CO·EVOLUTION

Re-engineering Human Networks. Rebuilding Natural Systems.

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 System.

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 the 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: © 1998 MICHAEL GALLIS & ASSOCIATES

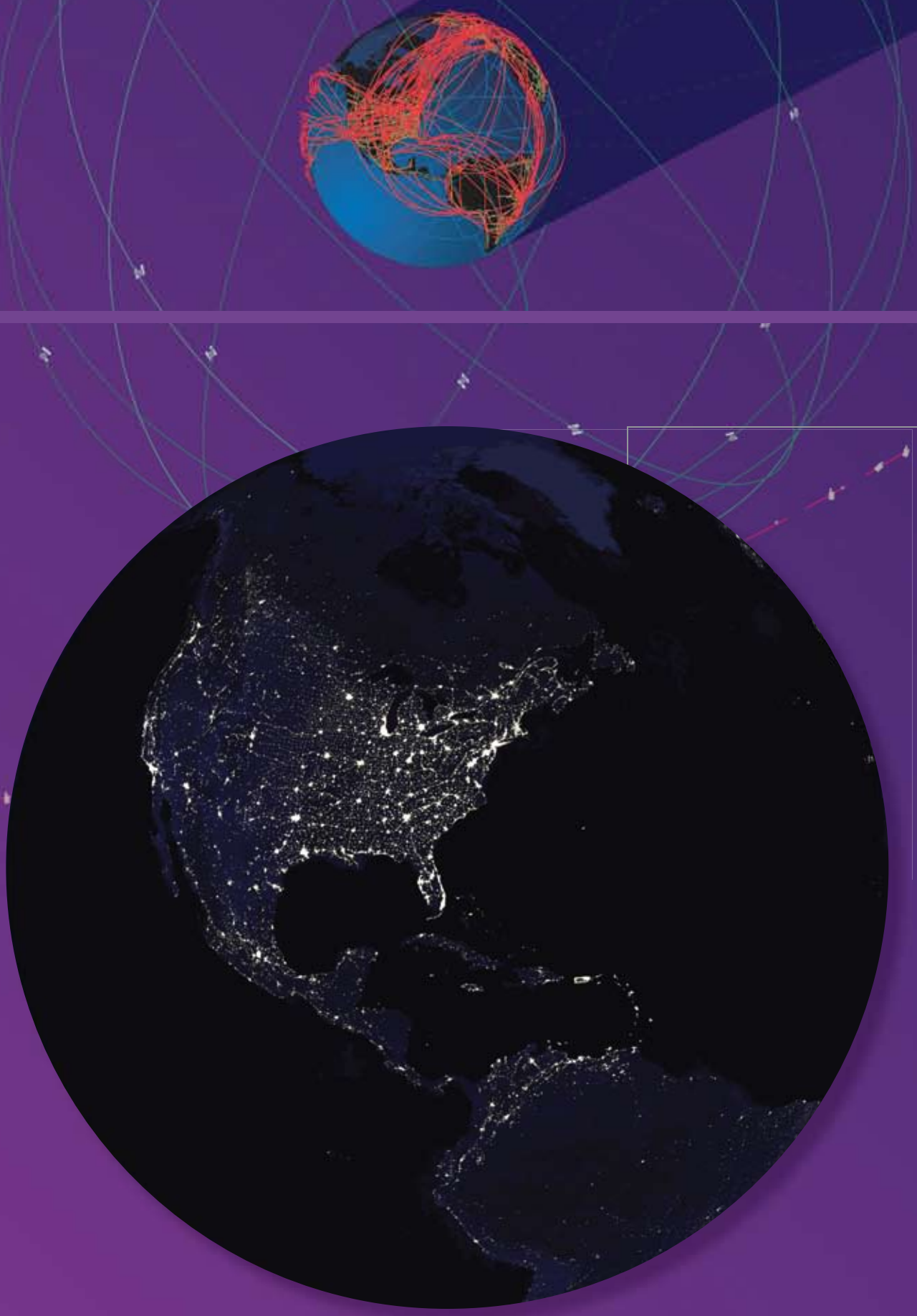
RETHINKING THE PROBLEM

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 PATTERNS AND PROCESSES. 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 the interactions between them.

NATURE: *adj.* 1. existing in or caused by nature; not made or caused by humankind. 2. of or in agreement with the character or makeup of, or circumstances surrounding, someone or something.
The New Oxford American Dictionary, 2005



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. To understand systems, their patterns and processes, we must use a consistent method of representing them spatially, a "visual language." This 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 System** 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: Its 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, healthcare, 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, the Human Network wraps the earth, and is continuous 24/7.

TOP: Transportation, logistics and communications systems including satellites and deep-sea cables now form a global network that wraps the earth, reaching far beneath the ocean and out into space.

"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: *adj.* 1. of, relating to, or characteristic of people or human beings. *The New Oxford American Dictionary, 2005*

The current crisis is global, 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?

NASA

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 upon 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.

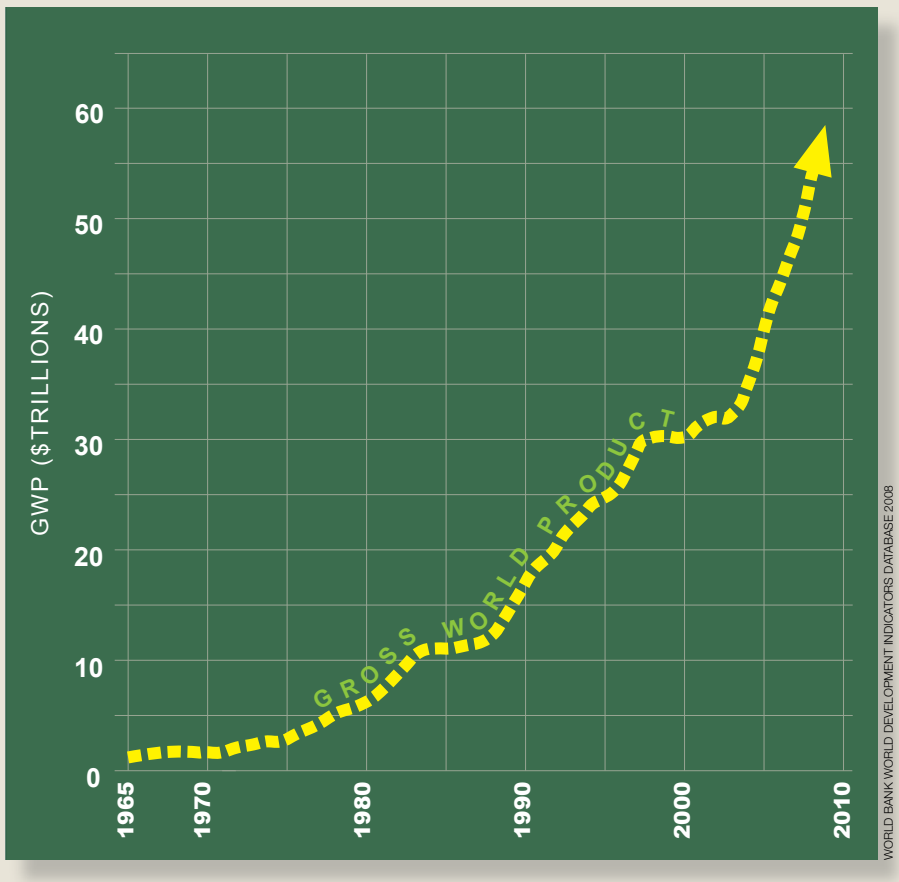
CONFLICTING DEMANDS. The Human Network relies upon many of the same resources needed by the Natural System. Cities, industry and agriculture need energy, raw materials and water. So do ecosystems. The Human Network demands more space for housing, agriculture, factories, roads, mines, timberlands. Yet 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 trillion to $40 trillion, a 33 percent jump. By 2007, the figure had reached $54.3 trillion, almost doubling in seven years. It is now predicted that world output could grow by at least 360 percent by 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 people, fueling a massive increase in demands for, and on, resources.



THE HUMAN NETWORK KEEPS EXPANDING

UNPRECEDENTED SCALE AND 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.

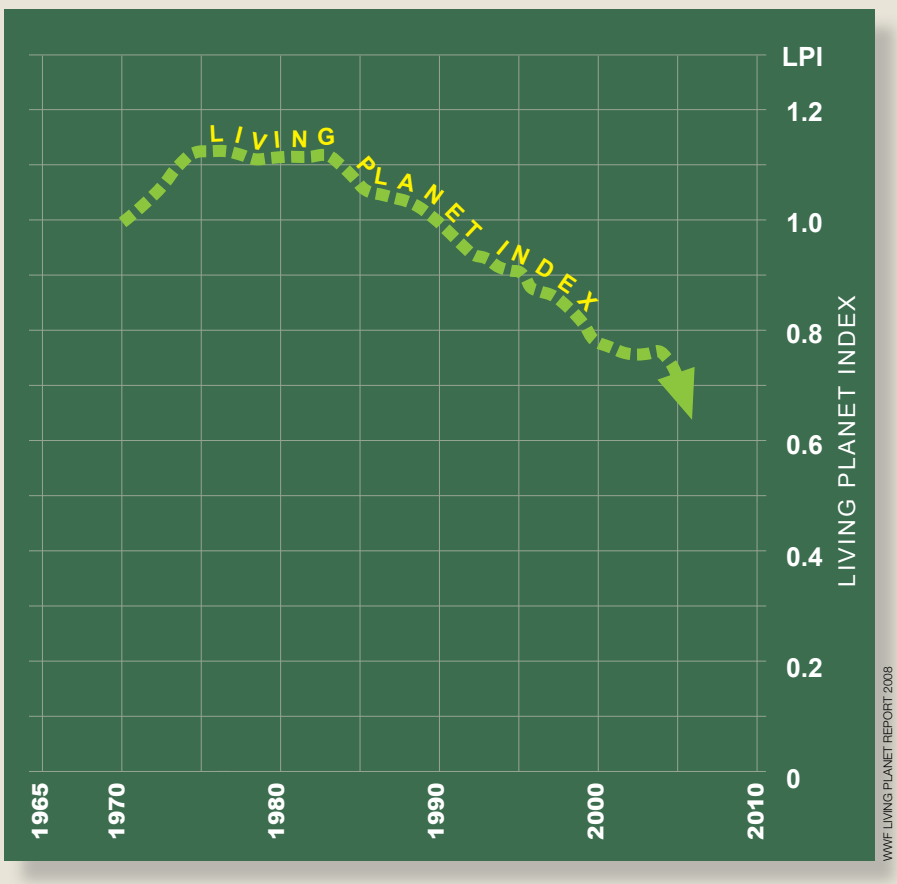
- In 1950, the earth supported 2.5 billion people. By 2000, that population had more than doubled, to 6 billion. By 2050, that figure could range from 9.3 billion to more than 12 billion.
- The global human economy has grown more since 1990 than it did during all the centuries from the dawn of agriculture 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.
- Urban areas have expanded on every continent: In 1800, only London boasted more than 1 million residents. Today, nearly 400 cities and metropolitan areas have 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 2,000 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.
- In 1900 there were no paved roads in America; by 2005 there were 4 million miles of paved highways. In 1905 there were 4,500 registered vehicles; by 2005 that number rose to 136.5 million.

SYSTEM: *n.* 1. a set of connected things or parts forming a complex whole; 2. a set of principles or procedures according to which something is done; an organized scheme or method. *The New Oxford American Dictionary, 2005*

LEFT: Daytime view shows the patterns of the Natural System.

RIGHT: Invisible during the day, the vast web of human activity built over the Natural System becomes visible at night.

