Sustainable Development Law & Policy

Volume 16
Issue 1 *Land and Water Use in the United States*

Article 3

You Probably Shouldn't Build There: Watershed-Based Land Use Strategies for Mitigating Global Climate Change in New Jersey's Freshwater Systems

Matthew Knoblauch

You Probably Shouldn't Build There: Watershed-Based Land Use Strategies for Mitigating Global Climate Change in New Jersey's Freshwater Systems

*Matthew Knoblauch**

I. Introduction

As the Summer of 2011 came to a close, a cataclysmic storm made its way into the east coast of the United States. Hurricane Irene ("Irene") wreaked havoc on many inland communities as it dumped torrential downpours across the region and recorded the highest flood gage levels in New Jersey.[1] However, Irene did not have as significant of an impact on the community of Bound Brook, adjacent to the Raritan River, as Hurricane Floyd ("Floyd") did in 1999. Floyd inundated the small town's downtown in more than twelve feet of water, killed several people, and required emergency shelters for thousands of people.[2] After Floyd, the town and the New Jersey Department of Environmental Protection ("DEP") spent millions of dollars enhancing the Raritan River community's defenses to counteract future storms.[3] These efforts arguably paid off when Irene only submerged the town in three feet of water.[4]

The story of Bound Brook highlights the dangers that urbanization along New Jersey's freshwater systems presents and provides an example of a reactive approach to a major problem. DEP's improvements to Bound Brook were more holistic than New Jersey planners had theretofore engaged in because DEP considered future inundation more critically by assessing a larger portion of the region's watershed, but the changes were still reactive in that the infrastructural enhancements were designed to suit previous flood levels[5] and no flood-resilient developments took place at other areas in the watershed.[6] Human development near bodies of water is naturally vulnerable to flooding. The siting of such development affects and is affected by other factors, such as topography and land cover; exurban development increases runoff that exacerbates flooding in urban areas, while paved surfaces in developed urban areas are not able to readily absorb water into the ground causing runoff to funnel into flood waters.[7] Moreover, as New Jersey's population expands, human habitation will spread into previously undeveloped areas, leading to an increase in exposed vulnerable regions. Also, as human activity changes earth's climate, the northeastern United States is likely to get more precipitation added to the increased exposure extant in the region.[8]

Combined, these local and climate changes mean a significant increase in risk to human development. "Development" means the creation of the built environment by human actors; it does not establish an inferiority complex by implying that adding structures to "undeveloped" land increases its inherent value. This Article will address the problems of New Jersey's residential trends, the increased risk of flooding, watershed-based proactive redevelopment plans, and the utilization of novel legal strategies to mitigate flood hazards.

Global climate change ("GCC") is currently a topic garnering almost zeitgeist-like attention among many intellectual communities around the world about how to deal with its current and future hazards.[9] This Article will carve a niche out of that broader trend and focus on New Jersey's land use in regions that impact and are impacted by freshwater systems, specifically floodplains, riparian zones, wetlands, and areas adjacent to them. This is followed by an assessment of New Jersey's legal framework for mitigating the hazards that result from an increase in precipitation combined with increased human development. It concludes that New Jersey is legally unprepared for dealing with the hazards that GCC presents and recommends a data-driven solution for mitigating these hazards. To accomplish this goal, the state should incorporate an interdisciplinary panel of various atmospheric and geographic science content experts to make recommendations or decisions about land use matters in specific watersheds. This Article will recommend that lawmakers create an entity or administrative agency that assesses regions at the

* Matthew Knoblauch is a J.D. Candidate at Rutgers Law School in Newark, New Jersey and also holds an Ed.M. and B.A., both from Rutgers University. In law school, Matthew catered his scholarship and service to reflect his interest in environmental and land use law by taking courses and working in those disciplines. He has interned at Yosemite National Park and the Environmental Enforcement & Homeland Security Section of the New Jersey Attorney General's Office, among other entities. Matthew was co-president of the Environmental Law Society and is a Marsha Wenk Public Interest Law Fellow. Prior to law school, Matthew experienced inland and coastal flooding first-hand during Hurricanes Irene and Sandy as he made water rescues while serving as a firefighter/EMT. Studying how human development and the natural world interact as both a scholar and a rescuer has made him keenly aware of nature's power as well as humanity's ability to augment and incite it, so he desires to be active in ensuring that land alterations, past, present, and future, are well-informed decisions. Matthew gives thanks to Joanna Jorge, for her companionship and encouragement, Michele Knoblauch, for her lifelong support of his dreams, Robert Knoblauch, both Jr. and Sr., for inspiring him to seek outdoor adventures from an early age, and his many family members and friends, for their tireless support and assistance. Matthew would also like to thank the late Professor Susan Schrepfer, for inspiring him to study the natural world, Professor Steve Gold, for guiding him in his environmental law endeavors, Professor Carlos Ball, for providing editorial assistance in this project, and the outdoors, for creating his passion to study and protect the physical environment.

watershed level while ignoring political boundaries to better assess and develop mitigation strategies.

First, this Article will explain New Jersey's history of human development, provide data on global climate change, present data indicating that regional increased levels of precipitation are likely,[10] and explore the synergy of these factors. Second, this Article will categorize and explain the available scientific and technological tools that legal practitioners and policy developers can use to tackle the hazards global climate change poses in conjunction with human development. This section will also explore man-made technology, such as geospatial measurement tools, and naturally occurring phenomenon, such as the propensity of wetlands to absorb floodwater, and their applications to global climate change.

Third, this Article will assess existing legal strategies for mitigating flood vulnerability, including, but not limited to, eminent domain, and government and non-profit-supported buy-back programs. Because a majority of New Jersey is developed,[11] it is necessary to analyze the strategies the state is using to mitigate hazards to existing built environments while focusing less on developing areas. Fourth, this Article will make policy and statutory recommendations that should be incorporated into land use regulation and legislation. This section will be subdivided into four mitigation strategies: 1) ideal proactive, 2) realistic proactive, 3) reactive, and 4) no action. This segment will also address other concerns and issues, such as environmental justice, landowner interests,[12] and the role of community activism.[13]

Important to understanding what this Article attempts to do is understanding what it does not attempt to do. The existing data that is produced by, among other techniques, measuring trends in sea temperature, air temperature, atmospheric composition, ice thickness, and precipitation is analyzed and interpreted by content experts.[14] The scientific community has come to a consensus about the reality of GCC through an analysis that synthesizes the available data.[15] This Article does not challenge that scientific consensus and merely seeks to use it as a tool in addressing future problems.

II. New Jersey's Ominous Future

A. Historical Background and Expanding Human Development

From New Jersey's first recorded human inhabitants, the Lenape, until the beginning of the nineteenth century, human land use in New Jersey was almost entirely agricultural.[16] As the Industrial Revolution altered the world's landscape, it changed New Jersey as well; the state became "among the most urban, industrial, and ethnically diverse states in America" by the end of the nineteenth century, as "[c]ities replaced farms" and "immigrant workers joined native-born laborers."[17]

New Jersey's population has grown rapidly since the inception of the United States, a pace that largely continued until the decades after 1970.[18] Until World War II, New Jersey's inhabitants resided largely in the state's urban centers as opposed to the rural and suburban areas.[19] Because the majority of the population was concentrated in these urban areas, there was minimal alteration of the agricultural, rural, and natural areas of the state.[20] However, this paradigm changed after World War II, when the majority of the nation's and the state's population shifted from living in an urban center to living in the suburbs.[21] The country's shift from urban to suburban living necessitated more land development per human.

But New Jersey is by no means unique in its growth, growth pattern, or land use alteration. What makes New Jersey unique is that the state is a container of residential human habitation.[22] Since the rise of suburbia, New Jersey has been continuously subdivided into residential homes to feed the mega cities of New York and Philadelphia, almost like a "barrel tapped at both ends."[23]

"…the state will more easily reach a critical mass of human development than a state that is more sparsely populated, has less people, or has more non-developed land."

In the last several decades, New Jersey's inhabitants' desire for larger parcels has led to an "exurbanization"[24] of the community, resulting in one that is more sparsely spread compared to a suburban one. The consequence of this has resulted in a greater consumption of land area while still housing the same number of people traditional urban areas and suburbs do.[25] Furthermore, there is a net decrease in the amount of farming and wooded areas.[26] Exurban development, combined with the fact that New Jersey is the most densely populated state in the nation,[27] means the state will more easily reach a critical mass of human development than a state that is more sparsely populated, has less people, or has more non-developed land.[28] Unfortunately for the inhabitants of New Jersey, development is projected to reach "build-out" by 2050.[29]

Three factors are critically important when discerning the consequences of human habitation on certain regions: population density, land use, and geographic location. Population density is how many people live in a specified land area, such as people per square mile.[30] Land use is critical for analyzing how factors like precipitation or population growth will proceed.[31] It includes general categories, such as plant-based agricultural, animal-based agricultural, residential, and industrial. Geographic location is relevant to the analysis of vulnerability of a particular area. For example, a community in a flood plain

is more vulnerable to inundation than a community on a hilltop, all other factors being equal. Combining land use into that situation, a similarly located industrial community, commercial community, or occasional residential community, will have many impermeable areas that do not allow rainwater to drain into the ground,[32] resulting in greater flood vulnerability.

