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A BIOREGIONAL STUDY OF THE CIÉNAGA DE ZAPATA

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DEDICATION

I dedicate this to Sara and Uma who have been infinitely supportive of all my efforts. Uma, some day you will be able to read this ‘species’ and understand why papa sits in his study for hours on end. Thank you both for giving me the encouragement to succeed and the room to work.

I also dedicate this to my human family: may we find the collective strength and wisdom to protect this planet, its bioregions, and its ability to sustain life.

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ABSTRACT OF THE THESIS
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The problem examined is the degradation of the Ciénaga de Zapata, the major wetland in Cuba and the possibilities for sustainability and restoration. This research project takes a qualitative, single case study approach to examining and interpreting the Ciénaga de Zapata bioregion. It attempts to synthesize current knowledge and places it within a bioregional framework, a concept which has not been applied to Cuban ecosystems before. The Ciénaga de Zapata has never been studied in its entirety as a bioregion and few if any data sources are in English. This research synthesizes and translates the relevant data that exists. The result is a bioregional study of the Ciénaga's geological processes and environmental history, climate, soils, hydrology, habitats, and biodiversity. The research concludes that operationalizing of the bioregional concept provides a means for finding common ground where reconciliation of human systems and natural systems can take place.

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LIST OF ACRONYMS AND GLOSSARY

CITMA	Cuba's Ministry of Science, Technology, and the Environment
COMARNA	Cuba's National Commission for the Protection of the Environment and Rational Use of Natural Resources
EIA	Environmental Impact Assessments
EMA	<i>Empresa Municipal Agrupcuaria" Victoria de Giron"</i> or Cuba's municipal agribusiness enterprise
INTUR	<i>Instituto Nacional de Turismo</i> or Cuban agency for national and international tourism
Bioregion	Living interconnected geographical units such as watersheds that represent the planetary building blocks, whose natural boundaries evolve over time
Bioregional study	Exploration of a bioregion's microhabitats, the human populations that settled in those habitats, the exploitation, degradation, restoration, and reinhabitation (Thomashow, 1999)
Bioregionalism	Bioregionalism is a movement that promotes self-reliant, sustainable communities in practice, the embodiment of thinking globally and acting locally
Ecological design	The point where human systems are reconciled to meet natural systems
Ecoregion	Geographically discrete units of habitat type (Dinerstein et al., 1995)
Reinhabitation	The ecological redesign of society's relationship with the entire community of life in a particular place
Restoration	The process by which an individual, community, or ecosystem become whole again, a healing process
Special Period	Cuba's economic crisis that began in 1990 as a result of the loss of economic dependency from the Soviet Union and Soviet-bloc states

Sustainability	That human systems operate within the limits of the Earth's natural systems so that its biodiversity is protected and ability to support life is not compromised
Worldview	The combined set of fundamental assumptions, beliefs, and values that shapes one's view of reality and determines one's actions

PREFACE

The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom.

--Isaac Asimov

We do not see nature with the eyes, but with the understandings and the hearts.

---William Hazlitt

A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.

--Aldo Leopold

It is this researcher's sincerest desire that this work's contribution to society and to the field might be that humanity could realize that although knowledge is vital; empathy, understanding, and wisdom far exceed the capabilities of knowledge to achieve sustainability. A groundswell of voices echo this call for wisdom on the part of humanity, as evidenced in the following statement signed by 1,600 scientists from 71 countries, including half of all Nobel Prize winners:

Human beings and the natural world are on a collision course. Human activities inflict harsh and irreversible damage on the environment and on critical resources. If not checked, many of the current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision the present course will bring about...

No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and the prospects for humanity immeasurably diminished. We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. *A great change in the stewardship of the Earth and life on it is required, if vast human misery is to be avoided and the global home on this planet is not to be irretrievably mutilated* [emphasis added]. (World Scientists' Warning, 1992, p.4)

It has been more than a decade since the scientific community officially recognized the urgent need for “‘a great change in the stewardship of the Earth’” (World Scientists’ Warning, 1992, p. 4). How much knowledge will be necessary for humanity to heed this warning? How will we acquire the wisdom and understanding to “‘sustain life in the manner that we know’” (World Scientists’ Warning, 1992, p. 4)?

Einstein suggested that humans look deep into nature to understand everything better. This thesis proposes to take an initial look into the nature of a particular ecosystem and to contribute to a more holistic understanding. Specifically, this research attempts a bioregional study, a place-based approach to comprehensive, trans-disciplinary understanding of ecosystems. A bioregional framework offers an opportunity to assess both ecological and cultural dimensions of a watershed, and to evaluate how their interaction can contribute to or detract from sustainability.

Humans have become the first species in 3.5 million years to live outside the confines of local ecosystems and interact as a whole with global systems (Eldridge, 1995). By facilitating a greater understanding of bioregions, such as the one under study here, it is hoped that we find the wisdom, courage and imagination to affect the “‘great change’” in stewardship that is called for (World Scientists’ Warning, 1992, p. 4). This change will become possible only when we begin to reclaim the place within the confines of local ecosystems.

I - INTRODUCTION AND LITERATURE REVIEW

This chapter serves to give the reader a clearer understanding of the scope of this study by explaining the background for the research, defining the research problem and its significance, examining the literature that forms theoretical basis for this study and presenting the organization of the thesis.

Introduction to Study

Background of Study

“The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats,” (Wilson, 1984, p.121). The world’s wetlands represent a significant portion of the natural habitat being altered and destroyed. The health of the world’s freshwater ecosystems has declined by about 45 per cent over the past 25 years and the populations of the 281 freshwater species examined by the Living Planet Index have declined by half between 1990 and 1999, a clear indication that the quality of the world's rivers, lakes, and other wetlands is deteriorating (WWF, 1999). Cuba is the country with the richest flora and fauna in the West Indies and is considered regionally unique; it harbors the highest number of migratory bird species from the US and Canada. In their report for the World Bank, Dinerstein and et al. (1995, p. 100) identify the Cuban wetlands as one of the four ecoregions within Cuba of “Highest Priority at Regional Scale” due to its “endangered” status and “regionally outstanding biological distinctiveness.” The Ciénaga’s territory contains the largest area of wetland in Cuba and indeed, the Caribbean, approximately 260,000 hectares. Indeed, The Ciénaga is one of Cuba’s most significant places, known

for the quantity and diversity of its ecosystems. This Watershed is considered regionally unique within the Caribbean due to the richness in biodiversity and number of endemic species.

Cuban wetlands are an important link in the chain of the world's wetland and are considered regionally unique within the Caribbean due to the richness in biodiversity and number of species that are only found there and nowhere else. However, Cuban wetlands are severely threatened (Dinerstein et al., 1995). The Ciénaga de Zapata is Cuba's largest and most important wetland ecosystem. Protection of this and other natural areas are limited (Diaz-Briquets & Perez-Lopez, 2000).

The research presented in this thesis is inspired by the concern that the health of the ecosystem could further decline causing damage to the sustainability of life support systems nationally, regionally and ultimately globally.

General Statement of the Problem

The problem examined is the degradation of the Ciénaga de Zapata, the major wetland in Cuba and the possibilities for sustainability and restoration.

The Ciénaga de Zapata watershed, like so many other natural systems, has been transformed and has deteriorated over time. Current management efforts are still confined almost entirely to extraction and protection efforts are weak against the mounting economic pressures. In order to frame the range of problems that afflict this ecosystem, this thesis adopts a bioregional approach. Operationalizing of the bioregional concept provides a means for finding common ground where reconciliation of human systems and natural systems can take place.

Thus, this research attempts a study of Ciénaga de Zapata as a bioregion. It attempts to synthesize current knowledge and places it within a bioregional framework, a concept which has not been applied to Cuban ecosystems before. It places human interactions with the Ciénaga within broader spatial, functional, cultural and temporal contexts. It applies systems thinking rather than analytical thinking (i.e. dissecting) to understand the complexities of the Ciénaga de Zapata as a web of interconnected living systems; these include: climate and soils, hydrology, ecosystems and habitats, biodiversity, demographics, economic activities, and human impacts. And finally, it proposes a vision of what a bioregionally restored Ciénaga might look like and how it might arrive there.

Research Questions

Question 1: What is the current state of knowledge on physical and ecological processes as well as social issues in the Ciénaga? How current is the knowledge of the living systems that make up the Ciénaga?

Question 2: What does that existing knowledge tell us about the current tendencies in the system? What are current government policies and practices towards the system? What are the policy interventions, from a bioregional perspective, that could reorient these tendencies?

Question 3: What is the promise and what are the limitations of a bioregional approach, as defined in the literature, in the restoration of the Ciénaga de Zapata? Can defining a living system such as the *Ciénaga* as a bioregion begin to address the mounting cultural pressures which are bound to negatively impact human interactions with these living systems?

Significance of Study

The Ciénaga de Zapata has never been studied in its entirety as a bioregion and few if any data sources are in English. This research synthesizes and translates the relevant data that exists to a large extent in Spanish and much of it localized in Cuba.

Literature Review

Introduction. This thesis applies bioregionalism and bioregional concepts to the Greater Ciénaga de Zapata watershed (hereafter, the Ciénaga). However, in order to form a more complete understanding of bioregionalism as a concept and as a movement, this portion of the chapter examines the research that forms the theoretical basis for this thesis. The subjects are the following:

1. The ecological crisis and its complexities;
2. The dominant worldview and its components responsible for the crisis;
3. The emerging worldview, its development and components, providing the space and context for bioregional movement;
4. Bioregionalism and the transition toward sustainability that highlights the ethical choices necessary to live within the natural limits of Earth's bioregions;
5. Defining and recognizing the bioregion with attention to its boundaries, scale, and ecological design; and,
6. An in-depth examination of what it means to reinhabit a bioregion, including topics of governance, economy, foodshed, and stewardship.

The goal of this literature review is to arrive at a conceptual understanding of bioregionalism within the fullest context of the emerging worldview and within the parameters of the dominant worldview that limits it. This review is limited to the fore mentioned subjects and later chapters will address Cuba, the Ciénaga and what bioregionalism might entail for both.

The Ecological Crisis

A planetary crisis. There is no shortage of warnings that a planetary scale crisis is at hand. Humanity is precipitating the degradation of the life systems of the planet profoundly affecting the global natural and human systems and severely diminishing the quality of life for any foreseeable human future (Berry, 1988; Berry, 1999; Eldredge, 1995; Swimme & Berry, 1992; Suzuki, 1997). These are evidenced by an unprecedented rate of mass extinctions caused mainly by habitat destruction (Berry, 1999; Eldridge, 1995). Orr (1992) predicts that the ecological crisis is a planetary crisis of unprecedented sheer complexity and Sterling (2001) describes how all global trends and issues are intertwined with each other: food/development crisis defined by soil loss and rising population; fossil fuels crisis marked by the end of inexpensive energy; and environmental crisis characterized by the straining of ecological limits and thresholds. Its wide range and scope affects many spheres: energy, resource use, population, climate, waste management, technology, cities, agriculture, water, biological resilience, biodiversity, international security, inequity, poverty, politics, and human values.

A crisis defined. Several authors concur that the ecological crisis is one of perception, of mind, beliefs, and of values and a direct challenge to those institutions that shape these; culture enforces self perpetuating distinctions between human and nature, local and global, present and future, cause and effect (Bowers, 1995; Orr, 1994; Sterling, 2001). In other words, ecological devastation has become an inseparable part of human culture. If worldviews represent the collective universal perceptions, values, and beliefs that are the underlying framework for human behaviors, then ecological crisis is a crisis of worldviews and results of cultural tension between two opposing worldviews:

mechanistic and organistic (Sterling, 2001, p.49; Swimme & Berry, 1992). The following section examines the dominant, mechanistic worldview, its implication in the ecological crisis, its origins, and how it pervasively manifests itself in all aspects of culture, regardless of political ideology.

The origins of the ecological crisis. The ecological crisis is a long time in the making. Wilson (2002) points out that human culture failed to coevolve and caused the destruction of ecosystem niches. By overrunning local ecosystems, humans have become a planetary force on par with all others. Berry (1999) claims that humanity has broken the general law of limits where every species has opposed species or conditions. Geography imposes order and natural limits and technology and industry bypass these limitations (Berry, 1988; Berry, 1999; Eldredge, 1995; Orr, 1994, Suzuki, 1997).

Local ecosystems and their limits. The planet is made up of functional geographical units referred to herein as bioregions. These bioregions represent the level at which human systems can reengage natural systems, in order that both are sustained within the limits of the ecosystem.

Relevance to Cuba and the Ciénaga. Cuba's environmental crisis is a microcosm of the global crisis. Possible solutions to this complex crisis in Cuba must be able to address economic, social, and ecological problems simultaneously. Cuba, as is demonstrated in the following chapters, has overrun its natural areas, especially the Ciénaga, in order to fuel a mode of economic development that is unsustainable. It is important to understand that this mode of development is not limited to Cuba, but is a product of the dominant worldview.

The Dominant Worldview

Modernity and Progress. There are no shortages of critical voices that connect the ecological crisis humanity faces to advent of modernity and progress that is part and parcel of the dominant worldview. This worldview is a deep cultural pathology that is counterproductive, addictive and paralyzing (Berry, 1998; Eldredge, 1995). Species and habitat loss are a direct effect of human development and environmental destruction is an integral design of capitalism and is at the source of personal and societal breakdown (Berry, 1988; Capra, 2002; Eldredge, 1995; Sterling, 2001). Indeed, Berry (1999) and Bowers (1995) equate the degradation of Earth directly to the construct of human progress. Indeed, society's linear view of progress has destroyed any sense of a larger order and broken connections to the past and to nature (Hutchinson, 1998; Orr, 1992; Swimme & Berry, 1992; Norberg-Hodge, 1991). Smith (1999) describes the modern world as culture set apart from place and the limits and obligation that place imposes.

Economic systems. The dominant worldview manifests itself throughout society, nowhere more so than in economic systems that serve to widen the separation between culture and place. Indeed, all institutions have become economic entities (Eldridge, 1995). Economic development is a crisis-driven, extractive process in which society outgrows its resource base: economic man knows no limits and aims to control the forces of nature (Berry, 1999; Orr, 1992; Smith & Williams, 1999). Nature has become a commodity for human use and the degree of control over it measures progress (Hutchinson, 1998; Swimme & Berry, 1992). As a result self-sufficient, traditional ways of life are being dismantled (Capra 2002; Norberg-Hodge, 1991). Material consumption poses the greatest threat to sustainability (Capra, 2002).

Globalism. Indeed the global character of this economic system seems to be of utmost concern. Capra (2002) and Berry (1999) both recognize that for the first time the whole world is organized around a set of common economic rules and standardized uniform processes that explicitly ignore bioregional diversity and aim for global control. Capra suggests that globalism is completely and uniquely unsustainable and is responsible for poverty, alienation, disease, weakening of democracy, massive ecological devastation, and social breakdown. Orr (1992) summarizes the failings of both capitalism and communism as expressions of modernity and progress:

Communism has all but collapsed because it could not produce enough; capitalism is failing it produces too much and shares too little. Communism imposed an ascetic morality on its subjects, while capitalism has permitted the collapse of morality itself. Neither system is sustainable in either human or ecological terms (p. ix).

As will be evident, in the following chapters, capitalism and communism have sacrificed the environment in Cuba as well as in many other countries without delivering the economic benefits to all as promised. The Ciénaga has paid the price of the rampant development espoused by the dominant worldview.

Components of the dominant worldview. The dominant worldview has many components that are expressed in culture; these are the very components that bioregionalism attempts to address by design and include domination and management; anthropocentrism; reductionism in knowledge, science, and education; and rootlessness. This subsection briefly surveys the literature in these areas to allow for a clearer contrast when it arrives at a description of bioregionalism.

1. Domination and management is characterized by industrial control and homogenized solutions based on cause/effect, predictability, and objectivism in a world

that is unpredictable and creatively complex. There is good reason to believe that Earth's complexity is well beyond human capabilities and rather society to should attempt to manage humanity's limits to growth (Berry, 1998; Orr, 1992; Orr, 1994; Sachs, 2001; Sterling, 2001).

2. Anthropocentrism is defined as a mindset where nothing matters except that which affects humanity. It is a form of consciousness that has created a radical separation between humans and the natural world and an attitude pervasive in all societal institutions that have co-evolved along side cultural traditions shaping human language, ideas, emotions, imagination, and spiritual and educational undertakings. It is the language that most clearly expresses the anthropocentrism and reinforces the dominant worldview (Berry, 1988; Berry, 1999; Wilson, 2002). The anthropocentric mindset is reinforced by a phenomenon referred to as biophobia: a fear, distrust, and profound aversion to the natural world that results in an urge to control nature results that comes from disconnected living (Berry, 1988; Cajete, 1999; Orr, 1994; Wilson, 2002). It is the domination of science and technology are severing connections to nature and eliminating cultural/natural diversity (Orr, 1992; Norberg-Hodge, 1991).

3. Reductionism in modern knowledge and science. Human mindset is a product of the cumulative knowledge and profound cultural assumptions passed down through generations; these include focused individualism, devotion to linear progress, anthropocentrism, authority of scientific knowledge and technological superiority, and commodization of the commons (Bowers, 1999). There exists a dangerously reductionist view across the sciences that divorces knowledge from place to universalize it; this reductionism is the very cause of the industrial malaise promoting analytical, fragmented,

and theoretical thinking that promotes the narrow economic paradigm of centralization and specialization (Capra, 2002; Goldstein, 1999; Hutchinson, 1998; Norberg-Hodge, 1991; Wilson, 1992). As science grows in complexity, it further defines its own limitations; a reductionist science is not capable of understanding relationships and defining values (Berry, 1988; Einstein, 1954; Orr, 1994; Sterling, 2001). Modern science and knowledge are the core transactions in education.

4. Modern industrial education by default reflects the values and limitations of the dominant worldview, which are anthropocentric, mechanistic, reductionist, unsustainable, and exploitative (Bowers, 1999; Hutchinson, 1998; Sterling, 2001). The purpose of modern education is to make the young globally competitive in an industrial, discipline-centric economy and contributes to disintegration of self sufficient local cultures and economies, to global warming, to the development of inappropriate technologies, and to a locus of control and power that further degrade natural habitats under stress (Berry, 1999; Bowers, 1999; Orr, 1994; Sterling, 2001). Modern education results in a lack of wisdom that produces unbalanced, narrow-minded people whose aim is to further conquer nature by circumventing its constraints and who will be unable to face the challenges of the ecological crisis (Berry, 1999; Orr, 1992). The challenges include rootlessness on a massive scale.

5. Rootlessness expresses a wedge between humanity and place. It is an all pervasive schism that finds itself replicated across all of society's institutions. Orr (1994) and Thomashow (1999) note that habitats are home for indigenous people, as well as flora and fauna, and their destruction leads to migration, both ecological and cultural and

this leads to homeless, de-placed people. It is a phenomenon of fragmented psyches as well as places (Thomashow, 1999).

The promise of bioregionalism. Bioregionalism is not a utopia or wishful thinking; it expresses a vision of where society needs to be heading. It is clear that modernization and progress have only deepened the ecological crisis, while widening social and economic disparities across the globe. Both communism and capitalism have failed to prove they are sustainable. Bioregionalism attempts to simultaneously address the environmental, economic, and social crises by brining natural systems and human systems in line with each other at the regional level effectively undermining the destructive elements of the dominant worldview. Bioregionalism contains great promise for societies such as Cuba and local ecosystems such as the Ciénaga which are explored in great detail in subsequent chapters. Bioregionalism is part of an emerging worldview that marks the unfolding of a movement towards a more sustainable future. It is a worldview that is based on holism and values ecological principles, respects the sacredness of life and the interconnectedness of living systems, promotes ethical obligations to land, recognizes the importance of place, and requires the adherence to the natural laws and limits.

The Emerging Worldview

The emerging worldview is a deliberate and purposeful movement of great importance. Norberg-Hodge (1991) calls it a countercurrent of minority voices. Sterling (2001) acknowledges an emergent, ecological, participatory worldview, where bold educational and cultural systems can develop. Orr (1992) recognizes it as a minority

tradition dating back at least as far as Jefferson, and includes Thoreau, Muir, Alfred North Whitehead, Gandhi, Schweitzer, Leopold, Lewis Mumford, Rachel Carson, E. F. Schumaker, and Wendell Berry. Indeed, the emerging worldview is bringing the environmental movement into a new phase (Desai & Riddlestone, 2002).

A new vision. As Einstein points out, “No problem can be solved from the same consciousness that created it. We have to learn to see the world anew” (Sterling, 2001, p.12). Movements are conscious decisions made by members of society that social change is needed implying new directions and new visions. Swimme and Berry (1992) describe the new vision as a realization that Earth is a one-time endowment and that sustainability requires that humanity live off the interest and not consume the principle. This movement implicates perceptions, thinking, and values and deeply questions every single aspect of the dominant worldview for what to keep and what to throw out; it is a countermovement that seeks a more viable context for humans within the Earth's life processes (Berry, 1988; Berry, 1999; Capra, 1996). In all spheres there is a growing awareness of interconnectedness of life spurring new movements committed to human-scale living and sustainable values; these many concurrent developments around the world include: ecophilosophy, deep ecology, ecofeminism, transpersonal and ecopsychology, creation spirituality, holistic science and medicine, Earth/ecological economics, sustainable agriculture and farming, ecological design/architecture, Local Agenda 21, and a reengagement of community (Norberg-Hodge, 1991; Sterling, 2001).

