CHAPTER 06

NATURAL SYSTEMS

THE CITY OF LAKEWOOD and its residents recognize the value of healthy ecosystems and rich biodiversity, which provide critical services that support our community's environmental, economic, cultural, physical, and mental health. Lakewood envisions a future where nature at all scales and its benefits are valued, conserved, enhanced, and responsibly managed, sustaining a resilient and thriving community.

GOALS

- Mitigate the negative effects of the built environment and human behavior on Lakewood's natural systems to ensure biodiversity and enhance ecosystem services.
- Enhance Lakewood's resilience to the impacts of climate change using green infrastructure and ecosystem-based adaptation.

TARGETS

- Increase the acreage of functional and healthy natural ecosystems (Specific target to be established after the completion of Implementation Strategy NS1-C).
- Ensure that all waters within Lakewood meet or exceed the Colorado Department of Public Health and Environment's Water Quality Standards for the uses assigned.
- Achieve tree canopy coverage of 30 percent by 2025.

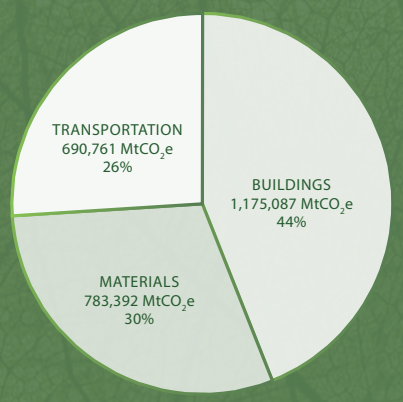
NATURAL SYSTEMS: GREENHOUSE GAS EMISSIONS REDUCTION POTENTIAL

BASELINE		
EMISSIONS BY SECTOR – MT CO_2E		
BUILDINGS	1,175,087	44%
MATERIALS	783,392	30%
TRANSPORTATION	690,761	26%
TOTAL GHG	**2,649,240**	**100%**

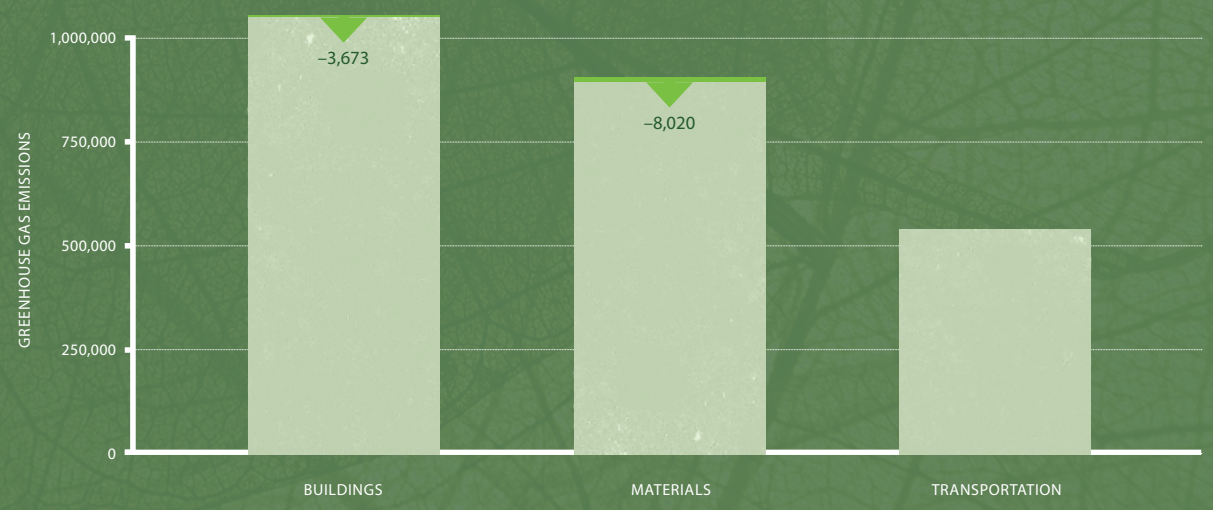
2025 BUSINESS AS USUAL (BAU)			
EMISSIONS BY SECTOR – MT CO_2E			CHANGE
BUILDINGS	1,053,368	42%	– 121,719
MATERIALS	903,600	36%	+ 120,209
TRANSPORTATION	539,165	22%	– 151,596
TOTAL GHG	**2,496,133**	**100%**	**–153,107**

2025 AFTER NATURAL SYSTEMS STRATEGIES ARE IMPLEMENTED			
EMISSIONS BY SECTOR – MT CO_2E			CHANGE
BUILDINGS	1,049,695	42%	– 3,673
MATERIALS	895,580	36%	– 8,020
TRANSPORTATION	539,165	22%	0
TOTAL GHG	**2,484,440**	**100%**	**– 11,693**

2007 BASELINE EMISSION BREAKDOWN



IMPACT OF NATURAL SYSTEMS STRATEGIES ON 2025 BUSINESS AS USUAL (BAU)



NATURAL SYSTEMS ARE THE FOUNDATION OF A HEALTHY AND SUSTAINABLE COMMUNITY.

OUR ECONOMIC AND SOCIAL STABILITY relies on functioning ecosystems for food, energy, clean air and water, aesthetic value, and other natural products and processes. These ecosystems include collections of species, habitats, and the interactions between the two. Maintaining biological diversity (biodiversity) is essential to ecosystem health and ensures that we retain our natural heritage.

