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I. Introduction

In the face of a changing climate, local governments play a critical role in ensuring that their communities are situated to adapt to new challenges. City and state governments do not have to wait for a top-down solution to the problems facing their residents, they can take the lead and implement policies that will have a tangible impact. Due to their ability to narrowly tailor solutions to match their climate, geography, and existing infrastructure, the policies implemented by local governments can be more efficient, more sustainable, and longer lasting than large-scale national initiatives.

One such policy is the implementation of vegetative landscapes within cities to, among other things, help reduce the rise in temperature caused by the pavement in cities, assist in water management, and promote biodiversity. Many cities around the country have begun to draft policies incorporating revegetation as a strategy to combat climate change, while others, such as Denver, Colorado, have already adopted comprehensive climate change plans that include updating infrastructure to reflect this recognized value in greenspaces. However, a myriad of hurdles stand in the way of fully implementing any such policies, despite their benefits.

The goal of this brief is to introduce these benefits alongside the unique regulatory framework of Denver's local government, and propose how to leverage existing resources to produce and manage climate-friendly vegetative landscapes that promote mitigation and adaptation to climate change. The brief has three sections. The first begins with an examination of Denver's climate, and then looks at the intersections between various native plant species and how those can serve as a guide for revegetating the cityscape. In the second section, the brief discusses how the City of Denver can use its legal authority to increase the footprint and utility of natural vegetative landscapes, including an analysis of Denver's existing master plan and

examples of existing projects in the city. The section also includes a recommendation for Denver's zoning authority for how best to integrate the built and natural environments to increase green space. Concrete steps the City should take to ensure implementation does not adversely affect environmental justice communities are included throughout. The final section looks at the existing paved spaces in Denver, and examines how the city can update those areas with vegetative landscapes or more efficient pavement management systems to increase the natural spaces within the city along with other benefits to the cityscape. In total, the brief overviews vegetative landscapes native to Denver and provides two case studies for how green spaces can be added to the urban landscape to maximize ecosystem services in the face of climate change.

II. Characteristics of Denver's Climate

Known as the Mile High City, Denver, Colorado sits at about 5,280 feet in elevation at the base of the Rocky Mountains.¹ The unique combination of high elevation, midlatitude, and continental geography results in a generally cool and dry climate, and allows Coloradans to boast about 300 days of sunshine per year.² The easternmost portion of the Rocky Mountains, known as the Front Range, creates a stark division between the eastern plains and the remainder of the state.³ It is on the plains, twelve miles east of where the gentle, rolling grasslands turn upwards, transforming into the towering, snow capped peaks of the Rocky Mountains, that Denver lies.⁴

¹ *Denver at a Glance*, Visit Denver, <https://www.denver.org/about-denver/denver-resources/denver-glance/> (last visited September 22, 2020).

² *Colorado Climate*, Colorado Encyclopedia, <https://coloradoencyclopedia.org/article/colorado-climate> (last visited September 22, 2020).

³ COLORADO'S GREAT PLAINS, COLORADO ENCYCLOPEDIA, <https://coloradoencyclopedia.org/article/colorado%E2%80%99s-great-plains> (last visited September 22, 2020).

⁴ *Denver at a Glance*, Visit Denver, <https://www.denver.org/about-denver/denver-resources/denver-glance/> (last visited September 22, 2020).

The climate of the plains is relatively uniform, with low humidity, abundant sunshine, lower precipitation than the national average, and large seasonal temperature changes.⁵ In the summers, the average temperature peaks in July at 88 degrees, and the city sees, on average, 34 days above 90 degrees.⁶ With winter comes drastically colder temperatures.⁷ The average high in January is only 46 degrees, while the average low temperature is 17 degrees.⁸ On average, 155 days each year see the nighttime temperature fall below freezing, and 6 days see the temperature fall below 0 degrees.⁹

Precipitation in Denver falls mostly in the form of rain during spring and fall thunderstorms.¹⁰ 17 inches of rain, on average, falls on the city each year, well below the national average of 38 inches.¹¹ Snowfall, however, exceeds the national average, at 60 inches per year vs 27 inches.¹² March is the snowiest month for the city, while nine months out of the year see significant snowfall.¹³ The Front Range also forms a portion of what meteorologists call “hail alley”, an area that averages nine hail days per year.¹⁴ From mid-April to mid-August, Denver sees on average three catastrophic hailstorms, where hail reaches baseball sizes and has caused upwards of \$700 million in damages to the city.¹⁵

⁵ COLORADO CLIMATE, COLORADO ENCYCLOPEDIA, <https://coloradoencyclopedia.org/article/colorado-climate> (last visited September 22, 2020).

⁶ *Denver, Colorado*, Best Places, <https://www.bestplaces.net/climate/city/colorado/denver> (last visited September 22, 2020).

⁷ *Id.*

⁸ *Id.*

⁹ *Id.*

¹⁰ *Id.*

¹¹ *Id.*

¹² *Id.*

¹³ *Id.*

¹⁴ Robert Garrison, *Colorado hail season: 7 things you need to know*, The Denver Channel, <https://www.thedenverchannel.com/news/local-news/colorado-hail-season-what-you-need-to-know>.

¹⁵ *Id.*

As global temperatures rise, Denver has seen a noticeable warming trend.¹⁶ Statewide annual average temperatures have increased by 2 degrees over the past 30 years, with four of the last six warmest years on record all occurred during the period of 2012-2017.¹⁷ The state has been in a relatively dry period since 2000, with below average snowpacks combining with the above average temperatures to create severe soil-moisture drought conditions across the state.¹⁸ Projections show that the state will continue to warm over the coming decades, from 2.5 degrees to 5 degrees by mid century.¹⁹ Denver may soon see even larger swings in seasonal weather, and a greater frequency of severe weather events.²⁰

III. Methodologies for Increasing Native Landscapes

1. Nonnative Plant Species

The combination of soil types, landscapes, and climate have allowed a wide variety of plant types to thrive in Colorado's foothills and eastern plains.²¹ As Denver was a major hub of westward expansion in the 1800s, many travelers brought seeds of plants from all across the globe.²² Many of these plants have come to dominate Colorado's landscapes and often it is hard to discern what is a native plant and what is not.²³ Colorado's Weed Management Act defines a nonnative plant species as "a plant which is not indigenous to the state or Colorado, nor to the native plant community in which it is found."²⁴ Although these plants have come to thrive in

¹⁶ Jeff Lukas, *Western water Assessment*, Western Water Assessment 1 (2014).

¹⁷ *Id.*

¹⁸ *Id.* at 2.

¹⁹ *Id.* at 3.

