Two systems cover our planet: The Natural System formed during the last 4.5 billion years. Over this, we have built the Human Network. Only 10,000 years old, the human pattern now forms a matrix over the natural world.

TWO SYSTEMS. ONE PLANET.

TWO VIEWS, ONE REALITY

We perceive our planet as one place. We don't really see the two systems that occupy it. When we think of "Earth," we are most likely to bring to mind the natural daytime image at right: the "Blue Planet," the outlines of continents, the swirls of sea and cloud. Yet a nighttime photo reveals an entirely different pattern: the vast webs of human activity, the lights that indicate metro areas and the corridors that connect them. It takes two pictures together to accurately describe the conflicted reality in which we live. Economies and populations will continue to grow, drawing increasing amounts of energy and resources; nature will continue to decline. Resolving the tension between the natural and human realms will require new patterns of thought and action.

GLOBE PHOTOS: NASA; BACKGROUND: MICHAEL GALLIS & ASSOCIATES (MGA)

RETHINKING THE PROBLEM

SYSTEMS, NOT PIECES. The planet is so large, so complicated. Understandably, we have tried to comprehend and manage our world by breaking it up into parts. We focus on pieces not systems: Chesapeake Bay and polar bears, Shanghai and San Francisco, General Motors and British Petroleum. Yet all these things are parts of two vast systems that operate globally. While nature forms a planetary system that sustains all life, the Human Network centers on human life. These two macro systems have millions of parts and subsystems: transportation networks and water cycles, trading blocs and air currents. The challenges that face us today demand that we begin to think of the planet's two realms as systems that intertwine and interact.

UNDERSTANDING SYSTEMS. Analyzing a system involves identifying its "state," the parts and connections that form a spatial pattern. It also requires understanding of "motion," all the interactions and processes that take place through the pattern of connections. This "systems analysis" has often been done at small scales. We need a framework that allows us to apply it to the largest scales: regional, continental, and global. Recent scientific advances make this possible; the problems facing us make it imperative.

BUILDING A BETTER FUTURE. As the global marketplace continues to integrate, environmental problems are increasingly global, rather than regional or local. To succeed in this 21st century reality, strategy, science and policy need to take complex, global-scale connections and interactions into account. We need to create new policy, management and financial frameworks designed to operate within these macro systems and macro-system interactions.

NATURE: Noun 1 The physical world, including plants, animals, the landscape, and natural phenomena, as opposed to humans or human creations. *Compact Oxford English Dictionary 2009*

NASA

VISUAL LANGUAGE AS A TOOL. From primary school, we are trained to collect data and to reach conclusions using words and numbers. We are not used to visual communication. However, understanding global systems requires an understanding of relationships best communicated visually. In order to understand systems, their patterns and processes, we must use a consistent method of representing them spatially, a "visual language." Visual language provides a new tool for abstracting the major characteristics of a system, its configuration and motion. It clarifies the relationships and interactions both inside and outside the system.

FAR LEFT: **The Natural Systems** forms a seamless structure that includes land, climate, water, animals and plants and all the planet's patterns and processes driven by its endless rotation about the sun: It's spherical shape is marked by poles of extreme cold and an equator of extreme heat. Tectonic plates and volcanoes regularly push carbon into the biosphere and prime it to sustain life. Ocean and air currents govern weather and create the cycles upon which crops and habitats depend. Landforms dictate how water flows and how ecosystems develop. Subtle chemistries keep the soil healthy, allowing it to support the plant life that in turn supports animal life. The Natural System's patterns and processes are continuous and interactive.

LEFT: **The Human Network** is the sum total of all human activity: commerce, transportation, agriculture, education, health, industry, communication and urbanization. This network's patterns and processes now stretch around the globe. Our webs of transit, utilities, communication and trade link the tiniest, remote villages to the most sprawling mega-cities. Agricultural regions in one hemisphere feed populations in another. Mines, refineries and factories in dozens of countries must all coordinate to feed the supply chains that result in complicated products like automobiles and DVD players. Our economies, cultures and governments have evolved into a planetary system that exists to meet human needs. Like the Natural System it wraps the earth, and is continuous 24/7.

"Without changing our patterns of thought, we will not be able to solve the problems we created with our current patterns of thought."

—Albert Einstein

HUMAN: Adjective 1 of, relating to, or characteristic of humankind
Noun a human being *Compact Oxford English Dictionary 2009*

The current global crisis is systemic, rooted in a clash between two systems that have radically different patterns and processes. Can we continue to improve human living standards while also sustaining and rebuilding nature? If so, how?

TWO SYSTEMS IN CONFLICT

NATURE & NETWORK COLLIDE

The needs, patterns and processes of the Human Network often disrupt, pre-empt or overwhelm the needs, patterns and processes of the Natural System. Humans want better lives for themselves and their children. Fulfilling those desires depends not only upon human economies, but the energy and resources that feed economic activity. Providing those necessary resources depends upon a healthy Natural System. We need to create a framework that allows both systems to thrive. Instead, our current policies, management, investment strategies, and programs more often create conflict between the two.

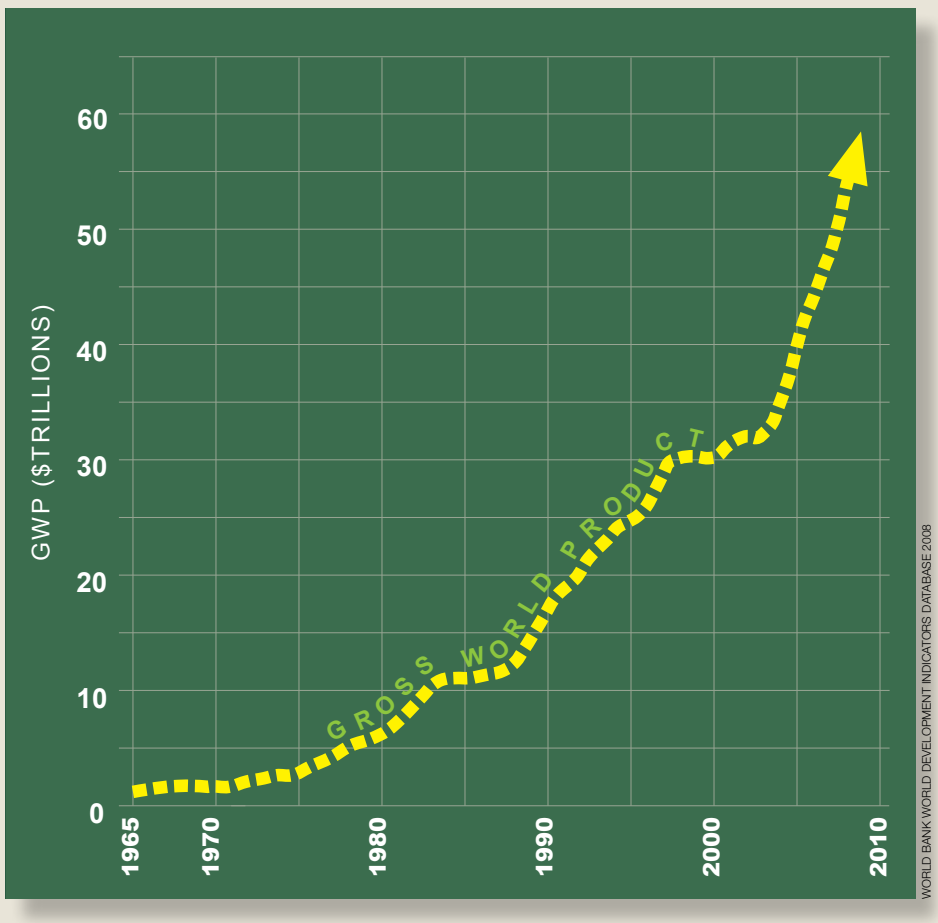
CONFLICTING DEMANDS. The Human Network relies upon many of the same resources needed by the Natural System. Cities, industry and agriculture need energy, raw materials, and water. So do ecosystems. The Human Network demands more space for housing, agriculture, factories, roads, mines, timberlands. Yet nature also needs space: Whales, birds and herd animals need corridors for migration. Large predators need to roam across wide territories.

CONFLICTING PATTERNS. If a coastal road runs north-south; the watersheds along that road will probably run east-west. Great port cities tend to form at the confluence of rivers, or at the mouths of river deltas, overwhelming large ecosystems. Vacation developments, slash-and-burn agriculture and logging roads fragment seemingly rural forests the world over. In countless ways—pipelines, power lines, dams, highways, irrigation ditches, railroads—human activities fragment the Natural System: A creek or river spanned by a road may not flow normally. A delta covered by a city can no longer support its native plants and animals. Fragmented bits of nature gradually cease to function as ecosystems. Extinctions follow.

CONFLICTING PROCESSES. The Human Network continually draws resources from the planet. As we consume these raw materials, we create power and products. We also produce waste. That pollution—of air, water and soil— changes the processes of the Natural System: the cycles of climate, the currents and chemistry of the ocean, the formation of fertile soil, the healthy respiration of plants. As the Human Network expands, it continually transforms the entire Natural System.

The World Bank predicted that in the first decade of this century, the annual World Gross Product would grow from $30 to $40 trillion, a 33 percent jump. By 2007, the figure had reached $54.3 trillion, near doubling in seven years. It is now predicted that world output could grow by at least 360 percent come 2050.

The developing world will fuel most of this growth, as large, once-struggling nations like Brazil, Russia, India, and China vault hundreds of millions into the global middle class. This could mean a better life for nearly 2 billion fueling a massive increase in resource demands.

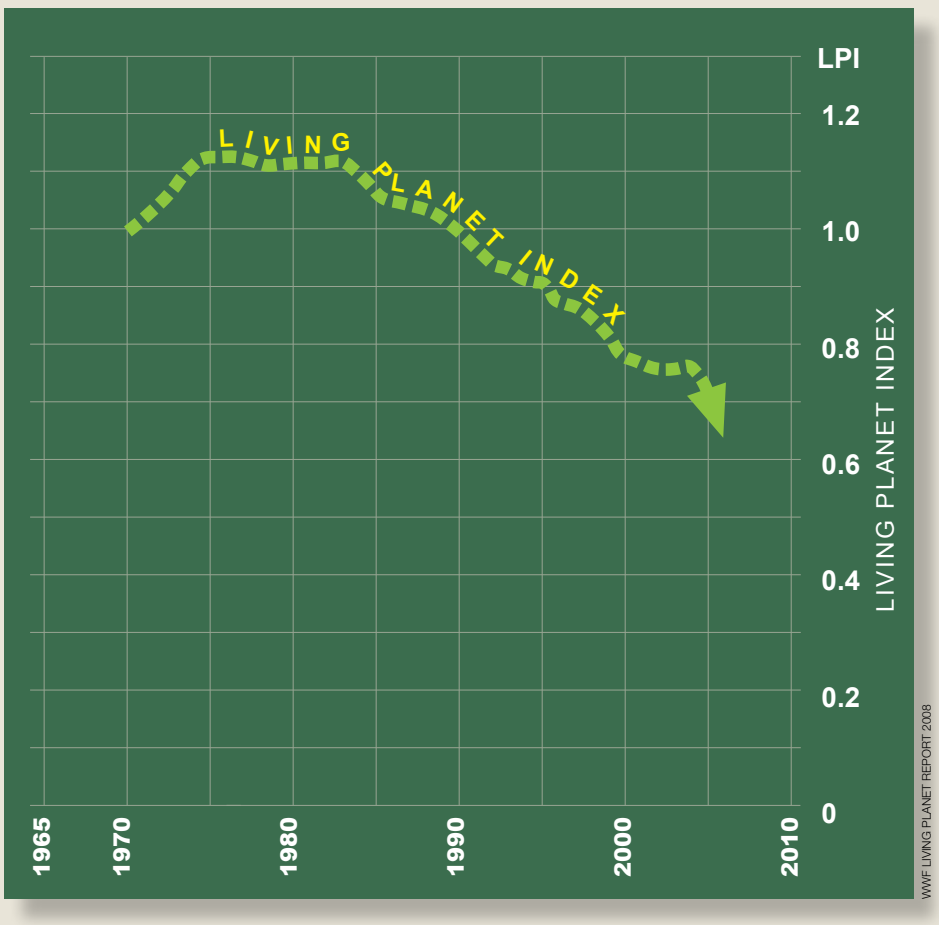


THE HUMAN NETWORK KEEPS EXPANDING

UNPRECEDENTED SCALE, WEALTH. Today, the Human Network has grown larger than previous generations could ever have imagined, connecting on a global scale and delivering ever more prosperity to ever more people. New roads, cities, and industrial facilities are being constructed across the world.

- In 1950, the earth supported 2.5 billion. By 2000, that population has more than doubled, to 6 billion. By 2050, that figure could reach 9.3 billion to more than 12 billion.
- The global human economy has grown more since 1990 than it did during all the centuries from the dawn of agriculture 10,000 years ago to 1950.
- Life is getting better for billions: Global per capita income has more than doubled since 1950. During the same time, global life expectancy has increased from approximately 48 years to nearly 70.
- Growing populations and economic activities have increased petroleum consumption, from 12 billion barrels a day in 1965 to 30 billion barrels a day now. Global fossil fuel carbon emissions have more than tripled since 1950.
- Urban areas have expanded on every continent: In 1800, only London boasted more than 1 million residents. Today, there are nearly 400 cities and metropolitan areas with populations of that size, or larger. Between 1990 and 2025, the number of people living in urban areas is projected to double to more than 5 billion.
- Global per capita food production has increased from about 2000 calories a day in 1950 to more than 2,750 calories now. People today eat three times as much fish per capita as they did in 1950. To meet today's demand for food, nearly all the oceans are being fished at, or above, capacity. How will we feed twice as many people tomorrow?

SYSTEM: Noun 1: a regularly interacting or interdependent group of items forming a unified whole *Merriam Webster Dictionary 2009*



WWF has created the "Living Planet Index," in an attempt to benchmark the changing state of global biodiversity and how human demands change the earth's biosphere. According to the 2008 report, the globe's health has declined by nearly half in the last 40 years. They project that, by 2030, we will need two planets' worth of resources to meet our demands.