B. Global Climate Change in General

Due to the prominence of the hazards that GCC poses, the science, data, and technology associated with measurement and mitigation has been the subject of exaltation and controversy.[33] GCC is an alteration to "the average weather conditions over an extended period of time."[34] Human activity has always modified its surrounding environment, but in the last fifty or so years, human activity has altered it on an unprecedented scale through the emission of greenhouse gases ("GHGs").[35] GHGs in the atmosphere retain the heat of sunlight, and the more those gases exist in the atmosphere, the more heat will be retained.[36] It is inarguable that the prevalence of those gases, mostly carbon dioxide, is increasing[37] as a result of growth of human industry since the Industrial Revolution.[38] Scientists have documented evidence of the impact of GHCs between 420,000 years ago and the Industrial Revolution by showing how the parts per million ("ppm") of carbon dioxide in ice cores has increased from 180 ppm to 280 ppm.[39] Carbon dioxide's atmospheric concentration is now at 400 ppm.[40]

Although the full consequences of such atmospheric change are unknown, there is a measurable trend of global warming.[41] As earth's climate warms, regions that were frozen are beginning to melt. There is a significant concern about rising sea levels due to this phenomenon,[42] because forty-four percent of the world's population lives in coastal areas.[43] However, there is a small minority, approximately three percent,[44] of the scientific community who disagree with the notion that GCC is human caused, or anthropogenic, even though evidence disproves their arguments.[45]

C. Increasing Precipitation

One of the most noticeable trends associated with GCC in the continental United States is that arid areas, particularly the southwest, are getting drier while northern and eastern regions, are getting more wet.[46] This trend means that the American northeast will likely experience an increased level of precipitation due to both an increase in mid-latitude cyclones and tropical depressions, tropical storms, or hurricanes.[47] More rain and snow in isolation will undoubtedly inundate more areas than currently flood during periods of increased precipitation, but this situation may worsen if development increases, particularly in areas that are either inherently vulnerable or made vulnerable by upstream development. Built environments are created with a great deal of thought given to drainage and flood management in the present,[48] but, because the areas where most humans tend to live are designed to manage specific amounts of precipitation, an increase in precipitation changes the calculus and results in more water than a given area will be able to handle as it was designed.[49]

D. Synergistic Problems

Each of the problems that New Jersey faces in the context of global climate change are individually noteworthy, but combined, are much more significant. New Jersey's future faces three distinct risk factors that together are much more dangerous than in isolation: 1) increased human development multiplying the number of places where development is vulnerable in net terms, 2) an expansion in the prevalence of impermeable surfaces increasing runoff, and 3) increasing precipitation.

As human development expands into previously undeveloped areas,[50] those areas will be more vulnerable to inundation.[51] As human development transforms the ground into impermeable surfaces, more water will be funneled into flowing bodies of water rather than drain into the ground, which relates directly to soil permeability.[52] Soil permeability is "'the ease in which water, air or gases can move through a layer of soil.'"[53] The more permeable the soil, the faster water soaks in and does not accumulate on the surface.[54] Essentially, areas that are evolutionarily designed to absorb surface water are eliminated by certain developments, turning a mitigating natural feature into an exacerbating human-made feature.[55] Added to this is the third factor of increased precipitation. These three risk factors will act in concert in New Jersey, to the demise of its residents.

In this context, it is important to note that the vulnerable areas this Article focuses on are broader than the term 'wetlands;' rather, the focus regions are areas that wetlands and riparian zones affect and are affected by. It is critical that policy makers and lawmakers understand the ecology behind the land they control and understand that these lands act in concert with one other. There is rarely a firm border between an area zoned as a wetland or a floodplain and the adjacent housing development, and the variability in a specific parcel of land is subject to the particular "soils, underground geology, escarpments, groundwater formations" and the like.[56]

To mitigate the hazards New Jersey faces, the applicable law must utilize available and innovative technology to assess potential solutions and curb future problems. These technologies will allow lawmakers, policy makers, and other interested parties to measure and predict problems in order to apply data-driven solutions.

III. The Technology of Defending Against Flooding

This Article considers two broad categories of technologies: human-made and naturally occurring phenomenon. There are two contexts human-made technologies can be applied to: geographic conditions and atmospheric conditions. Within each context, there are two practical applications: measurement and prediction. Human-made technologies will be explored in both contexts and in both forms of application. Naturally occurring phenomenon function to mitigate certain conditions, and they will be detailed as well.

Measurement is the simpler of the two applications, but still presents challenges of accurate assessment, particularly in the atmospheric context. It is not possible to gather every bit

of data in a world composed of untold quantities of information, and because prediction is based on the data acquired by measurement, atmospheric prediction is complicated. [57] In order to predict how the world works, climate scientists develop computer algorithms that model the real world by inputting the data that they gathered from measuring environmental conditions. [58] Rates of error certainly exist, but the predictions are nonetheless extremely helpful in analyzing future climate trends. [59] The available prediction and modeling technologies have the ability to produce a range of possible scenarios, just as a weather forecast gives precipitation, temperature, and other possibilities. [60]

Land is a factor that can be measured and predicted much more easily than future meteorological conditions because it is much less fluid and has fewer variables. Other than by earthquake, volcanism, or sinkholes, the only way surface land can change in a human lifetime is through external forces, such as a flood, surface mine, major construction project, or other external force. In New Jersey, this typically means that human development is the agent of change. Using the technologies that will be explored below, scientists can measure land and predict how it will respond under given amounts of development and precipitation, measure and predict atmospheric trends, and analyze the viability of biological solutions.

1. Geographic Measurement and Prediction

Geographic information systems ("GIS") are how modern scientists map geographic data; it is a type of computer program that records spatial data about the physical world so that a user can manipulate it for a particular purpose.[61] Using GIS, one can input data such as elevation, population, topography, land use, or any other metric and assess the data for correlations of variables, changes over time, or other purposes.[62] GIS permits a user to create his or her own hypotheticals by entering in specific variables that correlate to real-world factors as well as measure, store, and map existing geographic features.[63] The kind of data that gets incorporated into a GIS program is specific to the purpose of the program, and can be used to inform subsequent policy decisions.[64] For example, if a program's design is to measure flood vulnerability, the program will measure topography, hydrology, precipitation, and soil permeability, among other factors. From the incorporated data, a geographer can then overlay the various maps that each dataset creates and develop a composite map.[65]

Geographers at Rutgers University in the late 1990s used this technology to prevent development in critically important areas within a forest at the border between New Jersey and New York.[66] Using GIS, the geographers created a "cartographic modeling analysis" that assessed limitations in development due to soil conditions, terrain, flood vulnerability, proximity to wetlands, as well as ecological and other factors.[67] The experts' use of GIS successfully prevented a development company from significantly harming the region.

In the context of land use and land cover assessment, "[o]ne of the most effective ways to map [it] is through the use of remote sensing imagery collected from satellites and aircraft."[68] Indeed, GIS has allowed scientists to monitor geographic conditions around the world.[69] Once the data is collected, the specific GIS program allows the remote sensing imagery to be combined with other data so that "experienced image interpreters" can analyze how a particular region might respond to a particular situation.[70] While this technology is helpful in allowing users to assess an infinite number of situations in a specific region, there are limits to its usefulness. Like any computer-modeling program, GIS is only as useful as the data that gets inputted; inaccurate data increases rates of error. Consequently, accurate measurements are key for an accurate picture of a given scenario.

Unlike most other states, geoscientists in New Jersey have created a digital map of the state's land use and land cover.[71] These geoscientists created this data "utilizing multi-date digital orthophotographic imagery" to assess "the impacts of... urban growth on environmental quality."[72] Because New Jersey's land use is already measured, scientists only need to apply the data of precipitation to the length of time over which the precipitation occurs, on which particular surface it falls on, and any data relevant to new development. This existing data allows content experts to accurately predict how a given land area will respond to future conditions.[73]

The solution for practical applications of these overlapping technologies is to apply them holistically and individually. This means that content experts, administrative agencies, and lawmakers must assess each watershed or subwatershed with the same tools of assessment but apply solutions on an individual basis taking into consideration soil permeability, topography, land use, and other factors. If each municipality has its own zoning policies to deal with flooding, then there will not be a holistic approach, and the entire system's segmentation will cause it to fail.[74] So, while New Jersey has access to this uncommon asset of land use and land cover data, lawmakers must utilize it strategically in order to mitigate the hazards presented by increases in precipitation.

2. Atmospheric Modeling and Prediction

Atmospheric scientists can model the skies just as geographers model the ground. These programs are similar to geographic assessment procedurally, but differ substantively. Atmospheric assessment uses various technologies, such as radiosondes,[75] Doppler radar,[76] lidar,[77] and satellites, to measure trends in precipitation, air pressure, wind direction, wind intensity, viscosity, and other variables.[78] Atmospheric scientists break up earth's atmosphere into a "three-dimensional grid system" around the entire planet so that there are "thousands of points where the model calculates atmospheric processes."[79] This process involves complex mathematical algorithms that simulate the complex interactions of atmospheric particles.[80] Atmosphere scientists use the measurements and predictions to create a three dimensional simulation of the earth's atmosphere and predict future conditions.[81] From these measurements taken over the course of decades, a trend of climate patterns is derivable.[82] This process is has similarities to meteorological weather predictions, but is largely a vastly different procedure.[83]

Using these technologies and the producible predictions, climate science can inform legislative and administrative decisions regarding the best use for a given land area to mitigate flood vulnerability in New Jersey. It is in the best interests of New Jersey lawmakers and politicians, as well as the best interests of the residents of New Jersey, to incorporate the use of these technologies into their land use policies.

3. Naturally Occurring Phenomenon

Land use planners can use certain naturally occurring phenomenon to mitigate various hazards that modern human life makes more common; for example, plant life can be used as carbon sinks to sequester GHG emissions.[84] Similarly, areas such as wetlands, marshlands, and estuaries are biological systems that are evolutionarily designed to withstand and absorb the impacts of storms.[85] Whether those are saltwater marshlands or estuaries absorbing the rising seas of a storm surge or wetlands softening the blow of an inland storm, these areas nonetheless are important in calculating how a certain amount of precipitation or storm surge will affect a particular area.[86] Unfortunately, the plants that make up these ecological zones and the regions themselves have been the victims of New Jersey's ever expanding human development.[87]

Once these areas are destroyed because of development, it will affect the natural carrying capacity that a specific ecological zone is able to absorb.[88] "Natural resource carrying capacities" of particular areas cannot be improved by simple means and, moreover, once the carrying capacity is exceeded, it may not be possible to restore it.[89] Yet, replicating wetlands can exist in certain conditions,[90] which may allow for "protecting wetlands while simultaneously allowing development...."[91] While wetlands replication remains a possibility, it is a better solution to simply avoid the destruction of wetlands. In the game of zero sum loss of wetlands, replication is inadequate because space in New Jersey is too finite and no two areas have the same carrying capacity.[92] Moreover, wetlands are more than flood sponges, they are of vital ecological importance as well.[93]

"Moreover, wetlands are more than flood sponges, they are of vital ecological importance as well."