²⁰ *Id.*

²¹ *Low-Water Native Plants for Colorado Gardens*, Colorado Native Plant Society, <https://extension.colostate.edu/docs/pubs/native/FrontRange.pdf>

²² *Native Plant Revegetation Guide for Colorado*, Colorado Parks and Wildlife, 1 <https://cpw.state.co.us/Documents/CNAP/RevegetationGuide.pdf>. (hereinafter "CPW")

²³ *Id.*

²⁴ *Id.* (quoting Title 35, Colorado Revised Statutes: Colorado Weed Management Act)

Colorado's Front Range, there are many risks associated with the introduction and cultivation of nonnative plants.²⁵

Many nonnative plants are able to rapidly spread and outcompete their native counterparts for water, light, and soil nutrients.²⁶ Because nonnative plants did not evolve with local herbivores or diseases, often there are no predators to keep populations in check.²⁷ What's more, many of the nonnative plants brought to Colorado by settlers were bred for rapid growth and resilience, with the intention of spreading them far and wide to a range of conditions.²⁸ If unchecked, this can lead to single-species stands – areas where once there were diverse and productive communities of plants and animals.²⁹ For example, a creekside lined with purple loosestrife, a tall and admittedly beautiful perennial, is a pleasant site for most observers.³⁰ However, upon closer inspection it is clear that the weed has fully taken over the ecosystem, displacing the natural plants, stripping the riparian habitats of the base of their food chain.³¹ The US Fish and Wildlife Service estimates that over 400 of the 1,300 animal species currently protected under the Endangered Species Act are at risk partly due to displacement by invasive plant species.³²

²⁵ *Id.* at 1.

²⁶ *Id.* at 2.

²⁷ *Id.*

²⁸ *Id.*

²⁹ *Id.*

³⁰ *Id.*

³¹ *Pretty Evil: Purple Loosestrife*, About Boulder, <https://aboutboulder.com/blog/pretty-evil-purple-loosestrife/> (last visited September 25, 2020).

³² *The Cost of Invasive Species*, U.S. Fish & Wildlife Service, <https://www.fws.gov/verobeach/PythonPDF/CostofInvasivesFactSheet.pdf>.



Purple Loosestrife³³

While loss to natural habitat can be devastating to the natural ecosystem of the area, massive economic losses can also follow from these infestations.³⁴ On top of the cost of eradication, land infested by nonnative plants has a lower value for hunting, photography, or wildlife watching, lowering the revenue from these activities to towns that rely on them.³⁵ In 2011, the Department of the Interior spent \$100 million on invasive species prevention, detection, control, and management.³⁶ A study conducted in 2014 by the Colorado Weed Management Association found that the economic loss to the state caused by a group of ten invasive species had amounted to \$13,838,920.³⁷ While some nonnative plants can live harmoniously with the environment, the risk of biodiversity loss and economic loss acts as a guide, encouraging the use of native species whenever possible.

2. Native Plant Species

³³ About Boulder, *supra* note 31.

³⁴ CPW, *supra* note 22 at 2.

³⁵ *Id.*

³⁶ U.S. Fish and Wildlife, *supra* note 32 at 1.

³⁷ Ethan Proud, *Extension Viewpoints: The cost of noxious weeds*, Pagosa Springs Sun, June 1, 2020, <http://www.pagosasun.com/extension-viewpoints-the-cost-of-noxious-weeds/#:~:text=Simply%20put%2C%20noxious%20weeds%20by,populations%20and%20controlling%20other%20pests>. (last visited September 25, 2020).

While introducing nonnative plant species in landscaping or otherwise can be detrimental, using native species can have a cascade of positive effects. “Native” is broadly defined as a plant having occurred before European settlement in North America.³⁸ Using these plants in landscaping has an immediate positive impact on the environment and embraces the regional cultural identity that has been lost in conventional garden and landscape design.³⁹ Substituting suburban neighborhood lawns, for example, with regional style landscapes fosters a diverse habitat for plants and animals.⁴⁰ Native species are pre-adapted to the climate, allowing them to flourish without high inputs of energy, water, or fertilizer.⁴¹ As they stand now, most landscaping requires heavy fertilizer use, irrigation, and other resource inputs that native plants would not require.⁴²

Rapid urbanization in the Denver area has significantly reduced biodiversity as habitat is removed for development and replaced with landscaped areas.⁴³ Landscaping with native plants has been shown to help maintain that biodiversity, providing food, shelter, and other important resources for small mammals, birds, and native pollinators.⁴⁴ By choosing to work with native plant species, there is less disruption to the food web and other important ecosystems of an area during development.⁴⁵ Furthermore, because these species are adapted to the native soils, the roots are better adapted to capture rainwater and prevent runoff.⁴⁶ An added benefit to this soil adaptation is that a lack of fertilizer or other additives minimizes soil disruption during

³⁸ Scott LaFleur & Tom Smarr, *Going Native: the Sustainable Choice*, The Ecological Landscaper (December 15, 2010), <https://www.ecolandscaping.org/12/designing-ecological-landscapes/native-plants/going-native-the-sustainable-choice/>.

³⁹ *Id.*

⁴⁰ *Id.*

⁴¹ *Id.*

⁴² *Id.*

⁴³ Colorado Native Plant Society, *supra* note 21, at 4.

⁴⁴ *Id.*

⁴⁵ *Id.*

⁴⁶ LaFleur & Smarr, *supra* note 38.

construction and other development.⁴⁷ This is critical for ensuring the stability of the soil life web which enables proper nutrient cycling, an essential element in the prosperity of plants.⁴⁸

A. Native Plant Communities

In selecting native plants for landscaping or revegetation, it is essential to understand how various species work together in harmony. Colorado has several distinct “floristic regions” – i.e. subclimates that have distinct flora growth patterns.⁴⁹ Denver lies in the Eastern Plains and Foothills region, which is dominated by grasslands.⁵⁰ However, due to Denver’s proximity to the foothills, the soil contains a greater prevalence of rocky, moisture-retaining soils and irregular topography than the land farther east, allowing shrublands and woodlands to also thrive in small pockets.⁵¹

The short-grass prairie occupies the most space in the Denver region.⁵² The character of the short-grass prairie is drought-prone, mildly alkaline, medium and fine textured soils that have been shaped by the region's aridity.⁵³ Numerous grass species co-mingle in these communities, with dozens of forbs – flowering plants other than grasses – transforming the prairie into colorful wildflower gardens in wet years.⁵⁴ Only few shrubs can grow consistently in the short-grass prairie because the soils are too dry and compacted to support them.⁵⁵ However, plains yucca, certain cacti, sages, saltbush, and rabbitbrush have adaptations that allow them to survive in these areas.⁵⁶

⁴⁷ *Id.*

⁴⁸ *Id.*

⁴⁹ CPW, *supra* note 22, at 13.

⁵⁰ *Id.* at 16.

⁵¹ *Id.*

⁵² *Id.* at 18.