NASA



World Wildlife Fund has created the "Living Planet Index" 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. It projects 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 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. To meet today's demand for food, nearly all the oceans are being fished at, or above, capacity.
- Global water use has increased sixfold 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.
- Global fossil fuel carbon emissions have more than tripled since 1950. Most scientists now agree that carbon emissions are changing the climate, potentially upsetting delicate cycles.
- The chemistry of the oceans changes as they absorb greenhouse gases, making them more acidic and threatening coral and phytoplankton 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 antiquity, 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.

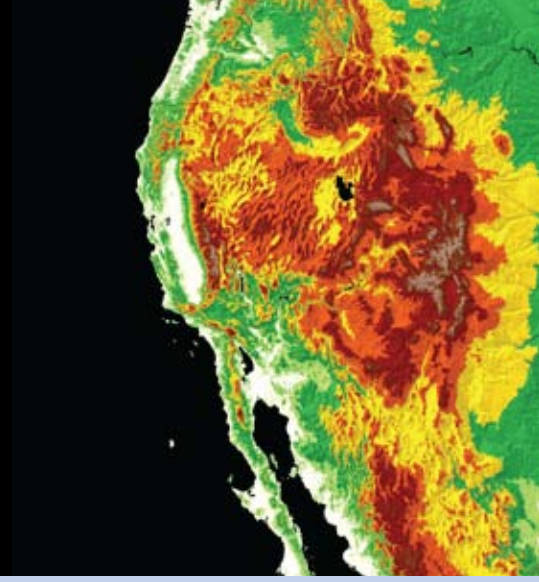
PIECES, NOT SYSTEMS. We have constructed the Human Network in parts—one road, one house, one factory at a time—with little understanding of the whole system. As a result, we have unintentionally created inefficiencies. Similarly, our environmental programs emphasize conservation and mitigation on a piecemeal basis. We focus on one problem at a time—one species, one pollutant or one watershed—rather than upon large environmental systems. But these efforts are not working: 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.

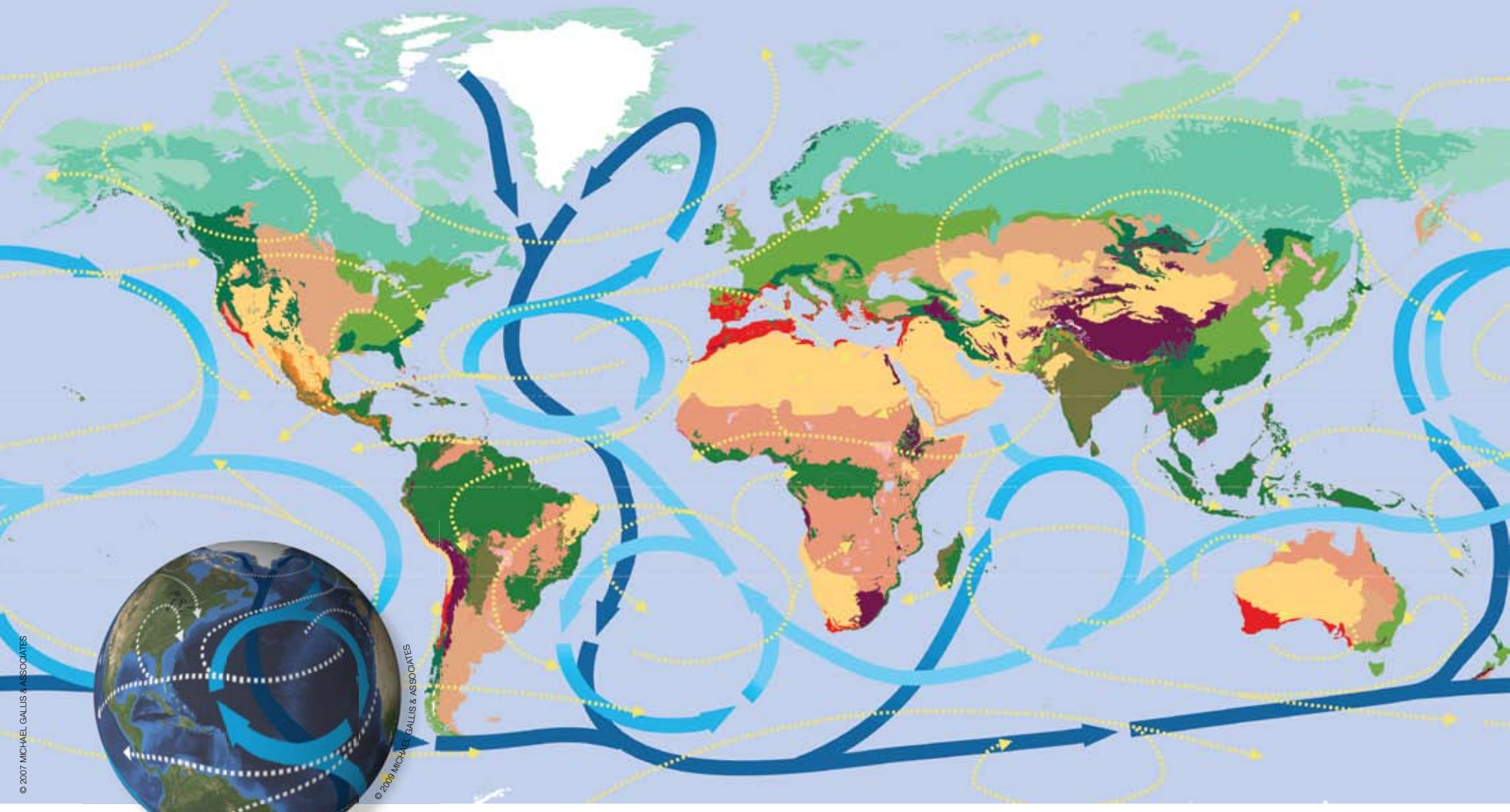
TECHNOLOGY IS NOT ENOUGH. Wind turbines, solar panels, electric cars—these are all good things. But these emerging technologies still do not address the systemic conflict between nature and humanity. The issue of "configuration"—how the pattern of the Human Network relates to the pattern of the Natural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

NETWORK: *n.* 1. a complex system of roads, railroads, or other transportation routes. 2. a group or system of interconnected people or things.
The New Oxford American Dictionary, 2005

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



Natural System patterns are generally curvilinear: Broad blue lines represent major ocean currents; dotted yellow lines, the path and direction of prevailing winds indicates the location of the 15 global "ecoregions," assemblages of plants, animals, water, air and topography that function as units.

THE NATURAL SYSTEM

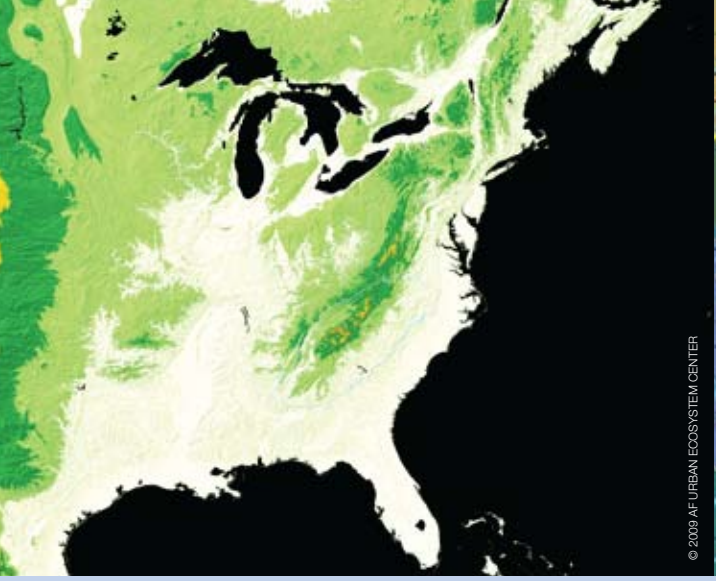
The Natural System is a highly differentiated and diverse fabric that covers the planet. It forms a continuous, global set of interactions. Maps represent the world on a flat surface. The reality, however, is that the world is a sphere. The edges and borders are illusions. Everything is connected.

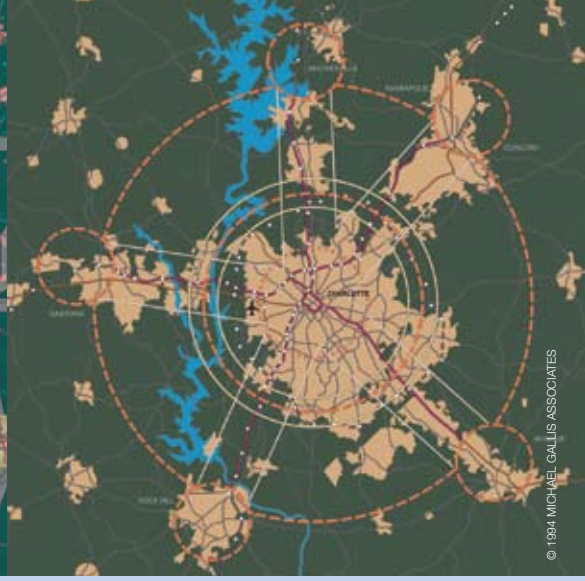
Ecological science, the study of biological systems and the interrelationships between them, remains a young discipline. The term has existed for little more than a century, and ecology has emerged as an active research specialty only in the past few decades. It has only just begun to plumb nature's 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, like 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 ecoregions.

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.

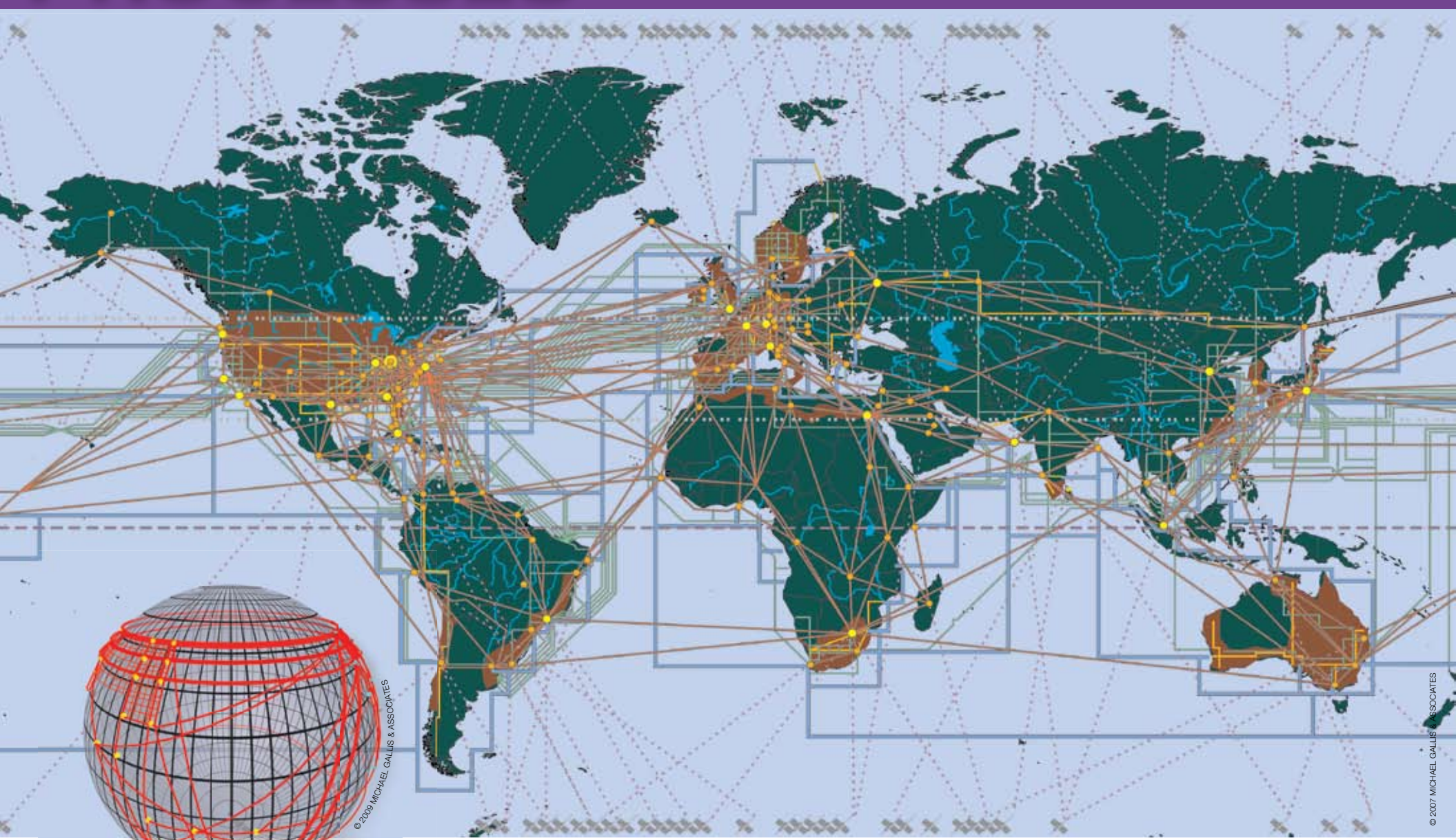
PATTERN: *n.* 1. an arrangement or sequence regularly found in comparable objects or events; a regular and intelligible form or sequence discernible in certain actions or situations. *The New Oxford American Dictionary, 2005*





PROCESSES

Multiple Scales. Understanding both systems requires that we analyze them at varying scales. LEFT TO RIGHT: Continental scale topography, the Upper Midwest scale drainage system; the Human Network in Illinois at state scale; Charlotte, NC, at metro scale.