Components of the emerging worldview. This section highlights some of the vital components of the emerging worldview, specifically because they relate to the bioregionalism. These components are crucial elements of rebuilding sustainable human

communities within bioregions; these include biophilia, interdependence, deep ecology, systems thinking and biocentrism, and living systems or complexity theory.

1. Biophilia is centered on the premise that continuation of life on Earth is an overarching priority for humans as well as the entire Earth community. In essence then, the ecological movement is concerned with degree to which humans express love for life, or biophilia; a sharp contrast to biophobia previously mentioned. Biophilia is the innate tendency to affiliate emotionally with life and all other life forms that contributes to physical, emotional, and mental well-being (Cajete, 1999; Wilson, 2002). The aspects of reverence for life and the notion of finding a place in the community of life is bounded by the fact that humans are dependent upon the rest of the biosphere for their survival.

2. Interdependence is the core concept of the web of life as expounded by Capra in this title work, where humans occupy one strand in the web, and are not at the center. Many authors support this essential theme that all of life is interconnected and the community of life includes human and non-human members (Berry, 1999; Capra, 1996; 2002; Norberg-Hodge, 1991, Suzuki, 1997). Suzuki (1997) cited Einstein as expressing this as such:

A human being is part of the whole, called by us the universe. A part limited in time and space. He experiences himself, his thoughts and feelings, as some thing separate from the rest, a kind of prison for us, restricting us to the personal desires and to affection for a few persons nearest to us. The task must be to free ourselves from this prison by widening the circle of compassion to embrace all living creatures (p.26).

The emerging, unified worldview allows for understanding of spiritual dimensions of life and true ecological awareness is spiritual in essence (Capra, 1996; Capra, 2002).

3. Deep ecology promotes spirituality within the emerging movement which promotes a more integral life orientation and embodies the interconnectedness of the human and natural world, the network of interdependent processes, and above all, the intrinsic value of all living beings (Berry 1988; Capra, 1996, Orr, 1992). It expresses the mystery of wildness without which life diminishes; alienating the spirit and taming the inner wildness leads to economic, biospheric, psychic, spiritual losses (Berry, 1988; Berry, 1999; Suzuki, 1997; Wilson, 2002). Spirituality can lead to biocentrism and systems thinking in all aspects of life.

4. Biocentrism is the opposite of anthropocentrism, where life and not human interests are at the center. To a biocentrist mind, Earth is wonder, magnificence, and mystery that produce imagination and delight; such a mind has the capacity to perceive a single integral Earth community (Berry, 1999). In order to apply biocentrism, one might employ systems thinking. Systems thinking allows for a complete understanding of life systems within which human systems exist. In Capra's (1996) words, systems thinking is:

...the understanding of a phenomenon within the context of a larger whole. This, in fact, is the root meaning of the word "system," which derives from Greek *synthistanai* ("to place together"). To understand things systematically literally means to put them into a context, to establish a nature of their relationships (p.27).

Systems thinking implies that whole is more than sum of the parts and that the parts of the system include subsystems or nested systems. Systems thinking models are derived directly from attempts to comprehensively understand living systems and processes.

5. Living systems encompass the entire self-generating metabolic network of life; they are always creating new forms, evolving and functioning autonomously but not

independently, and producing nothing but their organization and identity (i.e. boundaries). The very process of life is one of organizing activity of living systems at all levels. Self-organization becomes a constant interplay between chance and natural laws producing constant novelty (Capra, 1996; Capra, 2002). Indeed, the entire biosphere can be considered a single superorganism that tends towards self-organization; such is the concept behind Gaia theory (Berry, 1988; Berry, 1999; Suzuki, 1997; Wilson, 2002). The Earth, as an interconnected network of bioregions, is a multilayered self-regulating structure of living systems nested within other living systems (networks within networks); for example, small watersheds, within groupings of watersheds, within large drainage basins (Capra, 1996; Capra, 2001). In attempting to understand living systems, it is equally important to note that not only are they self-organizing, but also irreversible. Life and universe becomes synonymous with evolution – a single emergent process defined as a sequence of transformations that moves from a lesser to greater complexity and consciousness (Berry, 1999; Swimme & Berry, 1992). Systems themselves have emergent qualities; qualities of the whole that are not reducible to the parts of a system, for instance, life itself is considered an emergent quality of planets not of individuals (Capra, 1996; Sterling, 2001). Living systems are self-renewing; they have the ability to learn and adapt to changes.

The emerging, unified worldview is breaking down mental barriers erected by the dominant industrial worldview that separate the human realm and the natural world. By introducing the above components the ecological movement confirms the intuition that life is a highly complex system that cannot be easily predicted, managed, or controlled. It

aims to place humans back within the web of life and within the limits of the local ecosystems, those places called bioregions.

Bioregionalism and the Transition toward Sustainability

Bioregionalism as a movement. A new movement is emerging, in response to the widespread ecological and social crisis that exists and calls for fundamental change to preserve biodiversity and to ensure human survival. Up to very recently, it has been an inwardly focused, developmental movement (Aberley, 1999). According to Traina (1995) the term bioregion has been around since 1973, but the ideals represented are as old as human experience; he explains that because of its origins in the back-to-the land movement in the 50's and 60's, it has not come to the mainstream of academia or American culture. That does not detract from its importance as an authentic social movement within the environmental movement, in fact Berry (1988) describes it as:

...One of the most vigorous movements taking place on the North American continent. Its comprehensive concern is leading toward a reordering of all the existing establishments: political-legal, commercial-industrial, communications, educational and religious...[it] is fostering an ecological or bioregional context for every aspect of life...So far the movement remains a pervasive and growing mode of consciousness that is groping toward a more precise articulation of its own ideals, its institutional form, and its most effective programs of action (p. 170).

Bioregionalism involves understanding time, place, interconnections, and local systems. Aberley (1999) states that bioregionalism is a set of values that support grassroots, transformative social change. Thomashow (1999) explains bioregionalism as a place-based filter for everyday decisions involving community and ecological relationships; it represents a profound cultural vision that addresses ethical, aesthetic, and spiritual concerns affecting the boundaries of governance as well as experience. Traina

(1995) refers to it as deep ecology applied. Bowers (1995) elaborates that it includes forms of community, agriculture, work, and art that allow us to live closer to the natural world by placing people within a time horizon longer than one generation that values meaningful knowledge and sense of responsibility.

Bioregionalism affects all aspects of life in this modern, globalized culture. It addresses the tension between political and economic needs of modern society and values of conservation and protection and issues such as development, poverty, and democratization cannot be unbundled from it (Ankersen, 1999; Feldman & Wilt, 1999). It directly addresses the process of social exclusion brought about by globalism, whereby portions of every country, city, region and even entire countries are becoming economically and therefore socially, irrelevant (Capra, 2002).

Bioregionalism results in the ability of communities to co-evolve with local biodiversity (Shiva, 2001). Aberley (1999) notes that bioregions offer a scale of decentralization best able to achieve sustainability and he advises potential critics:

To those who hear only a part of the bioregional story, or who attempt to analyze bioregionalism only through the lens of academic or institutional specialties, it may seem to suffer a host of apparent weaknesses, contradictions and unresolved conflicts. However, chaos transforms itself into something that is properly perceived as an elegant, persistent, and organic pattern of purpose. As the human race collectively stumbles into a new millennium, bioregionalism offers the best hope for creating an integrative web of self-reliant, sustainable cultures (p.38).

Bioregionalism promotes self-reliant, sustainable communities in practice. However the move towards bioregionalism will confront communities and individuals with ethical choices. These ethical choices will involve a conscious effort to rebuild communities and reinhabit bioregions in sustainable ways; they potentially affect all aspects of society including economy, technology, science, education, politics, and

religious/spiritual and impact the preservation of the planet and its life support systems. A sustainable society will not undermine its life support systems (Sterling, 2001)

Sustainability and ethics. Sustainability requires building a culture of permanence using nature as a model (Orr, 1994; Wilson, 2002). Humans can search for fundamental patterns that work with nature; ones that will address people's basic needs (food, shelter, clothing, family, and community) and guarantee a sustainable place in the community of life (Berry, 1999 Norberg-Hodge, 1991). To accomplish sustainability, Wilson (1984; 2002) predicts the world will need a strong ethical framework to balance needs of current and future generations and proclaims ethics the new strategy to save biodiversity. He clarifies that science and technology represent what society can do and morality is what society agrees it ought or ought not to do. Capra (2002) states that, "Ethics refers to a standard of human conduct that flows from a sense of belonging. When we belong to a community, we behave accordingly" (p.215). Einstein (1954) wrote that "Religion is concerned with man's attitude for nature at large, with the establishing of ideals for the individual and communal life, and with mutual human relationship" (p.50). Several voices call for a collective ecological consciousness and a conservation ethic to pass on to the next generation, the best of the natural world (Orr, 1992; Wilson, 2002). Berry (1999) declares that human society must self-limit, involving a collective and painful learning process of where to place such limits. This collective and painful learning process, many believe, represents the next step in human evolution.

Reinventing the human. Society is involved in over consumption beyond what Earth can sustain; there exists a critical need to reinvent human relationship to the Earth (Desai & Riddlestone, 2002). The crisis of sustainability is calling society to reinvent the

human: To step back in to the natural world, using carefully chosen knowledge, wisdom and appropriate technology, reinhabiting bioregions as part of evolving Earth processes and by means of a shared vision and ecologically sustainable values (Berry, 1999; Norberg-Hodge, 1991). This means harnessing knowledge, science, and technology to respond to the challenge of sustainability where fragmentation and reductionism give way to multiple perspectives, where strict divisions are no longer be possible, and where science is oriented towards the long-term and towards whole knowledge (Capra, 2002; Orr, 1994; Smith & Williams, 1999; Swimme & Berry, 1992). Sterling (2001) states that this process is no less than ecological design of the future – the ongoing learning of values and systems that work guided by a vision of what is needed. A new shared understanding will require a renewed sense of place, language, and scale.

Reinventing culture requires new conceptions living in place. This is defined as a balance that links human systems to natural systems - seasons, weather, and water cycles - as manifested by place (Aberley, 1999; McGinnis, House, & Jordan, 1999). To accomplish this society must move to an Earth-centered language that can transform and extend the meanings of concepts such as self, knowledge, society, intelligence, and progress (Bowers, 1999; Swimme & Berry, 1992). It is also necessary to recreate the scale on which humanity designs its modes of living (Orr, 1994) Scale and decentralization become critical structural changes; human-scale social units, many local solutions, and a broader worldview are necessary (Berry, 1988; Norberg-Hodge, 1991; Orr, 1992).

As is discussed in the next chapter, Cuba will be faced with ethical choices and is poised to transition into a new form of governance. If it chooses to embrace

bioregionalism it must begin by reinventing the way it approaches its bioregions such as the Ciénaga de Zapata, recognizing them as interconnected living systems.

Recognizing the Bioregion

It is proposed herein that a bioregional approach is optimal in achieving ecologically sustainable communities that will collectively meet the challenges of the global sustainability crisis. It is imperative that an understanding is formed of what it means to take a bioregional approach by first recognizing the bioregion, and then, discussing what it means to reinhabit it. The Earth over time has been divided into arbitrary political boundaries that define nations and their subdivisions; rarely do they coincide with natural geographical units. The bioregional movement is attempting to bring recognition to these geographical units called Bioregions, in order to begin the process of realigning human political, economic, and social systems with natural ones. In order to recognize the bioregion it is imperative that a definition be provided, as well as a discussion on bioregional boundaries, scale and organization, and ecological design.

Bioregions defined. Bioregions are the unique, local, interconnected subsystems that make up Earth. The following from Berry (1999) best describes a bioregion:

While the Earth is a single community, it is not a global sameness. Earth is highly differentiated into...identifiable geographical regions of interacting life-systems that are relatively self-sustaining in the ever-renewing processes of nature... (p.162).

Traina (1995) describes a bioregion more specifically as follows:

A bioregion is an area without hard boundaries but which can be distinguished by its natural features including flora, fauna, soil, climate, geology, and drainage area. A critical component of each bioregion is the human culture that has developed within and is integral to that area (p.1).

Because bioregions are living geographical units such as watersheds that represent the planetary building blocks, their boundaries must by definition be fluid.

Bioregional boundaries. An essential method of studying a bioregion is to achieve a sense for its natural boundaries. Unfortunately, existing political boundaries are rarely aligned with nature (Lipschutz, 1999). Traina (1995) concurs by stating that political boundaries are meaningless for bioregions and for ecological and systems thinking. McGinnis (1999b) states that to restore value of place, society must reconcile spatial, functional, and temporal boundaries. It is suggested that potential natural boundaries might be based on geology, ecoregions, and watersheds (McGrory Klyza, 1999). Thomashow (1999) argues that strong communities allow for permeable boundaries where ideas and concepts, like people move in and out of a particular place; some of these settle and become part of the place. Capra (2002) sees these as boundaries of identity that foster communication and sharing, not as boundaries of separation.

Bioregional scale and organization. Scale and organization of a reinhabited bioregion are as critical to its functioning as boundaries are to its identity. Bioregions are the basic units where cumulative global resource regimes originate (Feldman & Wilt, 1999). Units such as watersheds lend themselves to perceptual limitations; are compact enough for human-scale society; and contain the building blocks of for sustainable human and natural communities (McGinnis et al., 1999; McGrory Klyza, 1999). Reinhabited bioregions demand decentralization in political and economic structures. Feldman & Wilt (1999) advocate bioregional responses to global issues (i.e. climate change, ozone). Orr (1992) argues that top down solutions are inflexible, destructive and unworkable and suggest resilient local economies and balanced trade are critical. Indeed Thomashow

(1999) argues for a cosmopolitan bioregionalism, one that is alert to global patterns and systems, as well as local experience and expertise. Lipschutz (1999) finds that a local focus brings scale of ecosystems and resource regimes; property rights; local knowledge; stakeholders; and feedback into proportion. He asserts that these are all part of the political economy and history vital to its long-term sustainability.

Ecological design. Gore (1992) declared that civilization must make the environment the principle around which everything in society is organized, if long-term sustainability is to be achieved. “We stand on the threshold of a second generation of ecological design. The second generation is not an alternative to dominant technology and design; it is the best path for their development” (Van der Ryn & Cowan, 1996, p. 31). Ecological design is central to sustainability and bioregionalism. It is the point where human systems are reconciled to meet natural systems. Capra (2002) states that:

...a sustainable human community is one designed in such a manner that its ways of life, business, economy, physical structures, and technologies do not interfere with nature's inherent ability to sustain life. Sustainable communities evolve their patterns of living over time in continual interaction with other living systems, other human and nonhuman. Sustainability does not mean that things do not change: it is a dynamic process of coevolution rather than a static state (p.230).

He states the goal of ecological design is to sustain life by creating opportunity for networks, cycles, solar energy, partnership, diversity and dynamic balance. Ecological design must include particularities of place such as climate, topography, soils, water, plants and animals, flows of energy and materials (Bowers, 1999). Particular strides can be achieved in redesigning energy and material flows in bioregions in order to assure sustainability (Capra, 2002; Hutchinson, 1998). Ecological flow concepts can be applied

to industrial processes to produce zero net waste; the now common equation, waste = food, can guide their redesign (Ackerman, 2001; Capra, 2002; Swimme & Berry, 1992).

Reinhabiting the Bioregion

Through ecological redesign of society it is possible to reinvent its relationship with the entire community of life in particular places called bioregions; this is reinhabitation. Communities face the task of rebuilding ecologically sustainable, socially just, and humane societies (Traina 1995). They must work hard to restore themselves to their places and recreate sustainable livelihoods. This affects all institutions: economic, familial, educational, political, recreational, and religious (Traina, 1995). Norberg-Hodge (1991) suggests that decentralization and attachment to place are prerequisite for reestablishing community. And, ecologically sustainable reinhabitation of rural areas enhances both rural and urban prospects (Orr, 1994). Aberley (1999) defines reinhabitation as:

Learning to live in place in an area that has been disrupted and injured through past exploitation; understanding activities and evolving social behavior that will enrich the life of that place, restore its life-supporting systems, and establish an ecologically and socially sustainable pattern of existence within it (p.214).

Traina (1995) states that becoming native to a place means to learn its particularities, to project what human activities might the land naturally support, rather than reshaping it to support to human needs. This will require a systematic process of restoring place-based knowledge of soils, microclimates, wildlife, vegetation, history, and cultural practices that work (Orr, 1992). However, Berry (1988) and Smith (1999) concur that re-integrating human community into natural setting, with all its severe demands placed on the occupants, is the only way towards sustainability.

Orr (1992) suggests that communities embrace socially resilient technology, land use/design with nature, agriculture, forestry, architecture, solar design, shelter, sustainable cities, good livelihood, and restoration in order to rebuild cultural patterns and livelihoods from the bottom up. The goal, as Berry (1988; 1999) sees it is unlimited renewal of living resources in Earth's bioregions and new technologies must function within a bioregional context and scale. Orr (1994) gives examples of components of sustainable communities: sustainable farms/forestry, communal land use and ownership, rail networks, rediscovery of region, and green cities. Lipschutz (1999) claims that reinhabitation calls for an ongoing process of renegotiations where places are held in collective trusts by a community without change in formal ownership. Redesigning communities for sustainability will result in a resurgence of values necessary to define creative ways to govern: self-limit people, communities, and bioregions (Orr, 1992).

Bioregional governance. Bioregional governance implies self-imposed limitations in a community through understanding of the reinhabited place. Bioregions can be autonomous, democratic, and participatory entities (1999). Ankersen (1999) argues for moving responsibilities to the local inhabitants for a bioregion's living resources to a more effective scale of governance. It would be their responsibility to regulate energy use, deforestation, transportation, land use, water projects, and diminishing biodiversity (Feldman & Wilt, 1999). It is what Orr (1994) terms ecological citizenship. Aberley (1999) states that communities must learn figures of regulation: balance points in people's interactions with natural systems that serve to limit or direct activities to achieve this balance. He claims that this model establishes a degree of legitimacy that equates to social and ecological justice that helps to ensure sustainability.

Bioregional economy. Economic activity in a bioregion should attempt the "highest possible level of cooperative self-reliance" (Aberley, 1999, p.54-55). A human-scale economy can fulfill local basic needs and is nested within Earth's economy (Berry, 1999; Norberg-Hodge, 2002). Norberg-Hodge claims that going local does not mean isolation from the outside world; it means nurturing local businesses which use local resources sustainably, employ local workers at decent wages, and serve primarily local consumers by becoming more self-sufficient, and less dependent on imports. In doing so, control moves from the boardrooms of distant corporations back to the community. She dispels several myths about locally sustainable economies: there is no necessary natural progression to global economy; more local production would indeed benefit poorer regions; there is no need to eliminate, just reduce unnecessary trade; and there are not too many people to go back to the land, many are still on the land, and the rest can begin to reconnect even in cities.

It is possible to foster resilient local economies protected from globalization and nourish the traditions of each region by localizing the supply of products and services that increase local recycling, improve diversification, reduce transport, and lessen related environmental costs (Desai & Riddlestone, 2002; Norberg-Hodge, 1991). The primary means to achieve a resilient and sustainable local economy based on place is through the way a community cultivates its land and nourishes its inhabitants. Bioregions, limited sections of land, can become abundant and sustainable regions of cultivation (Berry, 1999). There is the emerging concept of foodshed that accompanies discussions on sustainable communities and is helping to transform local economies.

Bioregional foodshed. Halwell (2002) in his seminal work on foodsheds reminds us that until very recently in human history, there was total reliance on local food sources and it is a new trend that money, jobs and food should flow out of local economies. He suggests that technology, urban sprawl, and mass transport make this possible. In fact, Halwell documents that the increased distance from the soil where food is grown, breaks waste cycles – rather than organic, soil-enhancing compost, it ends up in a landfill along with excess packaging. He states that loss of local food self-reliance produces unforeseen cost to environment, agriculture, and communities. The emerging local foods movement can help rural area, poor countries, suburbs, and cities become sustainable. He is clear that most communities possess the capacity to regain control of their foodsheds.

Barkin (2001) states that food self-sufficiency is part of a larger strategy; Norberg-Hodge (2002) explains that:

...localizing the production and marketing of food - our most basic of economic needs - is an urgent priority. When applied to farming, the global economic model is giving us food that is neither very flavorful nor nutritious, at a price that includes depleted soil, poisoned air and water, and a destabilized global climate. It is destroying rural livelihoods and hollowing out communities in both North and South. And it is enabling control over food to become dangerously concentrated within large corporations, which by their nature subordinate all other concerns to the economic bottom line. Perhaps worst of all, people everywhere are being encouraged to rely on a single model of food production - one that is dangerously lacking in diversity - thereby jeopardizing food production worldwide. (p.116)

Halwell (2002) documents many benefits of restoring local foodsheds and claims that local foodsheds offer the first genuine economic opportunity for agricultural communities in many years because *polycultures* (diverse plantings) require a highly sophisticated and intimate place based knowledge - something local small farms can better provide.

Bioregional science (place-based knowledge). Goldstein (1999) writes that “...bioregionalists [must] embrace what is irreplaceable in science, while sustaining a commitment to place-based knowledge” (p.157). He suggests that place-based knowledge becomes the linkage between bioregions and argues for this hybridized form based on both place and science. Orr (1992) defines traditional or place-based knowledge as a coevolution of social and natural systems rooted in a local culture. Both he and Wilson (2002) connect loss of traditional knowledge with loss of biodiversity and increase in monocultures of thought and control. Bowers (1995, 1999) claims that sustainability is a process of conserving and renewing place-based knowledge that is accumulated over generations of communal experiences that account for the environmental cycles and patterns - an evolution of deep lasting relationships with natural life-support systems (soil, water, animals, and weather).