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ *Id.*

⁵⁶ *Id.*



Shortgrass prairie with plains yucca and sandsage.⁵⁷

One characteristic of the prairie that makes the landscape so unique also makes it rather difficult to properly restore.⁵⁸ Prairie's once covered hundreds of thousands of square miles across the US.⁵⁹ These vast expanses allowed highly complex species interactions to take place and fostered deep connections between the flora and the land.⁶⁰ When attempting to recreate these landscapes, it may be impossible to fully cultivate these interactions on small parcels of land.⁶¹ If successful, it will likely take 3-5 years before the landscape resembles a true shortgrass prairie.⁶²

Shrublands, another possible native plant community in the Denver region, consists of shrubs as the dominant plant.⁶³ Shrublands occur naturally in specialized habitats, often in areas too dry for trees but where soil conditions will support the longer root systems of the shrubs.⁶⁴ The rocky hillsides found near Denver support many mixed shrubs and can vary greatly in variety.⁶⁵

⁵⁷ Chris Helzer, *Photo of the Week*, The Prairie Ecologist (October 3, 2014), <https://prairieecologist.com/tag/shortgrass/>.

⁵⁸ CPW, *supra* note 22, at 17.

⁵⁹ *Id.*

⁶⁰ *Id.*

⁶¹ *Id.*

⁶² *Id.*

⁶³ *Id.* at 23.

⁶⁴ *Id.*

⁶⁵ *Id.* at 27.

Shrublands are often considered to be transitional communities, existing where grasslands transition into forests or other woodland areas.⁶⁶ That means that shrubs can be a companion plant to many grasses or trees, as the soil and climate they exist in touches the boundaries of both communities.⁶⁷ Shrubs also thrive in areas where large rocks dominate the soil, making planting other species difficult.⁶⁸ The rocks catch the rainfall and direct the runoff to their edges, allowing moisture-hungry shrubs to thrive.⁶⁹



Sagebrush shrubland⁷⁰

The final floristic region found near Denver is the woodlands. This region occurs in the areas where canyons on the plains create foothills-like conditions.⁷¹ These areas are characterized as having one or more species of small trees, typically oneseed juniper, Rocky Mountain juniper, pinion pine, or limber pine, as the dominant form of upper vegetation.⁷² These trees require more moisture and deeper soils than shrubs or grasses, which restricts these

⁶⁶ *Id.* at 23.

⁶⁷ *Id.*

⁶⁸ *Id.*

⁶⁹ *Id.*

⁷⁰ *Ecological Systems: Sagebrush Shrublands*, Colorado Natural Heritage Program (November 29, 2011), <https://prairieecologist.com/tag/shortgrass/>.

⁷¹ CPW, *supra* note 22, at 28.

⁷² *Id.*

woodland communities to rocky, mesic sites that feature above average moisture levels for the area.⁷³

A common woodland community found in elevation ranges and climates that mimic Denver's is that of the juniper woodlands.⁷⁴ These communities are characterized by short, spaced out juniper trees, with several types of shrubs and cacti living between, and grass and forb cover inversely proportional to the density of the juniper.⁷⁵ Another common woodland community that is abundant in the Denver area is that of the ponderosa pine woodland.⁷⁶ These communities are characterized by spaced out ponderosa pines with dense shrubs in the understories and little to no grasses.⁷⁷ These sites typically occur at the base of foothills or atop mesas on rocky areas with less moisture.⁷⁸



Colorado Juniper Woodland⁷⁹

⁷³ *Id.*

⁷⁴ *Id.* at 29.

⁷⁵ *Id.*

⁷⁶ *Id.* at 31.

⁷⁷ *Id.*

⁷⁸ *Id.*

⁷⁹ Pinyon-Juniper Woodland, <https://www.sciencesource.com/archive/Pinyon-Juniper-Woodland-SS2506741.html>, (last visited September 25, 2020). a

Understanding the ways in which Colorado’s native plants work together to create these localized communities is essential to understanding the proper way to revegetate an area. The unique soil characteristics and subclimates found across the foothills and eastern plains region of Colorado create opportunities for those wanting to reintroduce native species to do so in accordance with the land. It is also important to note that as climate change progresses, these unique climate characteristics will change, possibly redefining what it means for plants to be “native.”

The fact that a species was here before european colonization, as the traditional definition provides, is of no consequence if Denver’s average temperature is far higher in a few decades. Solving this issue will be no simple task. Embracing adaptive management techniques, which provides a framework for making good decisions in the face of critical uncertainties, can help to improve management over time.⁸⁰ By working within this framework, developers can incorporate a degree of flexibility in their planning that will prove critical in the face of these uncertainties.

Depending on the speed of this change, some species will be able to evolve in response.⁸¹ These rapid adaptations can already be seen in many species that live near urban areas. Due to the increased temperature in cities from dark surfaces, these areas are much hotter than the surrounding landscape.⁸² The plants that live in these areas have already demonstrated the ability to quickly adapt to changes in climate.⁸³

⁸⁰ Department of the Interior, *What is Adaptive Management*, <https://www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/Chapter1.pdf> (last visited September 29, 2020).

⁸¹ Sarah Tangren, *Native Plants and Climate Change*, University of Maryland Extension, <https://www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/Chapter1.pdf> (last visited September 29, 2020).

⁸² *Id.*

⁸³ *Id.*

Whether looking at these changes already occurring in some plant communities or creating a framework to adapt to upcoming and unknown changes, it is crucial to understand that the landscape surrounding Denver will always provide a guide to the natural ways in which species interact with one another. These interactions of plant communities will serve as a guide throughout this brief, ensuring that all aspects of development are designed to serve a single purpose: to use the natural landscape to the benefit of urban design.

IV. Avenues for Local Management of Climate Friendly Vegetative Spaces

In order to increase the footprint of native plant communities in the urban landscape, the City of Denver needs to act purposefully and consider the adaptive and mitigative benefits of these landscapes. This section discusses the legal authorities guiding Denver’s planning and zoning decision-making and recommends adjusting the Denver zoning map to align with the goals of the City’s Master Plan.

1. Vegetative Landscapes

Integrating green spaces into the urban environment can play a critical role in mitigating and adapting to climate change.⁸⁴ Vegetative landscapes provide an opportunity to use land management techniques and local government legal authority to jointly address environmental challenges from stormwater management to increased carbon emissions. The ability of vegetative landscapes to assist in mitigation and adaptation underlines the importance of adjusting urban green spaces in a way that is mindful of “local characteristics and vulnerabilities to climate change.”⁸⁵

⁸⁴ *Green Spaces and Corridors in Urban Areas*, Climate ADAPT (2015), <https://climate-adapt.eea.europa.eu/metadata/adaptation-options/green-spaces-and-corridors-in-urban-areas>.

⁸⁵ *Id.*

While increasing greenspaces in an urban environment is a great way to provide essential ecosystem services in the face of climate change, it must be done in a just way. In order to equitably increase urban green spaces, substantial stakeholder engagement must be a part of the process.⁸⁶ Increasing urban greenspaces is often associated with the gentrification process and impacts on all communities must be considered as local governments use their planning tools to increase vegetative landscapes.⁸⁷ The City of Denver should use all the tools available to it to ensure that increasing green spaces to mitigate and adapt to climate change does not unduly burden environmental justice communities.