NATURAL SYSTEM DECLINES AS DEMANDS SOAR

UNPRECEDENTED IMPACT. As World Gross Product spiked and human prosperity increased, the impacts on the Natural System have escalated so quickly that we have not had time to really comprehend how Human Network growth changes nature's behavior:

- Nearly 80 percent of the world's forests have been cleared or degraded; half of this destruction has occurred in the last 30 years. Animals living in those forests disappear with the trees.
- Cultivated systems—land set aside to produce food, fiber, and biofuel—now cover 24 percent of the Earth's surface.
- Global water use has increased six-fold since 1900. Clean water shortages now affect every continent accelerated by changing weather patterns.
- Soil fertility is declining globally. All the best agricultural land has already been developed.
- Once forested parts of the African Sahel have become deserts. Saltwater intrusion, water-logging and overgrazing degrade large areas of Central Asia, Australia and India. Each year, these problems strip vegetation from an area the size of Iceland.
- Most scientists now agree that carbon emissions are changing the climate, potentially upsetting delicate cycles.
- The chemistry of the oceans changes in as they absorb greenhouse gases, making them more acidic and threatening coral and phyto-plankton that form the foundation of the marine food chain.
- Under all these pressures, plant and animal species are disappearing at 100 to 1,000 times the natural rate.

ARE WE PREPARED?

Our current institutions, bureaucratic structures and assumptions do not align with today's systemic conflicts.

OUTDATED INSTITUTIONS. Our industrial and business processes, government structures, and urban development patterns have their origins in ancient times, and rapidly developed during the 19th and 20th centuries. For most of this time, nature seemed limitless. Yet growing scientific evidence shows that we are reaching the limits of the Natural System's carrying capacity. This situation creates a widening gap between our institutions and their capacity to address the realities of a changing world.

ARTIFICIAL BOUNDARIES. Lines divide the world: property lines, court circuits, water districts, agency regions, the borders of states and countries. Yet neither the Natural System nor the Human Network respect these divisions. Both operate regionally, continentally, globally.

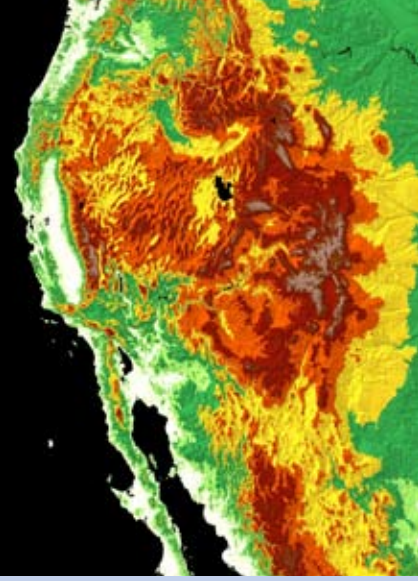
PIECES NOT SYSTEMS. We have constructed the Human Network, a system, in parts—one road, one house, one factory at a time—with little understanding of the whole system. As a result, we have unintentionally created profound inefficiencies in our economy and infrastructure. Similarly, our environmental programs emphasize conservation and mitigation on a piecemeal basis. We focus on one problem at a time: one species, one pollutant or one watershed, rather than upon large environmental systems. Despite some progress, these efforts are not working at the scale necessary. Ecological systems continue to decline everywhere, even within nature preserves.

INADEQUATE SCALE. Our bureaucracies have been set up to build things and to promote local business. Yet today's problems—climate change, economic turmoil, global-scale pollution, resource shortages—reveal a need to manage both the Human Network and the Natural System on regional, continental and even global scales.

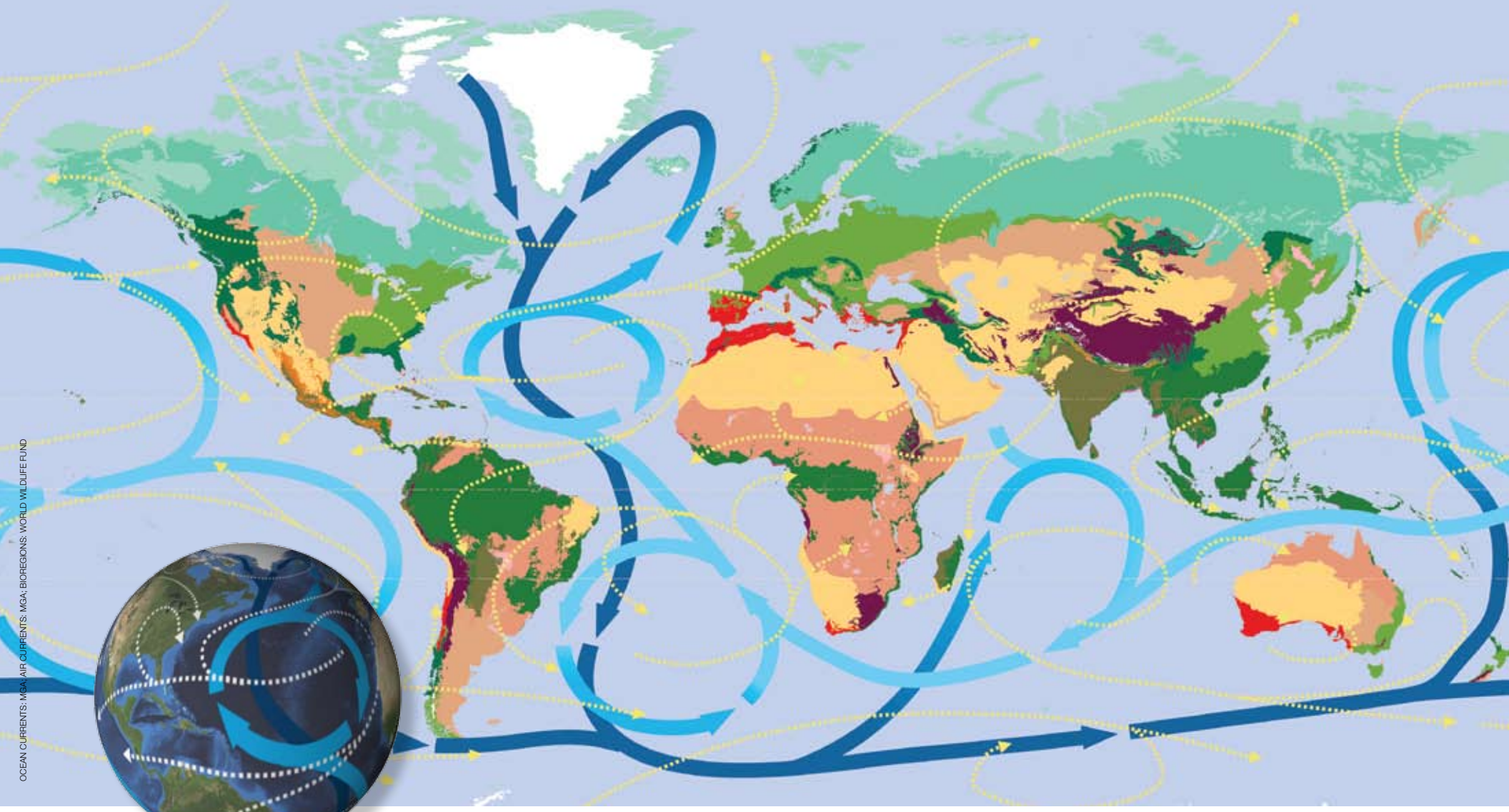
TECHNOLOGY IS NOT ENOUGH. Wind turbines, solar panels, electric cars—these are all good things. But these emerging technologies still do not address the systemic conflict between nature and humanity. The issue of "configuration"—how the pattern of the Human Network relates to the pattern of the Natural System—has not been recognized, much less addressed.

CONFLICT: Noun 2a: competitive or opposing action of incompatibles: antagonistic state of action b: mental struggle resulting from incompatible or opposing needs, drives, wishes, or external or internal demands *Merriam Webster Dictionary 2009*

Very different patterns and processes characterize the Natural System and the Human Network. While distinct, these systems, their patterns and processes deeply affect each other, resulting in new dynamics. We need to understand their configurations and interactions.



TWO SYSTEMS: PATTERNS AND



The diagram above illustrates the Natural System's patterns. Broad blue lines represent major ocean currents. Dotted yellow lines show the path and direction of prevailing winds. The shading of the continents indicate the location of the 15 global "bioregions," assemblages of plants, animals, water, air and topography that function as units.

THE NATURAL SYSTEM

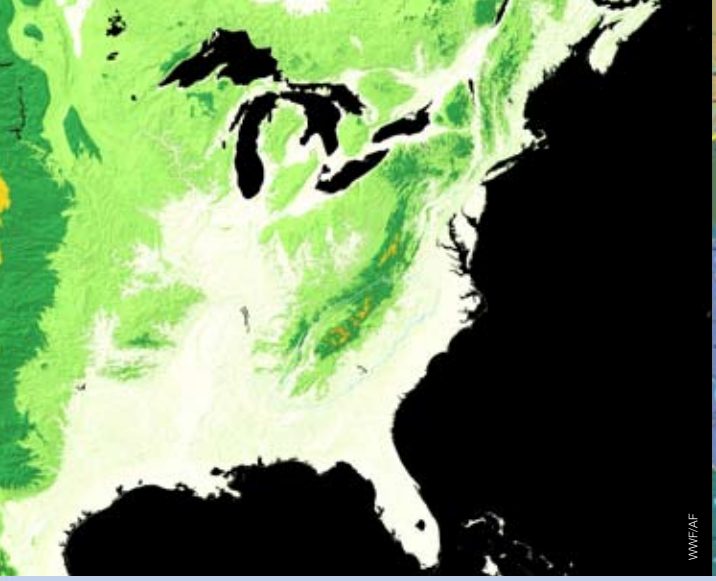
The Natural System is a highly differentiated and diverse fabric that covers the planet. It forms a continuous, global set of interactions. Maps represent the world on a flat surface. The reality, however, is that the world is a sphere. The edges and borders are illusions. Everything is connected.

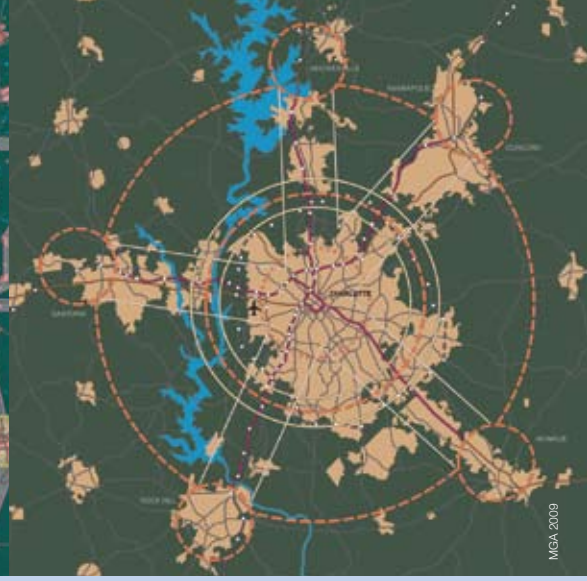
Ecological science, the study of biological systems and the interrelationships between them, remains a young discipline. The term has existed for little more than a century, and ecology has emerged as an active research speciality only in the last few decades. It has only just begun to plumb nature's depths. Still, new science and technology—satellite images, computer mapping, remote sensing—make it possible to illustrate the broad patterns and processes that build the foundation for life.

PATTERNS. Land, water and atmosphere shape nature's macro patterns. As hot air rises at the equator and falls toward the poles, it creates dominant wind currents such as the North American jet stream and the trade winds that move moisture and heat across the planet's surface. The earth's rotation sets the motion of ocean currents, which are further propelled by exchanges of hot and cold water. Topography determines watersheds and moisture levels. All these factors influence the distribution of flora and fauna and create the divisions between the earth's major bioregions.

PROCESSES. The Natural System's processes are less easy to illustrate. Ocean currents transfer heat from one part of the planet to the other and cycle nutrients through the seas. Other processes maintain the environment that makes life possible: Plankton and small plants convert sunlight into energy, forming the foundation of the food chain. Microscopic fungi and bacteria keep soils fertile. Nature cleans our air and water, maintains stable weather cycles, and supplies the resources for what we need and want.