When our natural systems are functioning correctly, we receive a myriad of benefits that enable us to meet our present and future needs. These benefits, known as ecosystem services, can be categorized into four types:

- **Provisioning services** are the material and energy outputs from ecosystems. Examples include food, water, and medicine.
- **Regulating services** are the results of ecosystem processes that regulate climate and soil erosion; protect air, water, and soil quality; moderate extreme weather events; facilitate pollination; and control pests and diseases.
- **Cultural services** are the aesthetic, spiritual, intellectual, and physical benefits we receive from nature, including recreation, ecotourism, inspiration, and sense of place.
- **Habitat or supporting services** make all other ecosystems services possible by creating a place for species to survive and maintaining genetic diversity.

Unfortunately, our natural systems' health and critical functions have been severely affected and face increasing threats and pressures. Population growth and development has resulted in habitat loss and habitat fragmentation, which isolates species and prevents the flow of genetic material between populations. High levels of nitrate and phosphorous pollution from sources like sewage and agricultural runoff, leaching of heavy metals and plastics from common waste streams, and spraying of chemicals like herbicides and pesticides all increase the toxicity in our soils, water, and air. Invasive species outcompete native plants and animals, significantly altering the intricate interactions and relationships that took millennia to evolve. As if all of these threats weren't enough, changes in climate have resulted in an additional layer of stress on biodiversity and ecosystem health.

These threats to our natural systems have serious implications for the future of our cities and our world. Disrupted and damaged ecosystems affect our ability to continue living healthy lives. The impacts of these collective threats are evident by the current rate of global species extinction, which is estimated to be 1,000 to 10,000 times higher than the rate of extinction across our planet's history. Climate change is expected to worsen this trend, potentially resulting in the extinction of 25 percent or more of all species on land by 2050.[1] When

These threats to our natural systems have serious implications for the future of our cities and our world.

ECOSYSTEM SERVICES

Natural ecosystems perform fundamental life-support services upon which human civilization depends. There are four categories of ecosystem services: provisioning, regulating, cultural, and supporting. Learn more about ecosystem services on page 126.

PROVISIONING

Material or energy outputs from ecosystems that benefit people

Food
Fiber
Medicine
Fuel
Dye, Wax, Resin, Oil

REGULATING

Benefits provided by ecosystem processes that moderate natural conditions

Air Purification
Water Purification and Storage
Decomposition
Pollination and Dispersal

CULTURAL

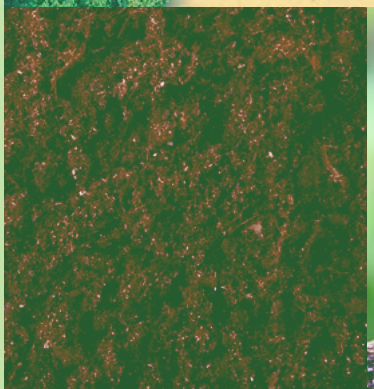
Nonmaterial benefits that contribute to the development and cultural advancement of people

Beauty
Spirituality
Behavior

SUPPORTING

Natural processes that sustain ecosystems and associated benefits

Soil Formation
Habitat
Biological Diversity
Nutrient Cycling



BIODIVERSITY

When we lose a gene or species, we lose it forever.

we lose a gene or species, we lose it forever, and along with the loss of each species, we lose the contribution or services that it provided. For example, services from bees and other pollinators affect one-third of the human food supply.[2]

Incorporating biodiversity and ecosystem considerations into our policy and planning is critical to protecting and restoring our natural systems. Rich biodiversity not only can exist in cities, but also help cities thrive. When we take a holistic approach to our natural, economic, and social systems, we can create a sustainable future for everyone.

TRENDS AND OPPORTUNITIES

URBAN LAND STEWARDSHIP

We use our land to produce food, aesthetic value, and recreational activities. Lakewood's large lots, neighborhood parks, and abundance of open space give residents of all backgrounds an opportunity to utilize and enjoy the land. However, the common use of pesticides and herbicides can have severe impacts on human health, flora, and fauna. Recognizing that the use of chemicals to control invasive weeds and public health related pests is often the most practical and effective management tool, their use should be evaluated and reduced where possible. One example of the negative impacts associated with the use of pest control chemicals is the damage caused by neonicotinoids on pollinator species. Neonicotinoids, one of the most widely used classes of insecticides in the world, are systemic, persistent neurotoxins that spread throughout a treated plant including to the pollen that is gathered by pollinators. A review of more than 800 scientific studies concluded that neonicotinoids are causing significant damage to a wide range of beneficial invertebrate species and are a key factor in the decline of bee populations. In response to this threat, several communities have banned neonicotinoids and increased awareness on the severe, unintended consequences of pesticide and herbicide use.

Increasing awareness and sharing best practices can help communities manage their land in responsible and productive ways. Ecological stewardship can be practiced at all levels, including individual residences. Backyard gardens can accommodate significant biodiversity with the proper shelter, food, and water. In a study of 61 gardens, researchers found more than 4,000 species of invertebrates, 80 species of lichen, and more than 1,000 species of plants.[3] By understanding our land and the web of life it supports, we can become good stewards of our landscapes and our earth.

