC)

Caufield C, 1990 *Multiple Exposures: Chronicles of the Radiation Age* (Harper & Row, New York)

Churchill W, 2002, "Geographies of Sacrifice: The Radioactive Colonization of Native North America", in *Struggle for the Land: Native North American Resistance to Genocide, Ecocide and Colonization* Ed. W Churchill (City Lights Books, San Francisco) pp 239-291

Cosgrove D, 2001 *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Johns Hopkins University Press, Baltimore)

Cowan F, 1952, "Everyday Radiation" *Physics Today* 10-16

Craige B, 2002 *Eugene Odum*: *Ecosystem Ecologist and Environmentalist* (University of Georgia Press, Athens)

Dibblin J, 1988 *Day of Two Suns*: *US Nuclear testing and the Pacific Islanders* (Virago, London)

Firth S, 1987 *Nuclear Playground*. (U of Hawai‘i Press, Honolulu)

Firth S, Von Strokirch K, 1997, “A Nuclear Pacific”, in *The Cambridge History of the Pacific Islanders* Ed. D Denoon et. al. (Cambridge UP, Cambridge) pp 324-358

Nature 2005, “Forensics: Age Written in Teeth by Nuclear Tests” **437** 333-334

Geertz C, 1973 *Interpretation of Cultures* (Basic, New York)

Golley F, 1993 *A History of the Ecosystem Concept in Ecology* (Yale University Press, New Haven)

Grove R, 1995 *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism 1600–1860* (Cambridge University Press, Cambridge)

Half Life: A Parable of the Nuclear Age. Dir. Dennis O’Rourke. CameraWork, 1986.

Hagen J, 1992 *An Entangled Bank: The Origins of Ecosystem Ecology* (Rutgers UP, Piscataway, NJ)

Hau`ofa E, 1995, “Our Sea of Islands”, in *Asia/Pacific as Space of Cultural Production* Eds A Dirlik, R Wilson (Duke University Press, Durham and London) pp 86 – 101

Hollywood’s Top Secret Film Studio. Peter Kuran. VCE, Inc., 1999.

Johnston, B, 2007 “Half Lives, Half-Truths, and Other Radioactive Legacies of the Cold War.” *Half-Lives and Half-Truths: Confronting the Radioactive Legacies of the Cold War* Ed B Johnston (School for Advanced Research Press, Santa Fe, NM).

Johnston B and H Barker, 2008 *Consequential Damages of Nuclear War: The Rongelap Report.* (Left Coast Press, Walnut Creek, CA)

Jungk R, 1958 *Brighter than a Thousand Suns: A Personal History of the Atomic Scientists* (Harcourt, New York)

Kingsland S, 2005 *The Evolution of American Ecology, 1890–2000* (Johns Hopkins University Press, Baltimore)

Kuhn T, 1979, "Metaphor in Science", in *Metaphor and Thought* Ed. A Ortony (CUP, Cambridge) pp 409-419

Kwa C, 1993, “Radiation Ecology, Systems Ecology and the Management of the Environment”, in *Science and Nature* Ed. M Shortland (British Society for the History of Science Monograph 8, Stanford in the Vale) pp 213-249.

Latour B, 1983, “Give Me a Laboratory and I will Raise the World”, in *Science observed, Perspectives on the Study of Science* Eds M Mulkay, K Knorr-Cetina (Sage, London) pp 141 – 170

Laurence W, 1946 *Dawn over Zero: The Story of the Atomic Bomb* (Alfred A. Knopf, NY)

Laurence W, 1946, “Is Atomic Energy the Key to Our Dreams?” *Saturday Evening Post* 13 April, 9-10, 36-41

Lilienthal D, 1947, “Atomic Energy is your Business” *Bulletin of Atomic Scientists* November, 3.11 335-336

Livingstone D, 2003 *Putting Science in Its Place*: *Geographies of Scientific Knowledge* (University of Chicago Press, Chicago)

Masco J, 2006 *The Nuclear Borderlands: The Manhattan Project in Post-Cold War New Mexico* (Princeton University Press, Princeton)

Mitman, G, *The State of Nature: Ecology, Community and American Social Thought, 1900-1950* (University of Chicago Press, Chicago)

Odum E, 1957, “Ecology and the Atomic Age” *ASB Bulletin* **4.2** 27-29

Odum H, Odum E, 1955, “Trophic structure and productivity of a windward coral reef at Eniwetok Atoll, Marshall Islands” *Ecological Monograms* **25** 291 – 320

Odum, H.T., 1970, “Preface.” *A Tropical Rain Forest: A Study of Irradiation and Ecology at El Verde, Puerto Rico.* With Robert F. Pigeon (eds). United States Atomic Energy Commission, National Technical information service.

Operation Greenhouse. Nar. Carey Wilson. Prod. Atomic Energy Commission and Joint Task Force 3. Lookout Mountain Laboratory, 1951.

Radio Bikini. Dir. Robert Stone. New Video Group, 1987.

Rhodes R, 1990 *The Making of the Atomic Bomb* (Simon & Schuster, New York)

Ricoeur P, 2003 *The Rule of Metaphor: The Creation of Meaning in Language* (Routledge, London)

Rosenthal P, 1991, “The Nuclear Mushroom Cloud as Cultural Image” *American Literary History* **3** 63 – 92

Seaborg Dr. G, 1968, Atomic Energy Commission Press Release

Sontag S, 2003 *Regarding the Pain of Others* (Farrar, New York)

Stephenson, M and J Weal, 1985 *Nuclear Dictionary* (Longman, London)

Tansley A, 2000, “The Use and Abuse of Vegetational Concepts and Terms”, in *The Philosophy of Ecology* Eds D Keller, F Golley (U of Georgia P, Georgia) pp 55 – 70

Taylor P, 1998, “Technocratic Optimism, H.T. Odum, and the Partial Transformation of Ecological Metaphor after World War II” *The Journal of the History of Biology* **21.2** 213 – 214

Teaiwa T, 1994, "bikinis and other s/pacific n/oceans" *The Contemporary Pacific* **6:1**

Virilio P, 1989 *War and Cinema: The Logistics of Perception* (Verso, London)

Weart S, 1988 *Nuclear Fear: A History of Images* (Harvard University Press, Cambridge)

Welsome E, 1999 *The Plutonium Files: America's Secret Medical Experiments in the Cold War* (Dial Press, New York)

Weisgall J, 1994 *Operation Crossroads: The Atomic Tests at Bikini Atoll* (Naval Institute Press,

Annapolis)

Worster D, 1994 *Nature's Economy: A History of Ecological Ideas* 2nd ed. (Cambridge University Press, Cambridge)

Worster D, 1993 *Wealth of Nature: Environmental History and the Ecological Imagination* (Oxford University Press, NY)