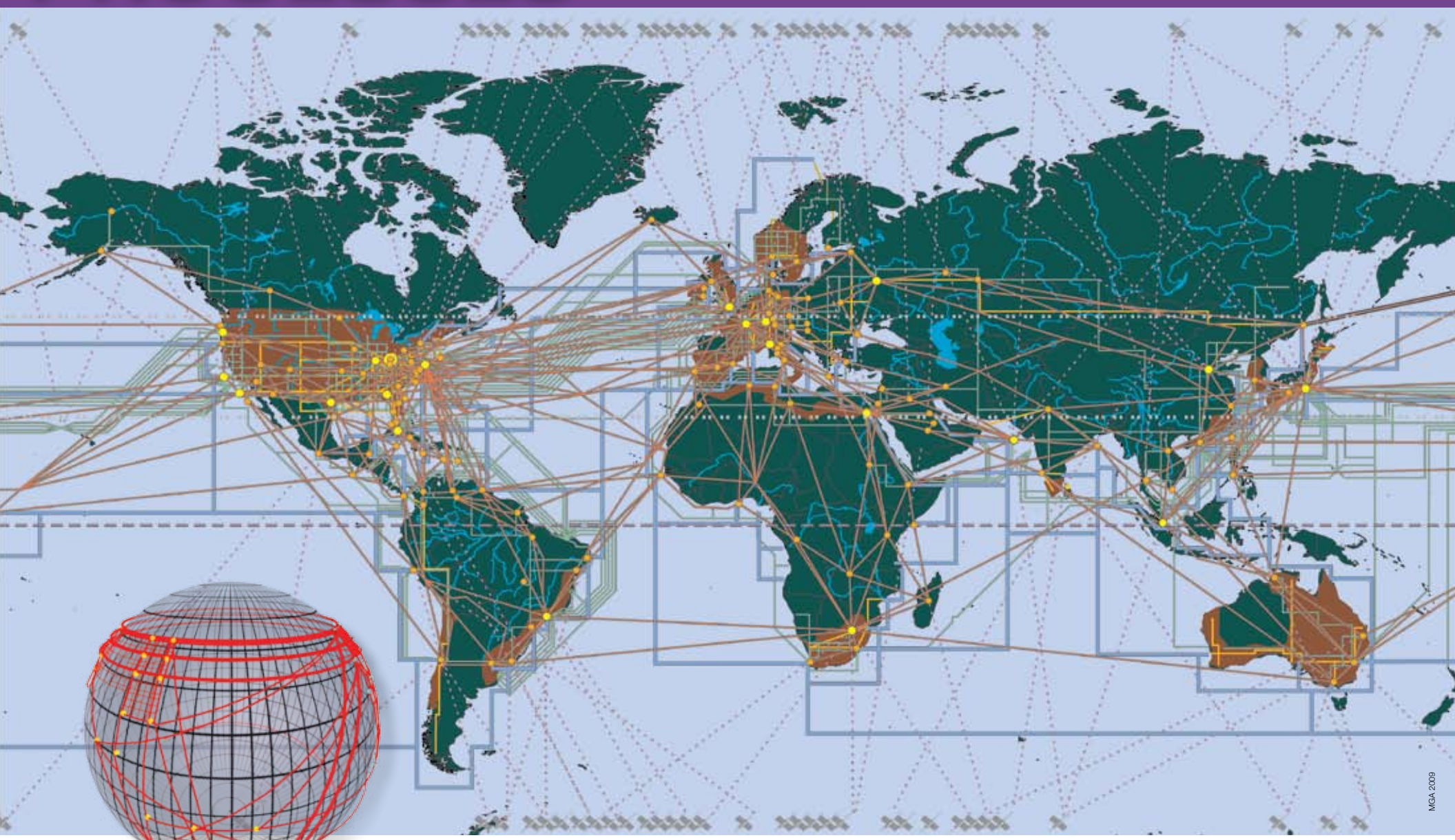
PATTERN: 4. a natural or chance configuration 10: a discernible coherent system based on the intended interrelationship of component parts *Merriam Webster Dictionary 2009*





PROCESSES

MULTIPLE SCALES. Understanding both systems requires that we analyze them at varying scales. LEFT TO RIGHT: Continental scale eco-regions, the Upper Midwest scale drainage system, the Human Network in Illinois at state scale, Charlotte, NC at a metro scale.



Hub Cities — Transportation — Communication

The diagram above outlines the configuration of our Human Network. Orange and yellow dots show the major cities that are the hubs, or points of connection. Broad orange lines indicate air routes; Broad blue lines map sea lanes. Yellow lines represent railways; dotted lines, satellite communications.

THE HUMAN NETWORK

The Human Network is the sum of all human activity, including the corridors for moving people, goods and information around the globe. This network has been developing for millennia, and continues to expand adding capacities and capabilities as it grows.

When we think of human systems, we are used to thinking in political divisions of edges and borders. But as is the case with the Natural System, these boundaries are illusions. Human activity is connected and continuous.

PATTERNS. Settlements and their connections form the pattern of the Human Network. Roads, rails, airports, seaports, communications, and utility grids form the framework for the growth of cities, agricultural regions and other human activities that span the planet. The Human Network pattern that results is composed of dots, lines and surface areas. The dots represent areas of settlements: from a collection of houses to vast metropolitan areas. The lines represent the connections that move people, goods and information between the dots. The surface areas include vast regions being used for farming and for extraction of resources like timber, fossil fuels and metals.

PROCESSES. Like the Natural System, the Human Network relies on complex, global processes: Supply chain networks operate across continents and hemispheres: The materials in a single cell phone may come from more than two dozen countries. Communication networks move voice, data and images around the world, making business and creative collaboration possible across many time zones. Transportation patterns determine the outlines of urban development and industry. Vast utility grids deliver water and energy while disposing of sewage and other waste. Like the Natural System, it is continuous and global.

PROCESS: 2a (1) a natural phenomenon marked by gradual chages that lead toward a particular result <the process of growth> (2) a continuing natural or biological activity or function <such life processes as breathing b: a series of actions or operations conducing to an end; especially: a continuous operation or treatment especially in manufacture *Merriam Webster Dictionary 2009*

Human impacts on the Natural System were once local and regional; today they are global and systemic. As our network evolved, it has created air pollution, transformed landscapes, cleared forests, drained watersheds and eliminated entire species. More than that, it has, with increasing speed and scale, "de•evolved" the Natural System.

EVOLUTION = DE•EVOLUTION

MGA

AN ANCIENT DYNAMIC. As the Human Network has evolved, the Natural System has devolved. Scholars believe that human hunters may have hastened the extinction of the mastodon. Pollution, erosion, and extinction began early as the human populations increased.

INCREASING SCALE. As populations, economies and cities have grown in size and complexity, the impacts on the Natural System have accelerated. These impacts were at first local, then regional. Today, they are global.

NETWORK STAGES. The global history of the Human Network may be divided into seven developmental eras: Pre-global, Silk Road, Age of Sail, Age of Steam, Age of Oil, Age of High Tech and Global Hypergrowth.

EVER LARGER DEMANDS. In no age have humanity's demands on nature decreased. Since the mid 19th century, science-based technology has accelerated both economic growth and resource demands.

TWO SYSTEMS, VAST DIFFERENCES

Consider the stark contrast between the Natural System and the Human Network:

- The Natural System is self-sustaining. The Human Network is not.
- The Natural System regenerates itself. The Human Network cannot regenerate. It must draw resources from the Natural System to grow.
- The Natural System operates efficiently, recycling everything. The Human Network operates inefficiently, wasting resources, energy and space.

THE HUMAN NETWORK EVOLVES. THE NATURAL SYSTEM DEVOLVES.

ALL TOP DIAGRAMS: MGA 2009

PRE-GLOBAL 3,000 TO 326 BCE

Agriculture and sedentary civilizations appear approximately 10,000 BCE. About 3,000 BCE, large states form in Sumeria, Egypt, India and China, each with a network of urban centers connected by roads. By 326 BCE, well-developed states thrive in the Mediterranean, Asia and the Americas, yet they remain separate and independent trade zones.

SILK ROAD 326 BCE TO 1492 CE

Alexander the Great crosses beyond the edge of the world known to Europe and reaches India. By linking the East and West, he creates the first transcontinental trade route, the first stage of the global network. During the next 1,800 years, as empires rise and fall, goods and information continue to flow through this network, laying the foundation for later stages of globalization.

AGE OF SAIL 1492 TO 1865 CE

Columbus discovers America. His voyage shifts the trade network from land to sea, making it truly global. The oceanfront nations of Spain, Portugal, England and Holland develop strong navies. Ultimately England comes to dominate trade through a global network that now links the continents across vast oceans.

KEYSTONE VIEW COMPANY, 1921

In 2200 BCE, booming Middle Eastern cities and states demand larger areas for farms and flocks. Resource needs grow. This leads to severe deforestation around the Caspian Sea and the eastern Mediterranean, resulting in massive soil erosion and an agricultural crisis. People depend on natural forces, wind, water and animals for energy.

FRANCISCO VALVERDE 2006

Rome moves resources along thoroughfares, aquaducts, and canals throughout the Mediterranean. Intensive cultivation exhausts the soils of Sicily, Sardinia, Spain, Gaul, Greece and Africa, leading to catastrophic crop failures by the 5th century CE. Over-irrigation leads to the desertification of the Middle East. Similar problems topple Mexican empires. China's population doubles in the first millennium CE, leading to massive deforestation.

INTERNATIONAL BOOK OF THE FOREST, SIMON & SCHUSTER (NEW YORK: 1981)

Competition for control of the global trading networks requires ships, each of which can require up to as many as 1,000 trees to build. The demand for wood clears European forests. Empires expand consumption, launching large-scale mining, whaling, fishing and logging industries. Plantation agriculture depletes New World soils. Large mammals begin to go extinct worldwide. This is the last era of dependence on natural forces for energy, and of an economy based on handmade, custom goods.

EVOLUTION: noun 1 the process by which different kinds of living organism are believed to have developed, especially by natural selection. 2 gradual development. 3 Chemistry the giving off of a gaseous product or of heat. 4 a pattern of movements or manoeuvres *Oxford Dictionary 2009*

LEFT: Global forest cover 10,000 years ago. RIGHT: Red indicates cleared and damaged areas of original forest cover. Nearly half of this destruction has occurred since 1980.

The Industrial Revolution begins in the late 18th century, as the Watt steam engine lays the foundations for the modern industrial economy. With the development of steel, the global network expands: Cities grow. Rails span continents. Steamships crisscross oceans. Modern finance, operating lines of credit and the stock market appear. Human wealth expands. Science-based technologies accelerate human capacities.

The lighter, more powerful internal-combustion engine makes autos and airplanes possible. Oil replaces other fuels as the dominant energy source. The industrial economy and the modern corporation create wealth at an unprecedented scale. Cities add skyscraper skylines. Radio and television bring global communication into its own. Jet airplanes make mass air travel possible. Competing economic ideologies, communism and capitalism, divide the world.

The computer chip radically transforms information processing and communications, making truly global management possible and creating new layers of the global network. Atomic power, jet engines and communications collapse time and space and the world grows smaller. Industrial techniques expand to agriculture. The "green revolution" improves diets worldwide. However, as communism expands an Iron Curtain divides the global geography and economy.

As Communism collapses, the divided global network reconnects and forms the foundation for the integration of the global economy. A new global economic geography appears based on trading blocs and economic regions, corporations merge to serve the world marketplace. Radical innovations in technology initiate an era of continuous, sweeping change. Former communist countries and undeveloped countries develop wealth. Billions join a rapidly growing global middle class.

AGE OF STEAM
1820 TO 1918 CE

KINSEY PHOTOGRAPHER, BLACK DOG & LEVENTHAL (NEW YORK: 1978)

Steam engines require increasing amounts of wood and coal. Coal burning produces devastating air pollution in major cities. On some days, visibility in London shrinks to 6 inches. Wastes foul entire aquatic environments in urban areas like Pittsburgh, and Germany's Ruhr valley. Rail lines reach into once remote regions. Extinction rates increase. Passenger pigeons, Eastern elk disappear. Steam-powered machinery reshapes landscapes.

AGE OF OIL
1900 TO 1960 CE

WALTER SIEGMUND 2008

The internal combustion engine replaces the steam engine. Oil becomes the major fuel. Petrochemicals become dominant, used in plastics, dyes, detergents, fertilizers and many other products that alter ecosystems and increasingly affect human health. Cars, trucks and airplanes make multi-city, low-density metropolitan areas possible. Energy needs soar. Roads slice regions into increasingly dysfunctional fragments. The expanded urban economic network creates air, water and soil pollution on a regional scale.

AGE OF HIGH TECH
1960 TO 1990 CE

DEREK JENSEN 2005

The air conditioner, interstate highways and the commercial jet accelerate urbanization in inhospitable environments but require more energy. Industrialized agriculture creates pollution across vast non-urban landscapes while depleting water supplies and soil fertility. Growing GDP and personal wealth, increased demand for a broader range of products, depletes resources and increases pollution. Richer countries make strides in environmental controls. Polluting industries shift to poorer nations with fewer regulations.

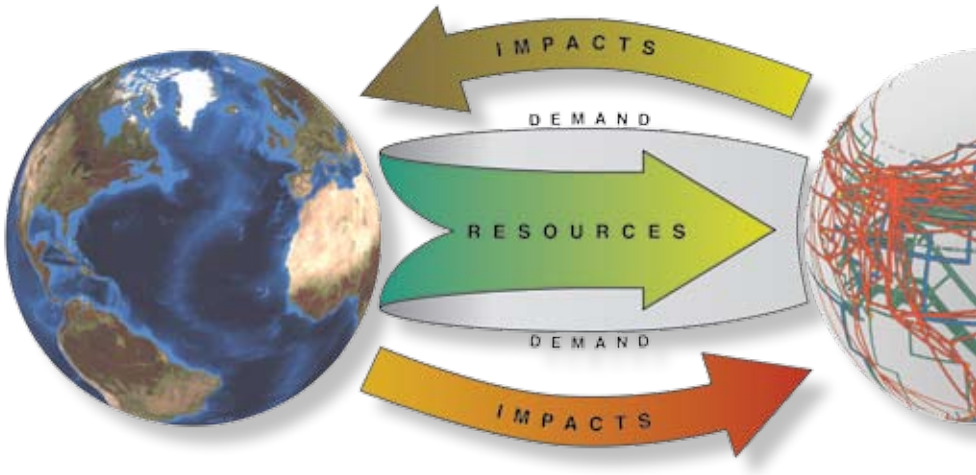
GLOBAL HYPERGROWTH
1990 TO 2009 CE

MICHAEL GALLIS

Integration of the global network and world marketplace initiates two decades of soaring global economic growth. Impacts expand beyond regions, becoming global. Rising standards of living accelerate the demand for food, water, resources and energy, leading to massive resource extraction, pollution, and climate change. Roads fragment habitats from Siberia to Brazil to Congo. The poorest nations struggle to assure basic health and sanitation, leading to cycles of deforestation and soil depletion.

DEVOLUTION: noun the devolving of power by central government to local or regional administration *Oxford Dictionary 2009*

As a global system, how does Human Network growth now impact nature? For the first time, A USDA Forest Service study looked beyond pieces to the systemic patterns that drive Natural System change.



SYSTEMIC IMPACTS HASTEN DE

MEASURING SYSTEM-TO-SYSTEM IMPACTS

No one has ever systemically analyzed both the Human Network and the Natural System. A year-long study mapped the configuration and dynamics of both systems as they operate across the southeastern US. Completed in 2008, the study for the USDA Forest Service advanced understanding of how the two systems intersect and interact.