Capra (2002) advocates for building ecologically sustainable communities through a non-intrusive material (technology) and social sciences (institutions) that do not interfere with natural processes that sustain life. A commitment to place-based knowledge will begin to ensure this. Indeed, Goldstein (1999) defines good science as both objective, cultural, and grounded in time and place. He assures that indigeneity can be earned over time and that place-based knowledge constantly regenerates itself through active participation of the individual with place and culture.

Bioregional stewardship. There are many emerging models of bioregional stewardship that are taking shape to foster the values inherent in bioregionalism. Many of these honor the experience of communities that have lived in their place enough to begin forming an intimate knowledge of these. Stewardship “requires wisdom, restraint, and,

above all, a commitment to an understanding of a particular place” (Van der Ryn & Cowan, 1996, P. 66). Berry (1999) refers to this as a conscious adaptation to place. Bioregional best practices incorporate principles of ecological sustainability through stewardship of human and natural systems. There are various models being employed to achieve this:

1. Ecosystems management provides an innovative “framework for achieving harmonious and mutually dependent sustainability of society and the environment that focuses on human and natural systems at regional scales across inter-generational time periods (Miller, 1996, p.12-13). Some of the basic principles of ecosystem management are attention to social values and priorities; a clear definition of boundaries and goals; understanding of ecological principles and interactions; and the monitoring of hierarchical ecosystems (Bourgeron & Jensen, 1994; Lackey, 1994). Although its references to concepts such as natural and human resources and hierarchical ecosystems, profess a less than biocentric view, it encompasses some of the basic elements of bioregional stewardship. Community-Based Natural Resources Management, Integrated Conservation and Development Project, and Man and the Biosphere program connect stewardship with economically sound and ecologically sustainable livelihoods also approximate bioregional management (Miller, 1996; Wise, 2001).

2. Bioregional management: According to Miller (1996) bioregional management seeks to encompass whole ecosystems in order to protect and restore them in an ecologically sustainable manner. This is done by employing a variety of protection types at a watershed scale, restoring degraded lands, conserving coastal/marine areas, respecting carrying capacities of human and natural communities, and incorporating

sustainable agriculture; all of this with the support of community-based institutions. Miller emphasizes that land use planning is critical in producing diverse landscapes that protect water, soil, and biodiversity and concludes by demonstrating how restoration and maintenance of the natural systems and processes that ultimately support people and natural communities depend on a community's commitment to health of natural systems. Crucial to this commitment is a spiritual and cultural affinity to land, ecological processes, political decentralization, self-determination, and social equity. Communities can improve awareness of linkages and interdependencies of living systems to jobs, food supplies, and material needs. These linkages are vital to restoring bioregions. Ecosystems and bioregional management are practices that to some degree espouse the bioregional values. These values consist of spirituality and wildness, community and rootedness, sufficiency, and stewardship (Aberley, 1999; Orr, 1992; Smith & Williams, 1999; Traina, 1995). It is critical for multiple ecologically sustainable solutions to begin to reverse the damage and face the challenges of restoring bioregions.

3. Bioregional restoration: McGinnis et al. (1999) suggest that humans yearn for a shared ecological identity that restores wounded landscape and reclaims individual wildness. They equate restoration of ecological systems to restoration of ecologically sustainable communities which by their definition are autonomous, self-regulating, and self-sufficient. They quote Berg and Dasman as follows:

The goal of bioregional restoration is to reemerge the practices of human community within the bioregions that provide their material support, as well as the direct relationships to the more-than-human world on which the full range of human experience depends. [It] is a performative, community-based activity based on social learning and cooperation...[and] can be a therapeutic strategy to expose ourselves viscerally to local ecosystem processes, to foster identification

with other life-forms and to rebuild community within place (McGinnis et al., 1999, p.23).

Indeed Capra (1996) proclaims that creating sustainable communities the great challenge of the future. Traina (1995) argues that bioregional restoration is imperative for planetary survival and personal wholeness. McGinnis et al. (1999) describe it as a marriage of cultural and place where locally appropriate technology, experimental science, and cooperation-oriented preservation are employed.

Reinhabitation requires that societies recognize the bioregions that exist and begin to reorganize itself to fit within these and their limits. In order for Cuba to accomplish this it must rethink aspects such as governance, economy, food production, place-based science, and stewardship to be all inclusive of human and natural systems, such as the Ciénaga. These aspects in particular are explored in depth in the Conclusion chapter of this Thesis. The following text from Capra (1996) captures the crux of the human condition and the essence of reinhabiting the bioregion:

The power of abstract thinking has led us to treat the natural environment - the web of life - as if it consisted of separate parts, to be exploited by different interest groups. Moreover, we have extended this fragmented view to our human society, dividing it into different nations, races, religions, and political groups. The belief that all these fragments - in ourselves, in our environment and in our society - are really separate has alienated us from nature and from our fellow human beings and thus has diminished us. To regain our full humanity, we have to regain our experience of connectedness with the entire web of life (p.296).

The commitment to eliminate fragmentation is essentially what is needed to create whole individuals, communities, and bioregions.

A bioregional study. Orr (1994) writes that reinhabitation begins with a study that details a place; produces a common understanding of landscape, local ways, and language; and creates a shared vision for action. He describes it as a regional survey of

local soils, vegetation, climate, history, economy, and society. Thomashow (1999) explains that, “To explore a local place is to engage in the rich textures of microhabitats, the tapestry of stories regarding the human populations that settled in those habitats, stories of exploitation and restoration, degradation and reinhabitation” (p.126). In fact, bioregional history can be a critical starting point for understanding a place in the context of its evolution and development reflecting close linkages between place and culture. This is precisely what this thesis accomplishes with the Ciénaga. Following chapters will address bioregionalism in Cuba, examine the Ciénaga as a Bioregion, and finally project what a reinhabited Ciénaga might entail.

Organization of Thesis

This thesis accomplishes two objectives: Firstly, to synthesize the accessible and relevant sources of knowledge on the Ciénaga de Zapata, and secondly to develop recommendations for a proposed restoration process.

Because the intended purpose (a bioregional study) and the nature of its content, this study has taken a non-conventional organizational format. The demands of this study require the review of literature chapter to be spread throughout the thesis. It is organized into the following sections: Context and Methodology, Results of Bioregional Study, and Discussion.

This Literature Review that began in this chapter were the theoretical perspective of this study is examined and developed and continues with Chapter 2. Chapter 2 continues the Literature Review and provides the context for the study. This chapter synthesizes the data on Cuba’s environmental record and state of the environment,

environmental protection infrastructure, and the socio-economic realities that impact environmental protection and restoration. It also provides the context for a bioregional approach as a possible working solution to Cuba's complex environmental and socio-economic challenges.

Chapter 3 delves into the results of the thesis, which is a bioregional study of the Greater Ciénaga de Zapata as an entire living system. It offers a bioregional history; it inventories the various layers of the living system such as climate and soils, hydrology, ecosystems and habitats, and biodiversity; and discusses demographics, economic activities, and human impacts to the natural system.

Chapter 4 concludes the thesis, summarizes the findings, and looks forward at the possibilities of restoration and reinhabitation of the Ciénaga by exploring Cuba's suitability for bioregionalism, the Ciénaga as a reinhabited bioregion, a possible roadmap towards bioregionalism, potential bioregional governance of the Ciénaga, and the role of social learning and ecological literacy. This final chapter ends with recommendations for future avenues of study.

II - CONTEXT AND METHODOLOGY

This chapter provides a synthesis of Cuba's environmental record and state of the environment, first examining the three decades since the Cuban Revolution and then since 1990 highlighting the policies of the Special Period. It is important to distinguish between the two time periods because the central policies affecting the environment shifted markedly as will be demonstrated. Following, is an examination of Cuba's environmental protection infrastructure and the socio-economic realities that impact environmental protection and restoration. This chapter also provides the context for a bioregional approach as a possible working solution to Cuba's massive environmental and socio-economic challenges. Although, Cuba is quite challenged particularly with the state of its environment and its economy, there are some elements of its social legacy that may prove opportune for future improvements in both areas, as is later argued. This chapter also presents the Methodology employed in this thesis as well as a description on the major sources of data and delimitations of the study.

By all measures, Cuba is a priority country for conservation of biodiversity in the Caribbean Basin (World Wildlife Fund [WWF], 1998). Cuba has the richest flora and fauna in the West Indies and is considered regionally unique; it harbors the highest number of migratory bird species from North America. Cuban wetlands are vital to Cuba and the whole of the Caribbean Basin and, by all accounts, are severely threatened (Dinerstein et. al., 1995). Even though Cuba has instituted a wide network of protected natural areas most of these are paper parks (protected on paper and not in practice). This research finds that this is due to unclear laws and legal loopholes, environmental abuses,

and weak policy enforcement. With only three years into the current economic crisis, labeled the Special Period, Cuba announced it would maximize the use of all its natural energy resources: lacking oil meant exploiting its forests and all its peat in the Zapata region (Wotzkow, 1998). Moreover, previous dependencies upon the Soviet Union and the structure of the political and legal system have led to inadequate environmental protection practices. There has been sparse research done on the Ciénaga de Zapata, particularly within the context of Cuba's economic climate or from a sociological point of view.

Environmental Record and State of the Environment

In the early seventies, when Castro proclaimed "...that not an inch of land should be left unused...that not a single drop of water be lost, that not a drop of water reach the sea...that not a single river not be dammed,...[and that] unless we conquer nature it will conquer us" (Diaz-Briquets & Perez-Lopez, 2000, p. 17), the general tone was set for Cuba's utilitarian policies towards natural resources and the environment. His remarks demonstrate an obvious willingness to sacrifice natural ecosystems to achieve pressing economic objectives.

Cuba's environmental problems are vast; they include soil degradation (erosion, poor drainage, salinity, acidity, and compaction), deteriorating sanitary and environmental circumstances in human settlements, and loss of biodiversity, deforestation, and contamination of inland and coastal waters (Dinerstein et al., 1995). Some of the causes include insufficient knowledge, awareness and education about environment, poor management, and limits in broad application of science and

technology to environment, but most importantly, poor attention to environment in development policies and plans (Diaz-Briquets & Perez-Lopez, 2000; Wotzckow, 1998). It bears mentioning that although many of Cuba's policies had a destructive effect on the environment it is not simply because they were a socialist country; most societies, whether communist or capitalist have had long-term exploitative development histories. Indeed Cuba had been drastically transforming its natural environment for over 5 centuries since the arrival of the Spaniards. As is demonstrated herein, not all of Cuba's policies have had a negative effect on its environment, some have been positive, however circumstantial.

The following sections explore specific policies of the Cuban government since 1959. These sections show how policies, due to their size, ambitiousness, and centralized orientation, neglected environmental concerns and caused irrational abuse of natural resources; specifically soils, water, forests, energy, natural habitats and urban environments. Further sections examine specific adjustment policies that Cuba has undertaken in order to survive the economic crisis of the Special Period. Although, these policies on the whole affected the entirety of Cuba's natural areas, it is important to note that the Ciénaga has been burdened with an inordinate share of the impact. These impacts alluded to here, are discussed at great length in the following chapter.

Agricultural Policies

In the three decades since 1959, Cuban government agricultural policies driven by extreme emphasis on sugarcane, in conjunction with the applied Soviet agricultural methods have had a significant impact on its soil, water, forest, and energy resources.

Soils. Cuba is endowed with some of the richest and some of the poorest soils. Misguided central government policies have contributed significantly to wide-scale soil degradation: Monoculture production policies ignored regional variations in soils; large-scale farm collectives necessitated heavy mechanization and unsustainable practices; and intensive use of marginal land needing irrigation and chemical inputs damaged fragile ecosystems, such as the Ciénaga de Zapata (Diaz-Briquets and Perez-Lopez, 2000). The direct implications, according to Saez (1997) have been widespread; of Cuba's 4.4 million hectares under cultivation, 4.2 m suffer from erosion, 2.7 m from poor drainage, 0.8 m from salinization, 1.6 m from compaction, and 1.1 m from acidification. Wide-scale desertification is evident (*Agencia Ambiental Entorno Cubano* [AAMEC], 2000).

Water. Cuba has adequate rainfall, but rainwater reaches the sea within a few hours, heightening the cycles of excess and paucity (Diaz-Briquets & Perez-Lopez, 2000). Cuba also has abundant underground water resources adjacent to coastal areas replenished by rainwater that are highly susceptible to contaminants and salt-water intrusion (AAMEC, 2000; Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992). This is a particular problem to low lying coastal wetlands such as the Ciénaga.

Central policies in Cuba have caused an inexhaustible demand for water resources; almost 90% dedicated to agriculture (Diaz-Briquets & Perez-Lopez, 2000). Sugarcane and other water-intensive agriculture necessitates extensive irrigation infrastructure, which has stimulated the construction of over a hundred dams and over a thousand mini-dams that continue to have extensive environmental costs; over-extraction and above ground retention has caused considerable salinization of aquifers due to saltwater intrusion (Espino, 1992). Manipulation of Cuba's hydrology has further

increased the land area prone to flooding. Agricultural run-off, waste, and soil erosion bring contamination to rivers, bays, and estuaries as well as coastal aquifers, affecting reefs, oyster beds, and fisheries (AAMEC, 2000; Espino, 1992), as shall be demonstrated in more detail in the following chapter. Significant contaminants are produced from livestock operations; however, the central economic role assigned to sugar and byproducts production makes it the most extensive pollutant source in Cuba (Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992).

Forests and energy consumption. Soviet-style farming has led to vast clear-cutting for intensive agriculture even on marginal land, especially drained wetlands like in the Ciénaga watershed; all in an effort to meet government quotas (Diaz-Briquets & Perez-Lopez, 2000). Much energy consumption has been devoted to agricultural cultivation and production because of Soviet-bloc subsidies, including: inefficient oil consumption; intensive irrigation, and extensive mechanization (Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992).

Forestry & agroforestry policies. Cuba for many years had a positive reforestation rate, one of few socialist countries to do so (Diaz-Briquets & Perez-Lopez, 2000). Between 1960 and 1990, it is estimated that 2.5 million trees were planted, accompanying the creation of national and municipal forestry reserves (Espino, 1992).

Although the quantity of trees reforested has been outstanding, many criticize the quality of these plantings that included widespread introduction of foreign species, including,

1) Eucalyptus (*Eucalyptus spp.*), that has not abated soil erosion and is a heavy water consumer;

2) Australian pine (*Casuarina spp.*) in coastal areas that has caused extensive sand erosion, and

3) Melaleuca (*Melaleuca leucadendron*), that has caused considerable habitat degradation, particularly in wetlands (Diaz-Briquets & Perez-Lopez, 2000).

Repercussions due to Cuba's central planning are evident in reforestation projects that continue to rely on single tree species not always well adapted to local conditions; loss of trees in many instances has worsened soil erosion problems as well as failing to stop water loss and absorb run-off (Wotzkow, 1998).

Regional Development

Industrial activity and secondary cities. Although central policies located different industries in secondary cities avoiding heavy industrial concentrations, Cuba's levels of pollution discharge increased greatly with the adoption of Soviet-bloc technology. Next to sugar and derivatives, Cuba's most prolific polluters include: nickel mining and production; oil drilling, refining, and transporting; cement processing; transportation; and energy production (Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992). There has been particular emphasis on exploitation of nickel resources. Its mining produces acid run off to nearby streams and rivers and its ammonia leaching production technology continues to contribute highly toxic pollutants (Oro, 1992). Although the Ciénaga is not directly affected by non-sugar industrial activity, its proximity to Cienfuegos makes it an indirect recipient of pollutants.

Water. Some of Cuba's finest bays, *La Habana*, *Moa*, *Nipe*, *Cienfuegos*, are highly contaminated and irreversibly damaged (Oro, 1992). Cuba's reliance of crude oil

and oil products require mass transportation meaning constant leaks and spills; Cuban refineries discharge heavy metals, oil, and other toxic waste into bays; and oil exploration/exploitation with inferior equipment endanger coastal areas, reefs, and fisheries (Diaz-Briquets & Perez-Lopez, 2000).

Air. Industrial activity in Cuba has had significant impact on air quality. Nickel processing plants, oil refineries, and electrical plants are heavy producers of soot, smoke, and high-level toxic emissions (Oro, 1992). Nickel and cement facilities are prone to huge, frequent dust emissions (Diaz-Briquets & Perez-Lopez, 2000). Transportation, although limited, contributes to high levels of air pollution. Most vehicles have no anti-pollution technology or use leaded gasoline (Espino, 1992).

Soils. Not only are Cuban soils being depleted due to deforestation and intensive agricultural practices, but also from industrial sector stresses. Nickel mining, specifically contributes to large-scale soil erosion and reforestation efforts have failed to abate this (Oro, 1992). The Cuban press has documented that most industries are prolific polluters via solid and liquid waste (Espino, 1992).

La Habana. Diaz-Briquets and Perez-Lopez (2000) document how in an effort to bring socioeconomic equity, central policies shifted resources away from La Habana, which has undergone serious physical and environmental deterioration. The authors report that housing stock is in poor shape, its century-old water and sewage system has received little maintenance, and Havana Bay is one of the ten most polluted in the world. It is estimated that the bay receives 300 tons of organic matter and 40 tons of oil products daily (Oro, 1992). Rivers typically carry waste from facilities upstream; during the dry

season, pollutants often exceed stream flow (Espino, 1992). La Habana also suffers from deficiencies in water quantity and quality, air pollution, sound pollution and tree loss.

Summary. Three decades of central government policies were imprudent, neglecting the environmental side effects in pursuit of economic gains. These tended to be centrally planned with disregard to regional/local conditions and were large-scale, unsustainable operations. Many of these policies promoted wasteful, high-polluting practices and technologies that failed to deliver the intended benefits; agricultural yields, overall, have significantly dropped since the 1950's (Diaz-Briquets & Perez-Lopez, 2000). With the collapse of the Soviet Union came the loss of subsidies and imports, forcing the government to implement policies in response to the subsequent crisis.

Special Period Adjustment Policies

This section shows the effects of the Special Period crisis that began in 1990 and the government's adjustment policies on the environment. They are mixed as follows: positive changes are attributed to lack of agricultural and oil imports, change in land tenancy, reduced industrial activity; negative effects include increased foreign investment, intensified tourism with greater demands on forests and urban areas, experimentation with biotechnologies, and fewer resources for environmental protection.

Agriculture. Since 1990 Cuba has been forced to embark on a substitution program that consisted of the wide-scale reintroduction of traditional farming methods, including: work animals, integrated pest-management methods and biological controls, reclamation of soils, intercropping and crop rotation, waste recycling, green manure and organic fertilizers, and extensive biotechnology (Diaz-Briquets & Perez-Lopez, 2000).

Cuba's countryside has witnessed a drastic reduction of mechanization, irrigation, chemical inputs, and oil consumption. New small cooperatives with limited autonomy have been formed to farm the land in perpetuity and should prove far less taxing on the environment. However, large scale use of biological agents without experimentation is cause for major concerns (Diaz-Briquets & Perez-Lopez, 2000).

Forestry. Housing shortages and tourism have placed added pressure on Cuban forests, especially the Ciénaga's. State-owned facilities are significant consumers of firewood; charcoal production is the only source for home cooking fuel; and subsistence agriculture is moving further into remaining forests (Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992). These demands for wood will intensify soil erosion and reverse positive reforestation trends.

Energy. Cuba has few non-renewable natural energy resources. Prior to 1990 it depended solely on Soviet oil subsidies for its intensive agriculture and industry; although current use is low, the quality is very poor, which has serious environmental and health consequences (Leiva, 1999; Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992).

Industrial activity. By 1993, an 80% reduction in industrial activity was directly attributed to the reduction in imports of fuels, raw materials, machinery, and spare parts (Mesa Lago, 1994). Cuba's secondary cities benefited from a brief environmental respite. But by 1995, Cuba had sought to increase industrial activity with over one hundred new joint ventures in manufacturing, mining, and oil exploration; increased exploitation of nickel, minerals (gold, copper, zinc), and oil has increased environmental burden on previously undisturbed, protected natural areas (Diaz-Briquets & Perez-Lopez, 2000).

Continued concerns exist with industrial equipment and inability to import pollution abatement equipment (Leiva, 1999).

Urban environments. The economic crisis of the 1990's has seen a massive boost in in-migration to La Habana; shantytowns have sprung up to pre-revolution levels and have added to the infrastructure demands (Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992). The quantity and quality of water in urban areas has decreased; this is due to limited fuel and chlorine imports (AAMEC, 2000). Cuba's transportation stock is getting older and many used, donated buses have non-existent pollution controls (Diaz-Briquets & Perez-Lopez, 2000). Conversely, the Special Period has had some unintended positive effects: mass bicycles use has increased exercise and reduced motor vehicle use; local gardens are common, promoting composting, organic produce, and increased recycling (Diaz-Briquets & Perez-Lopez, 2000).

Tourism. Cuba's Special Period tourism policies have caused some of the most severe environmental stresses to date; rapid expansion of low-cost infrastructure could be achieved only with extensive disregard for environment (Diaz-Briquets & Perez-Lopez, 2000). Although some tourism is being marketed as ecotourism, wide scale encroachment into pristine areas, like the Ciénaga, has alarmed the conservation community; several examples include: The construction of environmentally destructive land bridges (*pedraplenes*); a wildlife hunting reserve populated with African game; and tourist facilities constructed near endangered species breeding grounds (Wotzkow, 2000).