Hub Cities — Transportation — Communication

Human Network patterns set up by longitude and latitude are generally rectilinear: Orange and yellow dots show the primary and secondary hub cities. Orange lines indicate air routes; blue lines-sea lanes. Yellow lines-railways; dotted lines-satellite communications. The network's rectilinear pattern contrasts with nature's curvilinear pattern and is one of the roots of the conflict between the systems.

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 of 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 and communication 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 cellphone 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: *n.* 1. a series of actions or steps taken in order to achieve a particular end; a natural or involuntary series of changes. *The New Oxford American Dictionary, 2005*

Human impacts on the Natural System were once local and limited; 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

Global forest cover 10,000 years ago.

AN ANCIENT DYNAMIC. As the Human Network has evolved, the Natural System has de-evolved. 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 DE-EVOLVES.

Agriculture and sedentary civilizations appear in approximately 10,000 BCE. About 3000 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.

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.

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.

PRE-GLOBAL
3000 TO 326 BCE

SILK ROAD
326 BCE TO 1492 CE

AGE OF SAIL
1492 TO 1865

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, aqueducts 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 demand 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: *n.* 1. the process by which different kinds of living organisms are thought to have developed and diversified from earlier forms during the history of the earth. 2. the gradual development of something, esp. from a simple to a more complex form. *The New Oxford American Dictionary, 2005*

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 stock markets 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

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

Plastics, dyes, detergents, fertilizers and many other petroleum-based products 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

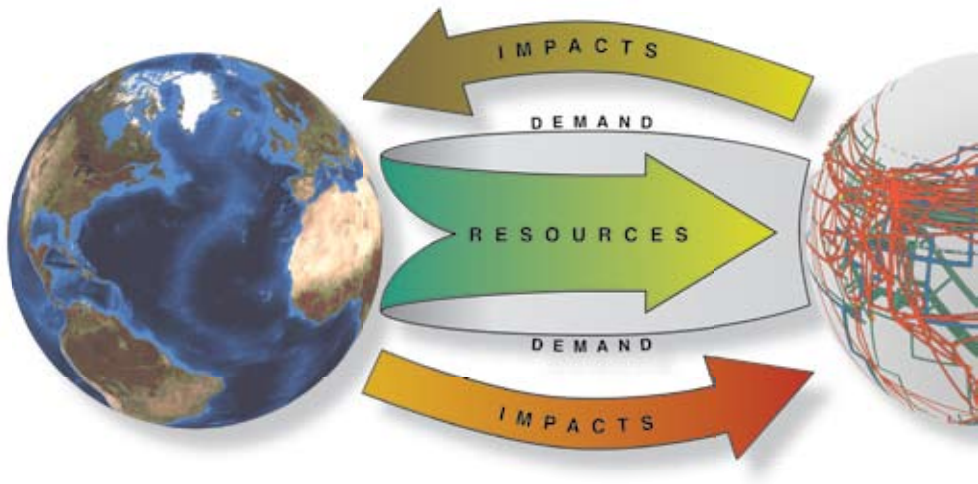
The air conditioner, interstate highways and the commercial jet accelerate urbanization in inhospitable environments but require more energy. Industrialized agriculture creates pollution across vast non-urban landscapes while depleting water supplies and soil fertility. Growing GDP and personal wealth,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

GLOBAL HYPERGROWTH
1990 TO TODAY

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.

DE-EVOLUTION: *n.* This word does not yet appear in any major dictionary. By it, we mean a process or dynamic that reduces the complexity, changes the functionality and connectivity patterns that lead to greater chaos or disorder in a thing or a system.

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.



The Human Network, the globe at right, demands resources from the Natural System, the globe at left. This creates impacts that de-evolve both the Natural System and the Human Network.

SYSTEMIC IMPACTS

MEASURING SYSTEM-TO-SYSTEM IMPACTS

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

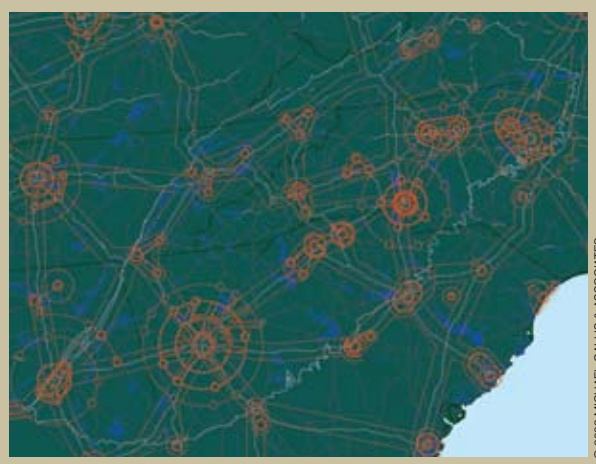
Many scientific studies have tried to describe regional ecosystems, and to measure environmental change. Many industry analysts and economic development groups have tried to describe regional patterns of commerce and urban development. Yet this study marked the first attempt to determine the macro-scale 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, an area known as the Piedmont Crescent. 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

HUMAN NETWORK



PIEDMONT CRESCENT. The Southeast's macro-scale pattern of metropolitan areas and the corridors, as of 2006.

■ Until the mid-20th century, the Southeast's heat, humidity and relative inaccessibility kept rapid urbanization at bay. The air conditioner and the interstate highway removed those barriers and created the "Sun Belt." 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. The Southeast gave rise to low-density metro areas with suburban shopping malls and "edge cities."

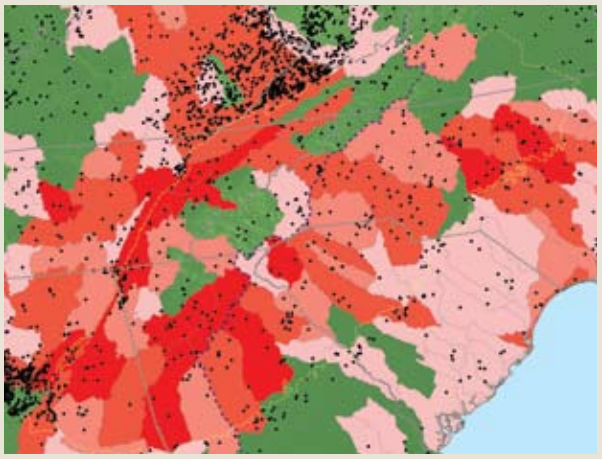
■ The growth of the Human Network results in the Five Impacts, shown at right.

FIVE IMPACTS THAT DE-EVOLVE THE NATURAL SYSTEM

1 FRAGMENTATION. Fragmentation is the breakup of natural corridors, ecosystems and watersheds by the construction of human systems. Fragmentation includes transportation infrastructure like roads, rail and trails; subdivision of large land parcels; and ecosystem alterations like dams.

■ Cities and businesses require more roads and more trade routes to access more resources. They build dams and aqueducts, cutting ecosystems into dysfunctional parts. ■ From the air, the Piedmont Crescent looks uniformly forested. The region's road and utility systems, in yellow, show the Natural System sliced into tiny bits.

■ Fragmentation disconnects and disrupts Natural System patterns and processes. It makes regeneration more difficult.



2 DEPLETION. Depletion means the Human Network's withdrawal of Natural System resources. Depletion includes renewable resources (forests, water); and nonrenewable 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. Mines, shown as black dots, inflict huge impacts even in rural areas. The darkest red areas suffer the greatest depletion.

■ Depletion leaves the Natural System with fewer resources to maintain natural cycles and processes.

IMPACT: *n.* the action of one object coming forcibly into contact with another; the effect or influence of one person, thing, or action, on another. *v.* 1. come into forcible contact with another object. *The New Oxford American Dictionary, 2005*

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 are in yellow lines; power lines in dotted yellow lines.

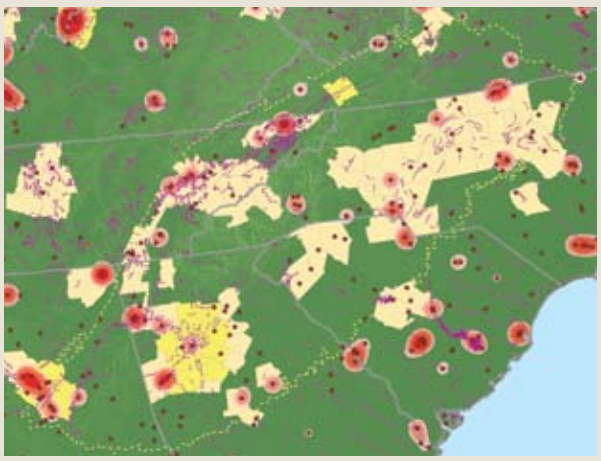
categories differ from categories developed by other studies in that they were not derived from an examination of either system in isolation, but rather of both systems and their interactions: an analysis of the relationship between the patterns and parts, the connections and dynamics between the Human 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, throughout the region. The team did not find one trend line that moved toward a lessened impact on nature.

SYSTEMIC, GLOBAL IMPACTS. What is happening in the seven-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 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 changes in the 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.

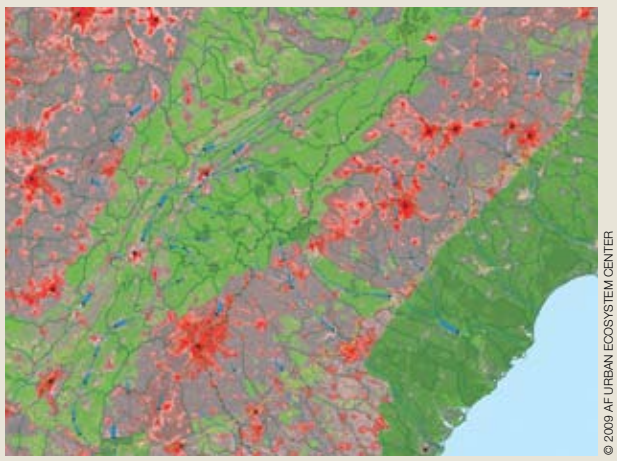


3 POLLUTION. Pollution means the introduction of non-natural waste products into the Natural System. Types of pollution include air, water, land and invasive species. ■ As farms, industries and cities grow, they create waste, or pollution, that can damage both natural systems and human economies. ■ Pollutants suffuse the Piedmont Crescent region. Toxic land releases are shown as red dots. 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. This alters Natural System components, patterns and processes.