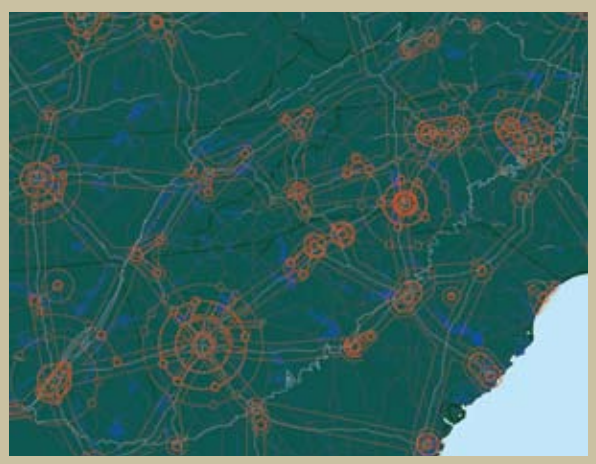
Many scientific studies have tried to describe regional ecosystems, and to measure environmental change. Many industry analysts and economic development groups have tried to describe regional patterns of commerce and urban development. Yet this study marked the first attempt to determine the macro scale relationship between the two systems. The study encompassed a region that has experienced profound economic and environmental transformation in recent decades: Atlanta, for instance, has grown from a small city of 200,000 just after World War II to a metropolitan region of 4.5 million today.

SUPER-REGIONAL SCALE. The extent of the southern forest determined the project area, extending across seven southeastern states from northeastern Alabama, to southern Virginia. This region encompasses some of the most biodiverse ecosystems in the world. It also includes some of the fastest growing economic centers in North America: Atlanta, GA; Charlotte, NC; and Chattanooga, TN.

A national environmental non-profit, a leading urban consulting firm and a major university formed the study team (see credits, back cover). At both micro and macro scales, they gathered data, statistics, and graphic images for both the Human Network and the Natural System. Based on this data, and using proprietary methods, the team generated a series of maps and diagrams to illustrate the patterns and processes of each system and how they interact across the seven-state region.

DEVASTATING RESULTS. Throughout the study area, the research shows that the Human Network has grown far larger than expected. Human impacts on the Natural System have also grown far greater than expected, both individually and collectively. For the first time in any environmental study, the team grouped human impacts on the environment into five basic categories. These five categories differ from categories developed by other stud-

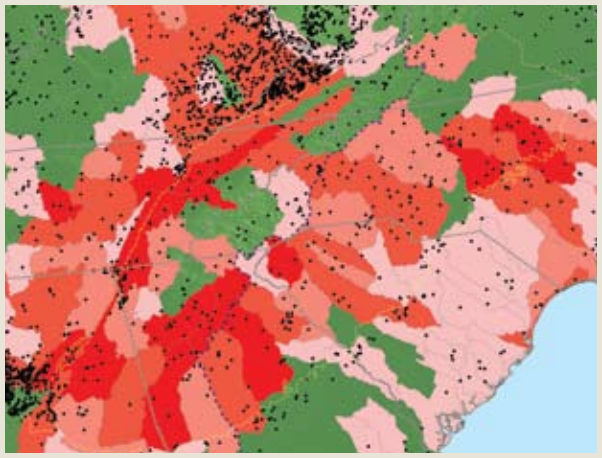
URBAN NETWORK



Until the mid-20th century, the Southeast's heat, humidity and inaccessibility kept rapid urbanization at bay. The air conditioner and the interstate highway removed those barriers and created the "Sun Belt." Populations quickly exploded across the Southeast. Massive metropolitan areas emerged, as did a network of highways and utilities to connect them. Unlike urban areas in the North, which developed dense cores in an age before automobiles, the Southeast's cities sprawled in the post-1960 auto culture. Places like Atlanta and Raleigh-Durham gave rise to low-density residential areas, suburban shopping malls and "edge cities" that competed with older centers. The diagram above illustrates the Southeast's macro-scale pattern of metropolitan areas and the corridors, as of 2006.

FIVE IMPACTS THAT LEAD TO DE·EVOLUTION

AF/MGA 2008



AF 2008

1 FRAGMENTATION. Fragmentation is the breaking up of natural corridors, ecosystems and watersheds by the construction of human systems. Fragmentation includes: subdivision of large land parcels, transportation infrastructure like roads, rail and trails and ecosystem alterations like dams. ■ As people build cities and businesses, they require more roads and more trade routes to access more resources. They build dams and aqueducts. These thoroughfares cut ecosystems into dysfunctional parts. ■ From the air, the Piedmont Crescent looks uniformly forested. Yet the map above, showing the region's road and utility systems in yellow, shows the Natural System sliced into tiny bits. ■ Fragmentation creates discontinuity in Natural System patterns and processes, making regeneration more difficult.

2 DEPLETION. Depletion means the Human Network withdrawal of Natural System resources. Depletion includes: renewable resources (forests, water) and non-renewable resources (minerals, pristine streams, wildlife habitat). ■ The growth of human societies requires more of everything: more arable land for farms, more water, more wood, more energy. ■ Great areas of the Piedmont Crescent have lost their forest cover, increasing erosion and flooding. Urban area demands have strained water supplies and altered watersheds. Even in rural areas, mines have taken a huge toll. The composite depletion map above shows mines as black dots. The darkest red areas suffer the greatest depletion. ■ Depletion leaves the Natural System with fewer resources to maintain regeneration cycles and other processes.

IMPACT: noun /impakt/ 1 the action of one object coming forcibly into contact with another. 2 a marked effect or influence; verb /impakt/ 1 come into forcible contact with another object. 2 (often impact on) have a strong effect. 3 press firmly
Oxford Dictionary 2009

·EVOLUTION

ABOVE: Detail of the network diagram showing the Charlotte, NC region, from the Piedmont Crescent Study. It illustrates the pattern and density of road traffic in red and orange lines. Railroads in yellow lines ; power lines in dotted yellow lines. ABOVE LEFT: The sphere at left represents the Natural System; the one at right, the Human Network. Human Network demand for resources from the Natural System creates impacts that lead to de•evolution. Increasingly, these changes in Natural System patterns affect the Human Network.

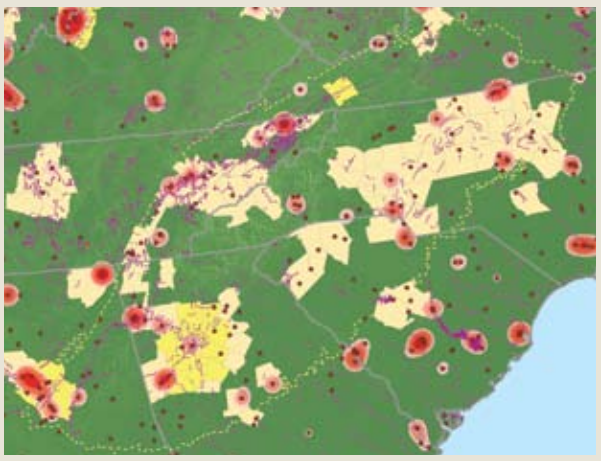
ies in that they were not derived from an examination of either system in isolation, but rather of both systems and their interactions: an analysis of the relationship between the patterns and parts, the connections and dynamics between the Human Network and the Natural System.

The study makes clear that throughout the region, Human Network expansion is overwhelming the Natural System. The expanding network of road, rail, and utility systems has become an expanding web that covers the entire region, growing denser in major cities and reaching far into natural areas. All the major streams in the region have been substantially altered. The majority of the minor waterways have been altered as well. Large areas fail to meet federal air and water quality standards. In some areas, 99 percent of native species have disappeared. Across the region, the demand for land, for resources and for water has increased, further altering the patterns and processes of the Natural System.

The study further concludes that Human Network impacts on nature are accelerating, not decreasing, throughout the region. The team did not find one trend line that moved towards a lessened impact on nature.

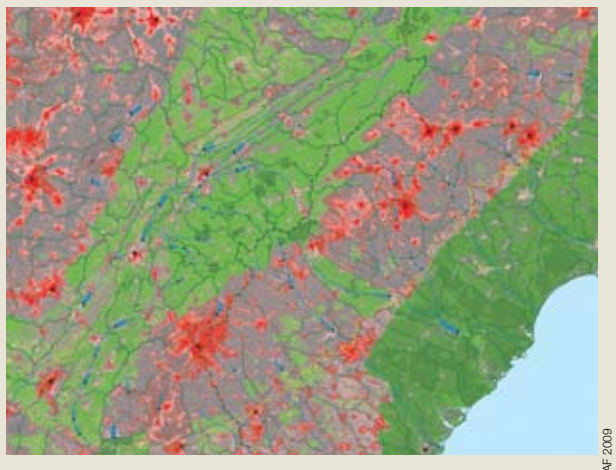
SYSTEMIC, GLOBAL IMPACTS. What is happening in the 7-state region of the Piedmont Crescent is also happening everywhere else. Around the world, the Natural System is being profoundly impacted by human activity. The Five Impacts identified in the Piedmont Crescent project form a system of impacts that are changing the patterns and processes of the Human Network and Natural System, as well as the relationships and interactions between them. These impacts are not limited by geography or boundaries but operate at all scales, from regional to continental to global. They do not respect national boundaries or political systems.

As of 1995, only 17 percent of the globe remained free from direct human influence. As the Human Network impacts the Natural System, it gives rise to unnatural, unpredictable patterns of climate, ocean chemistry, soil fertility and water cycles. These emerging patterns not only threaten nature, but jeopardize human economies, societies and political structures.



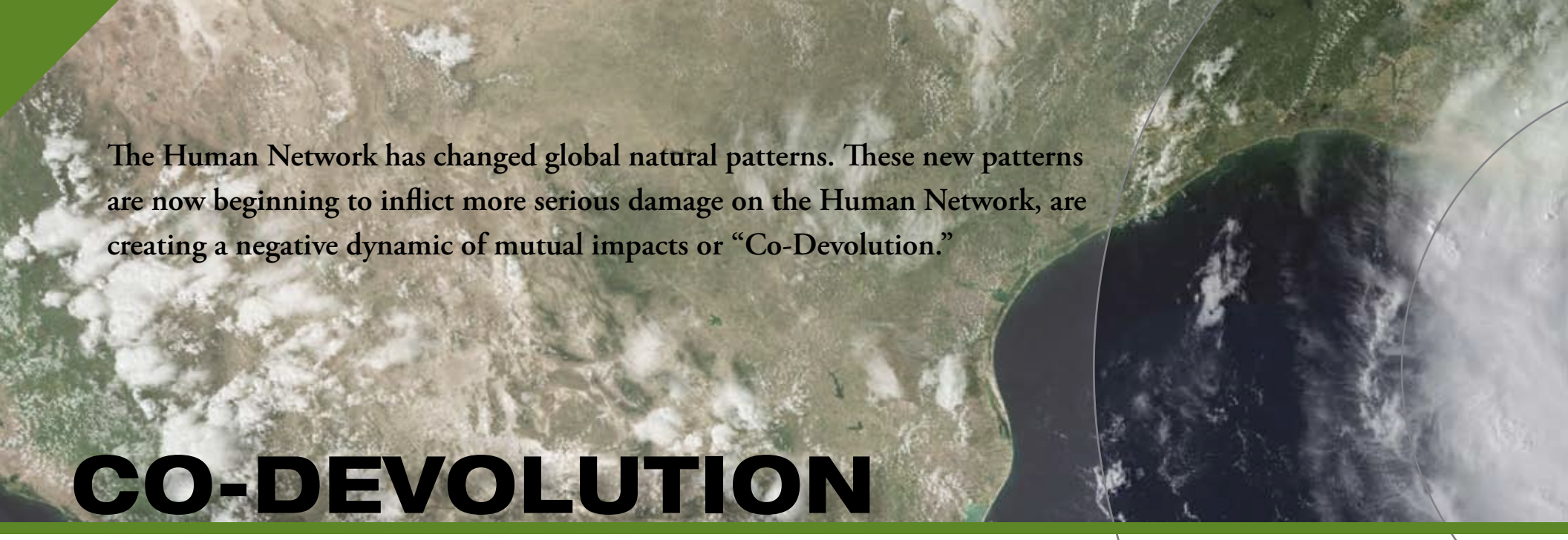
3 POLLUTION. Pollution means the introduction of non-natural waste products into the Natural System. Types of pollution include: air, water, land and invasive species. ■ As farms, industries and cities grow, they create waste, or pollution, that can damage both natural systems and human economies. ■ Pollutants suffuse the Piedmont Crescent region. The map above shows toxic land releases as red dots, and the releases' concentration is graded from pink (lower) to dark red (high). Polluted waterways are shown in purple. Areas that did not meet federal air quality standards as of 2000 are yellow. "Non-attainment" areas added in 2007 are light beige. ■ Pollution changes the chemical composition of air, water, land, flora and fauna. It alters the balance of Natural System components, resulting in more powerful storms, broken food chains, and other erratic patterns.

4 EROSION. Erosion is the displacement of natural areas by the growth of the Human Network including: urban expansion, resource extraction, agricultural development, and industrial forestry. ■ As metropolitan, agricultural and mining areas grow, they consume space and displace the Natural System, eroding its resilience or completely changing it. ■ In the Piedmont Crescent, agriculture and mining have displaced natural systems across vast areas, and are shown in the map above as yellow. Urbanism, at low or very-low densities, has eroded ecosystems' function. Urban areas in the map above are shown as red. ■ Erosion reduces the amount of land where the Natural System functions normally. It creates an unnatural world.



5 EXTINCTION. Extinction means the disappearance of species and the networks they support and depend on within the Natural System. Extinction includes animals, plants, and even entire ecosystems. ■ Because of post-WWII urban growth, only small pieces of the original ecosystem remain in the project area. ■ In the map above, red areas are cities and suburbs that have been totally cleared. In the light gray swaths in the Piedmont, nearly 99 percent of native species and ecosystems have disappeared. In the greener areas along the coast, 60 percent of native species have vanished. ■ Extinction creates massive species imbalances in the food chain and cycle of life. As natural predators disappear and keystone species are eliminated, the system becomes increasingly dysfunctional.