RESTORING AND RECONNECTING

Habitat loss is the no. 1 threat to biodiversity[4] and is steadily increasing with the rapid growth of cities and mismanagement of existing lands. Patches of isolated habitats prevent the movement of species and genetic variation. In order to reverse this trend, we must restore and reconnect habitats throughout the urban environment. This includes protecting large patches of habitat that provide shelter for species that are less tolerant of human activity, restoring connectivity between habitats to facilitate the movement of species, and providing a variety of habitats to preserve biodiversity.

By understanding how our land and the web of life it supports, we can become good stewards of our landscapes and our earth.

Restoration and connectivity not only ensures healthy ecosystems and biodiversity, but also enhances ecosystem services. By increasing the scope of our natural systems, we are cleaning our air and water, providing opportunities to produce food and medicine, and creating an environment that supports mental and physical health.

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[1] Eric Chivian and Aaron Bernstein. "How Our Health Depends on Biodiveristy." Center for Health and the Global Environment. Harvard Medical Center. 2010.

[2] T. Tscharntke. "Global food security, biodiversity conservation and the future of food security and sustainability in a changing world." FAO: 2011.

[3] UNEP & UN-HABITAT. "Ecosystems and Biodiversity The Role of Cities." Nairobi, 2005.

[4] City of Surrey. "Biodiversity Conservation Strategy." January, 2014.

CLIMATE ADAPTATION

In recent decades, Colorado has experienced increases in extreme heat, large wildfires, flooding, and drought. As our state and other communities across the world prepare for the effects of climate change, many are choosing to use ecosystem services to adapt. The capacity of our natural landscapes to store and filter stormwater can be applied to our urban environment through rain gardens, permeable pavements, bioswales, and simply increasing urban vegetation. Many of these features also serve to reduce urban temperatures and reduce carbon in the atmosphere. The metro Denver urban forest saves residences $21.8 million in cooling costs each year,[5] and a healthy tree can store 13 pounds of carbon each year. Collectively, these features are called "green infrastructure" and can be incorporated into our built infrastructure in order to help us successfully prepare for climate change. ■

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[5] E. Gregory McPherson, et al. "Metro Denver Urban Forest Assessment." March 28, 2013.

GOAL **NS1**

MITIGATE THE NEGATIVE EFFECTS OF THE BUILT ENVIRONMENT AND HUMAN BEHAVIOR ON LAKEWOOD'S NATURAL SYSTEMS TO ENSURE BIODIVERSITY AND ENHANCE ECOSYSTEM SERVICES.

TARGETS

- Increase the acreage of functional and healthy natural ecosystems. (Specific target to be established after the completion of Implementation Strategy NS1-C).
- Ensure that all waters within Lakewood meet or exceed the Colorado Department of Public Health and Environment's Water Quality Standards for the uses assigned.

OBJECTIVES & INDICATORS

- **OBJECTIVE:** Protect, restore, and enhance ecosystem health and biodiversity throughout Lakewood's natural and built environments.
  - INDICATOR: Acreage of land cover by habitat type
  - INDICATOR: Acres of Colorado List A noxious weed species on cityowned property
  - INDICATOR: Population counts of key indicator species
- **OBJECTIVE:** Minimize the volume of pollutants entering Lakewood's terrestrial and aquatic ecosystems.
  - INDICATOR: Number of developments that have installed or retrofitted BMPs to improve water quality
- **OBJECTIVE:** Facilitate communitywide stewardship of Lakewood's natural heritage and biological diversity.
  - INDICATOR: Number of environmental education programs and outreach events
  - INDICATOR: Attendance at Lakewood's annual Earth Day Celebration

CONCEPT

ECOSYSTEM SERVICES

BY KEN BAGSTAD, U.S. GEOLOGICAL SURVEY

AT THE U.S. FOREST SERVICE regional headquarters in Lakewood, a forest manager spreads out a map of the Pike-San Isabel, White River, and Arapaho-Roosevelt National Forests. Most of us only think about the forests when we're driving to the mountains for a ski trip, taking the kids to go hiking or camping, or pausing for a moment to admire the mountains from a distance. But today, let's think about fire and water. Here in a dry state like Colorado, these can quite literally be a matter of life or death, prosperity or ruin.

Forest fires are costly. Along with lost life and property, health effects from smoke, and the costs of firefighting, there are risks to our drinking water supplies. The 2002 Hayman Fire, southwest of Denver, burned nearly 140,000 acres — an area five times the size of Lakewood. On slopes where trees burned, soil and debris flowed into Cheesman Reservoir, and Denver Water spent more than $41 million to dredge the reservoir and keep it functional — costs that were passed on to their customers. Today, Denver Water and the Forest Service are getting proactive. There are maps that show areas around the reservoirs that are most important to keeping the reservoirs sediment-free. By charging each water user a nominal fee, Denver Water is raising $16.5 million over five years, which will be matched by the Forest Service to thin forests in these water supply protection zones, reducing fire risks and the potential for costly dredging in the future. So, in this example, the value of a healthy forest is at least $33 million. Economists call programs like this "payments for ecosystem services," and in everyday terms it's a classic example of paying for an ounce of prevention today to avoid the cost of a pound of a cure tomorrow.