4 EROSION. Erosion refers to the displacement of natural areas by the growth of the Human Network. It includes 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, shown in yellow. Urbanism, at low or very-low densities, has eroded ecosystems' function. Urban areas are shown in red.

■ Erosion reduces the area in which 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. ■ Red areas are cities and suburbs that have been totally cleared. In the light gray swaths, nearly 99 percent of native species and ecosystems have disappeared. Natural predators and keystone species are being eliminated. In the greener areas along the coast, 60 percent of native species have vanished.

■ Extinction creates massive imbalances in the food chain and in the cycle of life. The Natural System becomes increasingly dysfunctional.

INTERACT: *v.* act in such a way as to have an effect on another; act reciprocally.
The New Oxford American Dictionary, 2005

The Human Network has changed Natural System patterns and processes. These new patterns have begun to inflict serious damage on the Human Network. This creates negative, mutual impacts that lead to global de-evolution.

GLOBAL DE-EVOLUTION

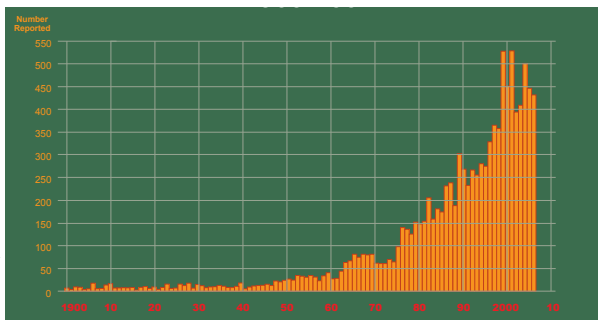
GLOBAL SCALE

De-evolution is becoming global, all-encompassing. It is also systemic: It impacts the functions of both the Natural System and the Human Network.

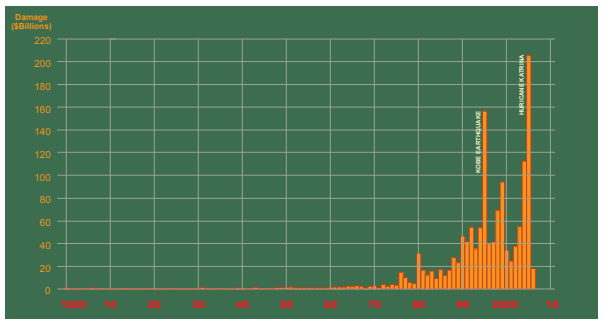
COLLECTIVE EFFECTS. Global connectivity now amplifies actions that may seem personal and local: Someone in Manhattan throws out a cell phone battery, rather than recycling it. Perhaps she has heard that the batteries contain mercury and heavy metals, but throwing it out seems like a small thing, just one battery. Multiply that simple lapse by even a fraction of 8 million New Yorkers. Multiply it again by the 400 cities worldwide that support more than a million people.

One simple act—tossing a battery—thus adds up to a collective force of global change leading to de-evolution. Many seemingly disparate acts now connect, interact and feed one another, forming a pattern of global destruction that is mutual and reciprocal: Human actions alter nature; nature reacts with new, unpredictable patterns and processes. This becomes global de-evolution: Each system negatively impacts the patterns and processes of the other.

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



Rising Number of Natural Disasters 1990–2007. Since 1900, the annual number of natural disasters has increased more than 40-fold: from fewer than 10 in the first decades to 400 to 500 in the last decades of the 20th century.



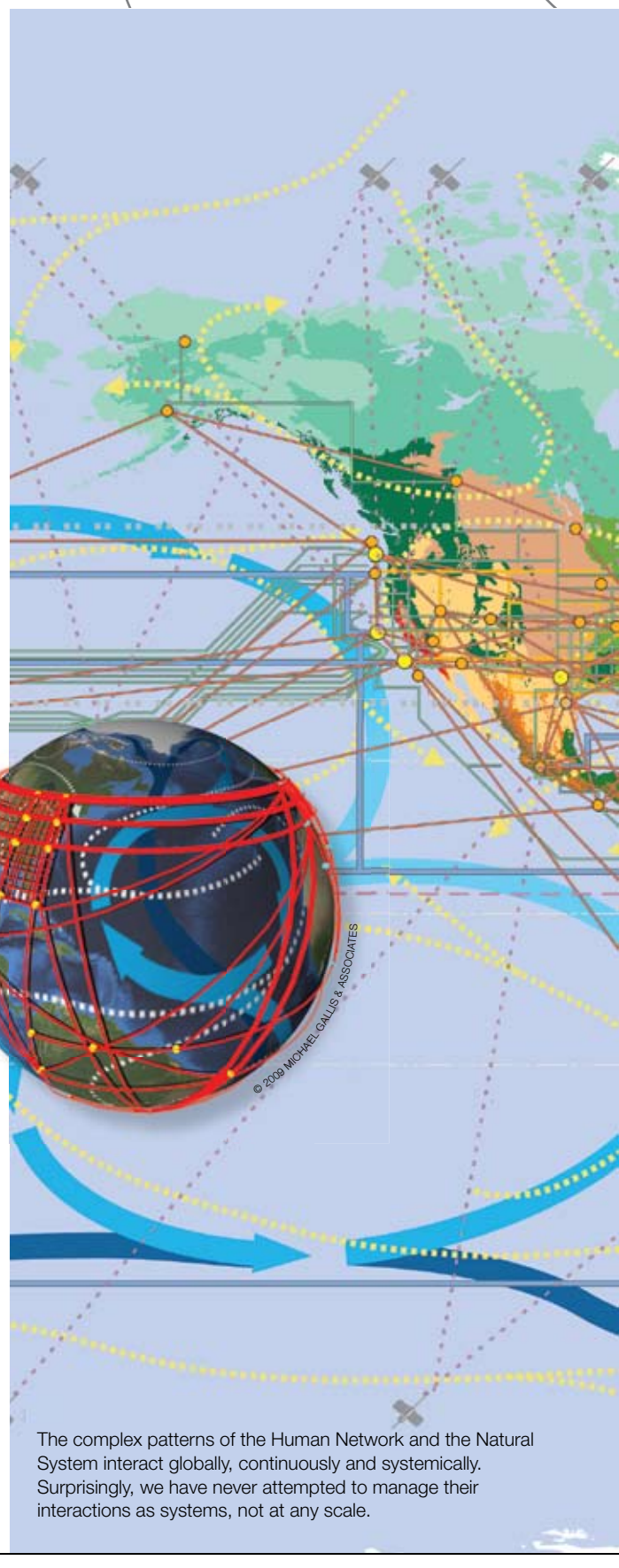
Rising Cost of Natural Disasters 1990–2007. The scale, and thus the cost, of natural disasters has also increased: from far less than a billion dollars in 1900 to more than $200 billion in 2005, the year Hurricane Katrina hit New Orleans.

RECIPROCAL IMPACTS. In the spring of 2008, all salmon fishing was banned off California and Oregon. To someone surprised by the spiking of fish prices, the crisis may have seemed sudden, but it had been building for decades. After World War II, Pacific Coast cities boomed. Demand for lumber led to the logging of redwood forests. Erosion from clear-cut forests warmed and silted streams, making it impossible for salmon to spawn. Meanwhile, increasing energy needs led to dams on salmon rivers like the Klamath, blocking salmon runs. Growing agricultural industries needed more water and built storage dams in places like the Sacramento River delta, fragmenting salmon populations and making them more prone to extinction. Health concerns led to a growing taste for fish, increasing Pacific salmon catches.

Finally, in the fall of 2007, the once-fabled fall run of Sacramento River Chinook salmon failed catastrophically and officials closed the fishery for the first time in the 160 years of commercial fishing there. The U.S. Commerce Department declared a "commercial fishery disaster," citing the devastating economic impact on fishermen, local business, tourism and boating. In short, economic growth and prosperity de-evolved the river system, and with it the salmon cycle. That Natural System de-evolution, in turn, de-evolved coastal economies, the Human Network.

DOWNWARD SPIRAL. Similar dynamics of systemic de-evolution now unfold worldwide. Water shortages from Australia to Las Vegas to Spain have limited urban development. Water tables lowered by industrial agriculture and urban development exacerbated 2008 and 2009 Midwestern floods that cost billions. Climate change has intensified hurricanes, disrupting major ports like New Orleans and Miami and forcing population shifts. Disastrous wildfires fueled by droughts, urban development and erratic weather have forced mass evacuations in Australia and California.

These disasters may seem local, but the Human Network connects them. These impacts, and the downward spiral, will only grow unless we find a new framework to build resilience into both systems.



The complex patterns of the Human Network and the Natural System interact globally, continuously and systemically. Surprisingly, we have never attempted to manage their interactions as systems, not at any scale.

GLOBAL: *adj.* of or relating to the whole world; of or relating to the entire earth as a planet ; relating to or embracing the whole of something, or of a group of things. *The New Oxford American Dictionary, 2005*

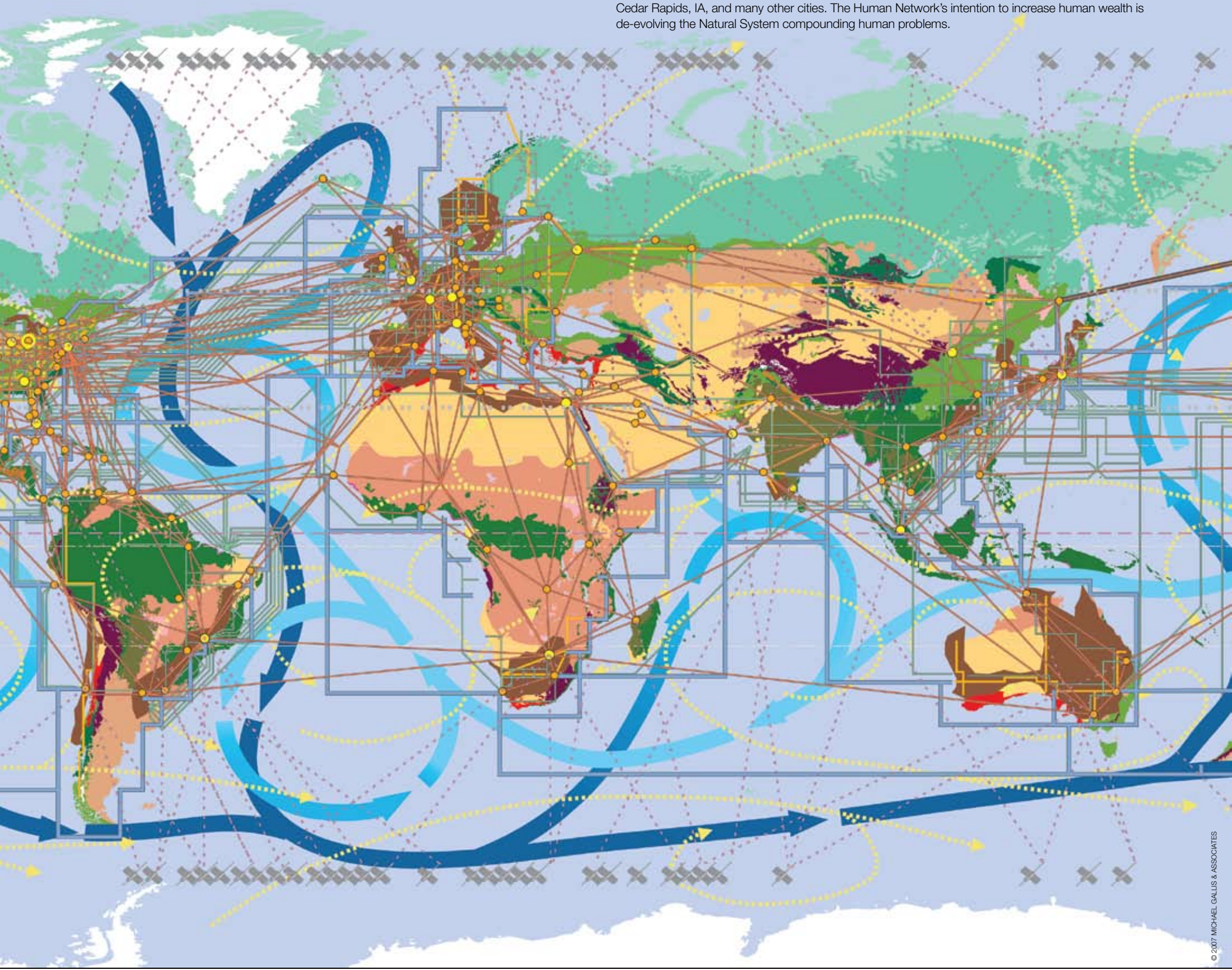
"For every action there is an equal and opposite reaction."