Naturally occurring phenomenon should be utilized even in the absence of any statutory scheme, because their benefits may not impede on private landowner's rights like many other strategies in that there is the possibility for landowners to still retain control over their land. Further, the benefits they create for air quality remediation and floodwater absorption are invaluable for a society where air quality and low-lying inhabitants are increasingly victims of industrial and residential development.

IV. Litigating & Legislating Against Disaster

A. In General

Interested parties in the Garden State have a variety of options for legally tackling many of the problems presented by GCC. State actors can use constitutional law, such as eminent domain,[94] statutory law, such as funding for environmental purposes,[95] and case law as well as administrative regulations to confront the presented hazards. Private entities can also take advantage of various statutes and regulations, as well as use the tool of legislative advocacy.[96] This segment will briefly discuss the currently available options as they presently exist and conclude that each mitigation strategy currently in use is inadequate because they are either used too independently from other strategies to be effective or simply not effective enough even in a best-case scenario. There are alternative strategies that can be more effective if they were more holistically applied and data-driven in basis.

B. Eminent Domain and Takings

Eminent domain can be useful for mitigating GCC hazards because a regional planner can take land that frequently floods or contributes to flooding elsewhere. In order for an eminent domain taking to be valid, it must be for a public purpose.[97] Under modern eminent domain, there are generally three categories of takings: physical takings, regulatory takings, and categorical takings.[98] These intertwined concepts will be explored here, followed by other state options.

Governmental takings are usually subject to constitutional restrictions requiring just compensation to the landowner,[99] making it an expensive process to deal with environmental protection in this manner. Physical takings are cases where the government physically takes a parcel of property and are subject to the just compensation requirement.[100] Under the regulatory takings analysis, as espoused in *Penn Central Transportation Co. v. City of New York*,[101] the government does not owe just compensation to a property owner whenever a property owner's interest in the parcel is outweighed by the "critical government safety objective it served."[102] Categorical takings occur whenever the government "deprives land of all economically beneficial use," as explained in *Lucas v. South Carolina Coastal Council*.[103] The court in this case, however, carved out an exception to requiring compensation: if, under the state's common law, "the proscribed use interests were not part of [the landowner's] title to begin with."[104]

Eminent domain may be a viable and inexpensive option because of the exception that the *Lucas* court noted, that some sticks in the bundle of property rights do not inhere in the landowner's title. But, more likely than not, it is still inadequate in

isolation because it cannot be applied holistically without watershed-level assessment. Moreover, it may be politically unwise for a government to simply take land across the board, especially without an administrative agency managing the affair from a larger perspective. Zoning is a state option that has the potential to run afoul into takings issues, because it is a regulation. In New Jersey, it is often the case that "environmental restrictions may have a greater claim to public interest than traditional zoning."[105] But this only applies to areas that are specifically protected, such as wetlands, which will be addressed in the next segment.

c. Statutory and Other State Options

In addition to the intricacies of constitutional takings issues, New Jersey has a body of statutory law that is useful for environmental protection in this context. The state's statutes have titles dedicated to relevant areas of law: Title 13 is for conservation,[106] including funding for local environmental organizations,[107] the Green Acres land acquisition program,[108] and protections for various ecologically sensitive areas; Title 20 lays out the procedures for eminent domain actions;[109] Title 40 includes sections on municipal land use and master plans.[110]

The DEP is the administrative agency tasked with carrying out many of the state's statutory requirements, and it operates using the New Jersey Administrative Code ("NJAC"), which contains the state's regulations.[111] The NJAC also has specific titles dedicated to various purposes, and for conservation purposes, all relevant regulations are contained within Title 7.[112] There are specific provisions that govern the safe and efficient management of storm water[113] and floodwater.[114]

The specific regions or ecological areas that are statutorily protected include coastal wetlands,[115] freshwater wetlands,[116] highlands,[117] and pinelands.[118] In the Freshwater Wetlands Protection Act, the legislature explicitly declared "that freshwater wetlands provide a natural means of flood and storm damage protection," which prevents harms like loss of life or property damage and mitigates flooding by absorbing flood water.[119] The statute goes on to say that New Jersey officially adopts the policy of preserving the "purity and integrity of freshwater wetlands" from any harm that might befoul them.[120]

After declaring the importance of freshwater wetlands, the statute establishes the criteria for "whether a proposed regulated activity in any freshwater wetland is in the public interest,"[121] including:

a. the public interest in preservation of natural resources and the interest of the property owners in reasonable economic development;
b. the relative extent of the public and private need for the proposed regulated activity;
c. where there are unresolved conflicts as to resource use, the practicability of using reasonable alternative locations and methods, including mitigation, to accomplish the purpose of the proposed regulated activity;
d. the extent and permanence of the beneficial or detrimental effects which the proposed regulated activity may have on the public and private uses for which the property is suited;
e. the quality of the wetland which may be affected and the amount of freshwater wetlands to be disturbed;
f. the economic value, both public and private, of the proposed regulated activity to the general area; and
g. the ecological value of the freshwater wetlands and probable impact on public health and fish and wildlife.[122]

Moreover, if a development creates adverse environmental impacts, the DEP has specific requirements for mitigating those impacts, including offsite creation of other wetlands.[123]

Accordingly, freshwater wetlands are exceptionally well protected in New Jersey; however, the areas that are the subject to flooding are much wider in scope than designated wetlands.[124] Consequently, of the existing legal solutions, the Green Acres program is the best suited to mitigate the hazards this Article seeks to address. Because this is better characterized as a landowner option than a state option, it will be addressed in the next segment.

Other potential legal solutions that scholars have suggested include using the public trust doctrine,[125] which is the idea that certain areas are of such importance that private owners cannot own them, but instead are held in trust by the state for public use in order to prohibit development in sensitive areas.[126] Traditionally, this includes riparian zones, or the areas along or underneath flowing bodies of water, shorelines below the high tide line, certain floodplains, certain islands, and other similar areas.[127] Unfortunately, because so much of New Jersey is already developed,[128] this doctrine is of limited use in this context because it is best applied to areas that remain undeveloped. Although, it is important to note that the public trust doctrine could be used as a legal shield in a *Lucas* analysis when a state actor defends against a landowner's action for just compensation, because the right to develop was never a part of the landowner's title to begin with.

Other scholars have suggested using nuisance law as a viable tool to combat development.[129] This is the idea that destroying wetlands, floodplains, or "other aquatic resources" is inherently a public nuisance.[130] Many jurisdictions have based nuisance holdings on this legal theory,[131] and some have even found that the destruction of wetlands may be a "community harm" entitling the government to proceed with a regulatory taking without just compensation.[132] Nuisance doctrine could leave room for an abatement seeker in a *Lucas* analysis to argue that using land in a manner inconsistent with public policy is not a part of the landowner's title, but, not all courts are willing to adopt such a premise, so a legislative solution may be more effective.[133]

The New Jersey Supreme Court might be in favor of this sort of an argument. In *Borough of Harvey Cedars v. Karan*, a case where a family sued a municipality for blocking their ocean-front views by increasing the size of sand dunes in an effort to protect the town from storm surges; after the family won at the trial court, the New Jersey Supreme Court held that the trial court erred by not instructing jurors to consider how much a protective sand dune would help them in the event of a future storm when calculating just compensation for a taking.[134]

Because of the trial court's erroneous instructions, the jury had awarded the homeowners $375,000, which was affirmed by the Appellate Division.[135]

The state's high court reversed, concluding that the lower court's calculus based on general versus special benefits flowing from the easement were of no value in the modern age.[136] The court stated that it "need not pay slavish homage to labels that have outlived their usefulness," and determined that the probative question was how much value the property has lost, regardless of whether it was a general or special benefit.[137] In concluding that the lower courts erred by not instructing jurors to consider how much a protective sand dune would help them in the event of a future storm when calculating just compensation for a taking, the court reasoned that the burden of the average taxpayer "may be infinitesimal compared to the value added to their home by the dune protection."[138] The parties later settled for one dollar.[139] This gives hope that New Jersey courts can adopt case law favoring development that is sustainable and ecologically responsible by liberalizing legal theories based on nuisance or public trust doctrine. Perhaps within a few decades New Jersey courts might even learn to "think like a mountain."[140] To be most useful, the doctrines of nuisance law and public trust must be more fully developed in this context, either by case law or ideally by statute, and then applied by a qualified planner.

D. Landowner Options

I. Green Acres Program

Of the existing options for both state and private actors, the Green Acres program presents the best solution under current law. Utilizing a portion of this program, called Blue Acres, New Jersey landowners can voluntarily apply to have their properties reclaimed by the state.[141] The policy of the broader Green Acres program is that it enables municipal governments and nonprofits in their conservation efforts, such as protecting wetlands, forests, and other natural resources.[142] The Blue Acres Floodplain Acquisition program is more specific for use in flood mitigation; enacted under the Green Acres, Farmland, Blue Acres, and Historic Preservation Bond Act of 2007, it authorized $12 million for acquisition of lands in the floodways of the Delaware River, Passaic River or Raritan River, and their respective tributaries, for recreation and conservation purposes.[143] The Green Acres, Water Supply and Floodplain Protection, and Farmland and Historic Preservation Bond Act of 2009 added "[a]n additional $24 million to the program."[144] Moreover, in the wake of Hurricane Sandy, $300 million in federal funding was added to the program to purchase flooded coastal properties.[145] Under this program, New Jersey landowners can voluntarily apply to have their properties reclaimed by the state.[146]

The program relies on a system of eligibility and points based on a variety of factors,[147] and legislative appropriations.[148] Local governments as well as private entities may apply,[149] and the land to be acquired must meet certain requirements, such as being suitable for recreational activities.[150] The ultimate criteria for being eligible is demonstrating a history of being repeatedly flooded.[151]

This program is an excellent idea in that it allocates funding and government resources to addressing the real problem of floodplain vulnerability. Yet, it has its drawbacks. First, funding is extremely limited,[152] and is more focused on shore recovery than inland mitigation in the wake of Hurricane Sandy;[153] this ignores the data that inland areas are likely more vulnerable than the shore to frequent flooding.[154] Second, these programs only apply to property owners who are willing to voluntarily sell their properties to the state,[155] so it is an ad-hoc application. Third, the programs only apply to some property owners, usually those who have been subject to severe storms in the past.[156] Because of this, it is underfunded, ad hoc, and reactive.