Environmental protection resources. Environmental research and training resources have been severely reduced; the tourist industry has attracted many scientists

away from environmental work; and replacements are not being trained in conservation and management (Diaz-Briquets & Perez-Lopez, 2000).

Summary. Adjustment policies of the Cuban government in combination with the economic crisis of the Special Period have had a net negative effect on the environment, considering the lack of short- to medium-term future resources available to address many of these problems and the likelihood of the policies with positive effect remaining in place if, for instance fuel becomes readily available. It bears mentioning again, that both Soviet-era and Special Period policies in each of the above sectors had an amplified impact upon the Ciénaga as is detailed in the following chapter. This next section examines the adequacy of Cuba's environmental protection infrastructure.

Environmental Protection

Socialist Cuba is a severely restricted society in most respects, especially where independent scientific research is concerned. Cuba's government structure is one of command and control that embodies central planning that leads to disregard of local environments, lack of property rights, wasteful use of natural resources, lack of civil society, and policy neglectful of consequences (Diaz-Briquets & Perez-Lopez, 2000). Within this context, the next section examines Cuba's societal structures (legal framework, government structures, and civil society) as they relate to environmental protections. It also surveys the state's commitment to environmental protection by examining the system of protected areas, of which a portion of the Ciénaga is a part of. It is important to remind the reader that the discussion herein is for contextual purposes. Although Cuba's legal framework, for instance, may not appear directly applicable to the

Ciénaga, it will prove necessary to understand the possibilities for Cuba's and the Ciénaga's future in the final chapter.

Legal framework. Cuba has a well-developed legal framework for environmental protection consisting of its 1976 Constitution amended in 1992; Law No. 33 from 1981; Decree-law No. 118, pursuant to Law No. 33 establishing the national system of environmental protection; regulations and complementary laws implementing Law No. 33; international and regional agreements; and Law No. 81, adopted in 1997 (The World Conservation Monitoring Centre [WCMC], 1992).

Prior to 1992, Cuba's 1976 Constitution had only briefly addressed environmental concerns (WCMC, 1992); however, in 1992, significant modifications were adopted. The Constitution maintains that it is the duty of the State to protect the environment and its natural resources connecting these with sustainable development for present and future generations; empowering citizens to protect the environment; securing the State's sovereignty over environment and natural resources; and establishing jurisdiction and oversight of protections at the provincial and community levels (Diaz-Briquets & Perez-Lopez, 2000; WCMC, 1992).

Although previous environmentally-related piecemeal legislation existed, 1981 brought Cuba's first comprehensive move towards environmental protection law - Law No. 33, *On the Protection of the Environment and the Rational Use of Natural Resources*, which took a holistic approach to confronting environmental problems. The law set a tone of vital importance to protection and conservation, stating objectives and definitions, establishing means of conservation, requiring environmental assessments/planning in development, holding State agencies, institutions, and

enterprises responsible for damage, and committing Cuba to international cooperation; it also addressed the protection of natural resources, the national government's principal functions, penalties and sanctions, and sets final provisions (Barba & Avella, 1995; Espino, 1992).

One of the provisions of Law No. 33 was that the organization, structure, and operation of the national system be developed within 180 days. Nearly ten years later, in 1990, Decree-Law No. 118 was passed by the Council of Ministers giving the required implementation parameters. Decree-Law 118 created COMARNA, National Commission for the Protection of the Environment and Rational Use of Natural Resources, charged with directing the national system. The system was composed of central government agencies, subsystems, provincial and municipal commissions, and the public at-large.

Implementation of Law No. 33 depended solely on decrees from the Council of Ministers or regulations from Central Government agencies responsible for management of natural resources. According to Diaz-Briquets and Perez-Lopez (2000), implementing instruments were issued in only a few instances. Complimentary environmental laws were also created in parts of the occupational safety and public health code of 1982; the 1994 tax code; and the 1985 foreign investment code.

In 1997, Law No. 81 was passed, superceding Law No. 33 and Decree-Law No. 118, updating Cuba's environmental legislation to address structural economic changes such as joint ventures with foreign investors, self-employment, and agricultural cooperatives; placing greater onus on individuals, either citizens or firms; and emphasizes sustainable development. This law places the responsibility on CITMA, the Ministry of Science, Technology, and the Environment that had absorbed COMARNA, of developing

and executing environmental policy. It has the discretion to decide whether an activity necessitates an environmental license. Wotzkow (2000) criticizes Law No. 81 for this practice. CITMA is also charged with conducting Environmental Impact Assessments (EIA) on new projects, expansions, modification, or restarts. Several economic tools promote legal compliance, such as taxes, special pricing, and fees; sanctions have been strengthened, remediation is encouraged, and criminal prosecution may be considered.

In addition to its domestic body of environmental laws and regulations, Cuba has ratified over two-dozen environmental conventions, agreements, and protocols that have become part of its national legal structure; these include some of the most important international agreements on environmental protection (WCMC, 1992; World Resource Institute (WRI), 1992). These agreements encompass the areas of atmosphere, hazardous substances, occupational safety and health, oceans, wetland protection, and wildlife and habitat. An example would be the Ramsar Convention on Wetlands of International Importance, of which Cuba is now a signatory; half a million hectares of the Lower Ciénaga are some of the first listed wetlands from Cuba. In addition, Cuba is party to several regional arrangements.

Yet, Cuban environmental laws have been criticized as too general, broad, weak, and unenforceable: Government agencies charged with environmental protection and enforcement of these laws are often weak themselves or lack the resources to do so and, the government and economy are controlled by sectoral ministries that largely regulate themselves; environmental concerns are often overruled by economic imperatives (Barba & Avella, 1995; Diaz-Briquets & Perez-Lopez, 2000; Espino, 1992). Barba and Avella (1995) described them as being more like a glossary of terminology or political

propaganda, than actual laws. This next section, explores the dynamics of Cuba's governmental agencies as they relate to environmental protection.

Governmental institutions. The early '70s marked Cuba's process of institutionalization; before 1977, Cuba had no governmental environmental protection institution (Diaz-Briquets & Perez-Lopez, 2000). It was then that COMARNA, along with provincial and municipal environmental commissions, was established; although, not until 1990, was its role legally recognized. In 1994, COMARNA was swallowed up into the newly created CITMA during that year's central government reorganization.

At the time of its establishment under the State Committee of Science and Technology, COMARNA was tasked with developing the conceptual framework for environmental protection and rational use of natural resources. COMARNA was run by a management and a scientific council, and by several working subcommittees; the scientific council included representatives from every ministry, institute, and mass organization in Cuba (Espino, 1992; WCMC, 1992). Although COMARNA was active in creating national parks and reserves, and drafting Law No. 33, there were few examples of vigorous enforcement laws or sanctions (Diaz-Briquets & Perez-Lopez, 2000).

The governmental structure proved problematic: there were no clear lines of authority, conflicts of interest within self-policing agencies were plentiful, and economic needs often supplanted environmental concerns (Barba & Avella, 1995; Espino, 1992). Cuba's government acknowledges that it created CITMA in response to these problems. CITMA was charged with managing sustainable development policies; developing national environmental strategies; enhancing controls, managing waste, and introducing clean technologies; settling disputes; approving EIAs; and monitoring all environmental

activities. Principal functions include ensuring environmental compliance, implementing EIAs, updating of environmental legislation, and closing the gap between science and management. CITMA oversees the Environmental Policy Directorate, the Environmental Management and Inspection Center, the Information and Environmental Education Center, and the National Protected Areas Center (Diaz-Briquets & Perez-Lopez, 2000).

The keys to CITMA's effectiveness are two-fold: strong adherence to the EIAs and thorough monitoring of all activities with possible environmental repercussions. Nevertheless, according to Diaz-Briquets and Perez-Lopez (2000), EIAs are typically afterthoughts and not part of the planning process, there is a lack of technical personnel and financial resources, and monitoring systems are not always available. Their concerns are heightened by the Special Period's boom in development and foreign investment projects, particularly in the tourism and mining sectors that most likely go unregulated.

In 1997, Cuba established the National Watershed Council in accordance with to Law No. 81 to act as the ultimate and coordinating body for regulation and integrated management of watersheds. This action defined watersheds as the basic unit for environmental management (CITMA, 2004). Provincial inter-sectoral watershed councils were established, one for every province, 15 in all; six special council districts were formed for those watersheds that extend beyond provincial boundaries, these are *Cauto*, *Toa*, *Almendares-Vento*, *Ariguanabo*, *Zaza*, and *Hanabanilla* (CITMA, 2004). According to the Cuban government there has been substantial effort as of 2003 in abating environmental damages within the eight designated watersheds of national importance (*Cuyaguajete*, *Cauto*, *Almendares-Vento*, *Ariguanabo*, *Zaza*, *Hanabanilla*, *Toa*, and *Guantanamo-Guaso*) by soil conservation and improvement; reforestation; reduction of

pollution load; water regulation strips and a network of dams, mini-dams, channels, and canals; waste water recycled from sugar refineries to irrigate and fertilize sugar cane fields (CITMA, 2004).

National system of protected areas. By 1991 the National Network of parks covered 12% of the total land area and comprised some 200 units; although the protected area network seems vast, most units are small fragments and many have deteriorated significantly (Santana, 1991). Another problem with Cuba's protected areas is that the levels of protection vary greatly and few categories really offer the necessary safeguards: Over half the land area is labeled Integrated Management Reserve offering scant protection; only a quarter is designated as National Parks offering the most protection but under a mixed-use format; there are no clear definitions of designations and the network does not function as a cohesive, national system (WCMC, 1992). Santana (1991) points out that that only 1-2% of Cuba is truly protected. While examples exist of sound conservation efforts, overall there are too many problems and structural weakness in the system, its designations, and lack of management standards for it to be effective.

Civil Society, local NGOs, and international NGOs. Traditional civil society is non-existent in Cuba. Although most Cubans are members of mass organizations, these are State-sponsored and have clear state agendas. Informal institutions of daily life potentially provide for the emergence of civil society; ironically, the formal and informal sectors of society encourage each other to exist weakening state institutions and limiting its power (Fernandez, 2000). The emergence of civil society in Cuba may further weaken the State's ability to control environmental deterioration and hamper its oversight on development projects.

Cuba does not allow environmental organizations to operate openly; even though, the 1992 Constitution permits it. While there are some local non-governmental organizations (NGOs) active in Cuba, most are dedicated to human rights and a handful to environment, all are considered dissident groups. Certain environmental groups exist or have been reported to exist such as *Naturpaz*, *Movimiento Ecopacifista Sendero Verde*, *CubaNet* (independent journalist reports), *Agencia Ambiental Entorno Cubano* (AAMEC) and *Alerta Verde*. Several International NGOs perform environmental work in Cuba such as Audubon Latin America, World Wildlife Fund Canada, the International Office of the Fish and Wildlife Service and several UN agencies. This author suspects their work is often limited or defined by the direct benefit to the Cuban government in the form of resources or amount of dollars attached.

Summary. Environmental protection in Cuba is limited; laws are weak and difficult to enforce, the economy is still controlled by sectoral self-regulating ministries, and environmental conflicts are regularly overruled by economic priorities. Resources are few and typically not diverted to strengthen environmental protection and monitoring of projects for compliance or sustainability. National parks and protected areas offer few real protective measures, suffer from a lack of definition and resources, and often are the target of exploitative activities. Civil society is lacking, local NGOs are either part of the State system or considered dissidents, and International NGOs are limited in the work they can do. Cuba's lofty environmental goals and structural weaknesses are part and parcel of political cultures, such as Cuba's, that tend to be locked in a vicious cycle of moral pursuits that are undermined by informality, vagueness, and ends-based

manipulation (Fernandez, 2000). Watershed councils, however, are a promising development for bioregionalism for Cuba.

Socio-economic Realities

Environmental institutions have few resources and less authority; civil society's ability to make a positive change is limited. Three decades of misguided, centrally planned, grandiose, environmentally unsustainable central government policies have failed to deliver economic benefits. The survival of the revolution, Cuba's top priority, has repeatedly sacrificed the environment for the sake of the economy. However, what Cuba's government has failed to note, is that the environment is the economy. The Cuba's environmental policies have directly affected long-term productivity of soils and fisheries, caused erosion of sand from beaches, destroyed habitats and diminished biodiversity, affected the availability and quality of drinking water, and have submitted the public to potential health risks; in short, they have caused great harm to the country's environmental and economic infrastructure.

With tourism and mining taking the economic lead over agriculture, the few pristine areas of the country, that were only indirectly affected previously, are now at risk. The future for Cuba's environment and especially the Ciénaga looks difficult; dedicated resources will be scarce for many years and a post-transitional government could potentially lean further towards unfettered development policies that fail to safeguard the environment. Although there have been overall negative environmental impacts, it is essential to recognize that there are opportunities to improve upon Cuba's social structure and this coupled with authentic enforcement and proactive measures

could begin to slow the environmental degradation. Indeed there are several factors that make Cuba a particularly good place for bioregionalism to take hold; the proceeding is a briefly discusses this topic. A more at length discussion is found in the last chapter with specifics on the Ciénaga's potential for bioregionalism.

Bioregionalism in Cuba

Both capitalism and communism have failed to achieve social justice, political stability, and economic equality in Cuba, or elsewhere. Bioregionalism borrows the best of both systems, while ensuring long-term sustainability as defined by natural systems and natural boundaries. This is the complete opposite of the short-sided, centralized policies brought about by destructive practices of unfettered, large-scale development.

There are several reasons why Cuba's political, economic, and environmental trajectory might lead it to consider bioregional governance:

1. Centralized, top down policies have proven politically repressive, economically dysfunctional, and environmentally destructive;
2. Cuba will be open to a reorganization of its societal, economic, and political structures;
3. Cuba is relatively disconnected from the global economy;
4. Consumerism and commercialism have not taken hold;
5. Individuals might be satisfied with the fulfillment of basic needs;
6. Community and social networks critical for daily survival, are strong, and;
7. Self-sufficiency is evident as exemplified by urban gardens and rural organic agricultural cooperatives, economic activities in the informal sector, bartering, trends in

natural medicine; in short, with limited imports, the Cuban people have learned how to survive and make due with the scarce resources at hand.

Cubans have shown a resiliency over the four decades of repression. They have proven creative and self-sufficient. Bioregionalism will allow Cuba a smoother transition to democracy at smaller, more decentralized community scale. Enabling them to keep the aspects of socialism that work and adopt the freedom and transparency offered by democracy. Restoring sustainability at that scale becomes the work of the community, not of a central government.

The following section covers the methodology employed in this thesis. It explores the data sources used for this thesis and the delimitations of the study

Methodology

This research project takes a qualitative, single case study approach to examining and interpreting the Ciénaga de Zapata bioregion. It has been conducted at the level of the watershed for two reasons: One, it is common in bioregional approaches to conservation to do so; and two, and more importantly, the Ciénaga de Zapata, as a wetland, is intimately and almost wholly defined by water regimes. Therefore, investigating the Ciénaga's geological processes and environmental history, climate, soils, hydrology, habitats, and biodiversity and at the watershed level will be essential to this understanding. The research attempts a summary understanding of the mechanisms that constitute the parts of this living ecosystem and their intersection with human settlements and human activities.

Data sources for this research primarily consist of secondary data collected both here and in Cuba. Specifically the research references documents related to natural inventories, geographical representations of ecological systems, land use and protection, and local studies of the ecosystem. These include:

1. *Conquering Nature: The environmental legacy of socialism in Cuba*. This work by Diaz-Briquets and Perez-Lopez has proved an invaluable resource that catalogs Cuban development policies since 1959 and their impacts on the environment. Although, the work covers central Cuban policies, there are frequent references to the Ciénaga de Zapata given its national importance and the disproportional impacts to it. It covers Cuba's legal framework and governmental structure as it pertains to environmental protection. It is an important, comprehensive work, probably the first of its kind anywhere, but certainly in the U.S. It led the researcher to many other useful sources of information on Cuba's environment and several minor works on the Ciénaga.

2. *Naturaleza Cubana*. This work by Carlos Wotzkow is highly critical of Cuban environmental protection. Although the book has a definite anti-regime bias, it contains many facts and documents many instances of environmental abuses on the part of the Cuban government as experienced first-hand by the author who is now in exile. Although the work is based generally on all of Cuba, it devotes a significant portion to the Ciénaga de Zapata. This source is published in the Spanish language and therefore citations were translated by this researcher.

3. *Estudio Geografico Integral: Ciénaga de Zapata*. This seminal work published in Cuba in 1993 was retrieved by this researcher in 2001 on his first trip to Cuba. It is by far the most comprehensive study of the Ciénaga de Zapata that this research has

uncovered. It is written in the Spanish language; citations have been translated by this researcher, and form the basis for a large part of the Bioregional Study found in Chapter 4. This study was commissioned by the Cuban Academy of Sciences and carried out by the Cuban Institute of Geodesy and Cartography. It covers the geography, geomorphology, climate, hydrology, soils, vegetation, flora, fauna, landscapes and ecosystems, economic activities, demography and socioeconomics, and tourism infrastructure.

4. *Memorias del Simposio Internacional de Humedales '94*. This work is a collection of papers presented at the 2nd Symposium on Wetlands held at the Ciénaga de Zapata. Because the main purpose of this conference is to discuss economic development of wetlands, it gives valuable insights into the human systems and the economic activities that are directly impacting the Ciénaga's natural systems. This work was also a product of the researcher's trip to Cuba and the citations translated by him into English from its original Spanish source. It covers important topics on the Ciénaga such as it's a historical perspective of its transformation and development; socioeconomic development including demography and settlements; management and exploitation of its resources; inventory of habitat, flora, and fauna; and interactions between human and natural components. This an important source for the researcher in that it verifies much of the information gleaned from the *Estudio Geografico Integral* mentioned above.

5. *Other*. There are many other works that have proved invaluable to this thesis; the ones listed here are only a few of them. Several works have been particularly important in documenting Cuba's environmental policies and practices. These include *Cuba: Report on the Environment, 1999* by Agencia Ambiental Entorno Cubano; Barba

and Avella's 1995 article, "Cuba's Environmental Law" from *Cuba in Transition*; Espino's 1992 article, "Environmental Deterioration and Protection in Socialist Cuba" also from *Cuba in Transition*; Oro's 1992 report *The Poisoning of Paradise: The Environmental Crisis in Cuba*; and the World Conservation Monitoring Centre's (WCMC) chapter "The Republic of Cuba" from *1992 Protected Areas of the World: A Review of National Systems*. Nieto Dopico's 1997 work *La Fauna Silvestre de la Ciénaga de Zapata* [citations translated by researcher] gives important insights into the Ciénaga's endemic species. The 1984 work on *Hydrobotanical Studies in the Framework of Cuban Zapata Project* by Bhoridi, Salabarría Fernández, and Voros contains detailed descriptions of the Ciénaga's matrix of smaller watersheds and canals that make up the Greater Ciénaga watershed. Although outdated, the *Nuevo Atlas Nacional de Cuba* from 1989 has proven an essential source for visualizing the Ciénaga's watershed, mapping its components both human and natural, and understanding the interactions flows throughout the system.

This research reviews the data collected on the Ciénaga de Zapata, including those listed above, for its adequacy in collectively formulating a thorough understanding of this living systems pattern of organization, structure, and life processes. Existing information is patchy and outdated. The Zapata Peninsula has been studied many times over by experts in many fields; reports can be found in many facets of the Ciénaga's ecology, hydrology, geography, economy, and sociology. However, a study of the watershed in its entirety - as one ecosystem framed by its natural limits and including its relation to the *Canarreos* archipelago to the south or upper portions of its watershed - has yet to be undertaken (Nieto Dopico, 1997).

Delimitations of the Study

Geographical boundaries. The Greater Ciénaga de Zapata Watershed, the subject of this study, encompasses an area twice the size typically assigned to the Ciénaga. The Greater Ciénaga watershed also known as the *Cuenca Sur de Matanzas* constitutes most of the southern half of *Matanzas* province in Cuba, extending East into *Cienfuegos* and west into *La Habana* provinces respectively covering a surface area of 9,000 km² (Molerio Leon, 2001). The reader should note, that with development over time the area referred to has changed dramatically, in size and character (see Appendix 2 for map).

There are many confusing references to the Ciénaga de Zapata found in the literature. Today's Ciénaga de Zapata, herein referred to as the Lower Ciénaga, with over 500,000 hectares, stretches from the *Cienfuegos* border on the East to the *Batabono* swamps to the West from the *Autopista Nacional* (National Highway) on the North to the Caribbean Sea to the South and is divided into East and West by the Bay of Pigs (Nieto Dopico, 1997). It includes the *Canarreos* archipelagos, a system of keys, encompassing the Isle of Pines (now called the Isle of Youth), that extend southeast from the western portion of the *Zapata* peninsula. The political boundaries of the municipality exclude the more distant keys and the *Isla de la Juventud*. The Zapata Peninsula or Zapata swamp typically refers to an even smaller area that juts out to the southwest into the Gulf of *Batabonó*.

Uniqueness of setting. This research argues that all bioregions are distinct and unique systems and that no two are alike on Earth. Therefore generalizations should not be made in reference to other bioregions and ecosystems. However the methods used herein to study and understand this bioregion can be transferable to any bioregion.

Limited accessibility. Because of the current political situation, Cuba remains a relatively closed society to the United States. Although this researcher was able to travel to Cuba, visit the Ciénaga de Zapata, and obtain documents, it is suspected that more data exist than was accessible.

Limitations of selected method. This study does not analyze or produce data of any kind. It synthesizes existing information and presents it in a manner where complex relationships can be understood as parts of a living system.