Nature provides value to people in many ways. It can supply clean air and water, protection from flooding and other natural disasters, pollination for our crops, and recreational, educational, therapeutic, and spiritual benefits. Ask one person about the value of nature, and they may tell you that nature has no value because it has no price tag. Ask another, and they might say that it is impossible, undesirable, or unethical to value nature. But we know that without natural resources as inputs to the economy and places to put the waste products of economic production, our economy would quickly grind to a halt. In mountain towns across the state, outdoor recreation provides a critical economic engine, adding $34 billion in economic activity per year to the state's economy. In cities, trees add property value for homeowners, reduce summer air conditioning bills, and filter air and water pollution. In addition, nature provides many less tangible values — places to disconnect from an increasingly fast-paced world, to meditate or find spiritual peace, to pass on outdoor skills and traditions from parent to child, even for psychological therapy and healing for returning veterans seeking nonthreatening environments or inner-city children experiencing wild nature for the first time.

For an economist then, the truth of how to value nature lies somewhere between the extremes of valueless and priceless. Like any economic good or service, something becomes more valuable as it gets scarcer. Today nature provides value to 5.2 million Coloradans and 7.2 billion people around the world. And in a globalizing world, connections matter. The choices we make in managing Colorado's forests affect water users in 13 downstream states (1 in 10 Americans), while choices made in coastal states to protect wetlands, dunes, and coral reefs can reduce the cost of natural disasters that are borne by all U.S. taxpayers. Meanwhile, economics, environmental science, satellite mapping, and computing technology are providing the technical tools scientists need to more accurately map and value nature's contributions to society's well-being. Public awareness of nature's importance to economic prosperity and community well-being are growing, and new policies to value and protect nature's economic benefits are being tested and developed in communities around the country and world. As we learn to build the value of nature into everyday economic decision-making, economic development strategies are emerging that protect a high level of economic and environmental quality.

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Bio: Ken Bagstad, PhD, is a research economist working with the U.S. Geological Survey at the Denver Federal Center in Lakewood. His work focuses on mapping and valuing how nature provides economic and cultural values to people. He has worked with communities, state governments, federal agencies, and international organizations (https://profile.usgs.gov/kjbagstad). ■

LEARN MORE ABOUT ECOSYSTEM SERVICES:

http://www.usgs.gov/climate_landuse/lcs/projects/ecosys_val.asp
http://www.fs.fed.us/ecosystemservices

IMPLEMENTATION STRATEGIES

NS1-A CULTURE OF ECOLOGICAL STEWARDSHIP

Facilitate communitywide stewardship of Lakewood's natural heritage by advancing understanding of the importance of biological diversity and the value of ecosystem services. Specifically:

- Continue to provide environmental education programs for residents of all backgrounds and ages;
- Identify opportunities for interpretive signage and on-site messaging in Lakewood's parks, natural areas, and other appropriate public spaces;
- Integrate environmental education into community events like Earth Day, Cider Days, and the annual Community Resources Plant Sale;
- Develop resources and tools that enable residents to share ecological stewardship concepts and programs with neighbors, employers, and co-workers; and
- Recognize efforts of residents, businesses, and organizations demonstrating stewardship of Lakewood's natural systems.

NS1-B LANDSCAPE AND AGRICULTURAL STEWARDSHIP

Reduce the impacts to ecosystem health, air and water quality resulting from landscaping and agricultural practices in Lakewood. Specifically:

- Increase resident awareness of the impacts associated with the use of chemical fertilizers, pesticides and other toxins on pollinator species and overall ecological health through education and outreach, including promoting alternatives;
- Consider enacting policies or regulations that limit the use of systemic persistent neurotoxins linked to significant declines in critical invertebrate species and pollinators;
- Work with the Colorado State Cooperative Extension and other organizations to develop urban agriculture stewardship standards including pest and invasive species management and animal waste management techniques;
- Encourage the use of "cover crops" during off season to reduce soil erosion and improve aesthetics; and
- Address the impact of open burns on air quality and public health through outreach and education. Consider adopting regulations to address the size, frequency, and timing of private open burns in the city.

NS1-C BIODIVERSITY INVENTORY, CLASSIFICATION, AND BEST MANAGEMENT PRACTICES

Identify natural habitat types in the city and establish management areas based on land-use context. Specifically:

- Inventory and map land-use cover and habitat types;
- Identify and count indicator species on an ongoing basis to monitor change over time. Host or support an annual "bioblitz" to conduct species counts. Consider opportunities such as the Audubon Society annual Christmas Bird Count;
- Establish management areas with consideration of habitat types, biodiversity value, current and potential future land use, level of human disturbance, restoration potential, level of fragmentation, and vulnerability to natural hazards;
- Maintain a database and map of management areas that include data on habitat type and size, ownership information, and potential restoration opportunities and constraints; and
- For each management area, develop restoration guidelines, best management practices, site development recommendations or standards with the intent of effectively managing and restoring habitat and biodiversity.

GARDEN FOR WILDLIFE: A SUSTAINABLE THING TO DO IN THE CITY

BY THOMAS SLABE, EIBER NEIGHBORHOOD

THE CITY OF LAKEWOOD is a great place to live for a host of reasons, including, but not limited to, a responsive city government, a healthy economy, copious amenities, world-class cultural and recreational opportunities, and local natural areas. Those natural areas are largely protected public lands now. But they are fragmented and surely not as wild as they once were. Some natural areas even to this day are being converted into housing or other kinds of developments. It goes without saying, then, that built-up environments exist at the expense of the city's wildness.