V. Conclusions

A. Solutions: Utilization of Statutory Schemes and Policy Positions that Incorporate Technology

New Jersey lawmakers are faced with the threat of global climate change in the form of increased precipitation compounded by human development that increases exposure and decreases the natural environment's resilience to such incidents. As a matter of policy, New Jersey's leadership can respond in four different ways based on the outcomes that the climate and geographical data predicts: a) ideal proactive, b) realistic proactive, c) reactive, or d) do nothing.

I. Ideal Proactive

In the ideal proactive paradigm, New Jersey lawmakers create a statutory scheme whereby content experts use modeling programs and the resulting data on the watershed level to assess the threat vulnerability and make recommendations or preferably binding decisions. Recall that if each municipality had its own policies to deal with flooding, there would be no holistic approach and the entire system would be so segmented it might fail to be of any use. This statute can operate as a parallel to New Jersey's land redevelopment statute in its ability to make a determination that a particular area is going to be utilized for a more beneficial purpose but would ideally be much more powerful.[157]

The statute would declare that environmental protection for the purpose of flood resilience is a public purpose, it would overtly recognize that the doctrines of public trust and nuisance in New Jersey equate to the legal fact that no private title can retain rights that intrude on either doctrine. It would create a panel of geographers, atmospheric scientists, and lawyers who would assess New Jersey's freshwater systems on a watershed level using the best available demonstrated technology.[158]

It is an unfortunate occurrence that the laws of human society and the laws of the natural world do not always coincide. In New Jersey and the rest of the country, legal jurisdictions can be arbitrary lines that have no natural significance.[159] To be effective in this context, legal solutions must be based at the ecosystem or watershed level.[160] Legal solutions, whether they are zoning, Blue Acres, or categorical takings, must be a planned process that incorporates the natural world into its legal solution, "not merely ad hoc, reactive experimentalism and incrementalism."[161] Indeed, these plans must predict how human

development, the land, and the skies will interact using GIS and other technologies, and mitigate the risks using legal doctrines as well as biological or natural technologies.

The path to accomplishing this is with GIS and other modeling programs that the law must use as its foundation. Using GIS to analyze land use, soil permeability, and other factors, as well as precipitation predictions and existing flood data, the expert panel can predict the areas that are increasingly vulnerable to inundation.[162] It can utilize designations such as unlikely, likely, or extremely likely in its characterization of specific areas within a watershed.

The statutory scheme could be very rigid, meaning that once a finding of a certain threshold is made, the area would be taken using eminent domain and made inexpensive by using a *Lucas* analysis with public trust doctrine or nuisance law. The argument can proceed as follows: if an area is so prone to flooding, then it is axiomatically a nuisance to build there or permit continued habitation there. Further, under the scheme, riparian rights were never a part of the landowner's title, so they could be taken by the state at will.

This might sound like a socialist plot to acquire vast swathes of private land, but it is better characterized dually as a capitalist money-saving venture as well as a conservationist's dream. Merely because a plan emphasizes an ecological principle as its basis does not exclude the fact that its reasoning is based in economic soundness. Hurricane Sandy was the second most expensive hurricane ever to hit the United States,[163] and in New Jersey it cost $29.4 billion.[164] Hurricane Irene, a storm much more pertinent in the context of inland flooding because it produced more rainfall was also astoundingly expensive.[165] But major hurricanes are not the most numerous causes of inland flooding; rather, it is the ebb and flow of lesser storms in succession in localized areas.[166] Wayne Township, an inland community in the Highlands region of the state has suffered more flood damage than any other town in New Jersey; more than 760 property owners have repeatedly flooded, totaling more than $100 million in damages.[167]

"It is an unfortunate occurrence that the laws of human society and the laws of the natural world do not always coincide."

Wayne is a single town in New Jersey, and the costs it has borne are extreme. The total costs of flood damage, adding every municipality in the state, significantly outweighs the societal and fiscal costs of taking private land for this purpose.[168] The key to fighting flood destruction is by predicting the areas that are vulnerable using GIS technologies to map geospatial data and remodel New Jersey's land use accordingly. In order to do this, it is important for the government to understand the dynamics of flood vulnerability so they can be realistic in planning for disaster when they make decisions about future development. [169]

Through the analysis of the interdisciplinary panel, the scheme can use a concept called integrated flood management ("IFM"), which

> identifies four key elements that should be present in order to ensure that floods are managed successfully within the greater context of integrated water resources management. These elements include: (1) ensuring the water cycle is managed as a whole, thus recognizing the linkages between ground water and flood water; (2) the integration of land-use planning in water management and the adoption of the best mix of strategies, both structural and non-structural, depending on the characteristics of the river system and the region; (3) a participatory approach involving users, planners, and policymakers at all levels; and (4) the adoption of integrated hazard management approaches whereby members from all sectors... are involved in the process of carrying out activities to ensure implementation of disaster management plans.[170]

This approach would also capitalize on biological or natural phenomenon that acts to reduce the destruction caused by flooding. Moreover, the scheme encourages green building in areas that are difficult to take for hardship reasons. It would implement this by incentivizing biological and natural technologies or incorporating them as alternatives to takings in particular situations.

Thus, the ideal proactive approach is named so because it uses GIS and climate modeling technologies to predict and anticipate vulnerability as well as natural technologies to increase resilience. It is holistic in that it assesses freshwater systems at the watershed level rather than ad hoc by each municipality or privately owned parcel. Also, it is relatively inexpensive because it avoids the just compensation requirements of most *Lucas* cases by utilizing nuisance and public trust law.

Of course, this could be a politically unpopular solution, even excluding the recent trend of demonizing climate activism and environmental concerns, [171] But this kind of argument is not about doing what the general populous would find the easiest, it is about doing what the data suggests is the best course of action. If all available evidence pointed toward a conclusion that has difficult implications, it is still the conclusion that the data supports. A lesser version of this would make the panel an advisory body without any taking authority, but, although it would likely be more politically popular, that would rob the scheme of its muscle.

II. Realistic Proactive

The realistic proactive approach could use the existing laws of New Jersey as the primary method of proactive mitigation. This is the best case scenario under current law because the primary arm of this approach will be the Blue Acres buy-back program[172] but also a heightened focus on the importance of utilizing GIS on municipal land use master plans as well as eminent domain in rare cases.[173]

New Jersey is a state that requires a master plan for a municipality's zoning,[174] but such master plans do not require municipalities to factor in the super saturation of human expansion.[175] Using already available GIS data and land permeability information, municipal master plans will be better suited to dealing with flood vulnerability than they are at present. Carrying capacity is a critical environmental characteristic of a focus region that is as important in a master plan as housing or any other element.[176] This is largely the approach that Bound Brook and DEP utilized after Hurricane Floyd in 1999, which spared the town from similar inundation when Irene struck in 2011 albeit taking years of flooding before state actors created and implemented this program.[177] The problem with this approach is that it is still ad hoc in nature and limited in funding. It rarely analyzes the bigger problems of flood vulnerability at the watershed level and still engages in "the science of muddling through" by not looking at the bigger picture.[178] Because "[t]he lessons of science and ecology are that ecosystems are complex and dynamic" and are subject to many variables that might not have any correlation at all.[179] Hence, it is critical to engage in "'big picture' thinking."[180] Moreover, Blue Acres and other programs are tied to legislative funding allocations.[181]

> *"The goal is to protect the world that humanity knows and that has supported human development heretofore."*

III. Reactive

The reactive approach is the method New Jersey lawmakers currently utilize to mitigate natural disasters. Whenever a particular parcel of property repeatedly floods, those property owners may apply to have the state buy their land. This approach utilizes the Blue Acres buy-backs and zoning when appropriate, but is significantly weakened by the economic interests of developers who desire to continue urbanizing New Jersey.[182] It is generally clear that many landowners are unwilling to part with their properties simply because of the nebulous risk of some weather-related event potentially years, decades, or centuries in the future that might destroy their homes. But, such a mindset ignores the environmental data, the reality of global climate change, and the fact that intense storms are going to be ever more likely.

IV. No Action

Fortunately, New Jersey's environmental protection laws are more progressive than most American jurisdictions, so this is an unlikely approach because it requires that the state literally do nothing at all, which is already not the case in the state.[183]

B. Other Considerations

I. Environmental Justice

Much of New Jersey's suburban and exurban sprawl tends to be white and relatively affluent.[184] The solutions proposed in this Article will likely affect these communities by ceasing upstream exurban human development, but it is communities of color that are most vulnerable to both environmental harm and governmental harm in this context.[185] Indeed, the United States has a long history of disproportionately adversely affecting less affluent and less white communities in how it handles natural disasters and land use issues.[186]

Consequently, the issues that springs forth from environmental problems undoubtedly have equity issues.[187] Environmental justice seeks to highlight the inequitable distribution of environmental amenities and burdens between more affluent versus less affluent populations and communities of color compared to white populations.[188] It is important to be mindful of this concern in the application of the proposed scheme, but ideally the mitigation strategies are based solely on the environmental data, yet if a discriminatory outcome results the application could be modified.

Indeed, if there is a population who has the financial and cultural capital to advocate on behalf of their own environmental interests, it is those engaging in exurban expansion.[189] Consider the case of the present Great Swamp Wildlife Refuge, where the Port Authority of New York and New Jersey desired to build a jetport until the community, nearly entirely affluent and white, fought it financially and legislatively.[190] That location later became the first federal National Wildlife Refuge in the United States, and remains federally protected today.[191]

II. Private Interests

Because of this country's idea of individual property rights, voluntary buy-outs are more favorable in political thought and possibly in economic terms as well. If a property owner voluntarily sells his or her property then there will likely be substantially less litigation costs because property owners do not sue to retain property they are voluntarily relinquishing. Further, the impact of taking one's property as a societal benefit is likely not one that property owners will complacently accept.[192] Homeowners associations, builders associations, and other groups are dedicated to increasing New Jersey's economy

by not hindering the private sector's ability to build and develop. Indeed, environmental interests often conflict "with traditional landowner beliefs in the freedom to use legally owned land as they wish."[193]

An important issue this Article may seem to gloss over is the economic interests of New Jersey residents. These individuals and entities no doubt desire to continue expanding and increase further development in order to stimulate New Jersey's economy.[194] Some entities see regulatory action as stifling economic growth.[195] But an analysis of the big picture rectifies the error of this view: annual flooding will stifle growth more than any regulation,[196] so New Jersey should build for the future that the data shows will happen, not the future homeowner's associations hope of what will happen. Situations where interested industries fight data-based conclusions are all too common in history; the tobacco industry fought warning labels[197] and the automobile industry fought to avoid eliminating lead in gasoline.[198] Growth may have been hindered but the industries are prospering today, and people are healthier because of it.