—Isaac Newton's Third Law of Motion

HURRICANE KATRINA SATELLITE IMAGE: NOAA

ST. BERNARD PARISH © CHRIS JORDAN

We have already seen the effects of de-evolution on metropolitan areas like New Orleans, Los Angeles, Cedar Rapids, IA, and many other cities. The Human Network's intention to increase human wealth is de-evolving the Natural System compounding human problems.



© 2007 MICHAEL GALLIS & ASSOCIATES

MUTUAL: *adj.* 1. (of a feeling or action) experienced or done by each of two or more parties toward the other or others; (of two or more people) having the same specified relationship to each other. 2. held in common by two or more parties. *The New Oxford American Dictionary, 2005*

We need a new framework to guide the way we build the future: Co-evolution means that the Human Network and the Natural System evolve together, reinforcing, rather than de-evolving, each other. The growth of one system cannot continue to come at the other's expense.

CO-EVOLUTION

RESOLVING SYSTEMIC CONFLICT

Where do we go from here? How will we cope if World Bank predictions come to pass, if the world's population doubles, and the global economy grows four to seven times larger by 2050? Unless we make profound changes, the downward spiral of "global de-evolution" will accelerate. Reversing this threatening trend will demand a new framework to guide growth.

LACK OF SCIENCE. Until recently, we did not have science that could help us understand our Natural System impacts. Ecological sciences were in their infancy as cities and economies grew rapidly during the 20th century. Only late in the century could we accurately measure our increasing impact on nature, or fully understand the importance of doing so. Today, we have the science and technology to measure the configuration and function of both systems. The Human Network operates as a system, but it was built in pieces and parts. Likewise, the Natural System is also a system, but it has been cut up into pieces and parts by human activities. Creating the sustainable economy of the 21st century will first require that we address the two systems, human and natural, as systems, rather than as a set of independent and disconnected components. We need to systematically weave together the two systems into a pattern of mutual reinforcement: co-evolution.

WE HAVE: A LOW EFFICIENCY, HIGH IMPACT NETWORK. The institutions we created to shape our world originated in a time when capital was scarce and resources plentiful. Financing was the major concern; environmental impacts were not.

We unintentionally created a "low efficiency, high impact" Human Network that wasted energy and resources, and consumed vast amounts of land, resulting in the Five Impacts. Well into the 20th century we lived in a bubble of security: Human impacts remained largely limited to the industrial countries. Most of the world remained undeveloped.

When the Soviet Union collapsed in 1990, it initiated global economic integration. Global business cooperation led to unprecedented growth, and to unprecedented demand for energy, resources and food as China, India and Brazil brought hundreds of millions into the global middle class. Our impacts on nature began to produce unexpected and undesirable results.

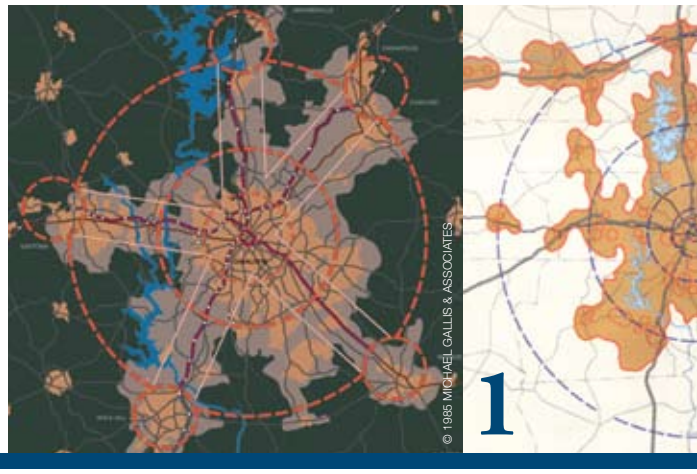
WE NEED: A HIGH EFFICIENCY, LOW IMPACT NETWORK. We need a new, systemic framework to guide the patterns and processes of the Human Network and the Natural System. This framework must be capable of resolving both the pattern and process conflicts. It must more efficiently use energy, resources and land. It must stabilize and rebuild the Natural System. We have guided our activities based on the performance of separate system components. In the future, we need to guide our growth based on the performance of whole systems, human and natural.

A NEW FRAMEWORK FOR ACTION. Co-evolution provides a way to reframe what we're seeing in today's world. It simultaneously addresses both systems and their relationships. It calls on us to:

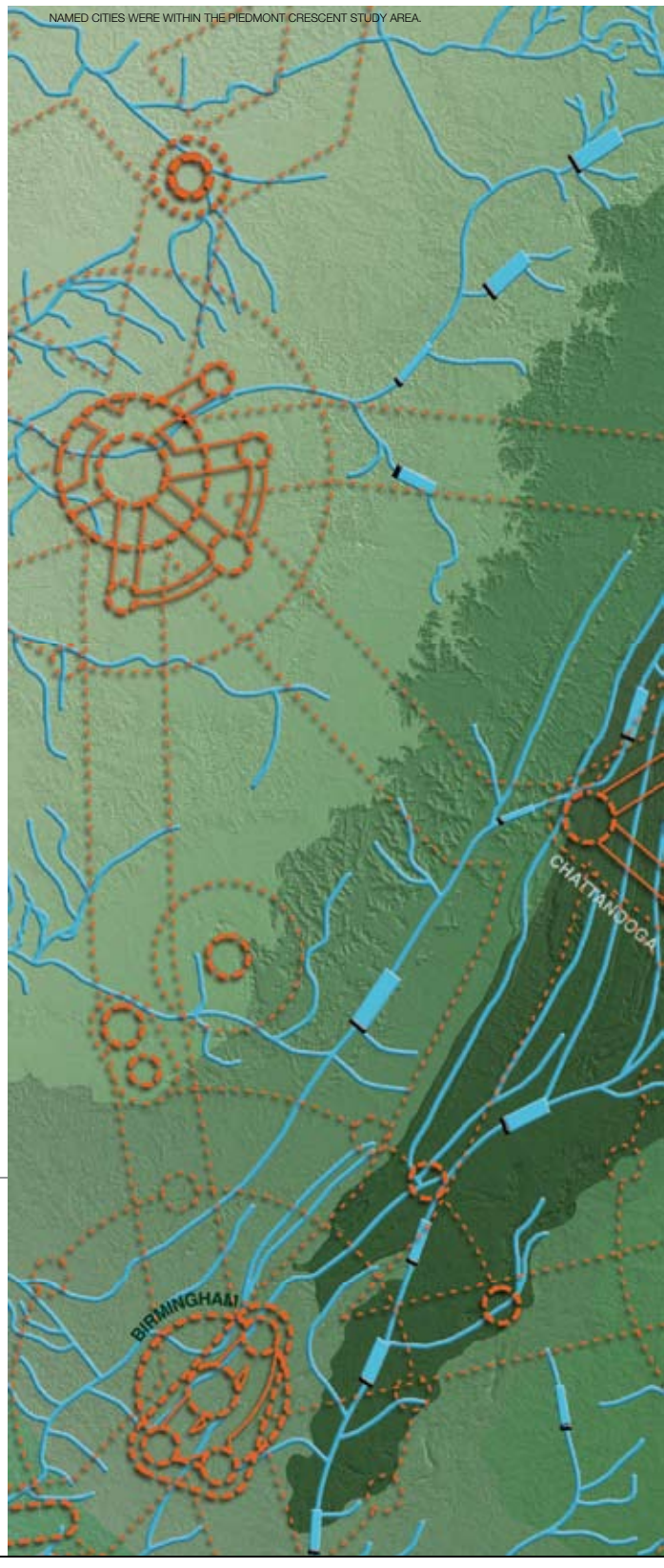
- Manage and understand the Natural System and the Human Network as systems.
- Better manage the Human Network by reshaping its configuration and by using new, more efficient technologies.
- Stabilize and restore the Natural System, making it more resilient.

UNDERSTANDING SYSTEMS. We need new tools to plan, develop and implement co-evolution strategies. Visual language is one of those tools. Based on abstracting data sets and satellite images, each of the two systems can be represented in a single image. By overlaying the two systems' patterns, the human shown over the natural, as in the diagram to the right, we can better understand their relationships. We can understand where the conflicts occur and thereby shape the future of both systems by better managing the relationships between them.

CHARLOTTE, NORTH CAROLINA: BUILDING A MORE EFFICIENT REGIONAL NETWORK



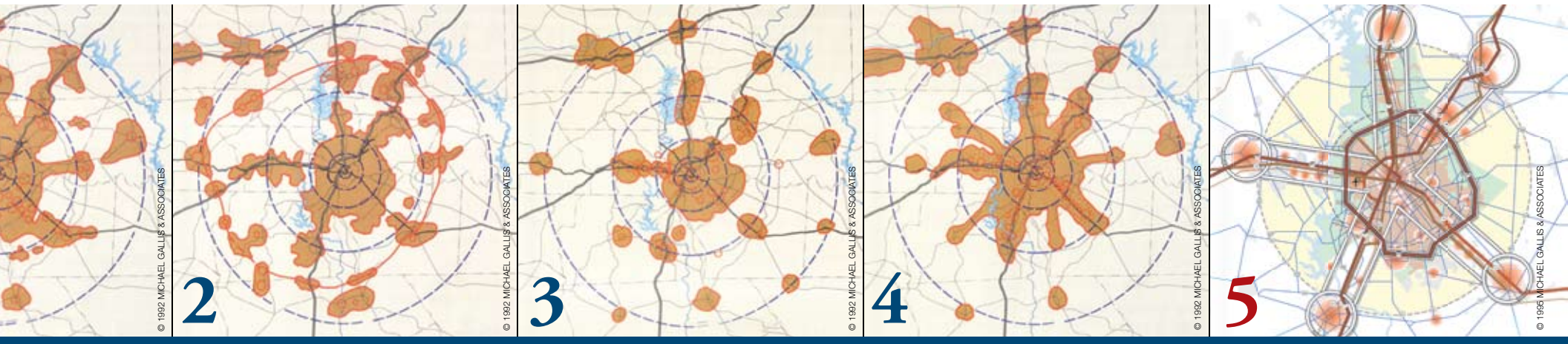
Charlotte 1985: Understanding patterns. The city of Rock Hill commissioned a study to understand its role in the Charlotte metro region. The study revealed that a two-state, seven-county, 33-city metro area had formed around a single dominant center. Five radial corridors connect the center to three concentric rings of smaller regional cities and commercial development centers.



Human Network. Red circles, sized according to densities of population and economic activity, denote urban "centers" of activity. Parallel lines, based on transportation and economic data, show the different types of "corridors" that form urban corridors and connect metro areas.