The good news is that there is something that each one of us can do to help wildlife within the city. And by helping wildlife you are also helping yourself and people around you. Why is that? Because, for one matter, wildlife is part of the natural heritage of the region. Wildlife, especially native plant and animal species, is what helps to make this place what it is — a high plains, prairie ecosystem. This ecosystem sustained itself somewhat uniformly over many millennia. But in recent times, starting a little over 150 years ago, wildlife habitat has become radically altered due to ongoing population increases and changing land-use patterns. Preserving remaining fragments of wildlife habitat is critical to our long-term sustainability.

Taking efforts to preserve our natural heritage is important. We obviously cannot bring back conditions in which the region's original Native American tribesmen were found hunting the bison. But we can preserve small fragments in wildlife gardens that have their origins rooted back to a time when Colorado was truly wild.

Wildlife gardens are many things to many people. They may be a single rabbit bush or a cottonwood tree or a rehabilitated short grass prairie. Wildlife gardens are forever changing and offer a level of complexity that the human mind craves. Our brains thrive on complexities, including different textures, odors, and colors that change with the seasons, and the various surprises one regularly encounters in their wildlife habitat, like the precision aerobatics of a dragon fly divebombing gnats and mosquitoes or the chance visit from a Western Tanager at the birdbath. We must cultivate "wildness" in today's day and age because wild areas are vulnerable to multiple threats such as pesticide applications, infestation from species on Colorado's noxious weed list, or ongoing development.

Just four elements are required for a wildlife garden:
1. Cover 2. Water 3. Food and 4. Places to rear young.

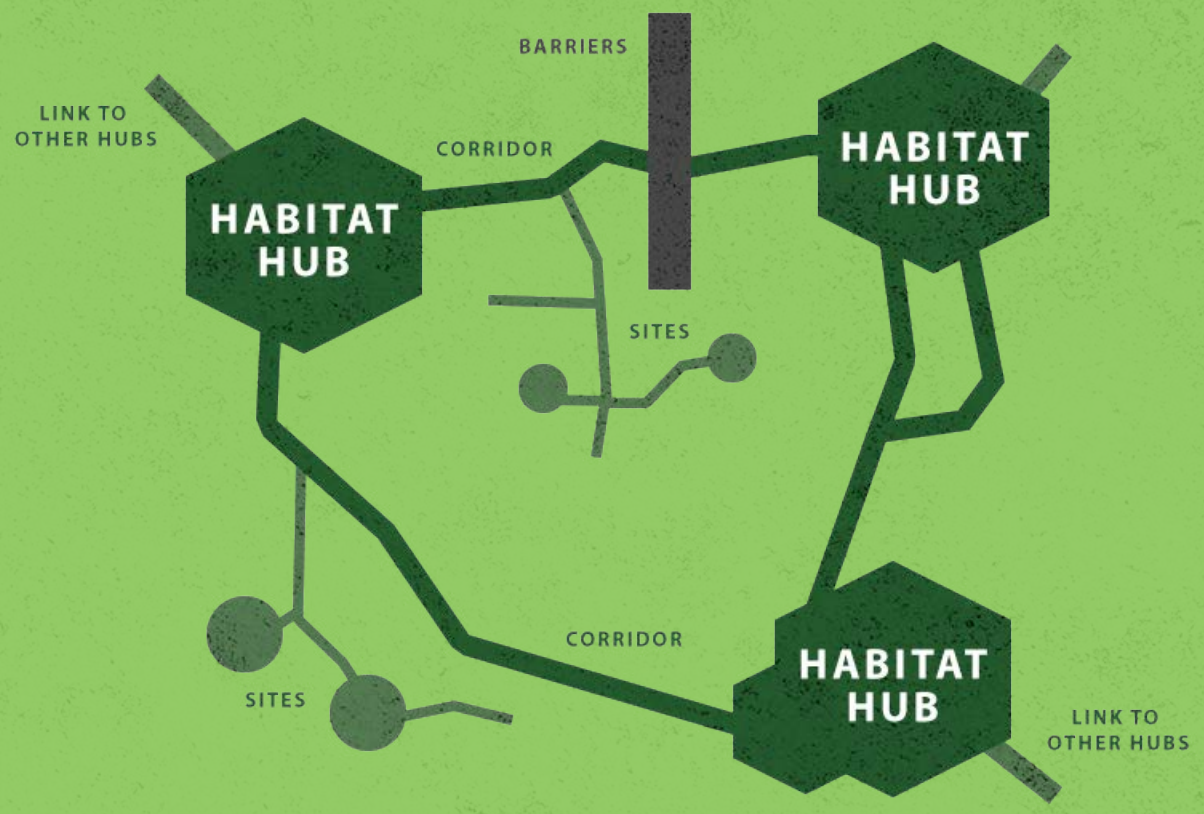
Gardening for wildlife in my yard has naturally reduced the numbers of pests, like aphids, while visibly increasing the numbers of beneficial animals living in and visiting the habitat — such as hummingbirds, ladybird beetles, and lacewings. Insect pests are naturally fecund, which means they reproduce rapidly, and as such they are meant to be food for other species. This is just one other of the multiple reasons why wildlife habitats are important and beneficial.

Gardening for wildlife is simply what you make of it. It can range from a simple, affordable, relaxing diversion to a major landscape restoration/design and implementation project. It simply depends upon your intention. You can garden for wildlife on the balcony, in a small grotto or nook in your yard, or, perhaps, at the neighborhood elementary school you may create a schoolyard habit.