SYSTEMIC: adjective 1 relating to a system as a whole. 2 Physiology referring to the non-pulmonary part of the circulatory system. 3 (of an insecticide, fungicide, etc.) entering the plant via the roots or shoots and passing through the tissues. *Oxford Dictionary 2009*



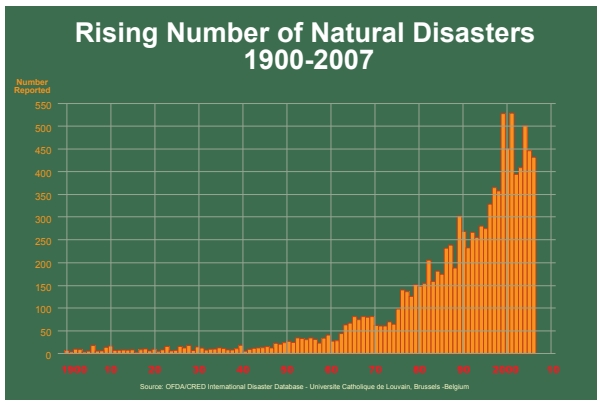
The Human Network has changed global natural patterns. These new patterns are now beginning to inflict more serious damage on the Human Network, are creating a negative dynamic of mutual impacts or "Co-Devolution."

CO-DEVOLUTION

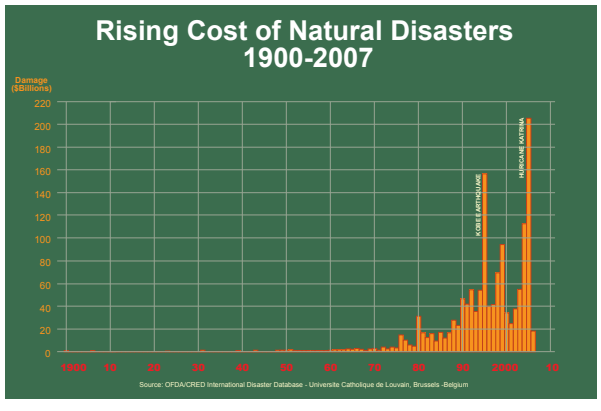
GLOBAL SCALE

Over the last three or four decades, the Human Network has grown so quickly and has become so vast that we have not fully grasped its effects on human society, nor have we grasped how these impacts that are causing the Natural System to de-evolve. Historically, Human Network effects on the Natural System were limited in scope and scale. Likewise, Natural System reactions remained local or regional. A natural disaster might precipitate the collapse of a regional human society like the Central American Maya or the tribes of Easter Island yet these imbalances did not pose continental or global threats. But today, the Human Network impacts on nature are global. As it de-evolves, the Natural System is beginning to impact the Human Network globally. These impacts drive and reinforce one another, threatening to become a self-reinforcing dynamic of mutual deterioration: Co-Devolution.

BOTH CHARTS: OFDA/CRED INTERNATIONAL DISASTER DATABASE, UNIVERSITE CATHOLIQUE DE LOUVAIN, BRUSSELS, BELGIUM 2008



Since 1900, the annual number of natural disasters has increased by more than 40-fold: from less than 10 in each year of the 20th century's first decade to between 400 and 500 in each year of the last decade.



The scale, and thus the cost, of natural disasters has also increased: from far less than a billion dollars in 1900 to more than 200 billion in 2005, the year that Hurricane Katrina hit New Orleans.

DOWNWARD SPIRAL. Regionally, continentally and globally, all trend lines point to declining function in both the Natural System and the Human Network:

- From New York to Florida, Holland to Bangladesh, rising seawaters threaten coastal regions and cities.
- Florida, for decades the nation's fastest growing state, is losing population and New Orleans has shrunk by 20 percent as hurricanes become more powerful and frequent. In 1996, 1997 and 1998, the United States weathers more than twice the number of hurricanes experienced annually during the 20th century.
- The 2008 closing of the Pacific Northwest salmon fishery devastated fishing towns up and down that coast. Many commercial fisheries are on the verge of collapse, threatening both the food supply and coastal economies.
- From Australia to Las Vegas to Spain, droughts limit urban development and agriculture and now water shortages affect every continent. Once wet, Atlanta ran dry in the summer of 2008.
- The functioning of major ports like New Orleans and Miami is being disrupted as altered ocean chemistries and climate change increase both storm intensities and insurance losses.
- In 2008 and 2009, floods cripple Midwestern agriculture and cities along the upper Mississippi. Industrial agriculture and urban development lower water tables and increase flood intensity.
- Hundreds of thousands must evacuate parts of the American West and Australia in 2007, 2008, and 2009. Trees lose moisture, urban development sprawls. These factors, added to water shortages and erratic weather, spark disastrous wildfires.

LACK OF RESILIENCE. We never anticipated that our effect on the Natural System could reach a level where nature impacts us. If we are going to reverse this downward cycle of mutual impact, we need to build resilience into our activities. We need to nurture resilience in nature.

The diagram illustrates the relationship between the patterns of the Human Network and the Natural System. It illustrates the complexity of their relationship, and makes clear that these two systems interact globally, continuously and systemically. Surprisingly, we have never attempted to manage their interactions as systems, not at any scale. We have neither planned nor implemented strategies to better manage the relationship and interactions between the two systems.

FRAMEWORK: noun a supporting or underlying structure *Oxford Dictionary 2009*

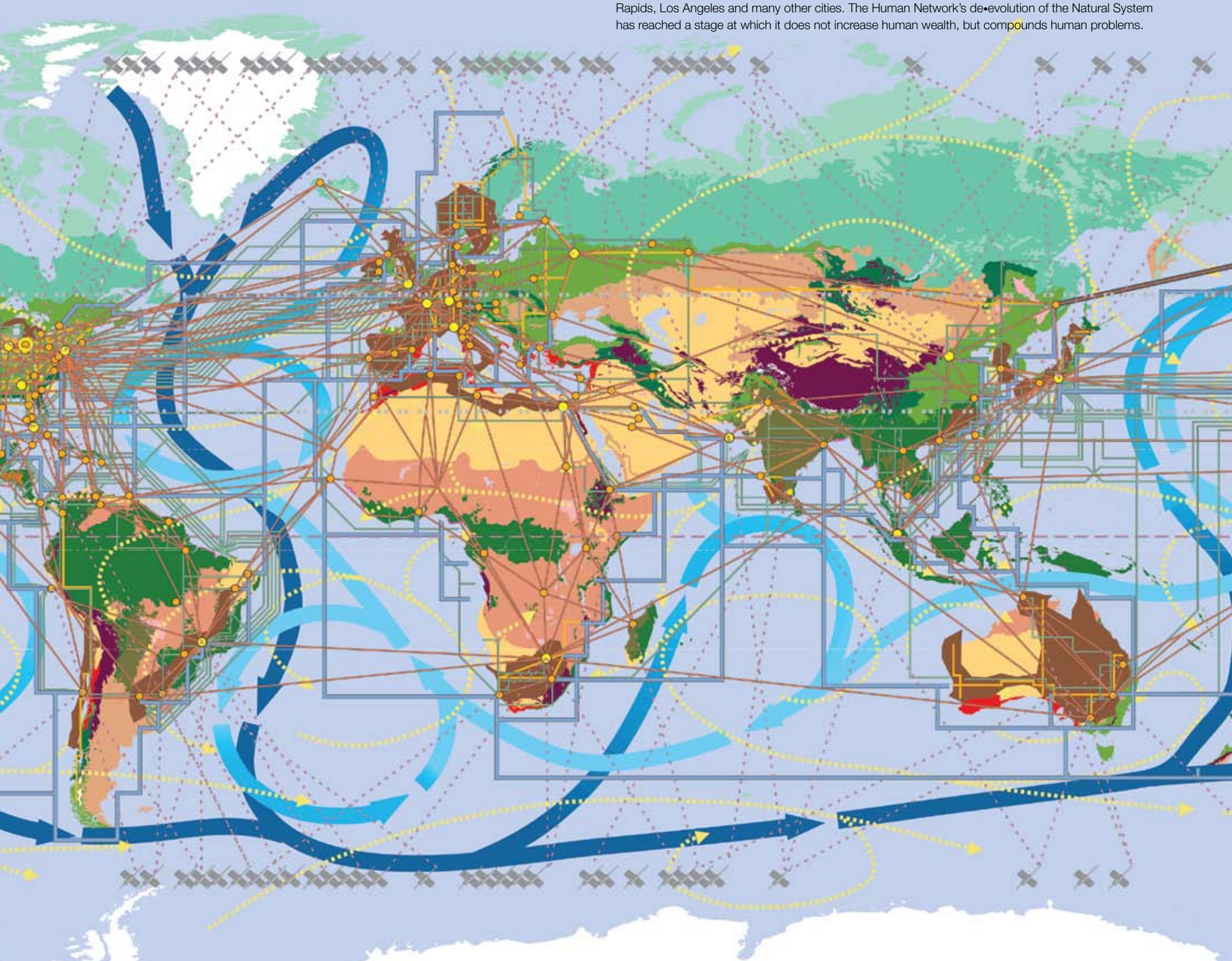
"For every action there is an equal and opposite reaction."

—Isaac Newton's Third Law of Motion

ST. BERNARD PARISH BY CHRIS JORDAN

HURRICANE KATRINA SATELLITE IMAGE: NOAA

We have already seen the effects of de•evolution on metropolitan areas such as New Orleans, Cedar Rapids, Los Angeles and many other cities. The Human Network's de•evolution of the Natural System has reached a stage at which it does not increase human wealth, but compounds human problems.



The growth of one system cannot continue to come at the other's expense. We need a new model to guide the way we build the future so that the Human Network and the Natural System can develop and evolve together, in a pattern of "Co-Evolution."

CO-EVOLUTION

RESOLVING SYSTEMIC CONFLICT

Where do we go from here? How will we cope if the world's population doubles, and the global economy four to seven times larger by 2050, as the World Bank predicts? Unless we make profound changes, the downward spiral of "Co-Devolution" will accelerate. To avoid this disaster, we need a new framework to guide growth.

The Human Network operates as a system, but it was built in pieces and parts. And the Natural System has been cut up into pieces and parts by human activities. We need an 180-degree shift: Creating the sustainable economy of the 21st century will require that we systematically weave together the Human Network and Natural System into a pattern of mutual reinforcement: Co-Evolution.

WE HAVE A: LOW EFFICIENCY/HIGH IMPACT NETWORK. The institutions and processes that created Human Network have roots in a world in which capital was scarce and resources plentiful. Financing has long been the major concern of those who build the Human Network. Environmental impacts have not been a significant concern. Ecological sciences were in their infancy as cities and economies rapidly grew during the 20th century. We had no way to accurately measure our increasing impact on nature, nor did we fully understand the importance of doing so.

Thus, we unintentionally created a "low-efficiency-high impact" Human Network. But since economic activity stayed low in both the communist bloc and the developing world, it created the illusion that resources remained plentiful, and that our impacts were manageable.

After 1990, formerly communist nations began to rejoin the global economy and huge developing nations like China, India and Brazil began to boom. The global economy grew at an unprecedented rate. At the same time, our impact on nature began producing unexpected results. We appear to be reaching a tipping point.

WE NEED: HIGH EFFICIENCY/LOW IMPACT NETWORK. We need to create a new framework that can regenerate our existing cities and build highly-efficient new cities and industries. We need to determine patterns that can adequately sustain our economies and cultures with less energy and fewer resources.

This means designing and managing our Human Network in a systemic way. We need to redefine the configuration of our cities. We need to apply new technologies and base our decisions upon system performance, rather than component performance.

A NEW FRAMEWORK FOR ACTION. Co-Evolution provides a way to "re-frame" what we're seeing in today's world. It's a framework and a strategy for addressing both systems simultaneously, redefining their relationship. This means:

1. Managing the Human Network to create "high-efficiency" human patterns and processes by using new technologies and reshaping the pattern's configuration.

2. Rebuilding and restoring the Natural System so that it stabilizes, and becomes more resilient.

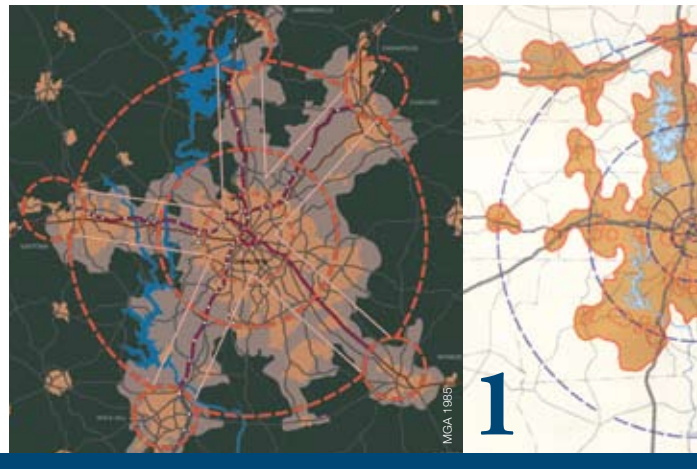
3. Systematic understanding and management of the patterns and processes of the two systems, so that we can manage their relationship.

Within the new framework, nature can function better and, in turn, reinforce the function of the Human Network. Ideally, the two systems will begin to strengthen each other. That would be Co-Evolution.