Natural System. While the Human Network is built in a pattern of points and lines, nature is a continuous fabric—land masses, atmosphere and oceans—filled with flora and fauna. However, "centers" do form: spawning beds, headwaters and wetlands, as well as "corridors," rivers and streams. Shades of green denote topography and different ecoregions.

FRAMEWORK: *n.* an essential supporting structure of a building, vehicle, or object; a basic structure underlying a system, concept, or text. *The New Oxford American Dictionary, 2005*



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

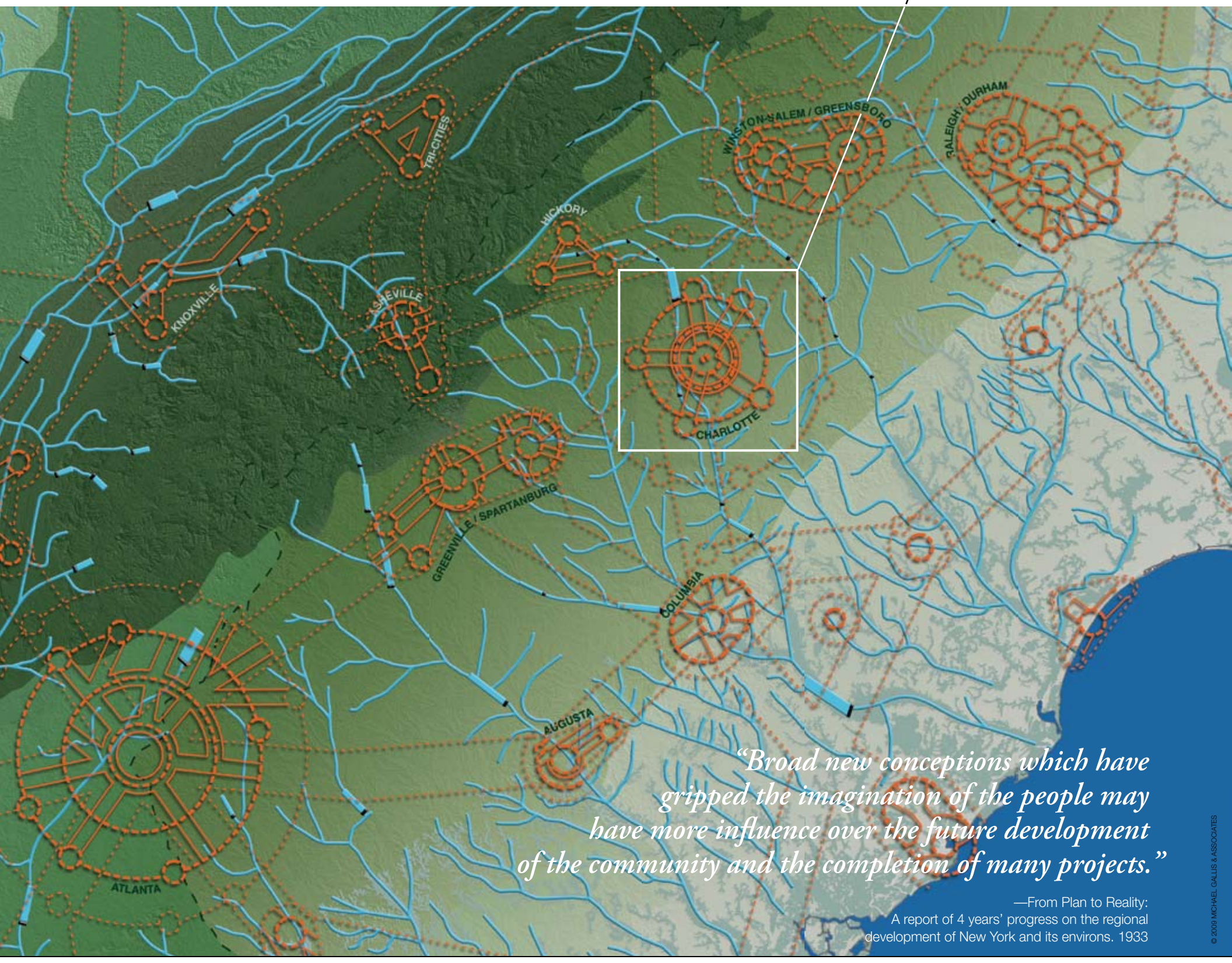
1. "Unplanned": Existing growth trends would produce a shapeless blob sprawling across the region.

2. "Dispersed Growth": Based on a proposal for an outer-outer belt, shown in red, growth would be propelled over an additional 3,600 square miles.

3. "Corridors": Future growth and development would be concentrated in the interstate and major arterial corridors.

4. "Centers": More concentrated future growth development in existing urban centers would be encouraged.

Charlotte 1995: Centers and Corridors. The selected choice, a 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.



"Broad new conceptions which have gripped the imagination of the people may have more influence over the future development of the community and the completion of many projects."

—From Plan to Reality:
A report of 4 years' progress on the regional development of New York and its environs. 1933

CO-EVOLUTION: The term co-evolution is used to describe two systems cohabiting our planet that are reciprocally affecting each others evolution.

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.

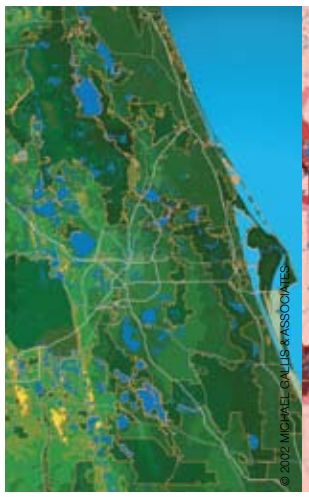
In the last several decades, we have developed a growing appreciation of nature's ordered intricacies—the water cycles, the processes of carbon sequestration and soil formation. We are realizing that nature, rather than being senseless and chaotic, is a highly ordered system that we have only begun to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

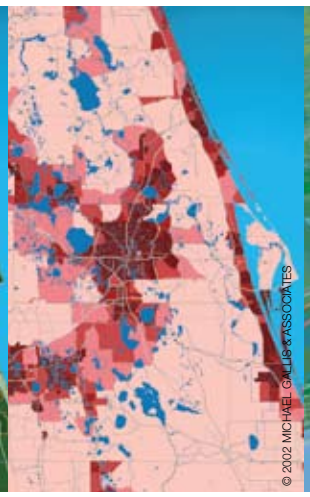
Our metropolitan regions did not spring, fully formed, into being. They grew from centuries of precedents, as the timeline below shows. "Planning" has always been a hard sell in America, where property rights were one of the founders' innovations. As a result, economic forces, rather than planning or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

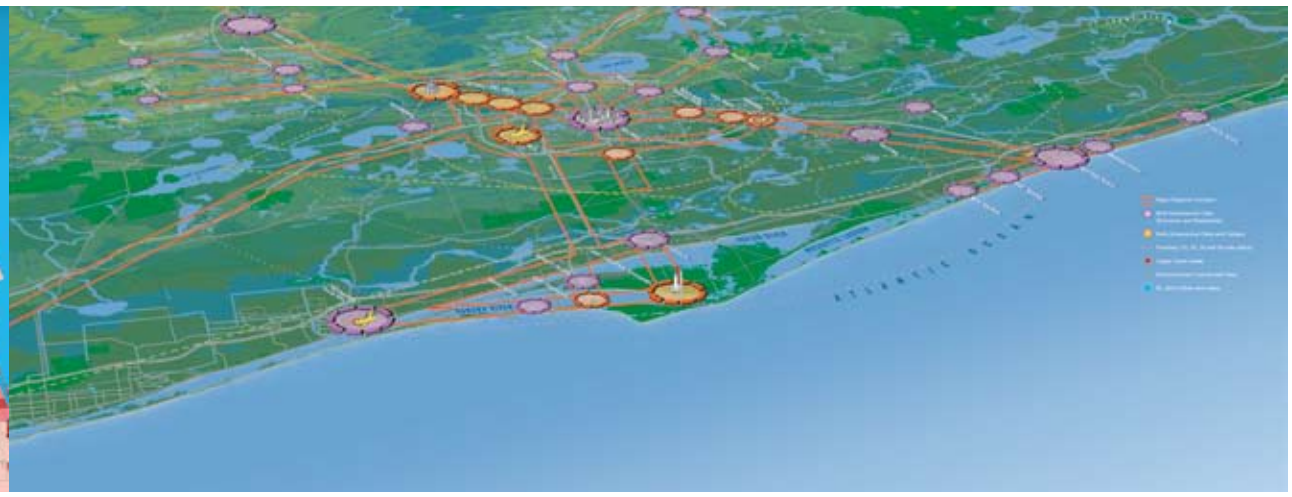
Yet, in some cases, large-scale planning produced very successful results. In 1909, Chicago began to implement the first major plan for an American city since Washington, DC, had been laid out more than a century earlier. Twenty years later, in 1929, New York City took planning one step further, developing 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



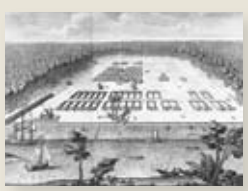




LEFT: The complex pattern of Central Florida's Natural System.
RIGHT: Darker red shows denser population areas, revealing the pattern of Central Florida's Human Network.

Central Florida's Human Network extends over seven counties. Multiple centers cater to winter vacations, sports training, agriculture, tourism and administration. A triangle of corridors connects these centers. This network overlays the nation's most biodiverse region, a complex pattern of rivers, estuaries, swamps and sinkholes teeming with life resulting from the overlap of the tropical and temperate ecologies.

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

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


STARKS W. LEWIS, BROOKLYN MUSEUM ARCHIVES

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


BURNHAM & BENNETT

Plan of Chicago - The nation's first regional plan, before cars and planes changed urban patterns. Uses "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, laying foundation for its rise in the postwar period.

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

PRECEDENT: *n.* an earlier event or action that is regarded as an example or guide to be considered in subsequent similar circumstances. *The New Oxford American Dictionary, 2005*

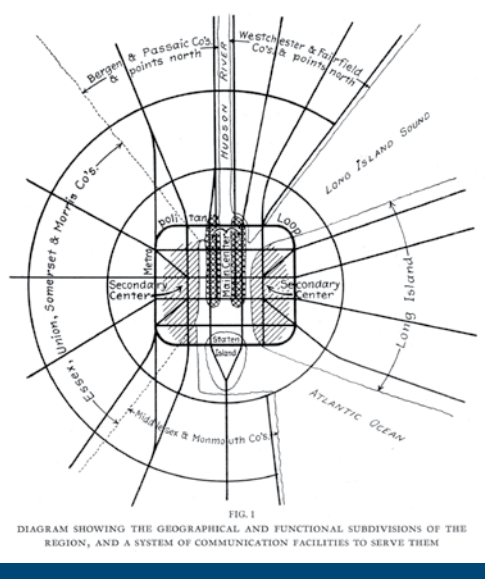
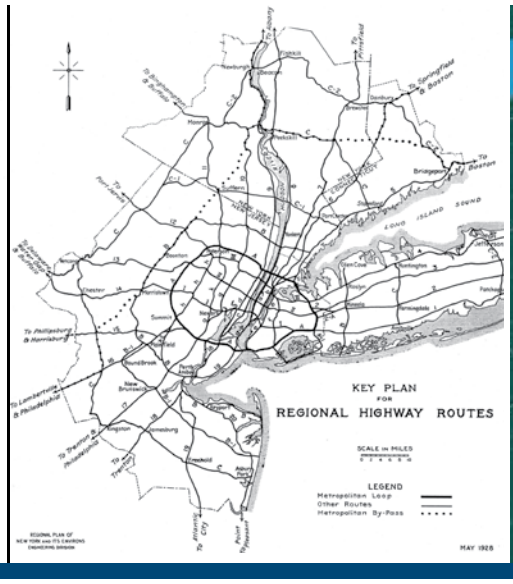
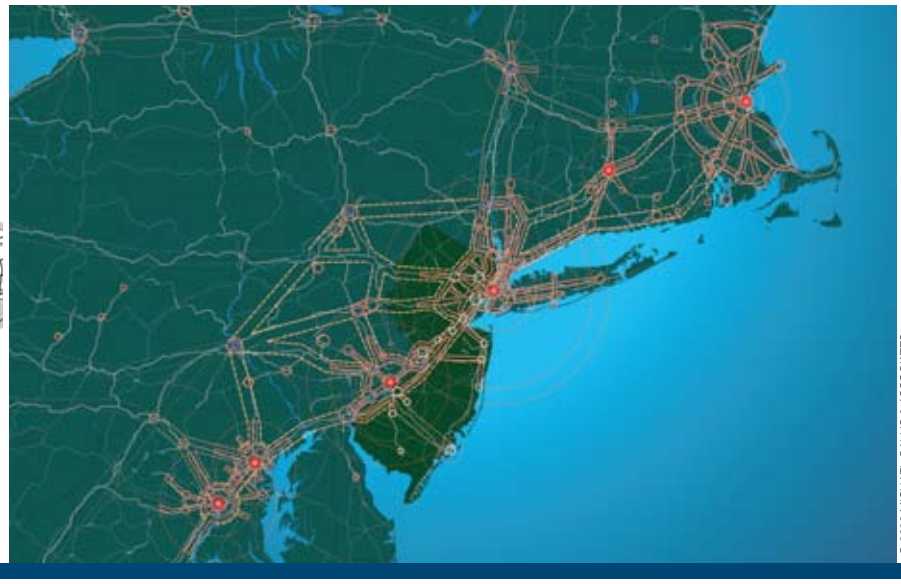