III - RESULT OF BIOREGIONAL STUDY

This chapter presents a bioregional study of the Greater Ciénaga de Zapata as an entire living system. It offers a bioregional history that documents natural and manmade transformations over time. The study inventories the various layers of the living system: climate and soils, hydrology, ecosystems and habitats, and biodiversity. It also discusses human systems: demographics, economic activities, and human impacts to the natural system.

This chapter relies heavily on several seminal works about the Ciénaga specifically having to do with its natural components, human systems, and the anthropogenic impacts to this watershed, these include: *Estudio Geografico Integral: Ciénaga de Zapata* by Rodríguez Yi, Fernández Reyes, and Cruz Nardo (1993), *Cuban Forests: Their history and characteristics* by Del Risco Rodriguez, *La Fauna Silvestre de La Ciénaga de Zapata* by Nieto Dopico, and *Memorias del II Simposio Internacional, Humedales '94* by Alfonso Martinez and Gutierrez Padron. All citations from these sources in this chapter are from this researcher.

Bioregional History

This section covers the History of the Greater Ciénaga de Zapata from geologic time forward. It gives a sense of the changes, both natural and manmade, over time.

Geological Processes

The Caribbean Islands can be viewed as a partially submerged mountain range. Many geological processes, including plate tectonics, ash accumulation from volcanic eruptions, fluvial sedimentation, and deposition of carbonates, have combined to control

the origin, distribution, and morphology of the Greater Antilles; the region is geologically complex and dynamic, currently undergoing geologic evolution (Back, 1988). The nucleus of the Greater Antilles contains igneous rocks forming the basal complex of Mesozoic age, which is covered by marine and volcanic Cretaceous sediments; Cenozoic sediments, mostly limestone, cover large areas; and younger Tertiary and Quaternary formations of alluvium, sandstone, and reef limestone are prolific in coastal areas (Back, 1988). Cuba is the largest archipelago in the Greater Antilles consisting of the mainland and 1,500 smaller islands.

Cuba is of Jurassic-Cretaceous-early Tertiary origin. It has been posited that Western and Southern portions of its land formations were once much closer to Central America and the Yucatan Peninsula, but through tectonic movement assumed their present location against the Bahamas platform that today forms northern portions of Cuba (Lewis & Daper, 1988). The morphology of much of Cuba is characterized by the vast extent and diversity of karstified Miocene limestone (Back, 1988).

By the Miocene period most of Cuba was formed, with the notable exception of the Ciénaga de Zapata peninsula (Back, 1988). The depression running east to west catches alluvial waters that run towards the depression and continue out to sea. By the late Miocene to Pliocene, fluctuating sea-levels and alluvial sedimentation processes had formed most of the land east of central depression; it is hypothesized that the *Laguna del Tesoro*, at its center, is a collapsed sea-cave (Lewis & Daper, 1988). The western portion remains partially submerged until today, populated mainly by mangroves and sandbars.

Transformation of the Ciénaga

The Ciénaga has been occupied by man for at least the last 10,000 years and modifications that have impacted it to varying degrees over time. Its development is documented by Arcia Rodríguez, Jordán Díaz, Gutiérrez Padrón and Martínez Hernández (1994) who divide it into five stages. This subsection relies solely on this work [all translations mine]:

Stage 1 (Paleolithic Times until 1557). The Zapata Peninsula was inhabited by Paleolithic indigenous peoples who subsisted from hunting, gathering, and fishing in marine and terrestrial environments. Via the study of Spanish historical accounts, bibliographies, and maps of the later part of this time period, it is safe to conclude that during this first stage modifications were completely insignificant. These records indicate that The Ciénaga was covered by vast forests, miniscule savannas, and four low-lying swampy zones, that later joined to form the vast wetland zones in existence today.

Stage 2 (1557 – 1845). The Ciénaga sees the first land distribution by Spanish colonial government encouraging settlers to divide up large swaths of land for pasture and corrals, both large and small. Slash and burn techniques are employed to clear vast areas of forest. This activity was not continuous and most forests saw varying degrees of natural regeneration. This stage saw the building of the Maneadero canal for cattle transport to *Ensenada de la Broa*. In the 1650s, the colonial government offered new land grants encouraged more intensive resettlement of abandoned operations. In general, transformations to the Ciénaga were more perceptible due to the introduction of exotic species such as cattle, dogs, cats, and pigs and alterations to its forests.

Stage 3 (1845 – 1900). This time period is marked by the explosive growth of the sugar industry. Within Matanzas this extended south, well into the upper third of the Ciénaga watershed. Immense stretches of forests were felled to provide the necessary fuel and make way for sugarcane plantations, homestead construction, and sugar production facilities. During this period, the Ciénaga served as refuge for escaped slaves, and during the war of independence (1868-1895) it saw the installation of hospital and camps. After the war subsided, a large-scale exploitation of precious timber and wood charcoal begins in the lower portion of the watershed; these are transported via canals and drainage ditches excavated in diverse parts of the territory. These extreme modifications affected significantly the hydrological regimen and caused massive erosion of soils, sedimentation of river beds, and soil accumulation in low-lying, wetland areas.

Stage 4 (1900 – 1959). This stage sees expanded timber and charcoal operations in the southern part of the Ciénaga, new canals for transport, several railways, and sugarcane fields planted from just north of the *Bahia de Cochinos* extending far towards the northeast. Most of these low-lying areas planted with sugarcane have since disappeared, reclaimed by the Ciénaga and its expanding wetlands. Slash and burn activity intensifies to make room for extensive cattle ranching, the first wood mills arise, a fertilizer factory is established to process peat, and over 40 year period trout had been introduced to the *Laguna del Tesoro*. This stage is marked by even greater development, bringing extensive alterations to most of the Watershed, which have resulted in changes to its landscape, vegetative distribution, hydrological network, and soil densities.

Stage 5 (1959 – Present). After the Revolution, the Agrarian Reform Law established cooperatives of charcoal producers and fisherman. Socioeconomic

development brought the first schools, tourism centers (*Guama, Playa Larga, and Playa Giron*), network of roads connecting tourist centers and settlements, Crocodile breeding farm, and drainage of the northeast Ciénaga for rice production. Reforestation efforts took place with mostly exotic, fast growing species such as *Melaleuca* and Australian pine. The Bay of Pigs invasion affected the central and western zones to some extent.

During the 1970s, the Northern portion of the Watershed is cut-off by the new National Highway, new large-scale agricultural operations, construction of dams, canals and straightening of rivers in the center of the province greatly diminishing the flow of water that reaches the rest of the system. Also during the 70s, rock and sand quarries are excavated and peat extraction occurs in the northeast. In 1975 The Ciénaga is incorporated as a municipality. By 1989, *Empresa Municipal Agrupcuaria “Victoria de Giron”* (EMA) is formed to manage the forestry operations and other extractive activities. New scientific and conservation endeavors bring set-asides for nature reserves, a national park, and other protective measures. Tourism expanded greatly. At the end of 2001, Cuba becomes party to the Ramsar Convention adding the Ciénaga de Zapata and other wetlands to the list of Wetlands of International Importance.

The Bioregion

The Ciénaga de Zapata Bioregion is a living system defined as much by its natural features and forces as by the human systems that have transformed it over time. The bioregion is identified by the natural boundaries of the watershed as previously described. This study investigates both the natural components as well as the human systems and concludes with a synthesis of the human impacts on the bioregion.

Natural Components

This section documents the structural, functional, and ecological components of this unique living system. The structural components include the watershed's geology, climate, and soils. Its functional component consists of its hydrology and the hydrological processes which define the living system. And, the ecological components that include the ecosystems, habitats, and biodiversity that are the results of the unique structural conditions and functional processes of this watershed. For the structural and functional components this study relies solely on *Estudio Geografico Integral* by Rodriguez Yi et al. (1993) as a source. For ecological components, the study uses this same work as well as by Del Risco Rodriguez (1999) on Cuban forests and Nieto Dopico (1997) on wildlife in the Ciénaga. The figures used in this portion of the study have been donated to the author from a source who wishes to remain anonymous; these figures have been adapted by the author as needed to better illustrate certain elements.

Geological structures. The Ciénaga de Zapata Watershed is one of the country's largest and most complex karstic drainage systems consisting of multiple aquifers; hydrologically, it represents the point of discharge designated the *Cuenca* Sur, the South Watershed. From a geologic standpoint, The Ciénaga is characterized by considerable densities of peat and significant extensions of carbonate formations (*Jaimanitas* y *Vedado*) from the Upper Pleistocene and the Lower Pliocene-Pleistocene, respectively. Deep fault lines are known to exist that divide The Ciénaga into Western and Eastern blocks (*Ciénaga Occidental* and *Ciénaga Oriental*). The Western portion is a mainly low-lying, cumulative coastal wetland; the Eastern portion's coast is more abrasive, and

elevated. The land surface ranges from marine wetlands to carbonate outcroppings, with varying degrees of karstification.

Climate. The Zapata region presents a series of climactic peculiarities that distinguish it from the rest of Matanzas province and, the rest of Cuba. The most pronounced difference involves the North-South gradients of change in climactic variables, from the central portion with extreme temperatures and precipitation to the coastal areas and keys with a more constant, warm temperature year-round, less mean precipitation, and well-defined local wind circulation patterns. Humid days are common most of the year, with the highest humidity levels occurring on the inland plains. The Ciénaga experiences predominantly light, easterly wind patterns; wave patterns on the Ciénaga's coasts follow these. Colder winds and stronger tides accompany the winter months and higher winds occur frequently during April and May.

The Ciénaga experiences wet and dry seasons annually. Dry seasons vary from two to eight months in length throughout different parts of the Ciénaga. The Ciénaga's rainfall annual ranges from less than 500 mm to just over 2000 mm. This precipitation regime provides the special conditions that add to the diversity of habitat possible in the Ciénaga's ecosystems. Storms and hurricanes frequent the Ciénaga during the late summer and early fall. The Ciénaga is prone to natural as well as manmade fire regimes prevalent at the tail end of the dry season (March – May).

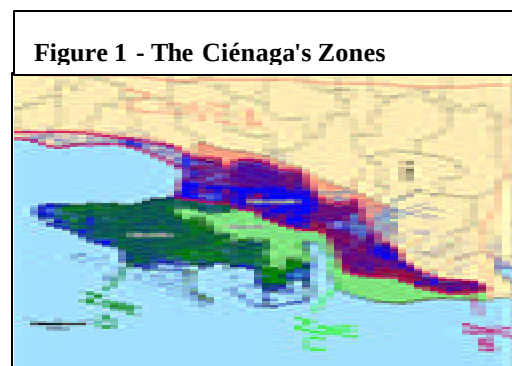
Soils. The distribution of the different soil types throughout the Ciénaga oriented East to West, directly related to geology, morphology, and hydrologic structure of the territory. Four soil types are found consecutive bands from north to south. These are ferrous reds and yellows, peat and peat-marl, black and red rendzinas, and coastal mud

and mangrove muck. Ferrous soils form a band stretching across the north of the Lower Ciénaga on either side of the *Autopista Nacional*. Red ferrous soils are more productive and have better drainage, containing little organic matter. Yellow ferrous soils are found further south, have less iron and more clay, and retain more water. The second band that occupies the wetlands swamps and bogs is composed of peat and peat-marl over a layer of limestone irregularly wrapped around clay-like loam and muddy deposits. These soils are rich in organic matter and retain much water. The third band of soils, the *rendzinas*, are composed of calcified humus and fed water via underground flows in the eastern Ciénaga where they are predominantly red accompanied by large holes in the rock and via saltwater intrusion in the west where they are black. Lastly, the coastal band of muck and mud has been produced with the constant influence of coastal waters. These are composed of sandy-mud and clay with organic matter and substrata of peat. These directly influence the composition of the aquifer, its recharge capabilities, its flow rate and direction, and the chemical composition of the water.

Hydrology of the Watershed

The waters that circulate throughout the territory present a wide range of hydro-chemical compositions both vertically and horizontally. They can range from bicarbonate/calcite with relatively low

mineralization in the upper strata not adjacent to coastal zones to more salty, mineral rich waters near the coasts and in deeper strata. Indeed most of its aquifer is below sea level,

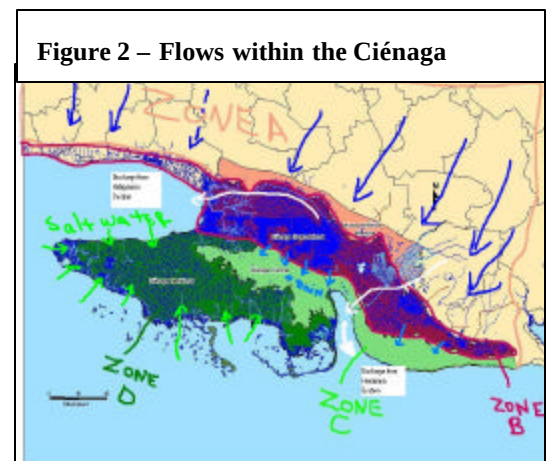


the Ciénaga is largely defined by the relationship with the marine environment. Salt water intrusion is common in most of the coastal areas and limits the fresh water flow to the sea. Since the discharge to sea is limited, it is fair to say that its major hydrologic function is the collection and storage of freshwater that flows through the system.

The Ciénaga de Zapata Watershed is divided into four zones according to its lithologic structure, geomorphology, and hydrodynamics by Rodriguez Yi et al. (1993): the Catchment zone (A) is a karst plain along the upper third portion of the watershed (*Llanura Carsica ‘Meridional’ y ‘de Colon’*); an Inland Wetland zone (B) is a peat covered wetlands that formed in the interior northern part of the watershed; the Upland zone (C) is a non-wetland, uplands found on biogenic limestone or calcareous sand, and the Coastal Wetland zone (D) composed of wetlands found in coastal areas in the southern portions of the Ciénaga with definite marine influence and sandy-clayey or lime sediment-based soils.

Flows within the system. Zone A denotes the catchment area where most of The Ciénaga watershed water originates. Geographically, it coincides with the *Llanura Carsica Meridional y de Colon* (see Exhibit 2), a karstic plain that stretches across the top of the Ciénaga watershed. It is comprised of

complex groundwater circulation patterns and has water table characteristics, especially in the lower portion of zone. Preferential flows drain generally in a southerly direction; these preferential flows are large conduits that occasionally collapse towards the surface.

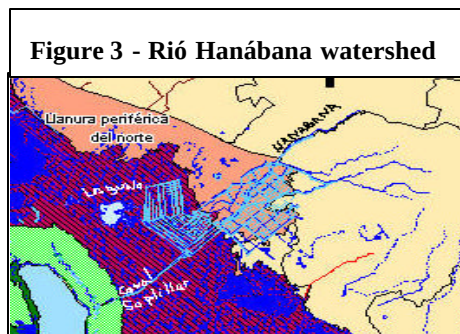


Zone B represents inland, wetland area fed almost exclusively from Zone A's underground flows and some saltwater intrusion; superficial flows are almost nil. It is composed of three layers of aquifers: the main and deepest layer is associated with the limestone caverns, containing bicarbonate/calcite waters; a second of biogenic limestone or calcareous sand, consisting of salty, mineral rich waters from upper layers where the depressed formation forms a natural path for salt water intrusion; and an upper layer of wetland water associated with peat (mucky water) composed of woody, woody-herbaceous, and herbaceous material. Superficial flows from Zone A are almost non-existent due to the high rate filtration caused by large extensions of bare karst and lapies in the lower plains. Other factors that limit flow are canalization of *Río Hatiguanico* and the regulation and canalization of *Río Hanábana*.

Zone C corresponds to the upland zone characterized mainly by limestone outcroppings, which incorporates an ancient, abrasive surface towards the West that at one point was the continental divide and a low, terraced coastal plain towards the East. The main source of water for this zone is precipitation that seeps in, almost in totality, via the karstic-limestone surface; a secondary, minor source are inflows from Zone B. Subterranean circulation is characterized by water table circulations generally free of pressure and stratification where freshwater lenses have a disposition over saltwater. A relationship exists between the water levels of this area and the tidal action on the coast. *Sabalo-Hondones* area has densities in excess of 30-40m, possibly indicating a system of preferential drainage lines oriented along the superficial karstic formations (dolines of dissolution and subsidence) intersected by main drainage lines out to sea.

Zone D represents coastal wetlands, whose main differences from inland; wetland (Zone B) is a higher elevation and the littoral composition of its aquifer horizon, one superior aquifer characterized by layers of limestone sediments, clay-sand, and no peat humus. It has direct influence from salt water at higher levels, large volume of subterranean flows are present, and is confronted by superficial saltwater influence of tides, storms, and hurricanes. Freshwater flows from Zones B & C are severely limited due to ample proliferation of saltwater in this area.

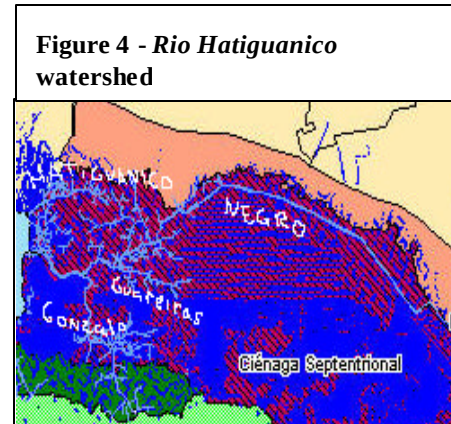
Flows In and Out of System. This system discharges most of its water out to sea via two flows that encompass a major part of the superficial and visible subterranean flows: *Bahía de Cochinos* and *Ensenada de la Broa*. The balance discharges via subterranean flows, not well studied but evident from the many underground springs that line coastal areas of the Ciénaga, visible from space via remote sensing. The outbound superficial drainage flow network is quite dismembered and complex due to the karst processes and the wetland features of this system.



Río Hanábana watershed originating towards the northeast, experiences autogenic drainage, is naturally dismembered in its lower third, and has been severely modified by canalization, regulated, and drained for irrigation of rice production (*Plan Arroz Las Amarillas*). It has two sub flows that branch out, a set of canals from *Plan Arroz* to *Laguna del Tesoro* (the largest freshwater lake in Cuba) and the other, *Canal Soplillar* to *Bahia de Cochinos* at discharging *Avalos* cove via a system

of swallow holes (ponors). These are fed by a series of superficial flows that drain large volume of freshwater to the Eastern Ciénaga, originating further towards the northeast.

Riό Hatiguanico watershed is composed of the *Hatiguanaco* or *Gonzalo*, *Negro*, *Azul* or *Cristales*, and *Guareiras* rivers. It is the single largest continuous water system in the Zapata Peninsula (Borhidi et al., 1986). This Watershed



diverts large volumes of water from the catchment area, in an east to west direction, directly to sea via *Ensenada de la Broa*. It originates in The Ciénaga proper, from “hydrological windows” (numerous subterranean springs that gush forth water), and drains the Catchment Zone, upper third of The Ciénaga watershed. *Rio Guareiras* flows at a slow rate (two m³/second), is of autogenic drainage, relatively low salinity, and impacted by artificial canalization and drainage.

Ecosystems and Habitats

The *Zapata* peninsula is an important area of mangrove, freshwater vegetation, alluvial, semi-evergreen, and dry evergreen forests. It is replete with freshwater and brackish lagoons, canals, lakes, and rivers; peat bogs and wetland habitat. It is host to hills and rocky coasts with underwater caves and underground caverns (Nieto Dopico, 1997).

Forests. The Ciénaga’s forests consist of Zonal, Ephadic, and Hydric forest types. Zonal forests are those whose characteristics are determined by climactic conditions, Ephadic forests by soil variations and hydric by humidity in the soils.

The Ciénaga's Zonal forests consist of three habitat types: semideciduous mesophytic, low seasonal evergreen, pre-coastal & coastal semideciduous, and dry-thorny shrub forest. Semideciduous mesophilic forests are composed of 40% deciduous trees, evergreen trees, epiphytes, and lianas; representative species include ceiba (*Ceiba petandra*), mahogany (*Swietenia mahoganii*), Cuban wild tamarind (*Lysoloma Sabicu*), gumbo limbo (*Bursera simaruba*), royal palm (*Roystonea regia*), and cedar (*Cedrela odorata*) with a rich and varied understory of shrubs and bushes. It occurs in large areas of the Ciénaga moderate rainfall and three to six months of dry season. Low seasonal evergreen habitat contains only 30% deciduous trees with a similar evergreen plant composition; these occur less frequently in the Ciénaga in areas of greater rainfall and shorter dry seasons. Pre-coastal and coastal semi-deciduous communities are low forest with two strata typically found growing on coastal limestone in the eastern peninsula, where higher temperatures and dryer conditions are prevalent. Representative species include lignum vitae (*Guaiacum sanctum* and *G. officinale*), gumbo limbo, bourreria (*Bourreria succulenta*), limber caper (*Capparis flexuosa*), pigeon plum (*Coccoloba diversifolia*), black ironwood (*Krugodendrium ferrum*), Florida thatch palm (*Thrinax radiata*), thorny shrubs, and some cactae. Dry-thorny shrub forest occur also occur on the southern coast of the eastern Ciénaga where they grow on bare limestone rock and have adapted two to dry seasons lasting eight months and very little rainfall. There are no deciduous trees, abundant cactae, and small trees, palms, vines and shrubs.