Just four elements are required for a wildlife garden: 1. Cover 2. Water 3. Food and 4. Places to rear young. When you garden for wildlife you most likely are providing cover, food, and places to rear young with the plants you choose to grow in the habitat. So what's left is to maintain a regular supply of water. Adding accessories, such as bird feeders, pollinator houses, logs, brush piles, rocks, and suchlike, is desirable but not required. The intent above all is to be aware of the importance of gardening for wildlife and to appreciate and enjoy the habitat you have created. The activity is as good for the soul and for one's mental perspective as it is for the wildlife and your community.

So, grow some "wild" on your balcony or in your yard or in your neighborhood schoolyard. You can access a wealth of information on the National Wildlife Foundation (NWF) website. For those who are so inclined, you may wish to join ranks with the approximately 176,000 others who have created NWF certified wildlife habitats to "protect wildlife for our children's future." It is up to us to turn the corner now and be better stewards of Earth's biosphere, starting in our very own neighborhoods. ■

LAKEWOOD GREEN INFRASTRUCTURE NETWORK



DEFINITIONS

- **HABITAT HUB**: Parks and other large areas of natural area
- **SITE**: Backyard gardens, pocket parks, and other small patches of habitat
- **CORRIDOR**: Gulches and other connections between hubs and sites
- **BARRIER**: Highways and other interruptions to connectivity

NS1-D GREEN INFRASTRUCTURE NETWORK

Establish a Green Infrastructure Network (GIN) to strategically facilitate habitat protection, restoration, and connectivity across the urban landscape. Specifically:

- Identify potential habitat hubs (large intact areas of habitat), sites (smaller patches of habitat), corridors (connections between hubs and sites), and connectivity barriers like road crossings;
- Prioritize key GIN elements for acquisition and preservation;
- Develop financing strategies for land acquisition for priority GIN elements;
- Identify ways to protect existing GIN elements on private property through various tools and resources including development standards, conservation easements, and technical support; and
- Assess opportunities and develop strategies to reduce barriers to movements including fencing and roadways.

CITY SPOTLIGHT

LAKEWOOD'S NATURAL SYSTEMS AND REGIONAL PARKS

THE CITY OF LAKEWOOD manages thousands of acres of open space and natural areas within the city boundaries that serve as important wildlife habitat, water resources, and recreational resources for hundreds of thousands of users each year. A variety of high quality wildlife habitats are found within the natural areas including riparian, wetland, rangeland, and shrub land. The natural areas also contain important wildlife corridors that link open space and park areas and provide food, cover, and other habitat needs for wildlife. All of the natural areas provide exceptional wildlife viewing opportunities for the public, along with endless opportunities for nature based recreation, and they serve as the outdoor classroom for Lakewood's active environmental education programs. The parks also serve as regional wildlife and recreational connectors to properties managed by other governmental agencies including Jefferson County, Foothills Parks and Recreation District, and the City of Denver.

The most abundant habitat type found within the natural areas is rangeland, made up of a wide variety of native shortgrass prairie plant species including blue grama grass, buffalo grass, Western heatgrass, and sand dropseed, as well as a variety of native wildflower species. This prairie ecosystem serves many wildlife species including deer, elk, coyotes, cottontail rabbits, raptors, prairie rattlesnakes, and ground nesting birds such as the Western meadowlark. The rangeland areas within Lakewood transition into many areas of shrub land near the foothills, dominated by pockets of shrub species including mountain mahogany, three leaf sumac, and golden currant. These areas serve various songbirds, bobcats, and the occasional mountain lion. Creeks, springs, drainages, ponds, and reservoirs within these areas create additional riparian and wetland habitats dominated by willows, cottonwoods, and areas of cattails. These areas are vital wildlife habitat, serving a large variety of bird, reptile, amphibian, insect, and mammal species. Many of these habitats are connected within the city by parks, golf courses, greenbelts, and ditches, providing important routes for wildlife to move between natural areas. These areas are known as wildlife corridors, and they are vitally important to many wildlife species to prevent habitat fragmentation and allow for migration and movement between wildlife populations.

All of the native habitat areas within Lakewood have been affected by human uses over the years, including agriculture, development, and mining. This has disturbed the native plant and wildlife communities and has allowed many invasive and noxious plants to take hold, reducing the overall quality of habitat and the scenic values. Lakewood manages these areas with the intent of restoring them as much as possible to presettlement conditions in order to provide the best possible wildlife and plant habitat, while also providing high quality outdoor recreation. A variety of techniques are used for this restoration. These include controlling noxious weeds through Integrated Pest Management; restoring native vegetation in highly disturbed areas; managing wildlife populations; restoring and improving existing wetland and riparian areas; enforcing park and environmental regulations; and providing high-quality environmental educational programs. Prescribed burns are also occasionally used to help manage and improve habitat. Historically, shortgrass prairies burned naturally every 1–10 years, but fire suppression by humans since the 1900s dramatically altered this process. Fire helps to remove dense vegetation areas, replaces soil nutrients, and can help control invasive species. ■

NS1-E MUNICIPAL NATURAL RESOURCE MANAGEMENT

Manage municipal natural areas, parks, right of ways, and other properties to maximize ecological health and biological diversity. Specifically:

- Integrate ecosystem health and biodiversity considerations in Citywide plans and policies;
- Implement prioritized GIN (NS1-D) strategies and management area best practices (NS1-C) on cityowned properties;
- Develop a water quality strategic plan to identify sites in need of water quality protection strategies;
- Coordinate with Urban Drainage and Flood Control District, Bear Creek Watershed Association, and other water quality managers to prioritize projects aimed at reducing point-source and nonpoint-source pollution in local waterways;
- Research and implement nontoxic management practices for pest and weed control where possible. Consider testing alternative management techniques on pilot sites and incorporate environmental education and outreach opportunities; and
- Support regional and state level air quality programs/initiatives.