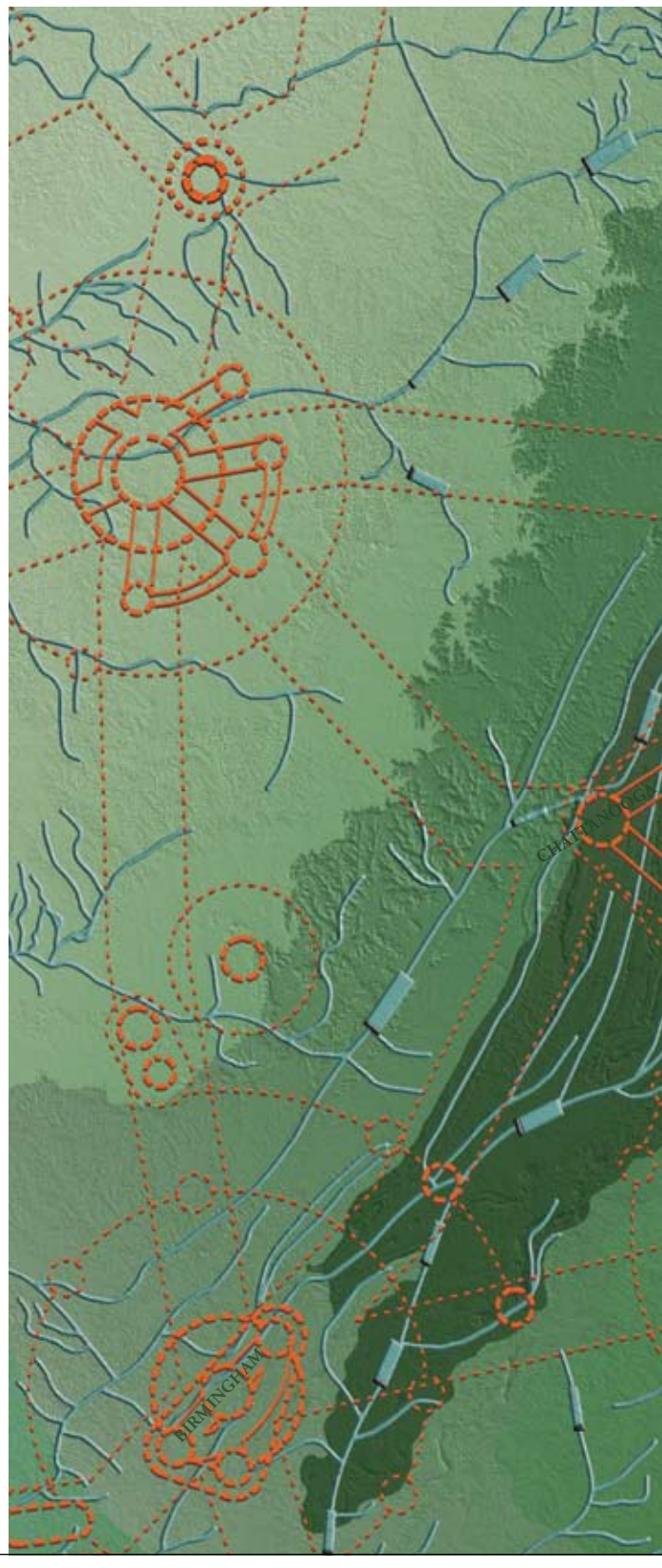
DIAGRAMMING THE SYSTEMS. We need new tools to plan, implement and develop Co-Evolution strategies. The diagram at right is one of those tools. Employing visual language based on abstracting data sets and satellite images, it shows how the planet's two systems can be represented in a single image.

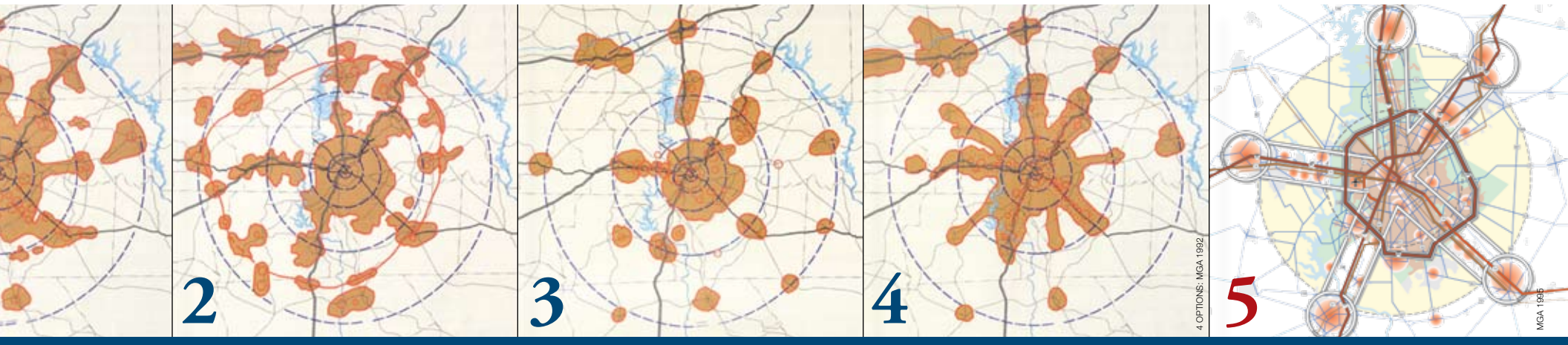
Mapping both systems reveals where hubs of the Natural System and hubs of the Human Network converge. It clarifies where the two systems mesh and where the two clash. For example, when a major transit corridor intersects with a major natural corridor, as it does in the Piedmont around Charlotte, extraordinary planning and engineering should seek to maintain the function of both corridors.

CHARLOTTE, NORTH CAROLINA: DEVELOPING A MORE EFFCIENT REGIONAL NETWOR



Charlotte 1985: Understanding patterns. The City of Rock Hill commissioned a study to understand its role in the form and structure of a metro region that includes two states, seven counties, and 33 cities. Ultimately the study revealed a single dominant center with five radial corridors linked to three concentric rings of smaller regional cities and commercial development clusters.





Charlotte 1992: Regional growth options. Charlotte leaders investigated a variety of growth strategies for the future. The alternatives were:

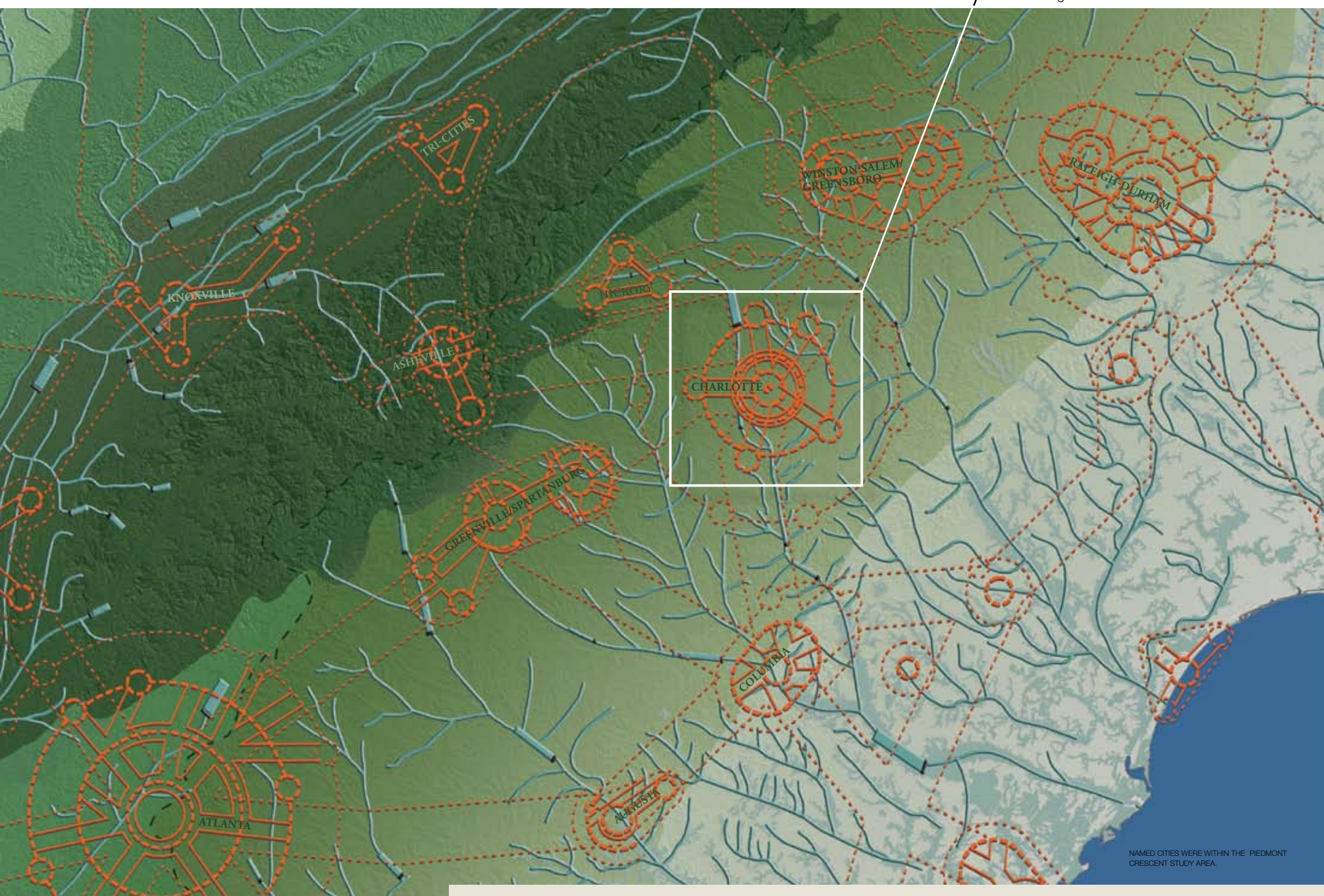
1. "Unplanned," existing growth trends would produce a shapeless blob sprawling across the region.

2. "Dispersed Growth," based on a proposal for an outer-outer belt, shown in red, propelling growth over an additional 3,600 square miles.

3. "Corridors," sought to concentrate future growth and development in the interstate and major arterial corridors.

4. "Centers," encouraged more concentrated future growth development in existing urban centers.

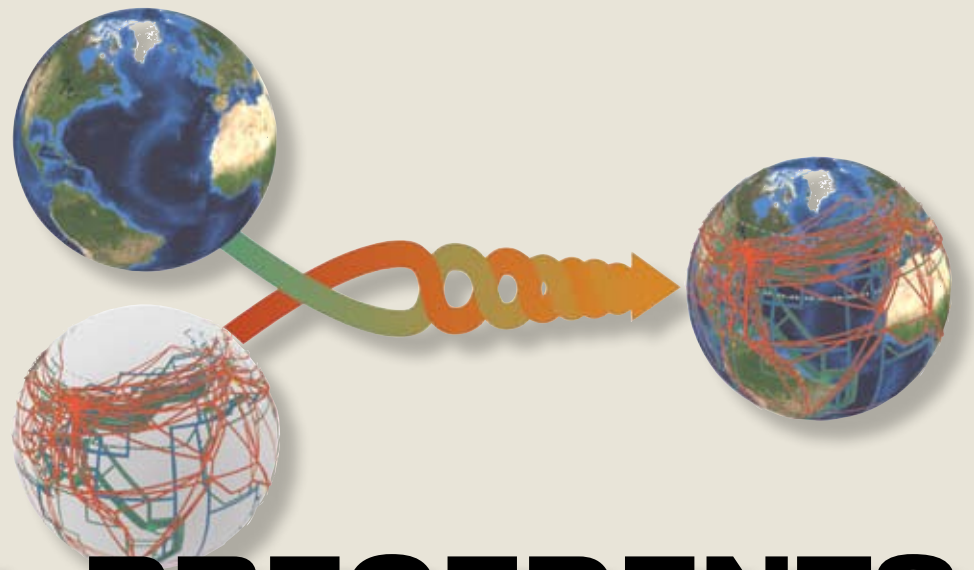
Charlotte 1995: Centers and Corridors
The selected choice, the fifth option, "Centers and Corridors" formed the framework for a more efficient and condensed regional network and ultimately led to light rail development along each corridor.



HUMAN NETWORK. Red circles, sized according to population and economic activity, denote urban centers of activity. Parallel lines, based on transportation and economic data, show the different types of "corridors" that connect urban centers. Together, these metropolitan patterns form the Human Network.

NATURAL SYSTEM. The Natural System has centers—spawning beds, headwaters and wetlands—as well as corridors—rivers and streams—shown in the diagram above. Yet nature is different from the Human Network as it is a continuous fabric—land masses, atmosphere, and oceans- filled with flora and fauna. The different shades of green represent the area's topography and ecoregions.

Co-Evolution is not beyond our reach. We have created and implemented large-scale metropolitan strategies throughout our history. These precedents can be used as a foundation for implementing Co-Evolution at local, regional, continental and global scales.



CO-EVOLUTION: PRECEDENTS

WE CAN ACT EFFECTIVELY AT LARGE SCALES

For most of human history, people have viewed the building of cities and transportation networks as the work of bringing order out of nature's chaos: taming the forest, winning the frontier, farming the prairie, bridging the river.

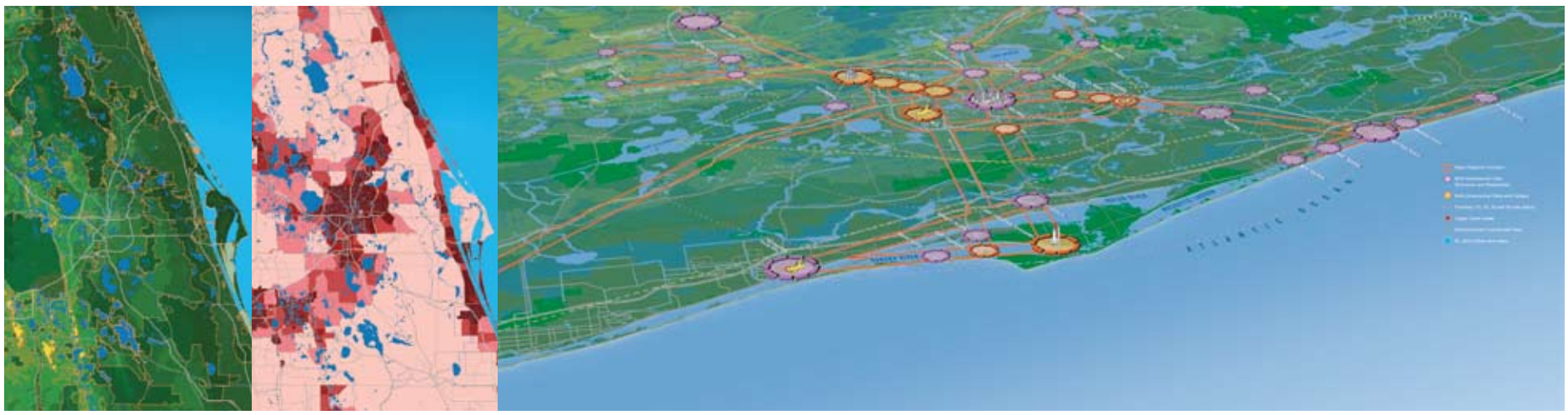
In the last several decades, we have developed a growing appreciation of nature's ordered intricacies—the water cycles, the processes of carbon sequestration and soil formation. We are realizing that nature, rather than being senseless and chaotic, is a highly ordered system that we have only begun to understand. Yet we have built our cities and industries so that they devolve the Natural System, producing the very chaos we have always sought to avoid.