This portion of the brief discusses how the City of Denver can use its police powers to increase the footprint and utility of natural vegetative landscapes to provide the greatest mitigative and adaptive benefits. It begins with a discussion of actors and agencies responsible for action and the legal authority directing and restraining these actors. The discussion then switches to a discussion of the land-use planning and zoning authority, focusing on Denver's Comprehensive Plan 2040. The Section concludes with a recommendation that Denver's zoning authority should rezone the city to include mixed-use zoning requirements that combine the built and natural environments to increase green space. Concrete steps the City should take to ensure implementation does not adversely affect environmental justice communities is also included throughout the discussion.

A. The Community Planning and Development Department's Legal Authority to Increase Vegetative Spaces

Denver has a consolidated city-county structure where the Mayor and thirteen member City Council are jointly and separately responsible for city administration: from transportation

⁸⁶ See generally KENNETH A. GOULD & TAMMY L. LEWIS, GREEN GENTRIFICATION: URBAN SUSTAINABILITY AND THE STRUGGLE FOR ENVIRONMENTAL JUSTICE (2017).

⁸⁷ See generally *id.*

planning to land-use decision making.⁸⁸ The Mayor oversees Departments, Offices, and Agencies that are either directly responsible for creation and management of vegetative spaces and landscapes or that, through law reform and implementation of progressive resource management policies, could be involved in such management.⁸⁹ These departments include: Community Planning and Development, Parks and Recreation, Public Health and Environment, and Public Works.⁹⁰ Agencies and offices that touch on vegetative landscapes include: the Board of Adjustment for Zoning Appeals. Denver Water Department, Performance Based Infrastructure, Emergency Management, and Denver Biological Gardens.⁹¹ The multiple governmental players involved underscores the importance of coordination across governmental entities and highlights the ability of innovation in maximizing the potential of ecosystem services from vegetative landscapes.

The Community Planning and Development Department (“CPD”) in concert with the Board of Adjustment for Zoning Appeals is responsible for planning and zoning in the City and County of Denver.⁹² Their responsibilities include: permitting, neighborhood planning, community engagement, and enforcing and implementing the zoning code.⁹³ The Planning Board, an eleven member board within CPD, is responsible for advising the Mayor and City Council on land-use planning and zoning decisions.⁹⁴ The Planning Board acts according to the

⁸⁸ *How City Government Works*, Denver, <https://www.denvergov.org/content/denvergov/en/city-of-denver-home/city-overview.html> (last visited Sept. 20, 2020).

⁸⁹ *Id.*

⁹⁰ *Id.*

⁹¹ *Id.*

⁹² *Community Planning and Development*, Denver, <https://www.denvergov.org/content/denvergov/en/community-planning-and-development.html> (last visited Sept. 19, 2020).

⁹³ *Id.*

⁹⁴ *Planning Board, Community Planning and Development*, Denver, <https://citycountydenver-prod.adobecqms.net/content/denvergov/en/community-planning-and-development/planning-and-design/planning-board.html> (last visited Sept. 25, 2020).

Charter of the City of Denver, the Denver Revised Municipal Code, the Denver Zoning Code, and State Statute.⁹⁵

State statutes delegate to municipalities the powers to create a planning commission such as the Planning Board and for that planning commission to “make, adopt, amend, extend, add to, or carry out a plan.”⁹⁶ According to state law, it is the responsibility of the planning commission to adopt a master plan for the physical development of the municipality.⁹⁷ This master plan is an advisory document unless it is adopted into municipal ordinances once due process requirements have been satisfied.⁹⁸ Colorado state statutes include general prescriptions of what shall be included in an adopted master plan but aside from these general prescriptions do not direct municipalities on how to plan and zone.⁹⁹ The purposes for which these plans should be carried out are also prescribed in state statute and are harmonious with the inclusion of additional vegetative landscapes. The statute describing the purposes for planning states planning should accomplish the “coordinated, adjusted, and harmonious development of the municipality and its environs which will, in accordance with present and future needs, best promote health, safety, order, convenience, prosperity, and general welfare.”¹⁰⁰ Given the threats of climate change, planning to increase natural landscapes aligns with the purpose for which these powers are delegated to municipalities. Once a master plan is approved all development plans must be submitted to and approved by the commission including those focused on open spaces.¹⁰¹ The

⁹⁵ Planning Board Bylaws, Art II. Sec. 2.

⁹⁶ Colo. Rev. Stat. § 31-23-202.

⁹⁷ Colo. Rev. Stat. § 31-23-206.

⁹⁸ *Id.*

⁹⁹ *Id.*

¹⁰⁰ Colo. Rev. Stat. § 31-23-207.

¹⁰¹ Colo. Rev. Stat. § 31-23-209.

planning commission is also given authority over approving all plans for improvements to city streets, as well as the installation of new city streets.¹⁰²

Colorado state statutes also grant municipalities the power to engage in zoning.¹⁰³ The grant of authority includes zoning for the,

“[P]urpose of promoting health, safety, morals, or the general welfare of the community, including energy conservation and the promotion of solar energy utilization, the governing body of each municipality is empowered to regulate and restrict the height, number of stories, and size of buildings and other structures, the percentage of lot that may be occupied, the size of yards, courts, and other open spaces, the density of population, the height and location of trees and other vegetation, and the location and use of buildings, structures, and land for trade, industry, residence, or other purposes.”¹⁰⁴

This delegation of the zoning authority as well as the legislative purpose for the zoning power makes it clear that the City of Denver can zone in a way that regulates the design and development of vegetative landscapes.¹⁰⁵ Further nothing in the City Charter or the Municipal Ordinances would restrict this authority. Both Chapter 12 and Chapter 59, the sections of the Municipal Code of Denver that discuss planning focus on advancing the purposes as set out in State statute.¹⁰⁶ Increasing vegetative landscapes in a responsible way, that is mindful of impacts on environmental justice communities and increases ecosystem services, will promote the

¹⁰² Colo. Rev. Stat. § 31-23-217.

¹⁰³ Colo. Rev. Stat. § 31-23-301.

¹⁰⁴ *Id.*

¹⁰⁵ Colo. Rev. Stat. § 31-23-303. “Such regulations shall be made in accordance with a comprehensive plan and designed to lessen congestion in the streets; to secure safety from fire, panic, floodwaters, and other dangers; to promote health and general welfare; to provide adequate light and air; to prevent the overcrowding of land; to avoid undue concentration of population; to promote energy conservation; and to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements.”

¹⁰⁶ See Chapter 12, Community Planning and Development, Denver Code of Ordinances; Chapter 59, Zoning Code of Ordinances.

general welfare.¹⁰⁷ All legal authorities that the CPD and the Planning Board are responsible for adhering to make it clear that planning and zoning to increase the general welfare is encouraged.

Given it's delegated legal authority from both the State and the City of Denver, the CPD and the Planning Board has the greatest ability to leverage the police powers of the City to increase green space in the urban environment. Planning and zoning to increase vegetative landscapes will increase the general welfare by providing critical environmental benefits. The next session uses the backdrop of CPD and the Planning Board's legal authority to further discuss the importance of land use planning and suggests a new zoning designation that combines the natural environment with the built environment.