The Ciénaga's Edaphic forests include pineland and sea-grape habitat. Pineland habitat is mostly found on sandy soils in the Isle of Pines and in northwestern portions of the Ciénaga closer to Pinar del Rio. These open stands are typically dominated by one or

two pine species, *Pinus tropicales* and *Pinus caribaea* spp. *Caribaea*, by a rich understory of small palms, shrubs, ferns, vines and grasses. Sea-grape forests are evergreen vegetation dominated by sea-grapes (*Coccoloba uvifera*) that accompany dune species or rocky coastlines. Other species include gumbo limbo, buttonwood (*Conocarpus erecta*), coco plum (*Chrysobalanos icaco*), Florida thatch palm, and limber and Jamaica capers (*Capparis cynophallophora*).

Hydric forest habitat in the Ciénaga includes semideciduous flood-prone, swamp, and mangrove forests. Semideciduous flood-prone forests are composed of 50% deciduous trees and occur in low areas with excess humidity and periodic flooding that have a combination of gravel and acid-humus soils. These forest contain several precious hard wood species such as mahogany and black olive (*Bucida buceras*), a shrub strata, and a less diverse herbaceous layer. Swamp forest habitat is found throughout the Ciénaga in areas of peat soils and permanent flooding of fresh or saltwater. Tree stands are composed of species with bulbous bases such as Carolina or pop ash (*Fraxinus carolineana* spp. *cubensis*), pond apple (*Anona glabra*), dahoon holly (*Ilex cassine*), wax myrtle (*Myrica cerifera*), buttonwood, and assorted palms such as Paurotis palm (*Aceolorrapphe wrightii*). These stands are interrupted by large areas of saw grass, ferns, and woody perennials. Mangrove forests are a highly specialized evergreen habitat occurring on low-level muddy/marshy soil in coastal areas and a large portion of the western Zapata peninsula. Communities are mainly composed of red (*Rhizophora mangle*), white (*Laguncularia recemosa*), and black mangroves (*Avicenia germinans*); but also include buttonwood, coco plum, seaside mahoe (*Thespecia populnea*), and ground covers of saltwort (*Batis maritima*) and ferns.

Water ecosystems. The Ciénaga is home to a vast array of water-based habitat; these range from freshwater and brackish (lagoons and lakes, rivers, and canals), marine habitat (sandy, sea grass, keys, and coral reefs) and underwater caves and caverns. The *Laguna del Tesoro*, the largest fresh water lake in the Caribbean with a surface area of nine km², forming the deepest part of the Ciénaga. The lake, with a maximum depth of 11 meters and an average depth of 3-4 meters, contains several small islands and is surrounded by mud banks and wetland vegetation consists of submerged and floating flora. It is home to many species of fish including the manjuari (*Lepisosteus tristochus*), a prehistoric fish, the Cuban terrapin, and many important species of waterfowl. The Ciénaga has several important smaller watersheds and riparian habitats, as well as various large canals that crisscross the territory (presented previously), predominantly surrounded by swamp vegetation with occasional open savannahs and occasional mangroves that form critical habitat for wildlife. These include *Santo Tomas-Guareira-Canal de los Patos*, *Hatiguanico-Rio Negro-Broa*, and *Los Sabalos-Jiqui-Cenote*. Marine habitat such as mangrove, sea grass, and oyster beds provide vital breeding grounds for most of Cuba's marine species. The coral reefs that line the shores form some of the largest continuous reef habitat in the world and are teeming with diverse species. Special coastal areas include *La Ensenada del la Broa*, *Cayeria de Diego Perez*, Ensenada de Cazonas, and the Southeast of Earnest Thaelmann key. The caves and caverns on the coasts of the Ciénaga between Playa Larga and Playa Giron reach a depth of 60 meters and provide habitat for blind fish, shrimp and other minute crustaceans; these form natural saltwater pools called *caletas*.

Wetlands and peat bogs. Wet prairies and peat bogs cover over 40% of the Lower Ciénaga. These vast prairies are dotted with tree islands, palm stands, and pools of pond-apple and wetland plants. These areas are replete with bare limestone ground that in many places is covered with a thick layer of rich peat soils, the accumulation of centuries of organic matter. These large areas of saw grass communities are flooded more than half the year and provide habitat for hundreds of wildlife species.

Biodiversity

The Ciénaga harbors the highest number of species of wildlife and the highest rate of endemism in Cuba (42% of animal and 51% of plant species); its maze of habitat is a haven for manatees, Cuban crocodiles, pink flamingo, and a wide variety of species either endangered or near extinction (Bequette, 1998; Nieto Do pico, 1997).

The Ciénaga is home to 60 species of mostly-small mammals over half of them endemic, including 31 types of bats, six rodents (hutia), and two insectivores. There are over 80 species of reptile, mostly endemic. The Ciénaga's waters contain 720 species of fish, 35 types of shark, 38,000 species of crustaceans, and 1,500 mollusk species, including the spiny lobster, land crab, and a variety of shrimp. The Ciénaga is host to more than 300 bird species of which 70 are endemic and many are migratory birds from North America.

The Ciénaga is home to many endangered animal species including: Gundlach's hawk (*Accipiter gundlachi*), Cuban tree-duck (*Dendrocygna arborea*), Zapata wren (*Ferminia cerverai*), Caribbean coot (*Fulica caribea*), Cuban parrot (*Amazona leucocephala*), Cuban macaw (*Ara tricolor*), bee hummingbird (*Calipte helenae*), ivory-

billed woodpecker (*Campephilus principalis*), Bachman's warbler (*Vermivora bachmanii*), Cuban kite (*Chondrohierax wilsonii*), Cuban flicker (*Colaptes fernandinae*), Zapata rail (*Cyanolimnas cerverai*), several species of sea turtles, American and Cuban crocodiles (*Cocdrilus acutus* and *C. rhombifer*), Cuban ground iguana (*Cyclura nubila*), Cuban boa (*Epicrates angulifer*), many sea mammals (whales, dolphin, seal, manatee), northern seahorse (*Hippocampus erectus*), several hutia (*Mesocapromys spp.* - Cabrera's, long-eared, dwarf, and little earth, Chapman's prehensile tail, Garrido's, Bushy-tailed, Isla de Juventud), Cuban flower bat (*Phyllonycteris poeyi*), and many insects and butterfly species (World Conservation Union [IUCN], 2002).

Human Systems

Socioeconomic Demographics

The *Ciénaga* municipality (Lower *Ciénaga*) is also inhabited by human beings, often referred to as *Cienagueros* or *Cenagueros*. At less than two persons per km², the ecosystem has the lowest population density in Cuba, a country of 11 million. Many *Cenagueros* are employed in forestry, tourism and fishing (Moreno, 1985). The following subsections, unless otherwise noted, rely mainly on the work of Rodriguez Yi et al. as well as that by Alfonso Martinez and Gutierrez Padron.

Population. In 1993, there were 8,212 people residing in 1.28% of Matanzas province, the area covered by settlements; a slight majority is male, most (70%) are age 15 - 64, a quarter is under 14 years, and the balance over 65. The growth rate from 1970 to 1990 averaged 1.05. Net migration from 1985 to 1990 was -28; on the whole people are leaving the *Ciénaga*. More than 40% of populations are not *Cienagueros*.

Settlements. As of 1993, there were 19 human settlements in the Lower Ciénaga; *Playa Larga* swallowed up what used to be *Mario Lopez*, *Buenaventura*, and *Caleton*. In fact from 1970-90, 17 smaller settlements with a total of 165 households and 625 residents completely disintegrated because more people are drawn to the larger settlements. There are four major population zones in the Lower Ciénaga, these are: Central with four settlements and 32% of the population, East-central with 10 centers and 57.5% of the population, Eastern extreme with three villages and 6.5%, and western zone with two villages and 4%. A majority (56%) of residents lives in three towns, two of which are considered urban centers (*Cayo Ramona* and *Playa Giron*); these have seen the most growth due to roadway access. *Playa Giron* residents are gradually being transferred to newer homes in a nearby development to make room for tourist infrastructure. Access to utilities and infrastructure is uneven; out of the 19 settlements, only 13 settlements had paved roadways, only 14 had central electric utilities, five had water by aqueduct, the rest distributed via truck, and only *Playa Larga* and *Playa Giron* had phone access.

Housing and social services. As of 1993, 80% of homes (2,100) were in rustic shape, including: 60% with thatch roofs, 64% with wooden walls, and 20% did not have cement foundations. Three quarter of the homes were built by the owners themselves. Although, 70% had basic electrical appliances, less than 3% had air conditioning. Ciénaga residents transported themselves mostly (54%) by bicycle or on foot (21%); the rest move by horse (12%), motorcycle (7%), and by cart, truck, car, or tractor (6%). Most (86%) in the Lower Ciénaga cook with kerosene; others cooked with charcoal, gas, wood, or alcohol.

Social services were available as follows: education - 14 primary schools (up to 4th grade), one special, and one vocational school; medical - 11 family practices, three clinics, one hospital, and three pharmacies; and retail establishments - four grocery stores and four general stores.

Labor. 43% of *Cienagueros* work; most of the workforce is imported and there is little workforce development. In 1993 *Cienagueros* worked in the following sectors: forestry (EMA) 41%, tourism (INTUR) 27.5%, fisheries 6%, health and education 9.5%, and other (commerce, public admin)17%.

The Upper Ciénaga. There are eight other municipalities that are partly or entirely within the Greater Ciénaga watershed. Because of political boundaries, these municipalities, with a total population of slightly less than 345,000 in 1998, are often ignored in literature referring to the Ciénaga. These municipalities include *Calimete*, *Colón*, *Jagüey Grande*, *Jovellanos*, *Los Arabos*, *Pedro Betancourt*, *Perico*, and *Unión de Reyes* (Statoids, 2004). Although all human activity within the watershed continues to have significant impact, the Upper Ciénaga, with its higher population density, intensified agricultural and industrial activity, and geographic position within the watershed cannot be ignored.

Economic Activities

The *Ciénaga de Zapata* is an enormous natural treasure worthy of the highest level of protection; at the same time, it is one of the largest fountains of untapped natural resources for the socioeconomic development of *Matanzas* as well as the rest of the country (Cabrera Hernandez and Mateo Rodriguez, 1991). Yet, numerous human

activities threaten its health and livelihood. Some of these activities pursued in the *Ciénaga* include agriculture, water management, tourism, forestry, fisheries, mining, and exotic species trade. Local populations also threaten the ecosystem through uncontrolled hunting and unsustainable fuelwood use (Wotzkow, 1998).

Agriculture. Much virgin forest has been cleared in the Lower Ciénaga for agriculture such as rice, potatoes, and cattle grazing activities; except for rice, much of these activities have proven economically unsuccessful due to flooding in the rainy season (Wotzkow, 1998). Poor agricultural and water management policies have caused an increase of nutrients, sediments, and pollutants into the ecosystem via aquifers; the ecosystem is further affected by poor agricultural, grazing, and irrigation management practices to the north; chemical runoff, waste, and soil sediments contaminate its waters (Wotzkow, 1998). Cuba and specifically Matanzas is still highly dependent on sugar production and sugar by-products processing (Diaz-Briquets & Perez-Lopez, 2000). Sugarcane, citrus, and pasture are water intensive forms of agriculture and are irrigated intensely; although, less than 50 % of the water reaches the crops (Diaz-Briquets & Perez-Lopez, 2000). Three decades of irresponsible pesticide and fertilizer use, has made the Habana-Matanzas plain, directly above the Lower Ciénaga, one of the two most chemically polluted land areas in the country with high levels of nitrogen, phosphates, and organochlorides (Oro, 1992). Organochlorides, highly toxic chemicals banned in the U.S. and other countries, are carried by rivers to coastal estuaries with mangrove lagoons, such as the Ciénaga, where most of the aquatic life resides affecting primary food sources, such as shellfish, crayfish, and shrimp (Diaz-Briquets & Perez-Lopez, 2000).

Water Management. Poor water management practices, due mainly to misguided agricultural policies have caused destabilization of the Ciénaga's local climate regimes, particularly rainfall and temperature; has diminished its capacity to retain nutrients, sediments and pollutants; and has caused a drop in water levels inviting saltwater intrusion. They have brought about the degradation of soils, salinization of aquifers, pollution and contamination of riparian communities, flooding, water withdrawal, water-logging, proliferation of aquatic weeds, and siltation; long-term impacts include reduction of oxygen flow, destruction of aquatic ecosystems, destruction of wildlife and bird sanctuaries, reduced fish reproduction, increased possibility of fish kills, and water shortage (Gujja & Humkziker, 2000). The hundreds of dams and mini-dams built for irrigating most of Cuba's agricultural lands are having an immense impact on the Ciénaga's ecosystem. The *Dique del Sur*, South Dike on the Hatiguanico River, is responsible for repressing the waters that otherwise would flow to the Ciénaga (Rodriguez, Fagundo, & Fernandez, 1991). It has caused a decrease in the sources of the subterranean water flows and has wrecked the coastal ecosystem via waterlogging and recurring floods in agricultural lands that decimated mangrove stands and caused high levels of coastal erosion (Wotzkow, 1998).

Tourism. The municipality of La Ciénaga de Zapata was declared a *touristic* territory by the central government; however, global demand for tourism in the Caribbean, mostly from Canada, Germany, Italy, and Spain, combined with the economic crisis of the Special Period has encouraged rampant, unsustainable infrastructure development and deforestation, draining in certain areas, and uncontrolled hunting in the Ciénaga. Sustainable tourism in the Ciénaga could have generated far more income than

the felling of trees, which only serves to degrade the areas touristic value; unfortunately, tourism has not been done responsibly (Wotzkow, 1998). Infrastructure development in the way of electricity; 100 kilometers of highways; resorts, museums, art galleries, and restaurants; 200 kilometers of causeways; and urban communities have changed the face of this ecosystem (Moreno, 1985). Amongst the many recreational activities offered is hunting. In fact, the locals hunt birds and jutias (*Capromysis sp.*), most of which are endemic and endangered, to satisfy tourists' exotic palates (Wotzkow, 1998). Tourist crafts include a ceramics center in *La Boca* and taxidermy, carved wood, brooms, and imitation jewelry in *Cayo Ramona* (Rodriguez Yi et al., 1993).

Lumber, charcoal, and firewood production. Rapid deforestation began in *Zapata* in 1983. By 1990, one quarter of the *Ciénaga* was under intense forestry production (Rodriguez Yi, et al., 1993). A study by Baez, Santana, Medina, Torres, and Vinola (1991) found that the area's forestry activities had been incorrectly and poorly managed since and at no time was the importance of the *Ciénaga*'s forests taken into account. The *Ciénaga* is home to $\frac{3}{4}$ of *Matanzas*' forests; about half the ecosystem is forested (Bequette, 1998). *Zapata* provides *Matanzas* with 75% of valuable timber production, 20% of charcoal production, 50% of the wood for tobacco drying houses and merchandizing, 39% of wood in logs and sawdust, and all the fuelwood for *Matanzas*' sugar refineries and other industries (Moreno, 1985). Over 83% of the 355,000 cubic meters of wood harvested in 1990 went for fuelwood and carbon production (Rodriguez Yi et al., 1993).

Moreover, once cut, the forests were replanted with exotic species such as melaleuca that in other wetlands have had disastrous effects (Cardenas, Vinola, Facundo,

Medina, Romaguera, Sanchez, & Mena, 1991). As of the early 90s, Cuba was estimated to have the world's tenth largest area of mangrove forest, the largest extent of which is in the Ciénaga de Zapata's interior zone (Jenkins and Harcourt, 1996). Mangroves, a vital part of this ecosystem, provide timber, tannins, and firewood, but have seldom been harvested in a sustainable way (Carbonell, 1996).

Aquaculture and fisheries. As much as 50 % of Matanzas' fish production comes from the Ciénaga (Reyes, 1991; 1985 estimates). Exploitative aquaculture activities continue to introduce exotic species into ecosystem, block canals, and promote excessive consumption of native aquatic plants. Inland fisheries are set up in canals that are corralled up to one hectare in size. These fisheries produce exotic species of fish such as tilapia, *carpa herbivora* (*Ctenopharyngodon idella*), and *bagre de canal* (*Ictalurus punctatus*) that are encouraged to eat off the vegetation of the canal. In 1994, 780 ha had been developed and an additional 1,600 ha were under preparation in the *Laguna del Tesoro*. In that same year, aquaculture yielded 400 tons. Fish egg capacity has grown from one million in 1989 to over three million with the new facility in *Amarillas* and floating, movable pens in *Los Patos*, destined to other parts of the Ciénaga (Alfonso Martinez, Sanchez Vicens, Gutierrez Padron, & Rodríguez, 1994).

Offshore fishing has been exploitative as well negatively affecting the Ciénaga's fisheries. From 1986-90 annual production had dropped by 33%. A typical catch consisted of snapper, shark, yellow fin tuna, grunt, rays, and grouper in the peak months of May, July, October. As of 1989, half the fishing fleet consisted of 20 cement/iron hulled boats with an average age of 13 years.

Mining. The *Ciénaga* has the largest deposits of peat on the entire archipelago. Even though mining is difficult, since 1961 Cuba has been seriously considering and unsuccessfully attempting to mine for peat to be used in energy production in the *Zapata* peninsula, at the risk of destroying large tracts of habitat (Olenin, 1985; Santana Maurell, 1991). Experiments in the Lanier Swamp on the Isle of Youth, have met disastrous ecological results (Wotzckow, 1998). Other schemes are planned to mine limestone from the coastal, underwater caverns on the east coast of the Bay of Pigs that provide habitat to many endemic species and a critical part of the *Ciénaga*'s drainage and filtration system (Balado Piedra, Nieto Misas, and Gonzalez Fernandez, 1991).

Trade in and exploitation of various species. Activities such as crocodile, parrot, and oyster breeding programs while economically successful have had detrimental effects on the natural habitat. Crocodiles are bred for taxidermy and meat/hide production out of *Criadero* with an annual potential 10,000 individuals per year (Rodriguez Yi et al., 1993).

Other species such as the land crab (*Cardisoma guanhumi*) and the Hawksbill turtle have been targeted for exploitation. (Gavino, Fiallo, Cotayo, and Pena, 1991; Alvarez, Gimenez, Machado, and Flores, 1991; Ramos Targarona, 1991; Hernández Vega and Rodríguez Carbajal, 1991). Land crab, which is critical to the *Ciénaga*'s ecosystem, have also been severely affected. During the May/June mating seasons alone, a harvest of 100 tons was not uncommon. The catch has dropped from a peak of 800 tons in 86 to 270 tons in 1990 and the ir populations have been heavily overexploited (Rodriguez Yi et al., 1993). Bullfrogs (*rana toro*) have also been extracted from the *Ciénaga* at an unsustainable rate. This activity peaked at 20 tons in 1986, down to less

than 50% in 1990; there is a marked decrease in weight of captured individuals (Rodriguez Yi et al., 1993). Another heavily exploited species is conch, whose captures ranged from 34 tons in 1981 to 1.6 tons in 1989. There are wanted mostly for their shells to feed the tourist trade (Rodriguez Yi et al., 1993).

Apiculture. Apiculture is an important economic activity in the territory; Matanzas is the country's majority producer of honey and beeswax and Ciénaga accounts for almost half. This activity takes place between January and July, when much of the Ciénaga's flora is in bloom.

Human Impacts to the Ciénaga

The whole of the lower *Ciénaga* encompassing **Zones B**, **C**, and **D** and a small percentage of **Zone A**, form part of a biosphere reserve whose resources are to be protected and managed wisely.

Figure 5 - Ciénaga de Zapata Biosphere Reserve



Within this Biosphere there are areas designated as National Park, Natural reserve, and 3 Wildlife refuges. Cuba is party to various regional and international treaties that apply varying levels of protection for this ecosystem, and many of its endangered species. However, as will be evident throughout the upcoming subsections, that these protections are inadequate, especially given the interconnectedness of this watershed's hydrology and the impacts of the contaminants flowing through it from all directions.

Agriculturally Related Activities

Intensive Agriculture. Intensive agricultural activities in this Watershed occur all throughout and include sugarcane plantations, citrus groves, rice paddies, banana plantations, livestock grazing (cattle, pigs, water buffalo), beekeeping, and assortments of less intense fruit tree crops and vegetable farming.

These activities are quite extensive in Zone A, the catchment area; this karstic plain is one of Cuba's largest agricultural areas, with thousands of hectares devoted specifically to sugarcane and grazing (see Exhibit 1); here use of fertilizer, pesticides, and irrigation is common. Contaminants from these activities enter the aquifer and move in southward direction to Zone B, the inland wetlands, which has been drained extensively to accommodate further grazing and sugarcane areas, but rice production dominates. Both the *Hatiguanico* and *Hanábana* Watersheds pick up contaminants and sediments from these two zones as a result of these activities and carry it throughout The Ciénaga and eventually out to sea, where it can affect ecologically sensitive bays, estuaries, keys, and coral reefs. Minor contaminant flows dissolved in water pass on to Zone C, where most of the human settlements occur within the Lower Ciénaga and with smaller scale agricultural activity. Most contaminants from these activities are dissolved and enter the aquifer as it is recharged by rainwater.