Our metropolitan regions did not spring, fully formed, into being. They grew from centuries of precedents, as the timeline below shows. "Planning" has always been a hard sell in America, where property rights were one of the founders' innovations. As a result, economic forces, rather than planning or regulation, formed most American cities.

Yet, in some cases, large-scale planning produced very successful results. In 1909, Chicago began to implement the first major plan for an American city since Washington, DC had been laid out more than a century earlier. Twenty years later, in 1929, New York City took planning one step further, developing a regional plan that integrated auto and air traffic. Neither regional plan incorporated the environment, but conceived of nature as "parks," "reservoirs" and other open areas for human use.

In the late 1950s and early 1960s, the Interstate Highway Act and "urban renewal" programs created massive tears in the urban fabric. Backlash against large-scale planning erupted, as activists fought big projects.

Thus large-scale planning fell into disfavor just as American cities began explosive growth between 1960 and 1990. As a result, we built sprawling, multi-city networks of industries, transportation systems and residential areas without



MGA 2003

LEFT: This diagram reveals the very complex pattern of Central Florida's Natural System. RIGHT: Darker red areas show denser population areas, revealing the population pattern of Central Florida's Human Network.

The map above utilizes "visual language" for describing both the patterns of the human and natural systems. Circles represent urban centers, parallel lines represent economic and transit corridors that form the Human Network. Tropical and northern ecologies overlap in the Natural system seen under the Human Network. It is the nation's most biodiverse region; an amazingly complex pattern of rivers, estuaries, swamps and sinkholes.

BUILDING THE HUMAN NETWORK

UNIV. OF GA

Savannah, GA, Plan - Unlike other early colonial cities, Savannah is planned, a rectangular grid formed by "city wards."

THACKARA & VALLANCE SC.

Washington, DC, Plan - Pierre-Charles L'Enfant - Modeled after Paris, a rectangular grid with radiating avenues, parks, squares and open spaces.

Riverside, IL - America's first planned suburb, Riverside, IL (by Frederick Law Olmsted).

STARKS W. LEWIS, BROOKLYN MUSEUM ARCHIVES

"The White City" - World Columbian Exposition and Fair - Millions throng a completely planned area on the waterfront. Sets off the "City Beautiful" movement.

BURNHAM & BENNETT

Plan of Chicago - The nation's first regional plan, before cars and planes changed urban patterns, utilizes "City Beautiful" concepts to address the reality of urban problems and demonstrates that large-scale plans can work.

New York World's Fair - General Motors pavilion, "Futurama," features a gigantic model of the automobile city, circa 1960.

GENERAL MOTORS CORP. © 1940

NY Regional Plan (see above) - Transforms the region's islands and peninsulas into a continuous system. By World War II's end, New York alone enjoys surplus infrastructure capacity. Lays foundation for its rise in the postwar period.

1725 1733 1791 1800 1850 1869 1893 1900 1909 1920 1929 1930 1940

PRECEDENT: noun /pressid'nt/ 1 an earlier event or action serving as an example or guide. 2 Law a previous case or legal decision that may or must be followed in subsequent similar cases. *Oxford Dictionary 2009*

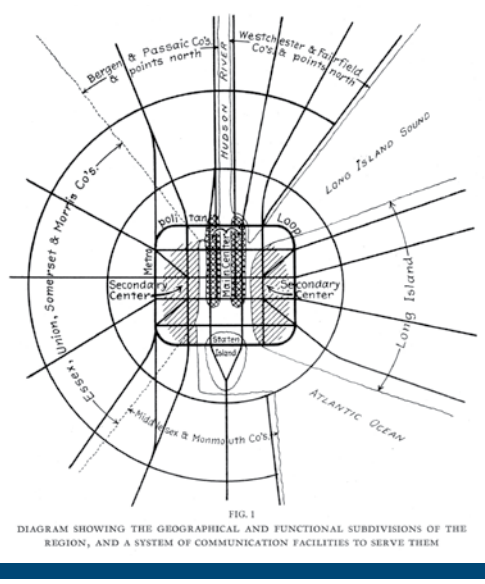
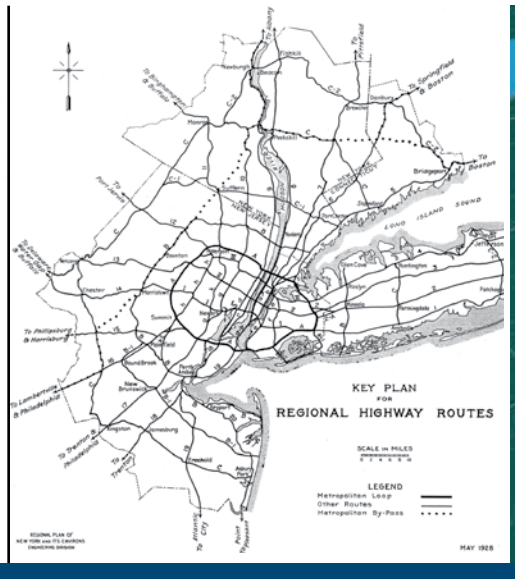
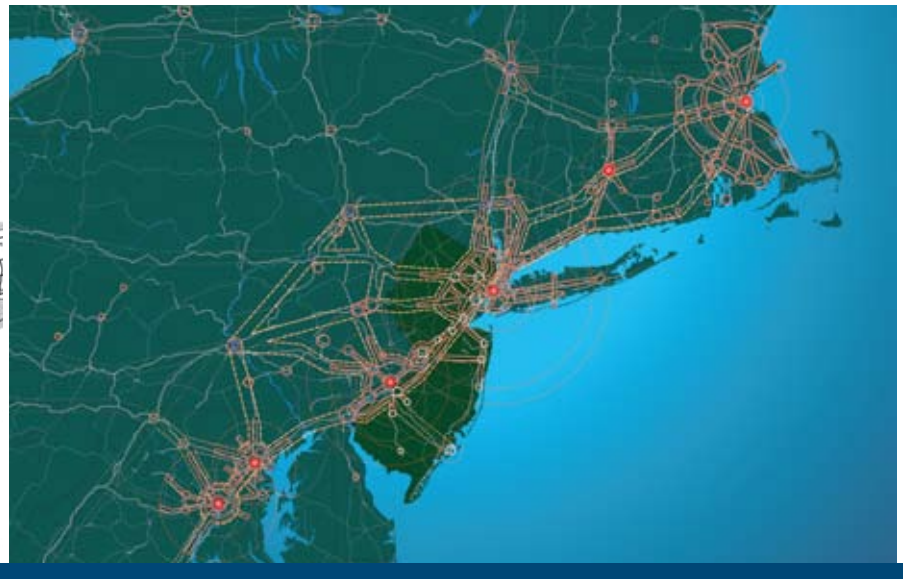


FIG. 1
DIAGRAM SHOWING THE GEOGRAPHICAL AND FUNCTIONAL SUBDIVISIONS OF THE REGION, AND A SYSTEM OF COMMUNICATION FACILITIES TO SERVE THEM





In 1929, on the eve of the Depression, the "Regional Plan for New York and its Environs" was published. The abstract diagram, above left, illustrates the proposed pattern of connections necessary to stimulate the economy and to facilitate the interactions necessary for the region's future. The diagram becomes the actual pattern of transportation routes, above center, that were built across the landscape. Today, New York is no longer a single metro complex, but one of several large metro areas within a vast 11-state, 52-million-person urban lattice, above right.

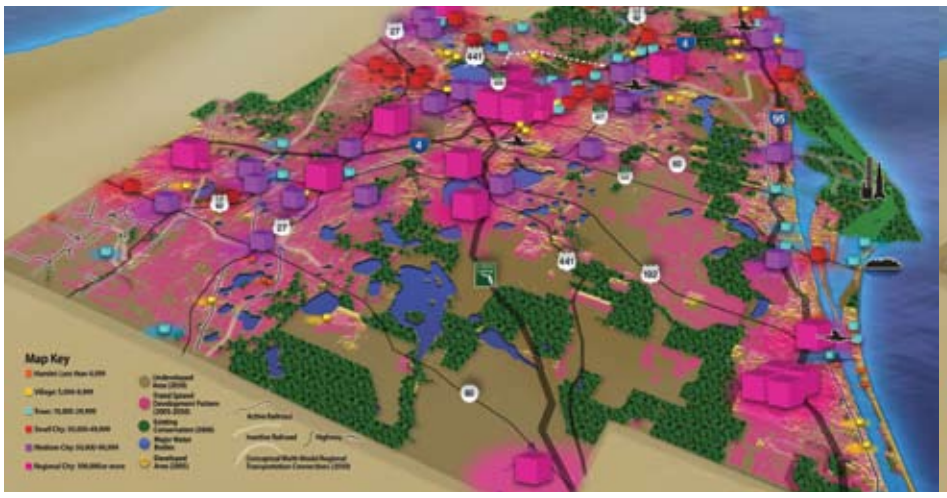
regional strategies. We did so with little understanding of how our network operated, let alone how its growth would affect the environment.

ORLANDO BUILDS AN INTENTIONAL FUTURE. For most of its history, Orlando, Florida could have been a poster child for these macro-trends. Orlando has led the nation in growth for nearly four decades, since Walt Disney World opened in 1971. Once a largely rural region populated by orange farmers and cattle ranchers, Central Florida grew into a complex metropolitan region with many growth centers: some based on tourism, others on agriculture or government.

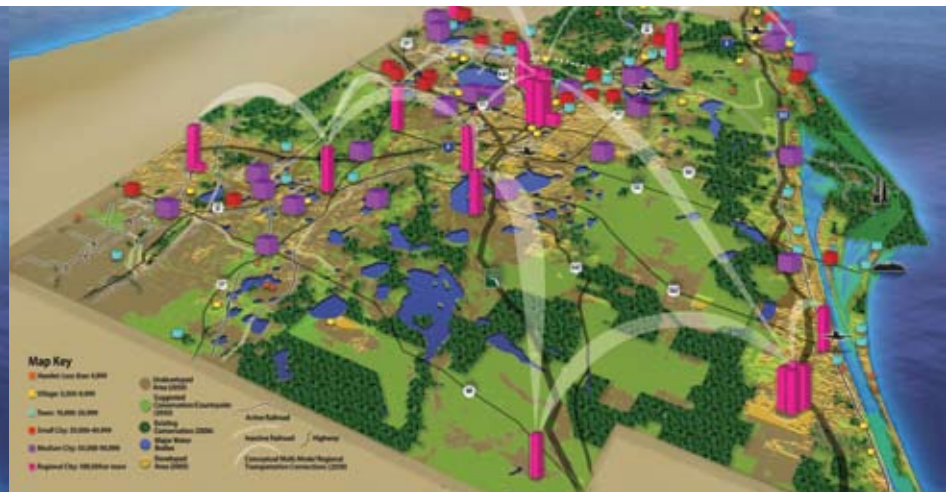
By 2000, Central Florida's legendary growth began to exact very real pain: Commute times soared. School and utility systems began to buckle under the strain of population growth. Water supplies dwindled. The leaders of seven counties founded an organization, myregion. Local businesses and governments funded myregion and charged it with developing a framework to guide regional growth.

As the systems-based study progressed, it found that the current, unplanned growth patterns would result in sprawl, completely overwhelming the ecosystems that attract millions of tourists and give the region its unique character. Not only would unmanaged growth create a place that no one wanted to live, but infrastructure problems, water shortages and pollution would add to the chaos and hobble business.

In 2007, myregion launched a "How Shall We Grow?" initiative, asking more than 20,000 residents which urban pattern they would prefer in 2050. A large majority opted for a "centers and corridors" structure that would shift development to metro hubs and transit spokes, allowing natural areas weave together with the Human Network and thrive. The study has resulted in a regional "Green Print" and in a congress of regional leaders that is still working to make this vision a reality.



One alternative was to let current trends continue. The pink areas above show the continuous pattern of low-density/high impact development that would result. This would completely erode and dismember the Natural System, disconnecting the rivers, destroying the remaining ecological diversity and damaging water supplies.

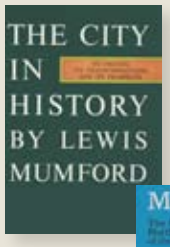


MYREGION.ORG "HOW SHALL WE GROW?" REPORT 2007

The diagram above shows how the selected choice, "Centers and Corridors," can become a reality: Human development will be concentrated in metro centers and along transportation corridors, preserving the area's world-famous ecosystems. Weaving together the human and the natural, Central Florida could well emerge as the world's first co-evolutionary region.

TXDOT ARCHIVE LIBRARY

Interstate Highway Act - Approximately 47,000-mile national highway system results, remaking the American city. Shows that national scale planning can work.

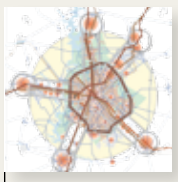


The American Metropolis - Three books appear that profoundly affect the American city: *The City in History* by Lewis Mumford argues against the sprawl and inner city decline that result from the suburban boom. *Megalopolis* by Jean Gottmann raises awareness that growth creates massive, continuous urbanized areas. *The Death and Life of Great American Cities* by Jane Jacobs condemns the destruction of neighborhoods by the urban interstates, argues for small-scale planning.

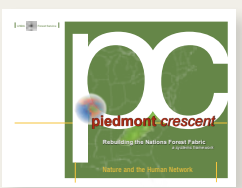
Design with Nature - This book by Ian L. McHarg explores the relationship of regional networks to ecological patterns. Helps build the foundation for "Earth Day," and "Environmental Impact Reports."