V. Existing Legal Mechanisms for Creating and Managing Vegetative Spaces and Opportunities for Increasing Vegetative Landscapes Through These Mechanisms

It is widely acknowledged that local governments are in the best position to promote and implement vegetative landscapes to provide ecosystem services such as stormwater management.¹⁰⁸ The two most effective tools the City of Denver has to encourage and develop vegetative landscapes are land-use planning, through the development of a master plan, and zoning that implements the master plan. The City's current master plan is Comprehensive Plan 2040, a comprehensive and holistic approach to planning.¹⁰⁹ The Planning Board and CPD should use the Comprehensive Plan 2040 to leverage implementation of vegetative landscapes in the short-term and in the long-term should create a master plan that explicitly addresses how to increase green spaces in an environmentally just way. Once this master plan is in place, the Planning Board can use it to guide zoning decisions.

¹⁰⁷ See discussion of benefits of natural landscapes in methodologies.

¹⁰⁸ *Overcoming Barriers to Green Infrastructure*, Environmental Protection Agency, <https://www.epa.gov/green-infrastructure/overcoming-barriers-green-infrastructure> (last accessed Sept. 22, 2020).

¹⁰⁹ *Comprehensive Plan 2040: Denver's Plan for the Future* (May 2019), [https://www.denvergov.org/content/dam/denvergov/Portals/Denverright/documents/comp-plan/Denver Comprehensive Plan 2040 city council draft.pdf](https://www.denvergov.org/content/dam/denvergov/Portals/Denverright/documents/comp-plan/Denver%20Comprehensive%20Plan%202040_city_council_draft.pdf).

The discussion below assesses the possibility and promise of land-use planning and the ability of rezoning to require the combination of the built environment with the natural environment.

1. Land-Use Planning

Land-use planning is a collaborative process where multiple stakeholders, both within government and outside of it, come together to create a plan for the development of a neighborhood or community.¹¹⁰ The stakeholder process of planning is critical to assuring that ultimate planning decisions are just. Planning should include voices from all communities with an emphasis on environmental justice communities.¹¹¹ Aspects of development that should be considered in a plan include the level, intensity, location, and character of development.¹¹² As important as considering the kind and quantity of development is planning what spaces should be set aside and for what purpose and the impact these decisions will have on the most historically vulnerable communities.¹¹³

Planning for conservation values and ecosystem services is a relatively new discipline but there is a history of success when these values are integrated into land-use planning.¹¹⁴ Conservation values and ecosystem services can be integrated into land-use plans by strategically considering the placement of vegetative landscapes and the ecological functions of these urban ecosystems.¹¹⁵ Considering ecologically sustainable land uses and their ecological benefits

¹¹⁰ *Understanding the Basics of Land Use and Planning*, Institute for Local Government (2010), https://www.ca-ilg.org/sites/main/files/file-attachments/2010_-_landuseplanning.pdf?1387495993.

¹¹¹ See generally KENNETH A. GOULD & TAMMY L. LEWIS, *GREEN GENTRIFICATION: URBAN SUSTAINABILITY AND THE STRUGGLE FOR ENVIRONMENTAL JUSTICE* (2017).

¹¹² *Id.* at 2.

¹¹³ *Id.*

¹¹⁴ *Case Study Briefs*, Landscape Performance Series, <https://www.landscapeperformance.org/case-study-briefs> (last accessed Sept. 23, 2020).

¹¹⁵ See *Ecological Principles for Managing Land Use*, The Ecological Society for America's Committee on Land Use (2000), <https://cfpub.epa.gov/watertrain/pdf/modules/landuseb.pdf>.

should become an essential part of land-use planning at CPD.¹¹⁶ In the age of climate change, in order for development to be sustainable it must be supported by vegetative landscapes that can provide mitigative and adaptive ecosystem services. Therefore, considering the highest value vegetative landscapes and identifying where their placement can provide the greatest benefit has increasingly become an essential part of the land-use planning process.¹¹⁷ Once these plans are in place, the governmental entities responsible for planning, permitting, implementing, or managing vegetative landscapes can feel confident that the implementation of any single vegetative landscape is feeding into and benefiting the larger urban ecosystem.

The City of Denver has previously engaged in land use planning and has recognized the value of greenspaces. The current Master Plan developed by CPD and the Planning Board is Comprehensive Plan 2040.¹¹⁸ According to Comprehensive Plan 2040, the city strives to be more resilient in the face of climate change and provide opportunities for outdoor recreation that are uniquely Denver and that allow people to have healthy and active lives.¹¹⁹ These two goals have a lot in common. Namely, increasing vegetative landscapes across the city will advance the mission of both goals. Vegetative landscapes can provide many ecosystem services that will make the city more resilient in light of climate change, increase opportunities for recreation, and otherwise improve the quality of life for Denver's residents. Master planning must occur every decade or so. In the next iteration of Master Planning, the City should go even further to encourage the integration of the natural environment into the built environment. Actualization of

¹¹⁶ *Id.*

¹¹⁷ *Id.*

¹¹⁸ *Comprehensive Plan 2040: Denver's Plan for the Future* (May 2019), https://www.denvergov.org/content/dam/denvergov/Portals/Denveright/documents/comp-plan/Denver_Comprehensive_Plan_2040_city_council_draft.pdf.

¹¹⁹ *Community Planning and Development, Planning and Design*, Denver, <https://www.denvergov.org/content/denvergov/en/community-planning-and-development/planning-and-design/comprehensive-plan-2000.html> (last accessed Sept. 23, 2020).

this ecologically minded planning, would be aided by adoption of the mixed-use zoning proposal described in detail in Subsection 3.

Denver has already successfully implemented vegetative landscapes into the urban environment through the planning and zoning process. Three case studies from the City stand out as strong examples of the successful integration of the natural or “green” environment into the built environment; the Cherry Creeks North Improvements and Fillmore Plaza, the Westerly Creek at Stapleton, and the TAXI II development.¹²⁰ These projects each highlight a different way to increase vegetative landscapes.

The Cherry Creeks North Improvement and Fillmore Plaza and the TAXI II development are both examples of integrating vegetative landscapes into commercial and residential developments.¹²¹ The Cherry Creek project sought to integrate vegetative landscapes to reduce energy and water consumption and revitalize the shopping district.¹²² To date, the integration has been extremely successful, reducing water consumption by over 3 million gallons annually and energy consumption by 223,000 kilowatts per year.¹²³ Given the 20 year drought on the Colorado River and the lack of water along the Front Range, these water consumption savings are of immeasurable value in a climate changed world.

The TAXI II development is similar in strategy to the Cherry Creek Project and has had similar success.¹²⁴ This development is along a waterway and provides considerable stormwater management ecosystem services. In a single year, the space helps divert, through natural

¹²⁰ *Case Study Briefs*, Landscape Performance Series, <https://www.landscapeperformance.org/case-study-briefs> (last accessed Sept. 23, 2020).