Ultimately, though these flood vulnerability mitigation strategies are supported by an economic analysis, their basis is in the idea of a land ethic.[199] Under the idea of a land ethic, a cost-benefit analysis of pure economics cannot work because it ignores the most fundamental part of the equation, that the value of the environment cannot be measured in terms of dollars and cents.[200] In scope, in scale, and in importance, the earth we live on is beyond the comprehension of our economic system.

New Jersey's environment requires protection not because it is so fragile that is incapable of protecting itself, it is so that humanity may continue to thrive as it has in the past, because the earth and the environment will recover, in the long run. The goal is to protect the world that humanity knows and that has supported human development heretofore. To do this, human development must be done responsibly and based on sound technology and data-driven models, not solely on economically profitable schemes. To obtain a sustainable existence in the Garden State, human development projects and state action must incorporate the idea that they are part of a larger picture by using various technologies to assess the scope of that picture, or face heightened vulnerability to, among other threats, inland flooding and Global Climate Change.

Endnotes: You Probably Shouldn't Build There: Watershed-Based Land Use Strategies for Mitigating Global Climate Change in New Jersey's Freshwater Systems

1 *See Summary of Flooding in New Jersey Caused by Hurricane Irene, August 27–30, 2011*, USGS, http://nj.usgs.gov/hazards/flood/flood1108/ (last visited Nov. 15, 2015) (Passaic River gage at Newark: 7.11 feet; Raritan Bay gage at Keansburg: 7.16 feet; Shrewsbury River gage at Sea Bright: 6.29 feet).

2 *See* Jill P. Capuzzo, *In Bound Brook, Reaching a Truce with Floodwaters*, The New York Times (Oct. 15, 2013), http://www.nytimes.com/2013/10/20/realestate/in-bound-brook-reaching-a-truce-with-floodwaters.html?_r=0.

3 *See* Green Brook Flood Control Project, State of New Jersey Dep't of Envtl. Prot., http://www.nj.gov/dep/floodcontrol/greenbrookfc.htm (last visited Nov 15, 2015).

4 *See* Capuzzo, *supra* note 3.

5 *See Flood Prevention Project in Bound Brook Keeps Hurricane Irene from Becoming Another Floyd*, NJ.com (Aug. 30, 2011), http://www.nj.com/news/index.ssf/2011/08/flood_gates_and_pumping_statio.html.

6 *See generally* Robin B. Valinski, *Green Brook Flood Control Project: Saving Bound Brook* 29-31 (Spring 2012) (unpublished paper) (on file with University of Pennsylvania), *available at* http://repository.upenn.edu/cgi/viewcontent.cgi?article=1046&context=mes_capstones; *see also* Joe Tyrrell, *Conflicting Priorities Slow Efforts to Save NJ Towns From Floods*, NJ Spotlight (June 28, 2012), http://www.njspotlight.com/stories/12/0627/2027/ ("legislators pointed out that [project in Bound Brook] only addresses one stretch of the Raritan").

7 *See* C. P. Konrad, *Effects of Urban Development on Floods*, USGS, http://pubs.usgs.gov/fs/fs07603/ (last visited Nov. 15, 2015) (finding that "[u]rbanization generally increases the size and frequency of floods and may expose communities to increasing flood hazards.").

8 *See Extreme Precipitation Events are on the Rise,* Climate Central (May 6, 2014), http://www.climatecentral.org/gallery/maps/extreme-precipitation-events-are-on-the-rise [hereinafter *Extreme Precipitation Events*]; *see also Extreme Precipitation in New York and New England*, Cornell University, http://precip.eas.cornell.edu/ (last visited Nov. 10, 2014) ("[I]n New York and New England... the frequency of 2 inch rainfall events has increased since the 1950s and storms once considered a 1 in 100 year event... are now likely to occur almost twice as often.").

9 *See, e.g.*, *Global Warming Impacts*, Union of Concerned Scientists, http://www.ucsusa.org/our-work/global-warming/science-and-impacts/global-warming-impacts#.VGF1evnF8yd (last visited Nov. 15, 2015) (detailing the progress of scientists and engineers of all specializations working towards solving climate problems).

10 *See Extreme Precipitation Events, supra* note 9.

11 *See* Laura Mansnerus, *New Jersey is Running Out of Open Land it can Build On*, The New York Times (May 24, 2003), http://www.nytimes.com/2003/05/24/nyregion/new-jersey-is-running-out-of-open-land-it-can-build-on.html.

12 *See* John R. Ottensmann, Market–Based Exchanges of Rights Within a System of Performance Zoning 1, 3 (Sept. 1998) (unpublished study, University of Southern California Planning & Markets), *available at* http://www-pam.usc.edu/volume1/v1i1a4s3.html ("By introducing controls on the private use of land…zoning…results in land use decisions that are less efficient from the perspectives of the individual landowners.").

13 *See* Cam Cavanaugh, Saving the Great Swamp: The People, the Power Brokers, and an Urban Wilderness 16 (1978) (providing a narrative of a particular instance of the community's role in environmental activism).

14 *See Climate Change: How do we Know?*, NASA, http://climate.nasa.gov/evidence/ (last visited Nov. 15, 2015).

15 *See Consensus: 97% of Climate Scientists Agree*, NASA, http://climate.nasa.gov/scientific-consensus/ (last visited Jan. 17, 2015).

16 *See* Paul G. E. Clemens, The Uses of Abundance: A History of New Jersey's Economy 10, 17, 29 (1992).

17 *Id.* at 33.

18 *See* Sen-Yuan Wu, *New Jersey Population: 1790 to 2010*, New Jersey Division of Labor Market & Demographic Research (Dec. 2010) http://lwd.dol.state.nj.us/labor/lpa/dmograph/est/nj1790_2010.pdf (New Jersey's population doubled in fifty years from about 150,000 in 1784 to about 320,000 in 1830, doubled again to 672,000 by 1860, and continued to accelerate until slowing in the decades after 1970. As of 2010, the state's population was 8.8 million).

continued on page 35

Endnotes: The Aftermath of *CARE v. Cow Palace* and the Future of RCRA in CAFO Cases

[1] *See What's the Problem?*, EPA, http://www3.epa.gov/region9/animalwaste/problem.html (last updated Oct.13, 2015).

[2] *See Animal Feeding Operations,* USDA Natural Res. Conservation Serv., http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/plantsanimals/livestock/afo/ (last visited Dec. 18, 2015) ("[A]n animal unit is defined as an animal equivalent of 1000 pounds live weight and equates to 1000 head of beef cattle, 700 dairy cows, 2500 swine weighing more than 55 lbs, 125 thousand broiler chickens, or 82 thousand laying hens or pullets.").

[3] *See What's the problem?*, *supra* note 1.

[4] *See* Fed. Water Pollution Control Act (hereinafter Clean Water Act) 33 U.S.C. § 1251 [As Amended Through P.L. 107–303, Nov. 27, 2002] 214; *see also Animal Feeding Operations*, *supra* note 2 ("Any size AFO that discharges manure or wastewater into a natural or man-made ditch, stream or other waterway is defined as a CAFO, regardless of size.").

[5] *See* Jonathan H. Adler, *Stand or Deliver: Citizen Suits, Standing, and Environmental Protection,* Duke Envtl. Law & Policy Forum 39, 46 (Mar. 2000).

[6] *See Cmty. Ass'n for Restoration of the Env't, Inc. (CARE) v. Cow Palace, LLC*, 80 F. Supp. 3d 1180, 1181 (E.D. Wash. 2015).

[7] *See* 33 U.S.C. § 1251.

[8] *See* Res. Conservation and Recovery Act 42 U.S.C. § 82 [As Amended Through P.L. 107–377, Dec. 31, 2002] 7.

[9] *See id. at 107.*

[10] *See Cow Palace*, 80 F. Supp. 3d at 1180.

[11] *See* 33 U.S.C. § 1251.

[12] *See* Carrie Hribar, *Understanding Concentrated Animal Feeding Operations and Their Impact on Communities,* Nat'l Ass'n of Local Bds. of Health 2, *available at* http://www.cdc.gov/nceh/ehs/docs/understanding_cafos_nalboh.pdf ("Annually, it is estimated that livestock animals in the U.S. produce each year somewhere between 3 and 20 times more manure than people in the U.S. produce, or as much as 1.2–1.37 billion tons of waste. Though sewage treatment plants are required for human waste, no such treatment facility exists for livestock waste").

[13] *See id.*

[14] *See What's the Problem?*, *supra* note 1.

[15] *See id.*

[16] *See id.*

[17] *See Cmty. Ass'n for Restoration of the Env't, Inc. (CARE) v. Cow Palace, LLC*, 80 F. Supp. 3d, 1180, 1181 (E.D. Wash. 2015).

[18] *See id.* at 1193.

[19] *See id.* at 1221.

[20] *See id.* at 1180.

[21] *See* Carol Ryan Dumas, *Yakima dairy challenge has broad implications, experts say,* Capital Press (Aug. 18, 2015), http://www.capitalpress.com/Dairy/20150818/yakima-dairy-challenge-has-broad-implications-experts-say.

Endnotes: You Probably Shouldn't Build There: Watershed-Based Land Use Strategies for Mitigating Global Climate Change in New Jersey's Freshwater Systems

continued from page 13

[19] *See* William Gillette, Professor of History, Rutgers University, Lecture in course on New Jersey History (Spring, 2009) (1875 was a milestone year for New Jersey; it was the first year when its population reached one million and it was the first year when more people lived in cities than in the surrounding countryside).