BUILDING THE HUMAN NETWORK: RECENT PRECEDENTS

Charlotte, NC Regional Growth Choices - Leaders choose the "centers and corridors" regional strategy developed using a new method of analyzing metropolitan patterns.



USFS Piedmont Crescent Study- Analyzes, for the first time, the interaction between man and nature in terms of two systems. Establishes "Five Impact" categories.



Central Florida Regional Growth Strategy (see above) - Region creates a systems-based framework to guide future growth. Puts environmental systems on a par with economic and urban systems for the first time.

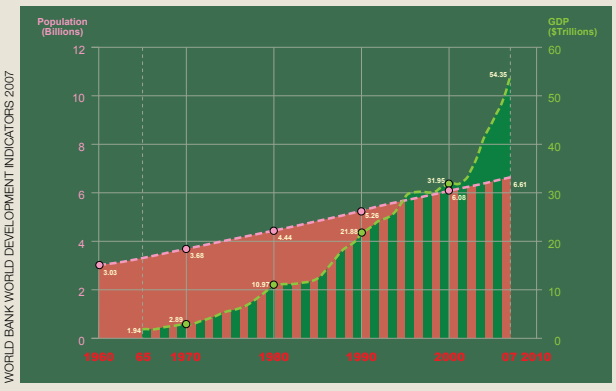
1950 1956 1960 1961 1969 1970 1980 1990 1992 2000 2002 2007 2010

Population and economic growth will accelerate. This creates the imperative to more effectively guide and manage the patterns and processes of that growth. Weaving together the Human Network and the Natural System will allow them to evolve together as systems.

CO-EVOLUTION: THE FUTURE

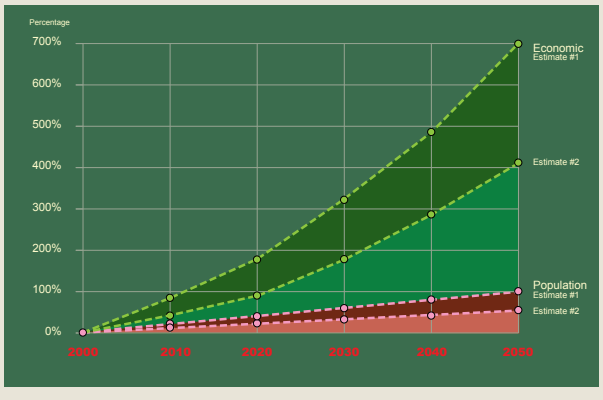
GROWTH IS COMING

The world is not standing still. Population growth, economic growth and technological change will continue to fuel the Human Network's expansion. Cities will double and treble in size. The number of cars will increase, as will the number of people flowing through highway systems. Cutting edge technologies will produce innovations. Not only will the Human Network add new areas, it will restructure and regenerate older sections. This means that the Human Network demands on the Natural System will also continue to grow exponentially. How we channel this growth and shape the relationship between the Human and Natural systems will be the challenge of the future.



WORLD BANK WORLD DEVELOPMENT INDICATORS 2007

1960-2007 ACTUAL POPULATION AND ECONOMIC GROWTH. Economic growth far exceeded population growth from 1960 to 2010. Economic growth, the green line represents Word Gross Product. It spiked sharply after 2000 growing from 30 trillion to more than 54 trillion by 2007.



WORLD BANK

2000-2050 PROJECTED POPULATION AND ECONOMIC GROWTH. The graph shows projections of economic growth in the first half of this century. While population will likely continue to grow steadily, economies will continue to expand, growing by four to seven times faster by 2050. Increasing populations and economic growth will place increasing strains on the world resources.

STRATEGIES FOR ACTION

The Human Network's inevitable growth gives us the opportunity to do things differently. We can do better than building piecemeal, creating inefficient, wasteful cities and industries. We can be smarter than engaging with the world economy as a simply a collection of separate markets, sectors, and disparate trade agreements. We can be more effective than trying to "save" the environment by focusing on disparate species, ecosystems, or single pollutants.

We live in a world in which people and goods, species and pollutants move continuously and seamlessly across the planet. We compete in a new economic geography with redefined trading blocs and market regions. We pursue our lives in a society that is increasingly globalized. The movement of people, goods and information form a network that transcends borders and forms a continuous pattern of global linkage.

To sustain the 21st century economy and the world's populations, we need to see things in a new way. We need to begin to understand our complex reality as it is: the intertwined patterns and interactions of two systems, human and natural. We can begin to expand and reengineer our cities and businesses as efficient systems. We can begin to restore nature's systemic function, rather than just preserving this single species or that disconnected place.

We need to create a framework that results in policy and management structures that allow us to succeed. We need programs and financing instruments that support system continuities and functions, rather than working against them.

Our current institutions and businesses were built around a set of cultural values and legal statutes. Within these parameters, we created mission statements. From those, we established procedures, policies and investments and finally performance measures to make sure we fulfilled the requirements of the statutes.

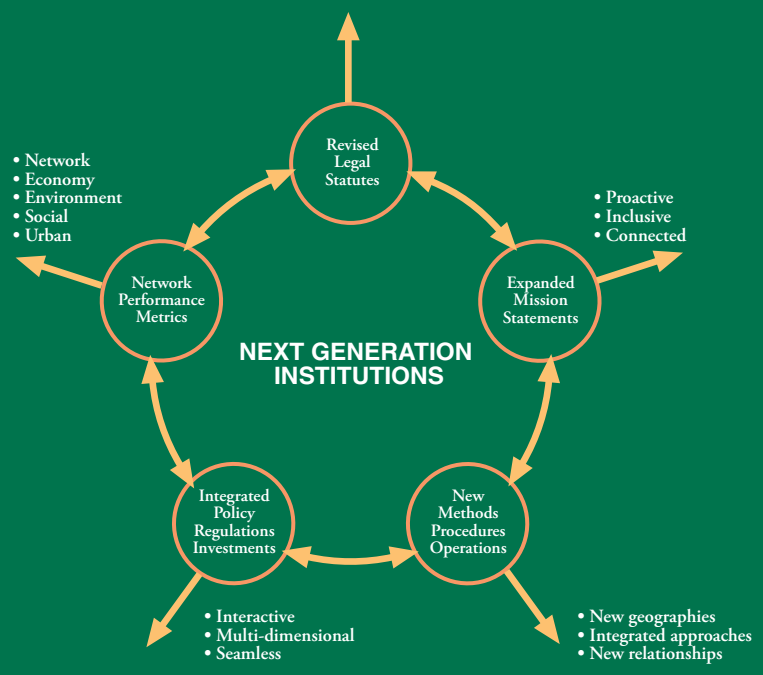
Yet within each agency, or each industry, or each business, this institutional structure is a closed circle that seldom connects outside itself. As new technologies produced new components we added statutes. Today the complex pattern of statutes, mission statements, policies, procedures and investments focus on parts, not wholes, on the function of components, not the function of systems. As a result, we work within a highly fragmented bureaucracy. Each silo within this structure has its own mission: to build or protect one part of the economy, or to "save" this or that bit of nature.

This inward-looking silo structure sets us up for failure in the 21st century simply because a fragmented system produces more friction, requires more energy, wastes more resources and reduces performance. An example of Human Network inefficiency is our transportation system where our airports, seaports and rail lines aren't connected, resulting in delays and business losses. We treat drowning polar bears and dwindling frog populations as separate issues, rather than as connected aspects of the same Natural System problem, climate change.

We need to change our mission for success in the 21st century: The goal needs to be the efficient performance of systems, both human and natural. This will demand fundamental shifts:

- This new mission will require agencies and businesses to look outward, rather than inward. How does one system relate to the others around it? For instance, how does transportation affect regional economics? How does a local economic conduit, like California's Alameda corridor, connect to global patterns, to Asia-Pacific trade?
- It will encourage interactive and inter-dimensional policies and procedures. How does managing infrastructure like power and water systems strengthen networks and ecosystems? How do investments fit into regional and national economic objectives?

Co-Evolution will form a framework for drafting new legal statutes, revising mission statements, redesigning programs. It will redefine the kind of new science and new methods we need to provide the system-wide data needed to measure Human Network performance in terms of Natural System function and vice versa.



MGA AND ROBERT PAASWELL, UTRC CCNY

LEFT: Our methods, procedures and practices focus inward not outward. We focus on components—highways or transit, clean air or endangered species—rather than the whole systems, such as transportation or the environment. RIGHT: Next generation institutions will focus on systems and be focused outward. Within them, each component will fit to a system and how the system interacts with other systems.

POLICY IMPLICATIONS

Using Co-Evolution as a framework for shaping the future will demand fundamental policy changes. We need to create a 21st century policy framework to meet the challenges of the 21st century Human Network and the 21st century Natural System.

1. NEW POLICY FRAMEWORK

- Based on system performance
- Understand how systems operate and interact with each other.
- Improve connections between regulatory and national policies.
- More integrated regional and national policies for growth, development and environmental function.

2. NEW MANAGEMENT STRUCTURES

- Reduce duplication, allow integrated management on a systemic basis
- Redraft agency policies and procedures so that they encourage coordination and cooperation.
- Develop metrics that measure the performance of both the Human Network and the Natural System.
- Streamline permitting and regulatory procedures to reduce duplication and encourage efficiency and competitiveness.
- Bring planning and environmental laws into the 21st century economy, emphasizing systems.

3. NEW FINANCIAL STRUCTURES

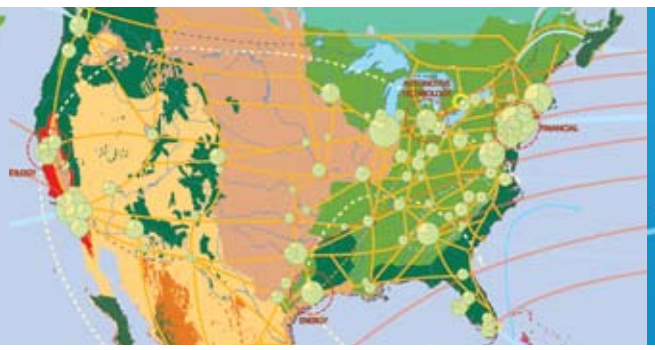
- Build system performance incentives into funding.
- Create financial incentives to encourage inter-agency and inter-departmental cooperation.
- Set goals that emphasize system-wide results and reward system, not component, performance improvements.
- Offer communities and regions incentives to cooperate and coordinate.

4. NEW PROGRAMMATIC STRUCTURES

- Simplify programmatic duplication to allow system-wide integration.
- Reposition projects as components of systems, as pieces of a larger whole.
- Develop regional and national programs for economic development and environmental function.
- Revise environmental and economic programs to fit the 21st century economy.

TWO SYSTEMS: ONE NATION

Different colored areas indicate the different major "bioregions" of America. Air currents are shown in yellow dotted lines.



Above; Green circles, scaled according to Gross Metropolitan Product, indicate the 100 largest metro economies. Yellow lines show major corridors. Red lines denote international air routes, blue lines shipping lanes.

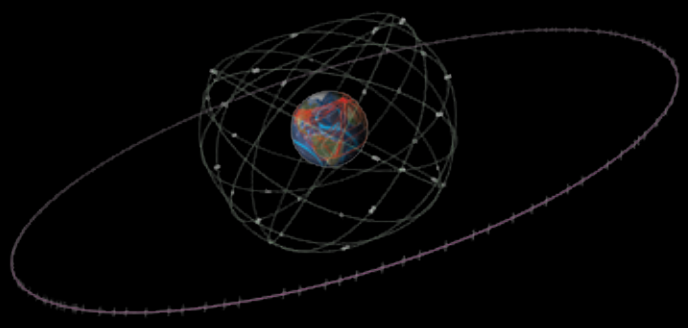
The diagram above shows the projected pattern of port and trade corridor growth. Ports will double and quadruple in size, swelling trade corridors across the nation.

North America supports the most diverse assemblage of plants, animals and ecosystems in the world. Of the world's 15 "bioregions," the US has 13. China has nine; Russia eight. Very different patterns and processes characterize each of America's large-scale eco-regions. Southwest deserts feature flora, fauna and natural cycles that have little in common with the temperate broadleaf forests of the Southeast. Yet our policies have been "one size fits all," rather than addressing the function of each bioregion.

North America also has developed one of the world's most unique Human Networks. Our economic centers are widely distributed, located in very different bioregions. The grid to connect them crisscrosses the continent. Many of our metro areas have become global industry centers: They have attracted not only American industry leaders, but the major global firms in those fields. Each of these global nodes—San Francisco for high technology, Houston for energy, Detroit for automotive, New York for financials and so on—is very unique, with different infrastructure patterns and needs. We have built this vast Human Network over a highly diverse Natural System. To succeed, our human systems must consider their broad ecological context and their global economic role.

The growth that will mark the coming decades is currently driven completely by economic forces concentrated in the private sector. We have NO public policy to guide the growth of cities, trade and economies within a systems framework. We lack any consistent public policy for guiding this growth within an environmental context.

We have an opportunity to do things differently, to manage our growth within a Co-Evolutionary framework. A new policy framework needs to be constructed to address The Human Network and Natural System on a systemic, basis.



Human and natural systems are on a path
of mutual decline, or Co-Devolution.

Can we create and implement a new framework, Co-Evolution,
that allows both the human and natural systems to thrive?

CO·EVOLUTION

Creating a New Framework for Shaping Our Future

More people live better in more countries than at any time in history. But this welcome prosperity requires ever more land, energy and other natural resources. Building cities and economic growth in the same ways will not only de•evolve nature, it will cripple the very cities and economies that we so desire.

As the Human Network evolves, it creates growing impacts on the Natural System. Until recently, humanity's impact on nature remained local and regional. Today it is global and systemic. The Natural System is striking back with hurricanes, droughts, wildfires and other erratic patterns that damage our economies.

We need a new system to avoid a continuing slide toward a future of Co-Devolution.

Co-Evolution provides a framework for systems thinking and planning at large scales. We cannot solve today's problems one at a time. Rather, we need to manage the Human Network and the Natural System in concert and in parallel. This will require a new framework to efficiently guide economic growth and to rebuild ecosystems.

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Re-engineering Human Networks. Rebuilding Natural Systems.