¹²¹ *Id.*

¹²² Yang, Bo, Pamela Blackmore, and Yue Zhang, *Cherry Creek North Improvements and Fillmore Plaza*, *Landscape Performance Series*. Landscape Architecture Foundation, (2012), <https://doi.org/10.31353/cs0400>.

¹²³ *Id.*

¹²⁴ Wu, Hong and Clarissa Ferreira Albrecht da Silveira, *TAXI II*, *Landscape Performance Series*. Landscape Architecture Foundation, (2017), <https://doi.org/10.31353/cs1290>.

ecosystem processes, 2 million gallons of water that would otherwise drain directly into the water way.¹²⁵ In addition, the trees planted in the development area sequester nearly 8,000 lbs of carbon a year.¹²⁶ These two projects show the ability of local governments to increase the ecological values of urban spaces through including small scale vegetative landscapes. Neither development project involved considerable footprints for the vegetative spaces but the strategic selection of plants and landscape strategies, such as the use of swales and stormwater gardens, provided considerable ecosystem services.¹²⁷

The third case study of the successful development of a vegetative landscape after land-use planning is the Westerly Creek at Stapleton.¹²⁸ This project is different in kind from the projects described above because the primary focus of the project was the vegetative landscape. This area includes fifty acres of native prairie vegetation along a waterway.¹²⁹ Through strategic development of the area to maximize the benefits of the vegetative landscape, the area now sequesters nearly 240 tons of carbon a year and decreased floodplain from 183 to 66 acres by increasing water holding capacity.¹³⁰ Like the other two development projects, many of the benefits provided by this area are related to water conservation and control; two major environmental issues facing expanding Front Range communities.¹³¹

The three projects that have already been completed within the City of Denver serve as examples of the opportunities that exist for integrating green space into development projects when vegetative landscape planning becomes a feature of land-use planning. Future master plans

¹²⁵ *Id.*

¹²⁶ *Id.*

¹²⁷ *Id.*

¹²⁸ Canfield, Jessica, Kevin Cunningham, and Kyle Koehler. *Westerly Creek at Stapleton, Landscape Performance Series*. Landscape Architecture Foundation, (2011), <https://doi.org/10.31353/cs0010>.

¹²⁹ *Id.*

¹³⁰ *Id.*

¹³¹ *Id.*

should prioritize the importance of this form of development. The following Sections discuss how Denver can leverage the zoning police power to require or incentivize integrative development.

2. Zoning

The zoning power is one of the most important powers of a local government. Through zoning ordinances, cities can shape the feel and character of neighborhoods and the urban landscape. As discussed above, in Denver, the entity responsible for zoning is the Denver Community Planning and Development Department (“CPD”).¹³² This is the same entity responsible for planning. Combining these responsibilities within one entity is permissible under Colorado law.¹³³ The zoning authority allows CDP to regulate the use and development of properties across the city.¹³⁴ Currently, CDP has three designations for vegetative landscapes: open space for public parks, recreation, and conservation.¹³⁵ While vegetative landscapes can be integrated into development projects in residential, business, and mixed-use zoning designations, explicit endorsement of vegetative landscapes in these spaces would facilitate increasing urban greenspace.¹³⁶

According to their zoning and planning powers, the Planning Board and CPD is responsible for reviewing and approving all proposed development projects to ensure they comply with the land-use plan and zoning regulations passed pursuant to their authority.¹³⁷

¹³² *Planning Board, Community Planning and Denver*, Denver, <https://citycountydenver-prod.adobecqms.net/content/denvergov/en/community-planning-and-development/planning-and-design/planning-board.html> (last visited Sept. 25, 2020).

¹³³ Colo. Rev. Stat. § 31-23-211.

¹³⁴ *Zoning*, Colorado Department of Local Affairs, <https://cdola.colorado.gov/zoning#:~:text=Zoning%20is%20the%20most%20common,development%20on%20parcels%20of%20land.&text=Other%20types%20of%20common%20zoning,uses%20within%20a%20particular%20district> (last accessed Sept. 25, 2020).

¹³⁵ *Denver Maps*, Denver, <https://denvergov.org/maps/map/zoning> (last accessed Sept. 23, 2020).

¹³⁶ *Id.*

¹³⁷ Colo. Rev. Stat. § 31-23-201 et seq; City Ordinance, Chapter 12, Community Planning and Development.

While many of the specific development decisions are made by developers, CPD should incentivize integration of green spaces by increasing areas zoned for open space, encouraging vegetative landscaping in areas zoned as business or residential, and redesigning the zoning map to add areas zoned for mixed use, where the mixed use is integrating the natural environment into the built environment. A new zoning designation that reflected the City's priority of blending the built and natural environments would help increase vegetative landscapes throughout the city and allow the city to reach the Comprehensive Plan 2040 goals of resilience and health.

3. Leveraging Existing Legal Frameworks to Increase the Footprint and Productivity of Vegetative Spaces

CPD should re-approve the zoning map and change the designate of select residential and commercial zones as mixed-use development zones, where the mixed-use is combining the built and natural environment. These mixed use development zones should require vegetative landscapes to be integrated into the urban built environment. This zoning requirement would be a permissible use of the zoning police power and would blend the land-use planning and zoning authorities of the City to achieve the resilience and health goals of the Comprehensive 2040 plan.¹³⁸ A new master plan that further reinforced the priority of integrating green space into the urban environment would further support this redesignation.

To be most effective, the mixed-use zones should be tailored to require vegetative landscape development that would be the most environmentally effective for a given area. For example, areas near riparian areas should have different requirements than areas in flood plains and likewise for areas in drier climates within the City. The specifics of these native plant and landscape design requirements could be adopted according to the Planning Boards regulatory

¹³⁸ Colo. Rev. Stat. § 31-23-301.

authority.¹³⁹ Regulations should be created to designate appropriate implementation of native vegetation for certain landscapes. This regulatory power should also be used to create a procedure for considering potential impacts of development on environmental justice communities. Under these regulations, developers should be required to adopt mitigation measures to ensure that their developments do not have inequitable impacts. The Planning Board should predicate approval of a development plan on adherence to these environmental justice and native species regulations.

In developing and implementing the regulations around appropriate native landscapes for certain areas of the City, the CPD should focus on increasing native species, benefits to pollinators, stormwater management functions, and reducing the urban heat island effect. The focus should be on increasing natural landscapes, replacing non-porous surfaces with green spaces, and strategically implementing vegetative landscapes to prevent water pollution, reduce excess erosion and lessen the impact of the heat island effect.

The City of Denver should combine the tools available to them under the land-use planning power and the zoning power to incentivize vegetative landscapes in the built environment. This should include tailoring the built and natural environment mixed-use zones to best accomplish the Comprehensive Plan 2040 goals of resilience and health. The City should implement and enforce regulations to do the same. These combined measures will help increase vegetative landscapes and assist Denver in mitigating and adapting to climate change. In taking all of the preceding actions, the CPD must prioritize reducing adverse impacts on environmental justice communities.