[20] *See id.*

[21] *See generally*, Adam Rome, The Bulldozer in the Countryside: Suburban Sprawl and the Rise of American Environmentalism 36-45 (2001) (describing the post-World War II suburban expansion as the model for late-twentieth century American life, as developers bought farms in eastern states, subdivided those farms into lots, built houses on each lot, and sold those lots to returning veterans eager to start new families); Kenneth T. Jackson, Crabgrass Frontier: The Suburbanization of the United States 283-84 (1985) ("Between 1950 and 1970, the [United States'] suburban population doubled from 36 to 74 million, and 83 percent of the nation's total growth took place in suburbs…. In 1970, for the first time in the history of the world, a nation-state counted more suburbanites than city dwellers or farmers.").

[22] *See* James W. Hughes & Joseph J. Seneca, *The Economy*, *in* Mapping New Jersey: An Evolving Landscape 152, 154 (Maxine N. Lurie & Peter O. Wacker ed., 2009) (explaining that the middle part of New Jersey between New York City and Philadelphia has a long history of being a supplier of human capital to those two cities, and is fundamentally tied to their growth in its development patterns).

[23] *Origins of the Nickname*, The State of New Jersey, http://www.state.nj.us/nj/about/facts/nickname/Statement (last visited Nov. 18, 2015); *see also* Hughes & Seneca, *supra* note 23 at 154 (mentioning that "New Jersey was described as a 'barrel tapped at both ends'" to explain that it acted as an economic function of New York City and Philadelphia and that New Jersey's economy rested on that of the two cities at its borders).

[24] See *Exurb*, Dictionary.com, http://www.thefreedictionary.com/exurban (last visited Nov. 18, 2015).

[25] *See* Richard Lathrop & John Hasse, *Tracking New Jersey's Changing Landscape*, in New Jersey's Environments: Past, Present, and Future 121-22 (Neil M. Maher, ed., 2006). *But see* Eric Sundquist, *Exurban Development Continues to Decline, While Cities Return to Pre-Recession Growth*, Smart State Transportation Initiative, (Apr. 16, 2012), http://www.ssti.us/2012/04/exurban-development-continues-to-decline-while-cities-return-to-pre-recession-growth/ (detailing decline in exurban development in favor of urban population growth).

[26] *See* Lathrop, *supra* note 26, at 121 (stating that "[t]he rate of forest conversion to development…has increased slightly from approximately 8,630 acres/year during the 1986 to 1995 time period to approximately 9,590 acres/year between 1995 and 2000.").

[27] *See Statistical Abstract of the United States Section 1. Population Table 14* 20, United States Census Bureau (2012), http://www.census.gov/compendia/statab/2012/tables/12s0014.pdf.

[28] *See* Mansnerus, *supra* note 12.

[29] *See* Lathrop, *supra* note 26, at 125-26 (explaining that "build-out" means when developers have built on all developable land).

[30] *See Population Density*, Dictionary.com, http://dictionary.reference.com/browse/population+density (last visited Sept. 19, 2015).

[31] *See generally* Lathrop, *supra* note 26, at 123-26.

[32] *See* Sampson, *infra* note 52.

[33] *See generally* Ian Sample, *Scientists Offered Cash to Dispute Climate Study*, The Guardian (Feb. 2, 2007, 10:11, AM), http://www.theguardian.com/environment/2007/feb/02/frontpagenews.climatechange (demonstrating the importance of global climate change in that certain interest groups are willing to pay vast sums of money to scientists for a favorable assessment of global climate change). *But see* Union of Concerned Scientists *supra* note 10 (asserting the various effects of global climate change).

[34] Joseph F.C. DiMento & Pamela Doughman, *Introduction: Making Climate Change Understandable*, *in* Climate Change: What It Means for Us, Our Children, and Our Grandchildren 1, 1 (2007).

[35] *See Causes of Climate Change*, EPA, http://www.epa.gov/climatechange/science/causes.html (last visited Nov. 18, 2015) (stating that since the industrial era, and especially in the mid-twentieth century, humans have notably increased the amount of greenhouse gases emitted into the atmosphere. *See generally Overview of Greenhouse Gases,* EPA, http://www.epa.gov/climatechange/ghgemissions/gases.html (last visited Nov. 18, 2015) (showing that greenhouse

gases include water vapor, carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons).

[36] *See also Causes of Climate Change, supra* note 36; *see also Overview of Greenhouse Gases*, *supra* note 36.

[37] *See Causes of Climate Change, supra* note 36.

[38] John Abatzoglou, et al., *A Primer on Global Climate Change and Its Likely Impacts*, *in* Climate Change: What It Means for Us, Our Children, and Our Grandchildren 27, 27-28 (Joseph F.C. DiMento & Pamela Doughman, eds. 2007) (showing that the combustion process has greatly increased the production of gases since the Industrial Revolution).

[39] *Id.* at 27.

[40] *Global Climate Change*, NASA, http://climate.nasa.gov/400ppmquotes/ (last visited Nov. 18, 2015).

[41] *See generally*, *Climate Change Indicators of the United States, 2014*, EPA, *available at* http://www3.epa.gov/climatechange/pdfs/climateindicators-full-2014.pdf (presenting various measurable criteria that demonstrate how global warming is affecting our environment).

[42] *See* David Appell, *Loss of Land Ice (Not Sea Ice) = More Sea Level Rise*, Yale Climate Connections (Nov. 14, 2014), http://www.yaleclimateconnections.org/2014/11/loss-of-land-ice-not-sea-ice-more-sea-level-rise/ (commenting that melting ice in the sea does not affect sea level rise because it is already in the water, while melting ice on land causes sea level to rise because it adds water to the sea that previously was on land).

[43] *UN Atlas: 44 percent of us live in coastal areas*, Coastal Challenges, (Jan. 31, 2010), http://coastalchallenges.com/2010/01/31/un-atlas-60-of-us-live-in-the-coastal-areas/. *See generally* Alistair S. Reiu-Clarke, *A Survey of International Law Relating to Flood Management: Existing Practices and Future Prospects*, 48 Nat. Resources J. 649, 649 (2008) ("the number of people vulnerable to floods will reach two billion by 2050 as a result of climate change, deforestation, rising sea levels, and population growth in flood-prone areas.").

[44] *See* Gayathri Vaidyanathan, *How to Determine the Scientific Consensus on Global Warming*, Scientific American (July 24, 2014), http://www.scientificamerican.com/article/how-to-determine-the-scientific-consensus-on-global-warming/?print=true.

[45] *See Climate Change Indicators of the United States, 2014, supra* note 42, at 3 ("Scientists are highly confident that many of these observed changes can be linked to the climbing levels of carbon dioxide and other greenhouse gases in our atmosphere…."); *see, e.g.*, *Global Warming Petition Project,* Petition Project, http://www.petitionproject.org/ (last visited Nov. 16, 2014) (a petition signed by members of the scientific community who deny anthropogenic climate change). *But see* Kevin Grandia, *The 30,000 Global Warming Petition is Easily-Debunked Propaganda*, Huffington Post (last updated May 25, 2011, 1:40 PM), http://www.huffingtonpost.com/kevin-grandia/the-30000-global-warming_b_243092.html (explaining that the Oregon Petition is not based on the opinions of the scientific community of the relevant field because .1% to .5% of signers are climate scientists, many signers may not be real people, and the documents are formatted to be intentionally misleading); *Oregon Petition,* DeSmogBlog, http://www.desmogblog.com/oregon-petition (last visited Nov. 19, 2015) (explaining that the Oregon Petition is funded by interests that desire to spread disinformation, such as oil companies, and many of the names are fictional, such as the stage name of a member of the musical group, "The Spice Girls").

[46] *Future Climate Change*, EPA, http://www.epa.gov/climatechange/science/future.html#ref1 (last visited Nov. 19, 2015); *see also* Tyrrell, *supra* note 7 (noting that New Jersey has gotten both warmer and wetter in recent years and that "[e]ight of the 50 highest rainfalls recorded in New Jersey have happened since 2002….").

[47] *See Extreme Precipitation Events, supra* note 9 (giving a brief discussion of the effect of water condensation through rain or snow affecting GHGs); *see* Tyrrell, *supra* note 7 (discussing the effects that various hurricanes throughout the last few decades has had on New Jersey).

[48] *See, generally* Justine Brown, *Water Wise*, 9 Emergency Management 1, 26-31 (2014), https://erepublic.box.com/shared/static/r21ht0ib4faqg20q44uc.pdf (describing flood management systems in major cities such as New York City and New Orleans).

[49] *See* Konrad, *supra* note 8 (discussing how paved surfaces reduce infiltration of water thus causing flooding).

[50] *See* Mansnerus, *supra* note 12 (presenting that land is consumed three to four times faster than the rate of population growth).

[51] *See* Skyler E. Sampson, *The Correlation Between Soil Permeability and Flooding in the Northeast Sector of the Dog River Watershed,* Univ. of S. Ala. Dept. of Earth Sciences 5, http://www.southalabama.edu/geography/fearn/480page/2014pdfs/14Sampson.pdf (last visited Nov. 16, 2014) (concluding that soil permeability in areas with paved surfaces causes significantly more flooding compared to non-paved surfaces).

[52] *See generally id.* at 1-6 (assessing the effects of non-permeable and permeable surfaces on FEMA designated flood zones to determine what effect, if any, these surfaces have. The study concluded that due to the increased amount of paved surfaces, flood zones continued to increase as well.).

[53] *Id.* at 1.

[54] *Id.* at 1.

[55] *See* Reiu-Clarke, *supra* note 44, at 653-54 (explaining that development on "wetlands and floodplains, which act as natural sponges during flood events" worsens floods and that "[d]eforestation has also been identified as a contributor to increased flood events as a result of greater runoff, mudslides, and the build-up of sediment loads within the river channel.").

[56] Judy Stewart, *Municipal "Direction, Control and Management" of Local Wetlands and Associated Riparian Lands: Section 60 of Alberta's Municipal Government Act*, 47 Alta L. Rev. 73, 80 (2009).

[57] *See Future Climate Change*, *supra* note 47.

[58] *See id*.

[59] *See id.* (emphasizing that it is difficult to predict future events).

[60] *See id.* (the scenarios including future temperature changes; future precipitation and storm events; future ice, snowpack, and permafrost; future sea level change; future ocean acidification).