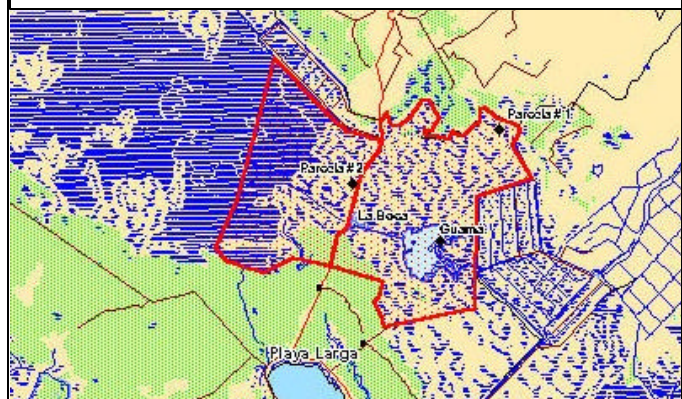
Forestry. Of the almost half a million hectares of forests in the Ciénaga watershed, about 128,000 ha are under production and are subdivided into the following units: *Unión de Reyes* and *Jaquey Grande* in Zone A with about 21,000 hectares and *Santo Tomas*, *Buenaventura*, *Helechal*, and *Guássasa* in Zones B & C with 107,000 hectares (Rodriguez Yi et al., 1993). Of the more than 230,000 m³ of forestry production,

over 85% is used for charcoal production or for fuel wood and basically it goes up in smoke (Paz Hernandez and Cuesta Gonzalez, 1994). The ongoing forestry activities in the Ciénaga in all zones, but more extensively inside the lower portions, are exacerbating soil erosion from agricultural activities.

Breeding Farms. Breeding activities of all sorts operate within the Watershed: crocodile are bred at Guama (Zone B) on a fairly large scale (10,000 hatchlings per year) for taxidermy (tourism) and consumption of meat and skins (Rodriguez Yi et al., 1993). Frogs are bred in Santo Tomas area. Many of the same concerns exist as with intensive aquaculture.

Exotic Species. The Ciénaga's lower portions are overrun by exotic species of flora and fauna that are severely threatening native and endemic species. Melaleuca and Australian Pine are the dominant plant species in

Figure 6 - Areas infected with Melaleuca



many parts of The Ciénaga. Many of the invasive fish species being bred have taken over the Watershed's waterways. Although invasive species are not a direct threat to the Watershed's hydrology per se, it does affect the character of its ecosystems and ability to carry out their biological functions.

Special considerations. Most of the impacts of agriculture on groundwater are well known, however, there are some very specific impacts that affect karst aquifers disproportionately. Because there is no clear distinction between groundwater and surface

water, contaminants typically associated with surface waters (phosphate, pesticides, absorbed or suspended sediments) may enter karst conduits from sinking streams (Coxon, 1999). The rapid throughput and lack of attenuation in these aquifers means that contaminants in groundwater may emerge at springs and contaminate surface waters, more so than other aquifer types. Land use changes, irrigation and drainage, and agricultural pollutants are the main impacts associated with agriculture and related activities such as forestry.

Any change in land use from a natural vegetation cover can bring with it the negative effects of soil erosion. In karstic areas erosion is easily triggered due to the shallowness of karst soils and aquifers are particularly vulnerable to the washing underground of soil material (Coxon, 1999). Increased grazing, particularly in areas where agriculture becomes less intensive, may have further effects on groundwater. Deforestation, reforestation, or conversion of grassland to tillage can all have effects to the amount and timing groundwater recharge and discharge.

Alterations to the soil water content by either increases due to irrigation or decreases due to land drainage operations will likely have an impact on the hydrological cycle. In karstic areas, where groundwater and surface waters are so closely intermingled, the impacts to both quantity and quality of water may be particularly pronounced. Irrigation or drainage will also affect changes in the amount and timing of recharge and discharge and bring about changes in water quality due to ease of entry of pollutants (Coxon, 1999).

Agricultural pollutant sources include both diffuse/non point sources such as inorganic fertilizers, spreading of organic wastes, and use of pesticides and point sources

that can range from animal groupings at troughs, shelters, or shady locations to poorly stored farm waste. Of particular concern is the increased mobility of these pollutants in karst aquifers; increased sediment loads from soil erosion can cause turbidity issues, but more importantly, can be an entry method for sorbed micro-pollutants such as nitrates, phosphates, and pesticides and viruses such as those associated with fecal microorganisms (Coxon, 1999).

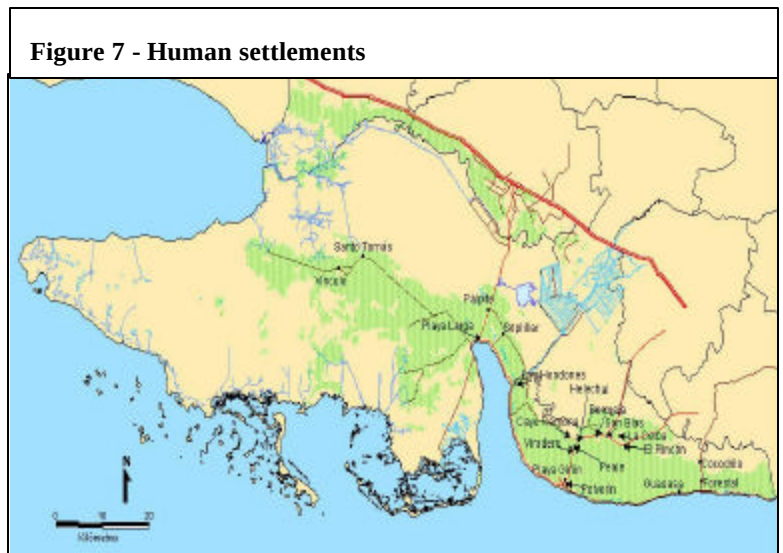
Industrial and Urban Activities

Industrial and Urban activities includes varying degrees of human settlements, industry, mining, roadways, and tourism.

Human Settlements. Zone A is much more extensively developed than the Lower Ciénaga. Large regional towns such as *Jovellanos*, *Jagüey Grande*, and *Colon* are larger population centers, with many smaller settlements spread throughout. These settlements add

further contaminants to the surface waters and vulnerable karstic aquifers underneath which flow on to the rest of the system.

Zone C contains most of the Lower Ciénaga's inhabitants. Although the population levels are relatively low, their impacts on their surroundings are amplified due



to the sensitivity of the Watershed. Sewage systems only service *Playa Larga*, and are absent from all other settlements.

Agro-Industry. The aforementioned agricultural activities inevitably imply some level of industrial production facilities which are heavy pollution contributors. Zone A, has many sugar refineries, several saw mills, and large rice production facility. The sugarcane and derivatives industry, particularly is a large contributor to Cuba's pollution; releasing soot, smoke, and steam into the atmosphere and toxic industrial waste and molasses surface and groundwater (Diaz-Briquets & Perez-Lopez, 2000). Agricultural industries, such as sugarcane, have highly aggressive wastewaters that have contributed to severe deterioration of groundwater (Coxon, 1999). Contaminants from this source also make their way throughout the system.

The rice facility, *Plan Arroz*, feeds contaminants directly into the *Laguna del Tesoro* via canals and into the *Bahía de Cochinos* where it discharges these into the sea via ecologically sensitive underground caverns. Almost half of the provinces honey and wax production comes from activities in The Ciénaga (Zones A & C), some level of contamination is assumed (Paz Hernandez & Cuesta Gonzalez, 1994). Other problematic agro-industries include dairy, which produce whey and wastewater, and forestry, whose timber mills can produce serious contamination by trace organic (Coxon, 1999). These can be problematic, especially in exposed karts areas.

Mining. Several limited mining activities exist currently within The Ciénaga. That mining is allowed at all within this very vulnerable watershed raises major concerns. Peat is being mined in the Western Ciénaga's Peninsula (Zone B), near Hatiguanico Watershed area. This consists of a four km² experimental polygon, where there lies an

estimated 500 million m³ of peat, the equivalent of 200 million tons of petroleum (Alfonso Martinez et al., 1994). The extractions are being used to produce fertilizers, asbestos-cement, as well as fuels. Rock and sand mining also exists in various places throughout The Ciénaga. Both activities are liable to continue causing great harm to the Watershed, its hydrology, and the ecosystems it nourishes via increased sedimentation and exposure to contaminants. Moreover, peat mining commercially from this ecosystem, would have serious consequences such as a drop in water levels during the dry season, drainage, and evaporation (Bueno, 1991) and to the local microclimates by disturbing the precipitation patterns (Florido Trujillo & Moya Gonzalez, 1994).

Roadways. Many roadways exist, especially in the upper portion of the Watershed. Zone A, is host to several large and many small paved roadways connecting the various centers of human populations, including the Autopista Nacional whose construction cut off the Upper and lower portions of the Watershed. Zone C, has several regional roadways including the main Ciénaga road, Las Salinas, Playa Larga - Caleta Buena, and many paved and unpaved smaller local roads. Paved road surfaces are major contributor to run-off and limit the free flow of surface waters throughout the Watershed. Any type of construction can cause concerns on karstified rock; however roadways and railroad tracks can involve deep cuttings into karstified rock exposing karst joints, shafts, and caves. The danger is not only structural, from the exposure to polluted water and toxic wastes which might flow quickly down to groundwater. Road discharge is known to contain heavy metals and polyaromatic hydrocarbons (PAH) (Hoetzel, 1999). It is quite likely that roadway construction will amplify with increased tourism demands.

Tourism. Current touristic activities are on the rise and planned tourism throughout the lower portions of the Ciénaga de Zapata promises to be quite extensive. Touristic activities include boating (coastal, *Riό Hatiguanico*, *Laguna del Tesoro*, other canals & waterways), hiking (*Santo Tomas*, *Bosque Sonoro*, *Los Arroyones*, *Cinco Furnias*, *Las Salinas*, *Bermejas*), hunting and fishing, resorts (*Laguna del Tesoro*, *Playa Larga – Caleta Buena*), and scuba diving, spelunking, and snorkeling (*Playa Larga – Caleta Buena*) (see Exhibit 3).

Tourism multiplies the concerns alluded to with human settlements. The impacts related to these activities may not be as geographically restricted; tourism will expose more natural areas to more people. Infrastructure demands will surely increase, it is not clear what The Ciénaga's carrying capacity is, but it may be well surpassed by the time it is calculated.

Special considerations. Urbanized areas along with the increased human activities in karst areas or in catchment areas that drain to karst areas have proven especially dangerous. Any activity that exposes the karst rock, increase the potential for contaminant flows directly into an already vulnerable karst system. The main impacts that threaten karst areas are emissions of air pollution, discharge of waste water and nonaqueous organic liquid, storage and deposition of solid waste, and excavations due to foundations in construction projects. Indirect impacts can include increased demand for more land leading to deforestation and destruction of natural areas, increased demand for construction materials and increased quarrying activities, growth of recreational sporting and tourism, and potentially intensifies agricultural activities (Hoetzi, 1999).

Water Management Activities

National policy. The national policy that “not a drop of water reaches the sea” has had grave consequences on Cuba’s environment, specifically the degradation of the soils, the salinization aquifers, pollution and contamination of riparian communities, flooding, water withdrawal, water-logging, proliferation of aquatic weeds, and siltation; long-term impacts include reduction of oxygen flow, destruction of aquatic ecosystems, destruction of wildlife and bird sanctuaries, reduced fish reproduction, increased possibility of fish kills, and water shortage (Diaz-Briquets and Perez-Lopez, 2000).

Dique del Sur. The *Dique Del Sur* or South Dike on the *Hatiguanico* River is responsible for repressing the waters that otherwise would flow to The Ciénaga. It has caused a decrease in the sources of the subterranean water flows due to the increase in the exploitation of water for irrigation and storage in the hydrological tracts M-III-2, M-III-3, and M-III-5. The superficial and sub-superficial water flows that ran south from the upper portion of the watershed to the Lower Ciénaga have been controlled with dams and micro-dams (Bueno, 1991).

Special considerations. Exploitation of karst water is often accompanied by a negative impact. The direct effects can include depletion of the piezometric levels, compartmentalization of aquifer, increased exploitation cost, deterioration of water quality, abandonment of wells, alteration of river regimes, and changes in wetlands. Indirect effects might include soil salinization, progressive desertification, induced collapses, changes in physical properties of aquifers, and induced pollution due to over-pumping (Pulido Bosch, 1999).

Summary

The *Ciénaga de Zapata* watershed is a confluence of hydrological features vastly complex and distinctively unique. Its mostly karstic features bring together surface waters and ground waters into an almost indistinguishable union. Likewise, terrestrial freshwaters meld indiscriminately with saltwater both above ground and below. Unfortunately, this watershed is as fragile as it is complex and unique.

Alterations including mass deforestation, hydrological controls (dams, mini-dams, canals and river-straightening), and the national highway in conjunction with unsustainable tourism, agricultural, forestry, and other extractive activities have serious damage to its ecological and hydrological integrity. This has brought severe decrease in water flow, soil erosion, habitat destruction, and extreme loss of biodiversity; all in an area that harbors most of Cuba's endemic species.

In the Upper *Ciénaga*, sugarcane production, sugar refineries, and other large scale agro-industrial activities and practices as well as human population centers are a critical concern due to their geographic position within the watershed. Within the Lower *Ciénaga*, large-scale rice production and processing, growing tourism infrastructure, extensive fuelwood extraction and charcoal production, and unsustainable exploitation of fisheries and wildlife, are of major concern. Human settlements within this part of the *Ciénaga* are less of a concern due to the low population density and the out-migration, although a trend of higher concentrations in certain larger centers could pose potential problems. The population trends within the Lower *Ciénaga*, in conjunction with a very limited utility infrastructure, very low dependency on energy use and motor vehicle transportation, low dependency of extractive industry for employment, and apparently

modest basic needs may prove on the whole beneficial for the beginning of reinhabitation of the Ciénaga bioregion.

Indeed, by recognizing the entire Ciénaga watershed, studying it as a bioregion, and coming to a comprehensive understanding of its structure, its processes both natural and human, and their impacts to this living system, it is possible to begin projecting what a restored Ciénaga might look like and how this reinhabitation process might unfold. The following and final chapter discusses these and other implications of bioregionalism for the Ciénaga and for Cuba as a whole as well as avenues for future study.

IV - DISCUSSION

This chapter examines possibilities of restoration of the Ciénaga. It will summarize the findings of this thesis and explore such topics as Cuba's suitability for bioregionalism, bioregional solutions necessary for reinhabiting the Ciénaga, and the role of social learning and ecological literacy in this process. Finally, the chapter recommends future avenues of study.

Summary of Findings

This thesis argues that the Ciénaga de Zapata must be defined and understood in its entirety as a living, integral part of the interdependent network of life systems on Earth in order to begin to ensure its adequate protection. It demonstrated clearly that human interactions to date have been the leading cause of the *Ciénaga de Zapata's* degradation and that a redefinition of these interactions will be necessary for the restoration and survival of this living system. Therefore, a significant shift is needed in our anthropocentric approach with living systems such as the Ciénaga. A bioregional approach would offer a more complete, holistic vision and a new language for us to frame human interactions with natural systems. By defining the Ciénaga as a bioregion and therefore integrating both the human (cultural) systems with natural systems, we begin to address the economic and social pressures on these natural systems. This approach offers a context for bringing wholeness to the cultural environment parallel to restoring the natural environment, a context which this chapter will explore.

Bioregionalism and Cuba

Bioregionalism will be the key to a sustainable future on Earth but it may be a long time in coming for most countries, with some possible exceptions. Cuba, over the next several decades, will have the opportunity to redesign its future. In chapter 2, many reasons were given as to why bioregionalism might take hold in Cuba. To review, these are 1) the failure of centralized, top down policies, 2) its relative isolationism, 3) its lack of lack of consumerism and commercialism, 4) satisfaction with the fulfillment of basic needs, 5) strong community and social networks and 6) a high degree of self-sufficiency. As previously stated, bioregionalism would provide a framework for sustainable transition to democracy at the community scale in Cuba, enabling it to keep the aspects of socialism that work and adopt the freedom and transparency offered by democracy. Restoring sustainability at that scale becomes the work of the community. This section explores concepts of bioregional reinhabitation such as governance and boundaries, economy and foodsheds, science and stewardship to examine to what degree a bioregional approach would possible in Cuba.

Bioregional Governance

There is a great disconnect between the Cuban people and the Cuban government. This is evident from the informal economy that has been vibrant for decades. As demonstrated earlier, the government's centralized policies have failed to deliver economic gains and have had tremendous economic costs. It is fair to predict that Cuban people would opt for a less centralized form of governance if given the choice. Bioregional governance offers such decentralization.

Indeed, there are aspects of the watershed councils currently operating that give Cuba an emerging political structure that could facilitate a transition to bioregional governance. These aspects are recognized as such by CITMA (2004:4) as the “added value of establishing watershed councils: Ecosystem focus...over and above national, provincial, and municipal political/administrative boundaries; an integral approach; systemic, harmonized, and coherent; territoriality [read place]; decentralization; and participation” . These are some of the critical aspects identified in the research on bioregional governance. The cited report also recognizes that to further the effectiveness of the watershed councils, Cuba will need to transform its political/administrative divisions and legal framework, use education to counter resistance to change, integrate sustainable development and science/innovation at the watershed level, and incorporate this in programs of higher education. Although, the word bioregion is not used or recognized in this report, it implies an initial degree of bioregional governance at the watershed level.

Boundaries. Likewise, Cepero (2004) recommends bioregional boundaries for a Cuba in transition, even though the word bioregion is not expressly used. He writes:

In the case of political boundaries, especially municipal and provincial ones, any new demarcations to take into account – in addition to social, cultural, and historical factors – the jurisdictions of natural territorial elements, as nature has outlined its own municipalities, provinces and nations. Hence, river basins and sub-basins, mountain ranges, plains, swamplands, and other areas exist where life interacts in harmoniously defined and geographically delimited ecosystems. ...In this way splitting in half of an ecosystem, such as the Ciénaga de Zapata wetland, between two provinces would be avoided... (p. 25).

Both these citations demonstrate that inside Cuba as well as in the exile community aspects of bioregionalism are being introduced intuitively, if not expressly, as solutions to comprehensive (economic-social-environmental) problems.

Governmental structure. A possible solution to the problem of governance would be to form a community system of direct participation. Each village or town within a bioregion would elect a governing council. Each of these governing councils would have one vote and one representative in the bioregional assembly. This assembly would uphold bioregional agreements and facilitate negotiations between communities on the interactions between communities and the natural environment. This assembly would coordinate the delivery of basic needs and sustainable livelihoods to ensure resilient ecosystems at the watershed level. All domestic policy within bioregions would be handled at this level.

To the extent that a federal government is necessary, each bioregion would have one vote and one representative to a national assembly. This national assembly would oversee inter-bioregional matters, decide disputes between bioregions, and shape foreign policy.

Bioregional Stewardship and Place-based Science

Cuba, with Soviet assistance, performed a thorough mapping that resulted in the 1989 atlas. It will again become necessary for Cuba to update its geographical data to take into account changes since the publication of its atlas. Indeed, as the research shows, the interconnectedness of living systems requires the study of relationships and flows, and mapping is the most adequate tool to understand relationships between human systems and natural systems. A new atlas could delineate Cuba's watersheds and depict

the natural flows as well as the economic, demographic, natural areas, and land use data. This would form a first step in defining and recognizing Cuba's bioregions.

Cuba has a national network of protected areas, six biosphere reserves, and several recognized wetlands of international importance, including the Ciénaga de Zapata. This is a good starting point for bioregional stewardship, which will require definition of zones not unlike those employed in biosphere reserves. The bioregional study of the Ciénaga, for instance, demonstrates that such protective zones are meaningless if the entirety of the watershed and its flows are not taken into account. The Ciénaga's core protected zones receive most of the contaminants from the Upper Ciénaga. Understanding relationships within each bioregion and between bioregions, will necessarily lead to the reconfiguring of protected areas and the wildlife corridors that connect these, as well as the buffer zones that collectively form these protective systems. Bioregional stewardship must be well integrated into all human activity for a bioregion to be sustainable. This is especially true for economic activities that occur within the bioregion.

Bioregional Economy

Cuba's economy, especially since the 1990s, has taken an inward turn and has become essentially self-reliant. This is evident from the drastic decrease of imports and exports since that time. There have been many unintended, but positive consequences including the resurgence of sustainable agricultural practices, low motor vehicle dependency, wide-scale implementation of alternative medicine, and a development of strong, informal social networks. At the community level, there is even more evidence of

cooperative self-reliance, such as the use of urban and community gardens for food and a thriving informal sector which emphasizes bartering and the importance of fulfilling basic needs. It is sheltered from globalism to the extent that Cubans are relatively unexposed to consumerism and commercialization. This in no way implies that Cuban's economy is sustainable, just locally oriented.

Sustainable livelihoods and basic needs. There are many aspects of Cuba's economy that would have to change if it were to develop truly vibrant and sustainable bioregional economies. Principally it would have to shift to a non-exploitative mode of operating, both socially and environmentally. This entails the promotion of sustainable livelihoods and the paying of living wages. It also would necessitate the drastic reduction of extractive economic activities that are mainly for export such as fisheries and wildlife, cement, minerals, and sugar. The economy must first and foremost be able to meet the basic needs (food, clean water, clothing, building material, a sense of community, access to healthcare and social services, sustainable education) of its populace in a sustainable manner. Each of Cuba's bioregion must be economically self-sustaining so that extraordinary burden being placed on the Ciénaga, for instance, need not exist.

Foodsheds. In many ways Cuba has a distinct advantage when it comes to local food production. The Special Period discussed in the research drove what many referred to as a green revolution in Cuba: a return to traditional farming practices, at least for the food grown to be consumed by the populace. Due to distribution difficulties, most of the food available to Cubans is grown locally, whether in urban garden plots or in rural farms. Cubans, for the most part, are not dependent on imports for their food and food production. According to the research presented, this makes for the beginnings of

bioregional foodsheds within Cuba. This does not imply that there need not be improvements to its bioregional food systems. There are many concerns with both environmental contaminants to foods, especially those grown in urban areas, and more so with the untested wholesale use of biotechnologies. Yet it appears that the basics are in place for a bioregional food infrastructure that can meet the basic needs of the Cuban people.