FIG. 1
DIAGRAM SHOWING THE GEOGRAPHICAL AND FUNCTIONAL SUBDIVISIONS OF THE REGION, AND A SYSTEM OF COMMUNICATION FACILITIES TO SERVE THEM





In 1929, on the eve of the Depression, the "Regional Plan for New York and its Environs" was published. The abstract diagram illustrates the proposed pattern of connections necessary to unify the fragmented region and its economy.

Throughout the Depression the construction of the Lincoln Tunnel, Triborough and George Washington Bridges and extensive road network provided the region with extensive economic benefits and system capacity.

Globalization, NAFTA and the impacts of new technologies have transformed the pattern of the Northeast' Human Network. Today, New York is no longer a separate metro area, but an integrated component of a much larger urban and economic network. This massive urban lattice supports 52 million people and stretches from Boston to Northern Virginia across 11 states and as far west as Harrisburg and Scranton, PA.

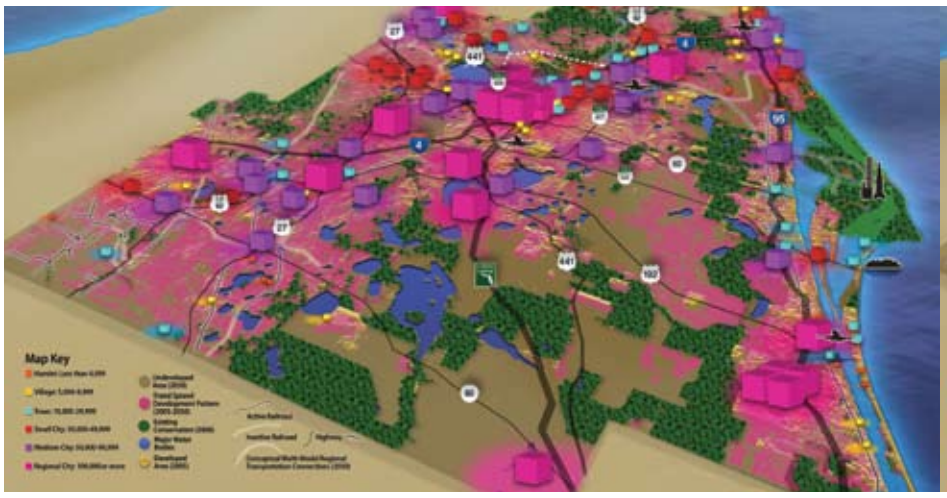
regional strategies. We did so with little understanding of how our network operated, let alone how its growth would affect the environment.

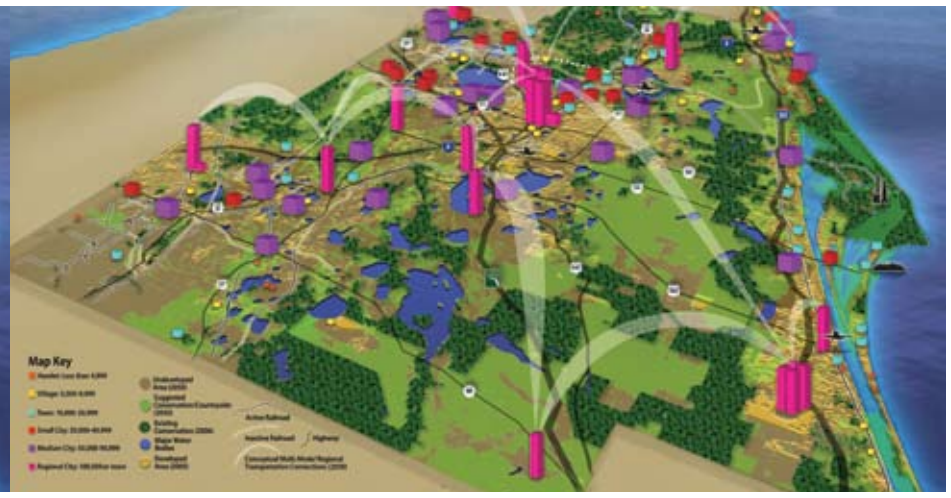
ORLANDO BUILDS AN INTENTIONAL FUTURE. For most of its history, Orlando, FL, could have been a poster child for these macro-trends. Orlando has led the nation in growth for nearly four decades, since Walt Disney World opened in 1971. Once a largely rural region populated by orange farmers and cattle ranchers, 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, funded by businesses and governments and charged 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.org 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 to 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 working to make this vision a reality.





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

One alternative for Central Florida was to let current trends continue. The pink areas 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.

The selected choice, "Centers and Corridors," would concentrate human development 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.

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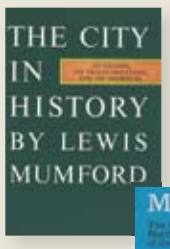
Interstate Highway Act - Approximately 47,000-mile national highway system results, remaking the American city. Shows that national-scale planning can work.

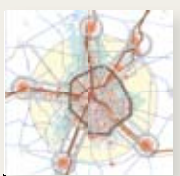


The American Metropolis - Three books appear that profoundly affect the American city: *The City in History* by Lewis Mumford argues against the sprawl and inner city decline that result from the suburban boom. *Megalopolis* by Jean Gottmann raises awareness that growth creates massive, continuous urbanized 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."

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 humans 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

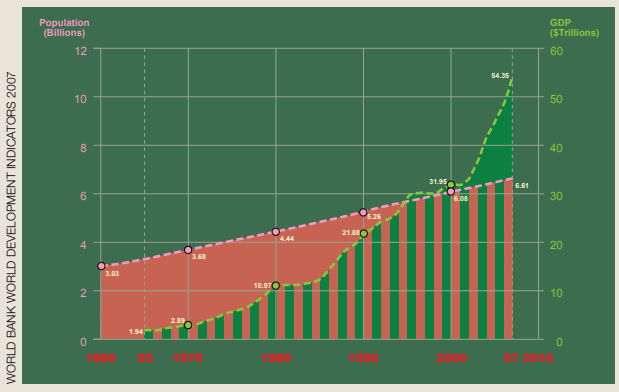
CHOICE: *n.* an act of selecting or making a decision when faced with two or more possibilities; the right or ability to make, or possibility of making, such a selection; a range of possibilities from which one or more may be selected; a course of action, thing or person that is selected or decided upon. *The New Oxford American Dictionary, 2005*

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.

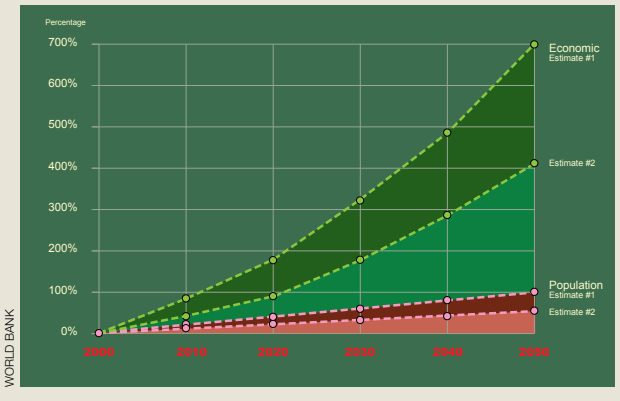
CO-EVOLUTION: 21ST CENTURY

GROWTH IS COMING

The world is not standing still. Population, economic growth and technological change will continue to fuel Human Network's expansion. Not only will this growth cause the Human Network to add new areas to cities, farms and areas of resource extraction, it will restructure and regenerate older areas of development. The increasing demands for energy, resources and land will continue to change the patterns and processes of the Natural System. How we channel this growth and shape the relationship between Human Network and Natural System will be the challenge of the future.



1960-2007 Actual Population and Economic Growth. Economic growth far exceeded population growth from 1960 to 2007. It spiked sharply after 2000, growing from $31 trillion to more than $54 trillion by 2007.



2000-2050 Projected Population and Economic Growth. Projections indicate that population is likely to grow 50 to 100 percent by midcentury. The economy will grow much faster, expanding by four to seven times by 2050.

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 more effective than trying to "save" the environment by focusing on disparate species, ecosystems or single pollutants.

THINK NETWORKS. To sustain the 21st century economy, 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 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 need to create a systems-based framework that results in policy and management structures that foster success. We need programs and financing instruments that support system continuities, rather than fragmenting systems.

LOOK OUTWARD, NOT INWARD. 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, investments and, finally, performance measures to make sure we fulfilled statutory requirements.

Yet within each agency, or each industry, or each business, this institutional structure is a closed circle, a silo, that seldom connects outside itself. Today, the complex pattern of statutes, mission statements, policies, procedures and investments focuses on parts, not wholes; on the function of components, not the function of systems. As a result, we work within a highly fragmented bureaucracy.

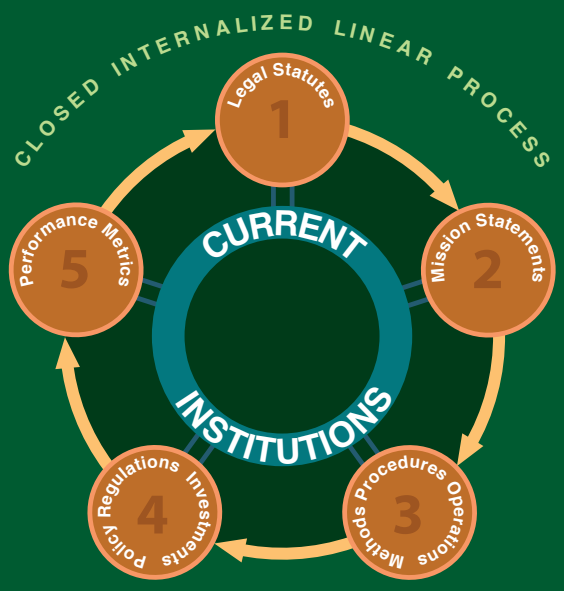
The U.S. has the most complex Natural System of any nation on earth. Major ecoregions shown in color; air currents in dotted lines.