SUPPORTING STRATEGIES	
COLLABORATION	▪ Work with neighboring communities and regional organizations to protect regional natural areas and corridors. ▪ Work with Denver Urban Gardens (DUG) to ensure Lakewood's native plants are preserved through seed banks. ▪ Collaborate with Project Learning Tree and other similar organizations to provide environmental education.
EDUCATION & PROMOTION	▪ Promote watershed awareness in schools, neighborhoods, and for City staff involved in the development process. ▪ Increase community awareness of the value of ecosystem health. Activities could include: community conversations, curriculum development, signage, website development, and nature walks. ▪ Educate garden centers and landscape companies on the impacts of fertilizers, pesticides, and other chemicals. ▪ Increase community awareness regarding air and water quality. Activities could include website development, stormwater vs. wastewater educational campaign, informational materials on mechanical systems maintenance, and publicizing available rebates for water conservation practices.
TOOLS & TECHNOLOGY	▪ Explore crowdsource data collection tools to enhance habitat and biodiversity inventories and monitoring.
RESEARCH & TRACKING	▪ Monitor threatened and endangered species and habitats. ▪ Monitor the presence and extent of state-listed noxious weeds on public and private property. ▪ Monitor the water quality of Lakewood's water bodies.

CROSSCUTTING STRATEGIES	
SUSTAINABLE ENERGY & WATER RESOURCE CENTER BE1-C | P. 39	▪ Share information and supportive services regarding water quality protection.
SUSTAINABLE BUSINESS HUB SE1-E | P. 61	▪ Utilize the Hub network and technical resources to implement management area best practices and GIN priorities.
SUSTAINABLE NEIGHBORHOODS CC1-D | P. 102	▪ Work with neighborhoods to develop neighbor-to-neighbor tools for education on ecological stewardship. ▪ Work with neighborhoods to pilot urban agriculture stewardship standards. ▪ Encourage initiatives aimed at ecological restoration, including backyard wildlife habitat and utilizing Neighborhood Participation Program grants for habitat restoration on public property.

TABLE NS1-1: STRATEGY BENEFITS

STRATEGY	ENVIRONMENTAL BENEFITS		ECONOMIC BENEFITS		SOCIAL BENEFITS	
	GHG REDUCTION POTENTIAL	ECOSYSTEM HEALTH	SELF-RELIANCE	HOUSEHOLD BENEFITS	COMMUNITY COHESION	PUBLIC HEALTH
NS1-A: Culture of Ecological Stewardship	🍃	■■■	■■■	■	■■	■■■
NS1-B: Landscape and Agricultural Stewardship	🍃	■■■	■■	■■	■■	■■■
NS1-C: Biodiversity Inventory, Classification, and Best Management Practices	🍃	■■■	■■	■	■■	■■■
NS1-D: Green Infrastructure Network	🍃	■■■	■■■	■	■	■■■
NS1-E: Municipal Natural Resource Management	🍃	■■■	■■	■	■	■■■

🍃 <5,000 $MtCO_2e$ Greenhouse Gas Emissions 🍃 ~10,000 $MtCO_2e$ Greenhouse Gas Emissions

■■■ High ■■ Medium ■ Low ⊘ Does Not Apply

TABLE NS1-2: STRATEGY FEASIBILITY

STRATEGY	CITY OF LAKEWOOD			COMMUNITY	
	UPFRONT COSTS	ONGOING COSTS	PAYBACK / REVENUE POTENTIAL	FINANCIAL BENEFIT FOR RESIDENTS	FINANCIAL BENEFIT FOR BUSINESSES
NS1-A: Culture of Ecological Stewardship	$	✓	✓	–	–
NS1-B: Landscape and Agricultural Stewardship	$	✓	–	✓	–
NS1-C: Biodiversity Inventory, Classification, and Best Management Practices	$$	✓	✓	✓	✓
NS1-D: Green Infrastructure Network	$$$– $$$$	✓	✓	✓	✓
NS1-E: Municipal Natural Resource Management	$	✓	✓	–	–

$** < 50,000 **$$** = 50,000–100,000 **$$$** = 100,000–1,000,000 **$$$$ > 1,000,000

GOAL **NS2**

ENHANCE LAKEWOOD'S RESILIENCE TO THE IMPACTS OF CLIMATE CHANGE USING GREEN INFRASTRUCTURE AND ECOSYSTEM-BASED ADAPTATION.

TARGETS

- Achieve 30 percent tree canopy coverage by 2025.

OBJECTIVES & INDICATORS

- **OBJECTIVE:** Leverage natural and built landscapes to regulate climate and manage stormwater runoff.
  - INDICATOR: Percentage of permeable land
  - INDICATOR: Percentage of 100-year flood plain with vegetative coverage

IMPLEMENTATION STRATEGIES

NS2-A STORMWATER MANAGEMENT AND FLOOD CONTROL

Increase the capacity of Lakewood's landscape to manage stormwater and protect water quality Specifically:

- Utilize the City of Lakewood's climate vulnerability study CCA1-C and Climate Preparedness Plan CCA1-D to help prioritize stormwater management projects and to guide development standards;
- Develop a suite of requirements, resources, and incentives that promote the use of green infrastructure for stormwater management, including green roofs, rain gardens, and bioswales;
- Explore opportunities to work with utility providers to create utility fee structures that create incentives for sustainable site designs;
- Identify funding mechanisms that can be used to acquire property in flood plains and floodways; and
- Review regularly and test emerging technologies and methods for managing and improving stormwater quality.