[61] David Hart, *Introduction to Geographic Information Systems GIS*, Great Lakes Coastal Planning, http://aqua.wisc.edu/CPR/IntroductiontoGeographicInformationSystemsGIS/tabid/78/Default.aspx (last visited Nov. 19, 2015).

[62] *Cf. id* (stating that GIS systems can input a multitude of attributes of different geographic locations).

[63] *Id.*

[64] *See generally Spatial Analysis*, ESRI, http://www.esri.com/products/arcgis-capabilities/spatial-analysis (last visited Nov. 19, 2015) (explaining the use of spatial analysis using different factors and variables); *see also* NJ Flood Mapper, http://slrviewer.rutgers.edu/ (last visited Dec.6, 2015) ("An interactive mapping website to visualize coastal flooding hazards and sea level rise" operated by Rutgers University and designed to "promote enhanced preparedness and land use planning decisions with considerations for possible future conditions.")

[65] *See* Richard Lathrop & John Bognar, *Applying GIS and Landscape Ecological Principles to Evaluate Land Conservation Alternatives*, 41 Landscape & Urban Planning 27, 35 (1998) (applying GIS overlay maps to the Sterling Forest on the New York-New Jersey border to protect the region from development).

[66] *Id.* at 27.

[67] *Id.* at 30.

[68] Lathrop, *supra* note 26, at 112.

[69] *Id.* at 112.

[70] *Id.* at 112.

[71] *Id.* at 113.

[72] *Id.* at 113.

[73] *Id.* at 112.

[74] *See* Craig Anthony Arnold, *Adaptive Watershed Planning and Climate Change*, 5 Envt'l & Energy L. & Pol'y J. 417, 418-21 (2010) (discussing how various negative inputs can affect the potential for flooding and the need for change to reduce flooding).

[75] *See Frequently Asked Questions about the NWS Radiosonde Observations Program*, NOAA, http://www.ua.nws.noaa.gov/Faq.htm (last visited Nov. 19, 2015).

[76] *See Doppler Radar,* NOAA, http://www.spc.noaa.gov/faq/tornado/doppler.htm (last visited Nov. 19, 2015) (giving a background of what Doppler Radar can measure).

[77] *See What is LIDAR?*, NOAA, http://oceanservice.noaa.gov/facts/lidar.html (a remote sensing method that uses lasers) (last visited Nov., 19, 2015).

[78] *See generally Model Analyses and Guidance*, National Weather Service, http://mag.ncep.noaa.gov/ (last visited Nov. 19, 2015).

[79] *Predicting the Future with Climate Models*, UCAR, http://www.eo.ucar.edu/basics/cc_5.html (last visited Nov., 19, 2015).

[80] *See Predicting Changes: Modeling the Climate System*, Science Museum, http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/Exploringwhatmighthappen/2point4/2point4point3.aspx (last visited Nov. 19, 2015).

[81] *See Predicting the Future with Climate Models*, *supra* note 80.

[82] *See Predicting Changes: Modeling the Climate System*, *supra* note 81.

[83] *See id*.

[84] *See* John R. Nolon, *Managing Climate Change Through Biological Sequestration: Open Space Law Redux*, 31 Stan. Envtl. L.J. 195 (2012).
[85] *See The Value of Wetlands*, WWF Global, http://wwf.panda.org/about_our_earth/about_freshwater/intro/value/ (last visited Nov. 19, 2015) (stating that wetlands near river basins can act as sponges for rainwater).
[86] *See id*.
[87] *Cf.* Ted Steinberg, Acts of God: The Unnatural History of Natural Disaster in America (2d ed. 2000).
[88] *See* Jonathan Douglas Witten, *Carrying Capacity and the Comprehensive Plan: Establishing and Defending Limits to Growth*, 28 B.C. Envtl. Aff. L. Rev. 583, 583-85 (2001) (discussing a natural environment's carrying capacity to allow human development without causing degradation).
[89] *Id*. at 589.
[90] *Id.* at 589-91 (replicating wetlands is the creation of new wetlands in areas that were previously not classified as such).
[91] *Id.* at 591-92 (discussing the importance of considering carrying capacity and its interaction with wetlands replication).
[92] *Id.* at 592.
[93] *See The Value of Wetlands*, *supra* note 86 (listing ways in which wetlands are ecologically important).
[94] *See* U.S. Const. amend. V (dictating that any taking of private property requires just compensation); N.J. Const. art. IV, § 6, para. 3.
[95] *See, e.g.*, N.J. Stat. Ann. § 13:1H-3 (West 1972) (the statute that provides the basis for funding environmental organizations).
[96] *See generally*, Cavanaugh, *supra* note 14 (detailing the history of a grassroots movement that saved a large land area in northern New Jersey from being turned into an airport).
[97] *See* Berman v. Parker, 348 U.S. 26, 33-34 (1954) (explaining that a public purpose determination is requisite to any real property taking; however, it is not the only option disposable to states); N.J. Const. art. VIII, § 3, para. 1. (1947) (constitutional provision explaining that land redevelopment is a public purpose).
[98] David M. Carboni, *Rising Tides: Reaching the High-Water Mark of New Jersey's Public Trust Doctrine*, 43 Rutgers L.J. 95, 107-08 (2012) (a physical taking is where "private owners allege the state has occupied or appropriated part of their property in order to accomplish some public use," while a regulatory taking is where the government intends to impose a "regulation limiting the use of property" that "unreasonably intrudes on a private owner's investment-backed expectations," and a categorical taking is when a private landowner argues that "the State's action has deprived their property of all economically productive use in order to promote the common good.").
[99] *See* U.S. Const. amend. V; N.J. Const. art. IV, § 6, para. 3.
[100] *See* Carboni, *supra* note 99, at 108 (citing *Yee v. City of Escondido*, 503 U.S. 519, 522 (1992)).
[101] *See Penn Cent. Transp. Co. v. City of New York*, 438 U.S. 104 (1978).
[102] Carboni, *supra* note 99, at 108 (citing *Penn Cent. Transp. Co. v. City of New York*, 438 U.S. 104, 124 (1978) where the court identified three dispositive factors for determining whether the regulation was a taking requiring just compensation: "the economic impact of the regulation on the claimant," "the extent to which the regulation has interfered with distinct investment-backed expectations," and "the character of the government action.").
[103] *See Lucas v. South Carolina Coastal Council*, 505 U.S. 1003, 1026-27 (1992).
[104] *See id.* at 1027.
[105] Jonathan E. Cohen, *A Constitutional Safety Valve: The Variance in Zoning and Land-Use Based Environmental Controls*, 22 B.C. Envtl. Aff. L Rev. 307, 362 (1995) (citing *Chirichello v. Zoning Board of Adjustment*, 397 A.2d 646, 652-53 (N.J. 1979) where the court determined that due to New Jersey's statutory protection of wetlands, such an ecological zone, is of elevated public importance and consequently a parcel within such a protected area is worthless without a variance).
[106] *See* N.J. Stat. Ann. tit. 13.
[107] *See* N.J. Stat. Ann. § 13:1H-1 et seq.
[108] *See* N.J. Stat. Ann. § 13:8A-1 et seq.
[109] *See* N.J. Stat. Ann. tit. 20.
[110] *See* N.J. Stat. Ann. tit. 40.
[111] *See About DEP*, Dep't of Envtl Prot., http://www.nj.gov/dep/about.html (last visited Nov. 23, 2015).
[112] *See* N.J. Admin. Code. tit. 7.
[113] *See* N.J. Admin. Code. §§ 7:8-1.1 to 6.3.
[114] *See* N.J. Admin. Code. §§ 7:13-1.1 to 19.2.
[115] *See* N.J. Stat. Ann. § 13:9A-1 et seq.
[116] *See* N.J. Stat. Ann. § 13:9B-1 et seq.
[117] *See* N.J. Stat. Ann. § 13:18A-1 et seq.
[118] *See* N.J. Stat. Ann. § 13:20-1 et seq.
[119] *See* N.J. Stat. Ann. § 13:9B-2.
[120] *See id.*
[121] N.J. Stat. Ann. § 13:9B-11.
[122] *Id*.
[123] N.J. Stat. Ann. § 13:9B-13.
[124] *See, e.g.*, Scott Gurian & Colleen O'Dea, *Interactive Map: State's Most Flood-Prone Areas Scattered Throughout NJ*, NJSpotlight (Apr. 11, 2014) http://www.njspotlight.com/stories/14/04/10/repetitive-losses/ (demonstrating how destructive flooding is to various areas of the state, most notably inland regions).
[125] *See* Carboni, *supra* note 99.
[126] *See id.*
[127] *See* Carboni, *supra* note 99 at 99.
[128] *See* Lathrop, *supra* note 26 at 125-26.
[129] *See* Christine A. Klein, *The New Nuisance: An Antidote to Wetland Loss, Sprawl, and Global Warming*, 48 B.C. L. Rev. 1155 (2007).
[130] *See id.* at 1203.
[131] *See id.*
[132] *See id.* at 1204-05.
[133] *See id.* at 1176 (citing *Rapanos v. United States*, 547 U.S. 715, 722 (2006) where the court failed to "recognize the national interest in preserving healthy wetland ecosystems.").
[134] *See Borough of Harvey Cedars v. Karan*, 70 A.3d 524, 530 (N.J. 2013).
[135] *See id.*
[136] *See id.*
[137] *See id.* at 413, 417.
[138] *Id.* at 415-16.
[139] *See* Mary Ann Spoto, *Harvey Cedars Couple Receives $1 Settlement for Dune Blocking Ocean View*, NJ.com, (Sept. 25, 2013), http://www.nj.com/ocean/index.ssf/2013/09/harvey_cedars_sand_dune_dispute_settled.html.
[140] Aldo Leopold, Sand County Almanac 215 (1949).
[141] *See What is the Green Acres/Blue Acres Program?*, MCLTRG.org, http://hub.mcltrg.org/what-is-the-green-acresblue-acres-program/ (last visited March 11, 2015).
[142] N.J. Admin. Code § 7:36-1.1 (pursuant to N.J. Stat. Ann. § 13:8C et seq.).
[143] *See Blue Acres Floodplain Acquisitions*, Dep't of Envtl Prot., http://www.state.nj.us/dep/greenacres/blue_flood_ac.html (last visited Nov. 22, 2015).
[144] *Id.*
[145] *See Blue Acres FAQ*, Dept. of Envtl. Prot., http://www.nj.gov/dep/greenacres/pdf/faqs-blueacres.pdf (last visited March 11, 2015).
[146] *See What is the Green Acres/Blue Acres Program?*, MCLTRG.org, http://hub.mcltrg.org/what-is-the-green-acresblue-acres-program/ (last visited March 11, 2015).
[147] *See* N.J. Admin. Code § 7:36-23.1.
[148] *See* N.J. Admin Code § 7:36-15.1.
[149] *See* N.J. Admin Code §§ 7:36-4.1, 7:36-15.2.
[150] *See* N.J.Admin. Code §§ 7:36-4.2, 7:36-15.2.
[151] *See Blue Acres FAQ, supra* note 146.
[152] *See id.* (only 1,300 properties are expected to be purchased, and 1,000 of them are coastal).
[153] *See Program to Buy Back Hurricane-Damaged and High-Risk Homes*, American Geoscience Institute, http://www.americangeosciences.org/policy/program-buy-back-hurricane-damaged-and-high-risk-homes (last visited March 12, 2015); *Blue Acres FAQ, supra* note 146.
[154] *See* Gurian & O'Dea, *supra* note 125.
[155] *See Blue Acres FAQ, supra* note 146.
[156] *See id*.
[157] *See* N.J. Stat. Ann. § 40A:12A-4.
[158] *See* Clean Air Act of 1970, 42 U.S.C. § 108(a)(2)(using only technological standard, not economic consideration).
[159] *See* Eugene Paik, *Manville's Flood Problems Continue as Different Groups Look to Find Solution*, The Star Ledger, (July 22, 2012, 8:45AM), http://www.nj.com/news/index.ssf/2012/07/manvilles_flood_problems_conti.html (noting that even after Bound Brook's major project, which purported to assess the larger watershed, the adjacent municipality is still subject to massive flooding).
[160] *See* Arnold, *supra* note 75 at 420.
[161] *See id.* at 420.
[162] *See, e.g.*, NJ Flood Mapper, *supra* note 65.