¹³⁹ Chapter 12, Community Planning and Development, City Code of Ordinances.

Expanding on this recommendation, the next section provides a case study of a specific development strategy that could be used to integrate native vegetation into the urban landscape in order to maximize resilience in the face of a changing climate.

VI. Paved Spaces

In rebuilding natural landscapes throughout the City, Denver will have to take a look at its currently paved spaces and determine where and how those can be changed to accommodate increased native vegetation. Luckily, we see this as an opportunity instead of a problem. While Denver would be increasing its natural spaces with native species, it can address some of the issues that paved spaces create in cities. First we will look at some of the problems we seek to address with paved management systems. Then we look at various paved management systems and their benefits. Finally, we will show why certain paved management systems are a great choice for Denver specifically.

Heat island effect refers to the anthropogenic rising of temperatures typically within cities.¹⁴⁰ The human causes are varied, but one of the main causes is the absorption and retention of the Sun's heat in paved spaces.¹⁴¹ Since so much of cities are paved, often discussed in terms of "impermeability," this effect is particularly evident with respect to the differences in temperature between cities and neighboring areas.¹⁴² What we intend to show is that by using varied types of paved spaces management systems instead of standard pavement, Denver's heat island effect can be dramatically reduced. Besides helping curb Denver's rising temperatures consistently reaching very hot zones,¹⁴³ pavement management systems can save energy that

¹⁴⁰ *Learn About Heat Islands*, EPA <https://www.epa.gov/heatislands/learn-about-heat-islands> (last visited Sep. 28, 2020)

¹⁴¹ *Id.*

¹⁴² *Id.*

¹⁴³ *Denver Sets Weather Record With 74 Days at 90 Degrees*, Denver Post <https://www.denverpost.com/2020/09/19/denver-sets-weather-record-with-74-days-at-90->

would be used to cool areas and reduce pollution by increasing carbon absorbing plant life, and reduce erosion. Additionally, as many residents have moved to Denver recently, the city has seen an alarming shrinkage in green spaces.

1. Types of Paved Spaces Management Systems

Although there are multiple different approaches to pavement management systems, we will focus on three types, and explain why two of these three are appropriate for Denver. The first type of pavement management system is a highly reflective pavement, also known as high albedo pavement (HAP). HAP combats the problem of pavement absorbing and retaining heat by cutting off the source and reflecting as much energy back as possible. Whereas a standard pavement might reach a certain temperature during a hot day, HAP will not reach that same temperature, often much lower in fact.¹⁴⁴ There are several ways to increase reflectivity of pavement, from using white instead of black pavement, using additives in the pavement, or even painting pavement with less absorptive pigments.¹⁴⁵ Aside from the temperature controlling aspect of HAP, this style of heat island control notably does not compromise the longevity of pavement systems,¹⁴⁶ meaning a city that uses HAP will not incur extra expenses in the maintenance of this pavement. This also makes HAP a prime candidate for higher-traffic areas.¹⁴⁷

[degrees/#:~:text=The%20city%20hit%2090%20degrees,with%20temperatures%20in%20the%2090s](#) (last visited Sep. 28, 2020).

¹⁴⁴ Mattheos Santamouris, *Using Cool Pavements as a Mitigation Strategy to Fight Urban Heat Island—A Review of the Actual Developments*, 26 *Renewable and Sustainable Energy Revs.* 224, 227 (213) [sciencedirect.com/science/article/pii/S136403211300350X?casa_token=rTljOMa3MQcAAAAA:fVxUe44q6bHyFwDURboJJ1xmVdyl22CTWzdZgMkoKmtM7GR_yvgwXnv-98GsLKHZe_2Ru16#bib70](https://www.sciencedirect.com/science/article/pii/S136403211300350X?casa_token=rTljOMa3MQcAAAAA:fVxUe44q6bHyFwDURboJJ1xmVdyl22CTWzdZgMkoKmtM7GR_yvgwXnv-98GsLKHZe_2Ru16#bib70).

¹⁴⁵ *See id.*

¹⁴⁶ QUANTIFYING PAVEMENT ALBEDO, NATIONAL CONCRETE PAVEMENT TECHNOLOGY CENTER 5 (2019) https://intrans.iastate.edu/app/uploads/2019/12/quantifying_pvmt_albedo_w_cvr.pdf.

¹⁴⁷ We believe that additional studies should be done to look at any potential safety issues that Denver would face in using HAP such as increased glare for drivers and reflecting sun into streetlights.

The second and third types of pavement management systems we will discuss are both known as permeable pavement. Like the variety of HAP, there are many ways to create permeable pavement, and we will focus on two distinct varieties of permeable pavements in this analysis. The first of the two types of permeable pavement is hard, permeable pavement (HPP) that uses a series of interconnected layers leading to reservoirs or water management systems.¹⁴⁸ The water management reservoirs store excess water and snowmelt, only to then release the water through evaporation and direction.¹⁴⁹ The problem with this type of system is that generally HPP reaches higher temperatures than HAP when it is dry¹⁵⁰, such as is often the case in more arid climates. Since Denver is such a climate, we have determined that HPP is unlikely to be better for Denver than HAP in the same spaces.

The second type of permeable pavement, however, has an important role in Denver's attempt to control its heat island effect. This is often called green or soft, permeable pavement (SPP). SPP also uses the concept of storing excess water, but uses plant life and engineered soil surfaces as its doorway mechanism for the regulation of moisture¹⁵¹. These spaces are also engineered at depth, and like the HPP require a system to appropriately manage water that is absorbed¹⁵². Green permeable spaces are often seen as grassy areas, but this is by no means the only way to create SPP. In fact, due to Denver's dry climate, a drought-resistant natural landscape is liable to be much more manageable for Denver. Due to this natural landscape use, SPP should be engineered with lower-traffic areas in mind.

¹⁴⁸ SOAK UP THE RAIN: PERMEABLE PAVEMENT, EPA <https://www.epa.gov/soakuptherain/soak-rain-permeable-pavement> (last visited Sep. 28, 2020).

¹⁴⁹ Santamouris, *supra*, note 144 at 225.

¹⁵⁰ Liv Haselbach, *Pervious Concrete and Mitigation of the Urban Heat Island Effect*, Nat'l Academies of Sci's., Eng'g, and Med. (2009) <https://trid.trb.org/view/880515>.

¹⁵¹ ELENA M. PASCARELLA, DESIGNING OPTIONS FOR GREENING URBAN ENVIRONMENTS, CONTINUING EDUC. CTR. ARCHITECTURE & CONSTR. <https://continuingeducation.bnpmedia.com/courses/bison-innovative-products/design-options-for-greening-urban-environments/3/> (last visited Sep. 30, 2020).