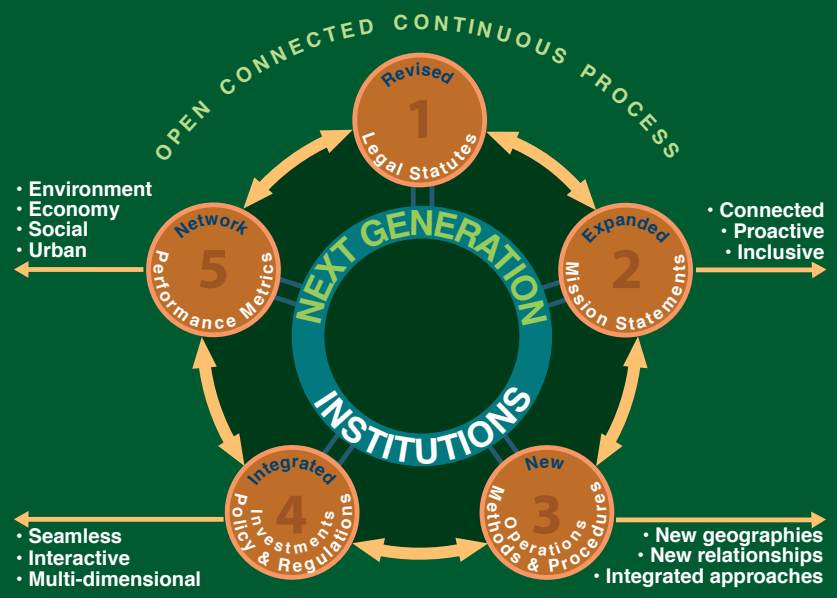
TWO SYSTEMS: ONE NATION

North America supports the most diverse assemblage of plants, animals and ecosystems in the world. Of the world's 15 "bioregions," the Continental U.S. has 11. (China has nine; Russia, eight.) Very different patterns and processes characterize each of America's large-scale ecoregions. Southwest deserts support flora, fauna and natural cycles that have little in common with the Southeast's temperate broadleaf forests. Yet our policies have been "one size fits all," rather than addressing the function of each ecoregion.

North America also has developed one of the world's most unique Human Networks. Our economic centers are widely distributed, located in very different ecoregions. The grid to connect them crisscrosses the continent. Many

PROJECT: *v.* 1. estimate or forecast (something) on the basis of present trends; plan (a scheme or undertaking). *The New Oxford American Dictionary, 2005*





Current Institutions. We developed our institutions to facilitate components—roads or transit, clean air or endangered species—rather than the larger systems of which they are a part—transportation or the environment. Each institution is a closed circle. It neither coordinates with the components of its own system, nor with the activities of other systems.

Next Generation Institutions. 21st century institutions must be based on systems and focus on enhancing integrated system level performance. We must understand that each system—transportation, environment, economy and all the others—affect each other. Then we can create patterns and processes that reinforce one another, rather than conflicting with each other.

This inward-looking silo structure sets us up for failure. A fragmented system produces more friction, requires more energy, wastes more resources and reduces performance.

NEW MISSION STATEMENT. We need to change our mission statement for success in the 21st century. This will demand fundamental shifts:

- This new mission will require agencies and businesses to look outward, rather than inward.
- It will encourage interactive and interdimensional policies and procedures.

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

POLICY IMPLICATIONS

Implementing co-evolution will require fundamental policy changes.

1. NEW POLICY FRAMEWORK

- Based on system performance, and an understanding of how systems operate and interact.
- Integrated regional and national policies for growth, development and environmental function.

2. NEW MANAGEMENT STRUCTURES

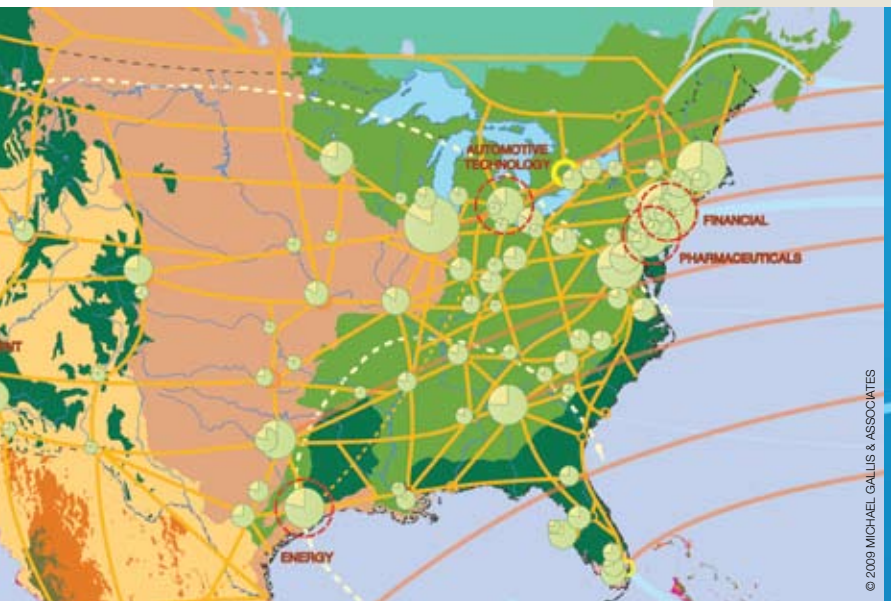
- Reduce fragmentation; eliminate duplication and overlap.
- Encourage coordination and cooperation to create integrated management on a systems basis.
- Streamline permitting and regulatory procedures to encourage efficiency and competitiveness.

3. NEW FINANCIAL STRUCTURES

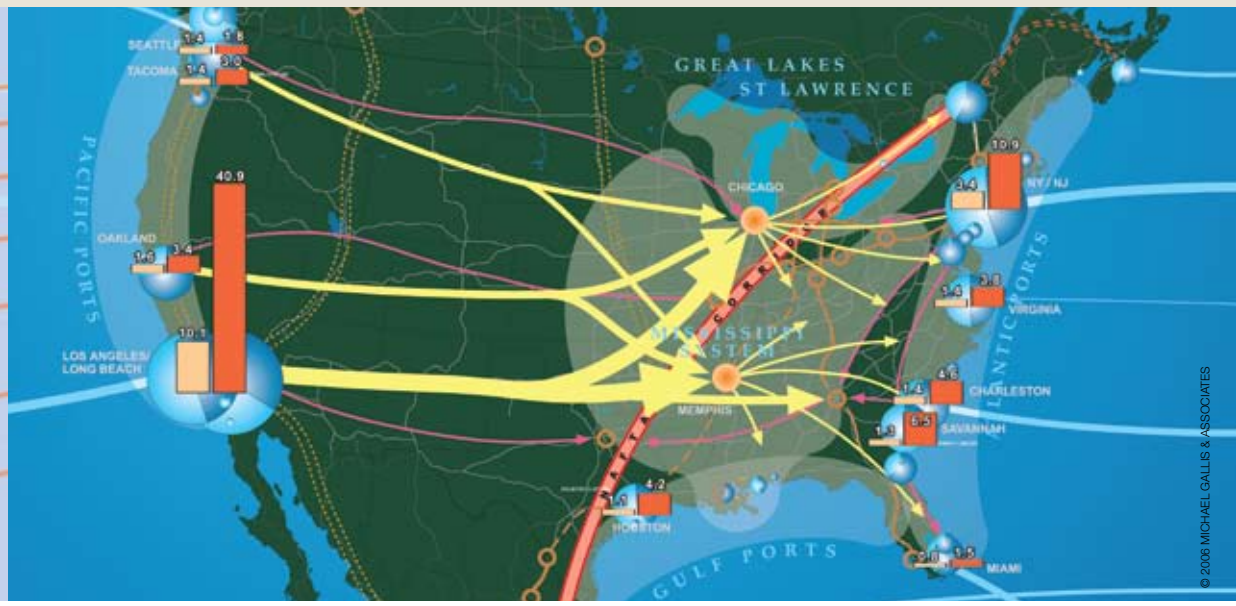
- Build system-level performance incentives to encourage interagency and interdepartmental cooperation.
- Create a reward structure that emphasizes system-wide performance.
- Provide incentives for communities and regions to cooperate.

4. NEW PROGRAMMATIC STRUCTURES

- See programs as pieces of larger. systemic wholes.
- Eliminate program duplication to promote systemic integration.
- Break down silos to reposition programs within a systems framework.



The Human Network of the U.S. developed around large metropolitan areas linked by corridors that form a continental grid. Air and sea routes connect globally.



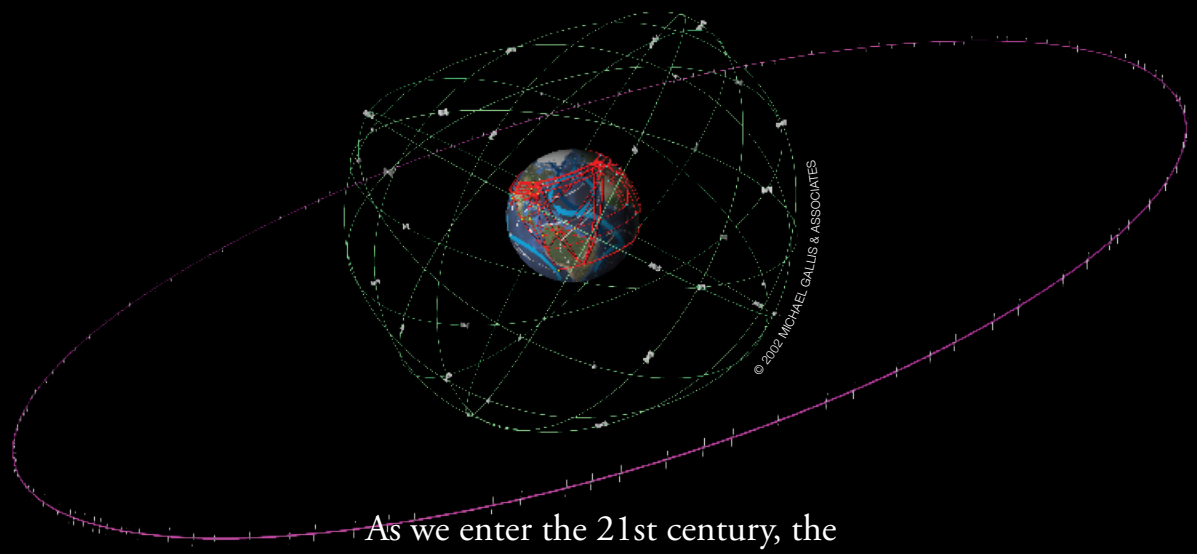
Projected pattern of port and trade expansion that will reshape the U.S. driven by the increasing levels of international trade and the demands of population and of urban and economic growth to 2020.

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 finance and so on—is unique, with different infrastructure patterns and needs. 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 private sector economic forces. The U.S. has 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.

REALITY: *n.* 1. the world or the state of things as they actually exist, as opposed to an idealistic or notional idea of them; a thing that is actually experienced or seen, esp. when this is grim or problematic. *The New Oxford American Dictionary, 2005*



As we enter the 21st century, the
Human Network covers the surface of the earth,
extending deep beneath the oceans and more than 23,000 miles
into space. This network is now de-evolving the Natural System, resulting in
unpredictable, destructive patterns. Can we create and implement a new framework
—Co-Evolution—that resolves the conflicts, supporting both humans and ecosystems?

CO·EVOLUTION

A New Systems Framework to Shape the 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 limited. Today, it is global and systemic. The Natural System is reacting 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 global de-evolution. 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. Co-Evolution provides a framework for systems thinking and planning at large scales.

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Mixed Sources

Printed on recycled paper including 25% post-consumer waste using vegetable-based ink.

SPONSOR

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First Printing 2009, rev 1

ISBN # 978-0-615-29386-8

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