CITY SPOTLIGHT

MORSE PARK RAIN GARDEN

THE MORSE PARK RAIN GARDEN is a water-quality feature designed to include a bermed, xeriscape garden. The shallow depressions within the garden collect rain water from the surrounding parking lots, street, and tennis courts and then filter out sediments and contaminants as the water drains through a sand filter located beneath the pond.

The primary goals in the design of the Morse Park Rain Garden were functionality and sustainability. Designed to reduce the risk of flooding and maximize water storage and treatment capacity, the rain garden uses swales to increase groundwater infiltration. Landscape materials were carefully selected for low water-use and low-maintenance operations and a soil moisture sensor controls garden irrigation cycles to conserve water. Dark gray, rock mulch was used to enhance aesthetics and obscure sediment deposits after storm events. Three stages of water filtration capture sediment prior to rain water entering the garden area to prevent clogging and reduce maintenance. The Morse Park Rain Garden is an example of multipurpose green infrastructure providing stormwater management, enhancing water quality, and providing a community amenity. ■

NS2-B COOLING AND CARBON SEQUESTRATION

Adapt to increased temperatures and reduce carbon in the atmosphere through healthy vegetation, tree canopy coverage, and use of low-reflective materials. Specifically:

- Track threats to Lakewood's trees and vegetation from pests and disease;
- Develop a suite of requirements, resources, and incentives to protect vulnerable trees, including funding sources and technical assistance;
- Utilize the Metro Denver Urban Forest Assessment to identify potential planting sites and facilitate community plantings;
- Develop a suite of strategies to facilitate tree and shrub planting including site planning requirements, funding sources, technical assistance, and incentives or requirements for vacant properties;
- Update recommended tree and plant species lists to focus on diversity of species and plants that can thrive under future climate scenarios; and
- Adopt site plan requirements or recommendations that facilitate the use of low-reflective landscaping and construction materials.

SUPPORTING STRATEGIES

COLLABORATION	▪ Collaborate with Lakewood water providers and ditch companies to facilitate implementation of water quality and vegetation strategies. ▪ Work with Urban Drainage and Flood Control to address existing and expected stormwater challenges.
EDUCATION & PROMOTION	▪ Increase community awareness regarding proper tree/shrub care, stormwater drainage, and soil erosion. Activities could include fairs for new products and techniques, an arboretum to showcase tree varieties, annual tree/shrub sales, tours of sustainable sites, and workshops on pruning, dying/dead tree care, and groundcover options. ▪ Promote low-cost erosion control techniques.
TOOLS & TECHNOLOGY	▪ Utilize available GIS and remote sensing technologies to monitor changes in land cover and composition. ▪ Utilize crowdsourcing tools to monitor flood and drainage patterns and problems.
RESEARCH & TRACKING	▪ Research and pilot permeable pavement systems. ▪ Research ways to leverage ecosystem services for climate adaptation.

CROSSCUTTING STRATEGIES

SUSTAINABLE ENERGY & WATER RESOURCE CENTER BE1-C | P. 39	▪ Provide information, technical assistance, and other resources on ecological climate adaptation strategies including cooling and carbon sequestration.
SUSTAINABLE BUSINESS HUB SE1-E | P. 61	▪ Provide technical resources and establish certification criteria related to climate adaptation.
SUSTAINABLE NEIGHBORHOODS CC1-D | P. 102	▪ Encourage initiatives that enhance Lakewood's urban forests. ▪ Use neighborhood workshops to educate residents on the importance of implementing resiliency strategies.

STRATEGY	ENVIRONMENTAL BENEFITS		ECONOMIC BENEFITS		SOCIAL BENEFITS	
	GHG REDUCTION POTENTIAL	ECOSYSTEM HEALTH	SELF-RELIANCE	HOUSEHOLD BENEFITS	COMMUNITY COHESION	PUBLIC HEALTH
NS2-A: Stormwater Management and Flood Control		■■■	■■	■	■	■■
NS2-B: Cooling and Carbon Sequestration		■■■	■■	■■	■	■■■

<5,000 $MtCO_2e$ Greenhouse Gas Emissions ~10,000 $MtCO_2e$ Greenhouse Gas Emissions

■■■ High ■■ Medium ■ Low ⊘ Does Not Apply

STRATEGY	CITY OF LAKEWOOD			COMMUNITY	
	UPFRONT COSTS	ONGOING COSTS	PAYBACK / REVENUE POTENTIAL	FINANCIAL BENEFIT FOR RESIDENTS	FINANCIAL BENEFIT FOR BUSINESSES
NS2-A: Stormwater Management and Flood Control	$$$$	✓	✓	–	–
NS2-B: Cooling and Carbon Sequestration	$$$	✓	✓	✓	✓

$** < 50,000 **$$** = 50,000–100,000 **$$$** = 100,000–1,000,000 **$$$$ > 1,000,000

PARK RANGER
Lakewood
Community Resources
DELTA
4X4