Infrastructure. Cuba has limited physical infrastructure, especially in rural areas. Heavy investment in infrastructure, not evident in Cuba, often proves a barrier to ecological redesign necessary to promote sustainability. Transportation, energy, housing, water, waste, and other human systems can be redesigned to meet the needs of communities without sacrificing the integrity of natural systems. This might entail an inter-regional light rail system between communities; distributed renewable energies such as solar and wind; water capture, reuse and natural filtration; local composting facilities. Homes might be built with rammed earth and other local materials and designed with proper ventilation and lighting; each with its own water supply, composting toilets, and a vegetable garden in the patio. However, before proper bioregional solutions are derived it is vital to examine some of the constraints inherent in the Ciénaga watershed, specifically as a result of the bioregional study.

A Ciénaga Reinhabited

Reinhabiting the Ciénaga as a bioregion necessitates, first, recognizing it as a bioregion as was done in the previous section and secondly, the redesigning of human systems by application of ecological design so that they work within the natural processes

of the bioregion, enhancing rather than disrupting them. Ecological design requires paying rigorous attention to particulars of place within the bioregion including: flows of energy, water, and materials; soil and climate characteristics; and subtleties of natural habitat. It requires considerations of appropriate scale and decentralization. It is a decentralized approach to complexity that allows local solutions to work sustainably because they are responsive to local conditions. The first step is to know the natural constraints of the bioregion; these will form the limits imposed upon any good bioregional design solution.

Bioregional Constraints

Most of the Ciénaga's constraints stem from the fact that it is such a hydrologically complex karstic drainage systems. Its formation in many ways dictates the diversity of climate, soils, habitat, and biodiversity that are intensely assembled in a relatively small area. This is true of its North-South gradients of change in climactic variables where dry seasons and rainfall vary drastically. Similarly its four soil types are assembled in consecutive bands from north to south. These conditions manifest themselves through the four hydrologic zones that define the watersheds processes and flows; as previously discussed these include: the karst plain, the inland wetland, the uplands, and coastal wetlands. Water flows drain generally in a southerly direction, with the inland wetland area fed almost exclusively by underground flows from the karstic plain. The uplands are fed by rain water, and the coastal wetlands receive freshwater from subterranean flows from the karstic plain as well confronted by superficial and underground saltwater influences. This system discharges most of its water out to sea via two flows and the balance via subterranean flows. These features and processes make for

extremely diverse sets of conditions that express themselves in the varied forest, water, and wetland habitat types that over time formed so many diverse life forms, many of which are endemic to Cuba and in some cases to the Ciénaga.

Many of the contaminants and sediments from karstic plain and the inland wetland are carried throughout the Ciénaga and eventually out to sea, to ecologically sensitive bays, estuaries, keys, and coral reefs. Other contaminants dissolved in water and enter the aquifer as it is recharged by rainwater. Karst aquifers are impacted disproportionately by land use changes, irrigation and drainage, and agricultural pollutants because there is no clear distinction between groundwater and surface water and because karst soils are so shallow. Any change in land use can cause soil erosion for which these aquifers are particularly vulnerable. Grazing, deforestation, reforestation, conversion of grassland to tillage, irrigation or drainage can all have effects to the amount and timing groundwater recharge and discharge. Urbanized areas along with their air pollution, waste water, solid waste, and construction projects have serious direct and indirect consequences to this delicate system.

In short, the watershed's fragility, complexity and uniqueness form major ecological design constraints that drastically limit the impact human activities can have on this living system for it to maintain its integrity and for these to be considered ecologically sustainable. Therefore, it is critical that a reinhabited Ciénaga pay the utmost attention to all human systems and processes, and redesign these to fit within the limits imposed by the delicate forms and functions of this living system. The following section details many opportunities for such redesign.

Ecological Redesign of Human Systems

According to Van der Ryn and Cowan (1996) the following principles are a necessary part of any ecological design initiative. The design must grow from place, be informed by ecological accounting (i.e. inclusion of all externalities), be responsive to and inclusive of natural processes (i.e. decomposition, reproduction, respiration), all inclusive (not expert-driven, everyone is a designer), and make natural and human systems visible (the opposite of flush and forget). Ecological redesign of the Ciénaga's human systems will require actions at three distinct levels. These are:

1. Preservation involving the slowing down of the deterioration of natural systems and biodiversity caused by human development with such measures as recycling, community design, fuel efficiency;
2. Restoration involving the active renewal of natural capital in communities and in natural areas by recreation of habitat, restoration of streams, regeneration of soils, and redesigning of industrial processes.
3. Stewardship concerning the long-term care necessary to enhance the living systems that life is dependent on while supporting sustainable livelihoods and lifestyles.

The following recommended solutions are based on the researcher's limited exposure to and knowledge of the Ciénaga. They form a starting point whereby the Ciénaga's citizens can begin a deliberate, comprehensive effort to reinhabiting the Ciénaga while satisfying their needs for water, food, shelter, material, food, medicine, community, spiritual sustenance, and right livelihoods.

Water. Natural water flows of the entire Ciénaga must be restored. This includes dismantling many of the dams, including the *Dique del Sur*, restoring the many of the

rivers, reassign the main roadways that divide the watershed, and eliminating or backfilling canals that drain various portions of the watershed. Constructed wetlands and marshes at strategic points would ensure water availability for small-scale sustainable agriculture, self-sufficient sustainable industry, and residential use, while providing flood control buffers. Large-scale irrigation and manipulation of water is simply not sustainable within this sensitive watershed. All buildings within the Ciénaga can be improved to capture the more than adequate rainwater for drinking and everyday use. Grey-water can be reused to irrigate garden plots.

Agriculture. Most of the agricultural activity occurs in the Upper Ciénaga, which is also the catchment area of the watershed, the most vulnerable to contaminants.

Agriculture here must be completely re-configured to be sustainable. Scales of farms must be limited to small organic farms with diverse plantings, interwoven with fruit tree islands, transitional zones of natural habitat, cisterns, wind generators, on-site treatment of waste and wastewater, recycled water for irrigation. Large-scale grazing is not sustainable. Most of the grazing that occurs can be severely curtailed; it likely supports exports since Cubans get very little beef in their diets.

In the Lower Ciénaga, most of the farming can be limited to subsistence farming occurring in small plots, within settlements and in the patios of people's homes. Some small-scale raising of backyard animals is possible, but no large-scale grazing would be possible.

Industrial agriculture based on monocultures must be severely limited. It cannot be done sustainably on a large-scale and is not needed to meet basic needs of the bioregion. Sugarcane and rice particularly, require heavy chemical inputs and produce

much waste. Production of both crops can be reduced; limited only to the most suitable soils and the industrial processes for production must be redesigned to recapture wastes and reuse water.

Industrial processes & material use. Any industrial activity must be limited in scale and to places within the Ciénaga where they can be done sustainably. Principles of industrial ecology must be applied to assure drastic reduction in the use of raw materials and recapturing of all waste to feed other industrial or agricultural processes or safe reintroduction of non-toxic material back into the ecosystems. Serious consideration must be given to the sugar refineries in the Upper Ciénaga and the rice production facility within the Lower Ciénaga and how they would meet ecological sustainability criteria.

Restorative material cycles, cycles in which waste become food for another process, are enhanced when incorporated with the sustainable use of local materials, local wastes, and local vegetation. These processes must ensure designed reuse, recycling, flexibility, ease of repair, and durability (Van der Ryn & Cowan, 1996).

Waste & wastewater. Waste produced from human settlements and economic activity in the Ciénaga must be completely redesigned to be assimilated within the natural processes of the bioregion. Organic, non-toxic wastes can be composted to begin rebuilding soils in agricultural areas and human waste can be composted to rebuild soils in natural areas. Non-organic waste such as glass and plastic can be recycled or reused (excessive marketing-driven packaging is not currently a problem). Wastewaters can be filtered through constructed wetlands to remove impurities before being reintroduced into the natural environment. Bioremediation can be applied to contaminated soils using plants known as hyper-accumulators; the heavy metals can be collected and recycled.

Economy. The whole bioregional economy can be redesigned to function around social and ecological restoration. It is important to restate that less than half of the Lower Ciénaga's inhabitants choose to work in the current extractive economy and many laborers are imported from other provinces. Many small human-scale industries will arise in response to bioregional restoration. Specifically much work will be generated directly from conservation, regeneration, and stewardship activities that have the potential to employ many throughout the watershed in public works style movement. These include protection of wildlife and habitat, reforestation, reconfiguring of agriculture for sustainability, responsible tourism, home building, sustainable harvesting and growing of building materials, constructed ecosystems, restoration of rivers, and hundreds of other reinhabitation-based activities.

Forestry. Up to 80% of the extractive forestry activities within the Lower Ciénaga exist solely for the production of charcoal and fuelwood and can be completely eliminated. There are many viable alternatives to these fuels. The balance of the forestry activity can be done selectively and sustainable, so long as it is done outside the core zones of the Ciénaga's. Much reforestation of native species must occur, simultaneous with removal of invasive species. Invasive species may be used in the interim in a transition from fuelwood to renewable energy sources. Recuperating lands can be used temporarily for growing materials for building, clothing, regenerating soil, and other uses; these might include as bamboo, hemp, thatch, and other tropical fibers. Transitional zones between natural habitat and agricultural areas or between agricultural areas and settlements can be used for these purposes as well.

Fisheries, aquaculture & wildlife. There is little room for exploitative, non-sustainable extraction-based activities within the Ciénaga. Its ecology is too sensitive and must be protected. Fisheries and coastal habitat have been continuously depleted over the last several decades. A moratorium on all industrial fishing must occur for at least a decade, to allow them to rebound. This does not preclude subsistence fishing for food. This does mean complete redesign or elimination of aquaculture activities. Aquaculture has introduced several destructive, invasive species of fish into the Ciénaga's waterways and its main lagoon. This practice must be eliminated or at best replaced with the aquaculture of native species. A serious effort must be undertaken to eliminate invasive species from the bioregions waters.

Tourism. There is a big potential for responsible tourism. But the first priority must be the protection of the ecological integrity of the bioregion. Any exploitative tourism activity must be eliminated. This means no hunting, no fishing in protected zones, and no extracting of coral from reefs or of wildlife from natural habitat. The crocodile breeding farm can be used to repopulate this and other species throughout the Ciénaga's coastal waterways.

Tourism activities can be limited to hiking and wildlife viewing, light camping, non-motorized boating on sensitive inland and coastal waters, limited off-shore fishing, interpretive archeological sites, ecological design tours, and longer term restoration camps. Tourism infrastructure must be limited to rustic, self-supporting structures built with locally available materials and functioning on renewable energy sources.

Transportation & roadway design. Since individual car ownership and dependency on automobiles are relatively low, a sustainable transportation system could

be implemented to by-pass the possible over-reliance on automobiles in the future. As previously mentioned, a light rail system can service communities. It must be designed consistent with the ecology of the Ciénaga, for instance, it must be elevated at certain points to not disrupt the water flows or avoid wildlife corridors. Busses running on biodiesel, slightly-modified, recycled vegetable oil, could service the points that the rail system does not. Roadways must be reconfigured, with constructed wetlands to capture any pollutants coming off of them. They also must be elevated or re-routed to not interfere with natural flows. This applies particularly to the *Autopista Nacional*, which dissects the Ciénaga watershed in half and greatly interferes with its hydrological functions. A true shift to bioregionalism will undoubtedly lead to less dependence on large-scale, high-maintenance transportation infrastructure and reduce energy consumption.

Energy. There are many distributed, renewable energy solutions that would be adequate for the Ciénaga, considering the limited infrastructure availability and the destructiveness of non-renewable sources. The bioregions inhabitants need not be cooking with charcoal, fuelwood, or worse yet kerosene. Some of the renewable solutions can include solar, wind, small-scale hydro (i.e. tides or converted mini-dams), and biomass recaptured from industrial processes.

Shelter and community design. Villages and homes can be designed and laid out to make use of natural lighting, produce energy, recycle water and waste, grow food, and reduce significantly their impact on the natural environment. Structures can be built from locally available material such as thatch palm fronds or from bamboo. Structures in

sensitive areas can be constructed on pilings. Walls can be constructed of rammed earth bricks or other material responsive to climactic considerations.

The Upper Ciénaga's larger towns and settlements, especially due to their location within the watershed, must be reexamined to assess the level of sustainability. Many will have to undergo a redesign process. Community design must be deliberate and follow landscape-level ecosystem patterns such as watershed, energy, and material flows. There should be no hidden features, such as far-away land fills or invisible pollution sources. All design solutions, whether constructed wetlands, composting facilities, or use of local and recycled building materials, must be visible because design transforms awareness.

Wilderness. The celebration and enhancement of wilderness must be a leading principle in the reinhabitation process. Wilderness can be infused into every area of the Ciénaga bioregion through improvement of the green infrastructure. These include natural habitat and land forms, especially in core areas; aquifers and recharge areas; heritage landscapes and archeological sites; parks, trails, and open spaces; and as buffers in between small-scale agricultural, industrial, or residential areas. A vast network of protected areas must be implemented with larger wildlife corridors between core zones and many more and larger buffer zones.

The goal of reinhabiting the Ciénaga is to eliminate monocultures and fragmentation at all levels: monocultures of the mind that foster narrow solutions that lead to fragmented societies and fragmented landscapes. Bioregional solutions in the Ciénaga and elsewhere must conform to the limits and subtleties of the bioregion's natural infrastructure. These solutions must embody diversity and wholeness, so that they

grow whole individuals and communities that become integral to the natural infrastructure of the bioregion.

The Role of Social Learning and Ecological Literacy

Reinventing human systems at the scale of a bioregion will require a widely-spread, deeply-participatory, cultural process. All Cubans will have to acquire a basic competence in the shaping of local and bioregional solutions. This will require a shared understanding of the problems to be addressed that can only come from wide-spread ecological literacy and social learning.

Ecological literacy is defined as understanding and application of the principles of interdependence, recycling, partnership, flexibility, diversity that lead to sustainability (Capra, 1996; Orr, 1992). Some of the concepts that all bioregional participants should understand are the workings of earth's systems, its ecology and vital signs, human ecology, natural bioregional histories, and how to restore natural systems and build ecologically resilient communities and economies (Orr, 1994) This means promoting new relationships with place by conserving the relevant ecological infrastructure, understanding humans as part of the natural world and particular places (Bowers, 1999; Smith & Williams, 1999). Ecological literacy to be effective and comprehensive within a bioregional context, must be delivered as part of a social learning process.

Social learning is a continuous coevolution between society and natural systems (Bowers, 1995; Eldredge, 1995; Sterling, 2001). There is no distinction between living and learning; learning is mastery of the art of life that can only be taught by example. By reinhabiting bioregions deliberately and be ecological design, societies become living

examples of interactions of between human and natural systems that not only do not deplete or are benign, but enhance the capacity of natural systems to sustain life. To accomplish this, society must develop the full range of human capacities not by accumulation of knowledge but education of independent thinking and acting persons who serve their community first (Einstein, 1954; Orr, 1992; Orr, 1994).

On a longer-term basis, there is a need to reconstitute an ecological foundation in culture, which involves communicating intergenerational visions and values; this will mean placing more emphasis on trans-generational communication, handing down of accumulated wisdom of individual, cultural, and natural system connections (Berry, 1988; Bowers, 1995; Capra, 2002). In other words, to assure the long-term sustainability of bioregions will require social learning across generations. Cuba's capacity for bioregionalism, social learning and other such topics bring forth many opportunities for future study.

Recommendations for Future Study

The following are recommended topics for future study on Cuba and specifically about the Ciénaga:

For Cuba, it would be necessary to map out of all of its bioregions, the flows within and activities within them and between them, and their human and natural infrastructure. It would be important to study what adjustments are needed in Cuba's policies and laws to support decentralized bioregional governance. Within this, the re-establishment of limited property rights with communal stewardship of biodiversity should be studied. It would be critical to know what can be produced sustainably within each bioregion and what limited trade is necessary. Along these lines, it would be

important to derive protective criteria necessary to entertain limited, non-exploitative foreign investment that meets the needs of each bioregion. It will be crucial to ascertain Cuba's capacity for widespread social learning and what appropriate methods can be implemented for sustainable, bioregional education.

For the Ciénaga de Zapata bioregion, it would be necessary to generate new comprehensive maps and or/atlasses of the entire Ciénaga watershed, including detailed depiction of flows (water, air, materials, energy, economic, and human), remaining habitat, and land uses. This can include the development of a bioregional directory of all available building materials and appropriate building methods responsive to climate and other conditions.

A more detailed synthesis of ecological constraints is needed that delineates subtleties and local variances between habitat and local conditions so that these are understood and human systems that grow in this bioregion can be responsive to them. Another future area of study will include the development of comprehensive bioregional sustainability indicators, benchmarks, and monitoring plans custom to the Ciénaga natural processes and cultural systems. Parallel to this, reconfiguring of the biosphere reserve to include the entire watershed will be necessary and require study to determine where new or expanded core zones must be located to truly protect ecologically sensitive areas. It will be critical to generate more intense study of settlements and activities in the Upper Ciénaga because of their geographic position within the watershed and how these can be redesigned to enhance the bioregion's sustainability. It will prove important to examine the parallels between the Everglades and the Ciénaga and to be able to learn from the Everglades Restoration Project what might work for the Ciénaga.

The Way Forward

Although this thesis lays out a vision for the Ciénaga de Zapata Bioregion and a model for other bioregions to follow, it is vital to acknowledge that there will be innumerable difficulties in achieving such a vision. The societal transformation outlined here is drastic, all-encompassing, and far-reaching in scope. Many proponents of the Emerging Worldview believe that complete societal transformation is the only way forward towards a sustainable future. This chapter alludes to social learning as a long and arduous evolution of mind that must occur to achieve societal transformation. Humanity is in a transitional period and facing a planetary crisis of immense proportions and complexity. Society will be faced with increasingly difficult challenges that it can ignore and then react to or that it can embrace and address. Bioregionalism is an intentional and proactive approach to addressing multiple, complex global challenges at the local level.

We humans, as a species and as the planetary force that we have become, have the ultimate responsibility to give birth to a new world. This will not be easy; it may very well be the hardest thing we do as a species. But, as Reinhold Niebuhr said:

Nothing worth doing is completed in our lifetime; therefore, we are saved by hope. Nothing true or beautiful or good makes complete sense in any immediate context of history; therefore, we are saved by faith. Nothing we do, however virtuous, can be accomplished alone; therefore, we are saved by love. No virtuous act is quite a virtuous from the standpoint of our friend or foe as from our own; therefore, we are saved by the final form of love which is forgiveness (Wisdom Quotes, 1995)

Implementing bioregionalism in Cuba, however daunting, would be one of many crucial steps towards sustainability. Cuba, like Earth, is an island. Achieving relative self-sufficiency there would prove that a sustainable world is possible.

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APPENDIX A

Land Use Map of Ciénaga Watershed (copied from 1989 Atlas)



Fraytag & Berndt Map of Cuba



APPENDIX C

Lower Ciénaga Tourism Infrastructure and Activities (Rodriguez Yi et al., 1993)

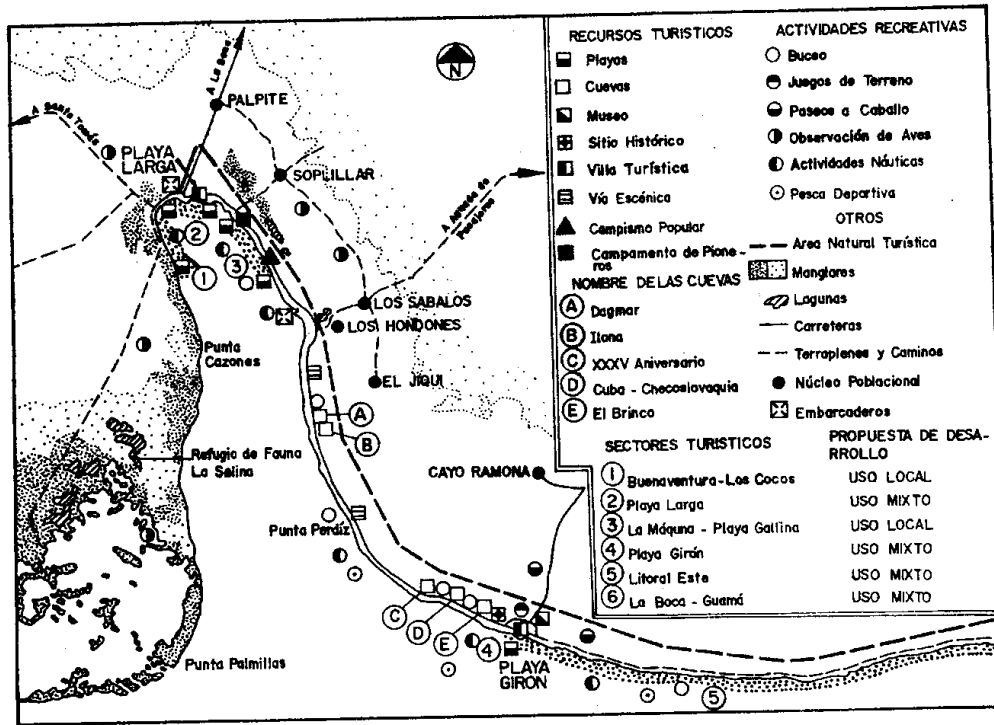


Figura 1. Zonificación funcional de los recursos turísticos del sector Playa Larga - Playa Girón