[163] *See* David Porter, *Hurricane Sandy Was Second Costliest in U.S. History, Report Shows*, Huffington Post, (Feb. 12, 2013), http://www.huffingtonpost.com/2013/02/12/hurricane-sandy-second-costliest_n_2669686.html.
[164] *See* Chris Francescani, *Chris Christie: Hurricane Sandy New Jersey Damage Will Cost At Least $29.4 Billion,* Huffington Post (Nov. 23, 2012), http://www.huffingtonpost.com/2012/11/23/chris-christie-hurricane-sandy-new-jersey_n_2179909.html.
[165] *See* Andrew Freedman, *Hurricane Irene Ranked Most Coslty Category 1 Storm*, Climate Central (May 10, 2012), http://www.climatecentral.org/news/hurricane-irene-ranked-most-costly-category-1-storm.
[166] *See* Gurian & O'Dea, *supra* note 125.
[167] *See id.*
[168] *See id.*
[169] *See* Jonathan Douglas Witten, *Carrying Capacity and the Comprehensive Plan: Establishing and Defending Limits to Growth*, 28 B.C. Envtl. Aff. L. Rev. 583, 586 (2001).
[170] Reiu-Clarke, *supra* note 44, at 650.
[171] Klein, *supra* note 125, at 1165-66; Naomi Klein, *Capitalism vs. the Climate*, The Nation, Nov. 9, 2011 ("A 2007 Harris poll found that 71 percent of Americans believed that the continued burning of fossil fuels would cause the climate to change. By 2009 the figure had dropped to 51 percent. In June 2011 the number of Americans who agreed was down to 44 percent").
[172] *See* N.J. Admin. Code. § 7:36-1.1.
[173] *See* N.J. Stat. Ann. § 40:55D.
[174] *See id.*
[175] *See* N.J. Stat. Ann. tit. 40.
[176] *See* Witten, *supra* note 89 at 593.
[177] *See generally*, Robin B. Valinski, *Green Brook Flood Control Project: Saving Bound Brook* (2012), *available a*t http://repository.upenn.edu/cgi/viewcontent.cgi?article=1046&context=mes_capstones.
[178] *See* Arnold, *supra* note 75 at 421 (citation omitted).
[179] *See id.* at 433 (explaining that ecological changes are "characterized by: (1) nonlinear and unpredictable change; (2) many interconnections that cross scales of time, space, natural processes, and societal dynamics and effects; (3) organization by nested scales, networks... and nonlinear transition; (4) feedback effects; and (5) phenomena that may lack analogies in past experience, data, and models").
[180] Witten, *supra* note 89 at 593.
[181] N.J. Admin. Code. § 7:36-15.1, at 49-50 (2011).
[182] *See* Lathrop, *supra* note 26.
[183] *See e.g.*, N.J. Admin. Code. § 7:36-1.1 at 3-4.
[184] *See generally* John Hasse*, Evidence of Persistent Exclusionary Effects of Land Use Policy within Historic and Projected Development Patterns in New Jersey: A Case Study of Monmouth and Somerset Counties*, Geospatial Research Laboratory, Rowan University (2011), *available at* http://gis.rowan.edu/projects/exclusionary/exclusionary_zoning_final_draft_20110610.pdf.
[185] *See* Renee Skelton & Vernice Miller, *The Environmental Justice Movement*, Natural Resources Defense Council http://www.nrdc.org/ej/history/hej.asp (last updated Oct. 12, 2006).
[186] *See* Steinberg, *supra* note 88, at 61 (providing an example of how Florida legislators racialized human-exacerbated natural disasters).
[187] *See id.* at 61.
[188] *See* id. at 61*; see also What is Environmental Justice?*, EPA, http://www3.epa.gov/environmentaljustice/ (last updated Nov. 16, 2015) http://www.epa.gov/environmentaljustice/.
[189] *See* Hasse, *supra* note 185.
[190] *See* Cavanaugh, *supra* note 14.
[191] *See About the Refuge*, Fish and Wildlife Service, http://www.fws.gov/refuge/Great_Swamp/about.html (last visited March 13, 2015).
[192] *See* Jonathan E. Cohen, *A Constitutional Safety Valve: The Variance in Zoning and Land-Use Based Environmental Controls*, 22 B.C. Envtl. Aff. L Rev. 307, 329 (1995).
[193] *Id.*
[194] *See* Ottensmann, *supra* note 13.
[195] *See* Naomi Klein, *supra* note 172.
[196] *See* Francescani, *supra* note 165 (the cost of Hurricane Sandy).
[197] *Inside the Tobacco Deal*, PBS, http://www.pbs.org/wgbh/pages/frontline/shows/settlement/timelines/fullindex.html (last visited Nov. 21, 2015).
[198] *See, e.g.*, *Lead Industries Assoc. v. EPA*, 647 F.2d 1130 (D.C. Cir. 1980).
[199] *See* Leopold, *supra* note 141.
[200] *See* Leopold, *supra* note 141.

Endnotes: Indoor Aquaponics in Abandoned Buildings: A Potential Solution to Food Deserts

continued from page 22

[16] *See id*. (referring to the video); *Basic Questions about Aquaculture*, NOAA, http://www.nmfs.noaa.gov/aquaculture/faqs/faq_aq_101.html#18whatdo (explaining the dietary regimen of farmed fish) (last visited Nov. 4, 2015).
[17] *See Aquaponics*, *supra* note 12 (referring to the video).
[18] *See id*.
[19] *See id*.
[20] *See id*.
[21] *See id*.
[22] *See id*.
[23] *See id*.
[24] *See id*.
[25] *See id*.
[26] In Australia, it has become increasing popular to have at home aquaponics systems. While in the United States, the interest in aquaponics tends to be at a larger commercial scale. *See* Michael Tortorello, *The Spotless Garden*, N.Y. Times, Feb. 17, 2010, *available at* http://www.nytimes.com/2010/02/18/garden/18aqua.html?_r=0.
[27] Modern day aquaponics systems have grown from two distinct forms. A North Carolina State University researcher, who submerged fish tanks below a greenhouse, created the first form. The water from the fish tanks was used to irrigate the hydroponic grow beds that were located in the greenhouse. As the plants in the grow beds purified the water, the water returned to the fish tanks below the green house. Researchers at the University of the Virgin Island, who developed a system using fish tanks and floating raft hydroponics, created the second form. *See* Steve Driver, *Aquaponics-Integration of Hydroponics with Aquaculture* 3-4, 7 (2010), *available at* https://attra.ncat.org/attra-pub/download.php?id=56.
[28] *See* Wells, *supra* note 5.
[29] *See id*.
[30] *See* Craig Lawson, *Vertical Farming: A Hot New Area for Investors*, CNBC (Apr. 2, 2015, 2:19 PM), http://www.cnbc.com/id/102557803.
[31] *See* Jon M. Shane, *The Problem of Abandoned Buildings and Lots*, Center For Problem-Oriented Policing, http://www.popcenter.org/problems/abandoned_buildings_and_lots (last visited Nov. 4, 2015).
[32] *See id*.
[33] *See id*.
[34] *See id*.
[35] *See* Mari Gallagher, *supra* note 3.
[36] *See Aquaponics*, *supra* note 12.
[37] *See id.*
[38] *See id*; *see also* Tinker-Kulberg, *supra* note 5.
[39] *See Aquaponics*, *supra* note 12.
[40] *See Benefits of Aquaponics*, Volcano Veggies, http://www.volcanoveggies.com/benefits-of-aquaponics/ (last visited Nov. 4, 2015).
[41] *See Organic Agriculture*, USDA, http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=organic-agriculture.html (last updated Nov. 4, 2015) (describing the process of becoming an organic farm and the benefits of going organic); *see also* Kassandra Hinrichsen, *Farmers Market Now Doubling Link Dollars*, The Plant (Aug. 19, 2015), http://www.plantchicago.com/farmers-market-now-doubling-link-dollars/ (explaining how one commercial scale aquaponics farm, the Plant, will participate in a double dollar matching program for Illinois food stamp cards, making the produce affordable to low income families).
[42] *See* Wasim Aktar, et al., *Impact of Pesticide Use in Agriculture: Their Benefits and Hazards*, 2 Interdisc. Toxicology 1, 1-12 (2009), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2984095/.