¹⁵² *Id.*

Soft, permeable pavements are not only exceptional heat reducers as compared to traditional paved spaces, but are important for water management.¹⁵³ One of the problems with making a city largely impervious is that rainfall and snowmelt is whisked away quickly, eroding the path of the waterflow and rendering much of the water unusable as it is carried away¹⁵⁴. A similar problem with impervious areas is a lack of flood management¹⁵⁵. Having a soft, absorptive ground can increase water retention and management, thus reducing erosion and using that water for heat management¹⁵⁶. Additionally, as a natural landscape, SPP can help to reduce carbon in the local environment through the carbon absorbing plant life, if Denver chooses to revitalize native style natural areas.

A diverse-use setting, such as throughout a city, would require a mixture of HAP and SPP for the most efficiency. Denver, as a growing city, is exactly the type of environment that lends itself to this combination approach.

2. Use of Paved Spaces Management Systems in Denver

As we have seen, Denver's climate is simultaneously arid, and in a substantial portion of the year quite hot. This means that HPP, which does not reduce heat when dry, would not be a reliable way to fight Denver's heat island effect. Instead, we believe that focusing on a combination of the SPP and HAP is most appropriate for Denver.

¹⁵³ Miklas Scholz, *Review of Permeable Pavement Systems*, 42 Building and Env't 3830, 3831 (2007) https://www.sciencedirect.com/science/article/pii/S0360132306004227?casa_token=uhqyRSodiu0AAAAA:t-XEEtUGymfgkUINev1hJ-jEBnWXV15l6JC86iWcvMFaasThEoGubXUNGDirP1CZFMRGBGR7sg; *The Morton Arboretum: Meadow Lake and Permeable Main Parking Lot*, Landscape Performance Series, <https://www.landscapeperformance.org/case-study-briefs/morton-arboretum-meadow-lake-parking> (last visited Sep. 28, 2020).

¹⁵⁴ Permeable Vs. Impermeable Surfaces, Univ. of Del., <https://www.udel.edu/academics/colleges/canr/cooperative-extension/fact-sheets/permeable-impermeable-surfaces/> (last visited Sep. 30, 2020).

¹⁵⁵ *Id.*

¹⁵⁶ Santamouris, *supra*, note 144 at 233.

By utilizing SPP in low traffic areas, some of the previously discussed benefits that Denver would take advantage of are: an increase in resistance to water erosion, decrease in flooding during heavy waterfall, increase in carbon offset with plant life, decreased heat island effect, and reduction of energy consumption for cooling purposes.¹⁵⁷ All of this is combined with the intangible factors such as more beautiful cityscapes with natural terrain, such as shrublands discussed above, as opposed to impermeable paved surfaces, and increased biodiversity as native fauna take advantage of the revitalized natural environment. This type of SPP could easily be utilized in areas with recreational foot traffic or parking,¹⁵⁸ alongside sidewalk areas for business districts,¹⁵⁹ even transition spaces,¹⁶⁰ covering a large portion of Denver. Since we know that the reduction of green and natural spaces in Denver has been a contentious issue in recent years,¹⁶¹ we are hoping to take advantage of areas that are more readily under local control than the expensive plots of land being developed into residential areas. Although the benefits of SPP usage in Denver seem real, Denver must keep in mind increases in difficulty for snow removal during its lengthy snow season.

In order to fully take advantage of engineered pavement solutions, Denver can marry the low-traffic SPP with HAP in areas seeing higher traffic. This includes business areas, and other high-volume sidewalks, and streets. Considering the impressive results in heat reflection of HAP, Denver could realize large reductions in its heat island effect. Additionally, since Denver would

¹⁵⁷ See generally Scholz, *supra*, note 153.

¹⁵⁸ NRG STADIUM (FORMERLY ASTRODOME & RELIANT), INVISIBLE STRUCTURES, <https://www.invisiblestructures.com/project/nrg-stadium-formerly-astrodome-reliant/> (last visited Sep. 30, 2020).

¹⁵⁹ PARK AVENUE/US 50, PHASE 1 REDEVELOPMENT, LANDSCAPE PERFORMANCE SERIES, <https://www.landscapeperformance.org/case-study-briefs/park-avenue-us50-redevelopment> (last visited Sep. 28, 2020).

¹⁶⁰ CENTRAL WHARF PLAZA, LANDSCAPE PERFORMANCE SERIES, <https://www.landscapeperformance.org/case-study-briefs/central-wharf-plaza> (last visited Sep. 28, 2020).

¹⁶¹ Bruce Finley, *As Development Eats Away at Denver's Green Space, the "City Within a Park" Is Becoming a Concrete Metropolis*, Denver Post (Jan. 13, 2019), <https://www.denverpost.com/2019/01/13/denver-green-space-urban-density/>.

plan the two pavement systems in the same program, a reworking of water runoff paths in the HAP could allow water and snowmelt to be directed into the SPP systems, as already shown in Denver's Cherry Creek North remodel.¹⁶² This will capitalize on the increased water storage capacity, further reducing erosion and flood potential, and help to support the native flora and fauna established in the SPP areas.

3. Incentives & Implementation Strategy

Implementation for these pavement management systems rests on two pillars, alongside several supporting benefits. First, Denver already has a large and frequent pavement repair program in place. Second, usage of these pavement management systems have the potential to generate income, or at a minimum pay for themselves.

Denver's pavement repair program is a massive undertaking.¹⁶³ The maps over the past three years show that Denver has resurfaced many different streets across the city. Denver's sidewalk repair program, though often funded through residents owning adjacent properties, is similarly in a situation of constant use.¹⁶⁴ What this means, practically speaking, is that there is already a system in place for repairs that can be adapted, instead of created from scratch. This time, infrastructure, and money saving is just a part of what puts the pavement management systems within reach.

Not to be understated is the potential for economic gain, or at least self-funding replacements. Revitalizing an area and bringing in business can be a powerful economic incentive. The Cherry Creek North example, *supra*, had a budget of \$18.5 million, but

¹⁶² Yang, *Supra*, note 122.

¹⁶³ STREET MAINTENANCE AND IMPROVEMENT, DENVER DEP'T OF TRANSP. & INFRASTRUCTURE, <https://www.denvergov.org/content/denvergov/en/transportation-infrastructure/programs-services/street-maintenance-improvement.html> (last visited Sep. 28, 2020).

¹⁶⁴ ABOUT THE NEIGHBORHOOD SIDEWALK REPAIR PROGRAM, DENVER DEP'T OF TRANSP. & INFRASTRUCTURE, <https://www.denvergov.org/content/denvergov/en/transportation-infrastructure/programs-services/pedestrians/sidewalks/neighborhood-repair/program-info.html> (last visited Sep. 28, 2020).

simultaneously helped to decrease retail vacancy rates over three years and also brought in an additional \$1 million in tax revenue the first year alone.¹⁶⁵ Many other examples of pavement management systems have shown that careful planning can lead to decreases in watering, replacement, and maintenance costs.¹⁶⁶

Besides these two obvious incentives, there are the factors of decreasing energy usage by reducing the heat island effect, increasing natural spaces, and water reclamation to consider. Overall, the incentives are strong enough to justify the City's use of these pavement management systems.

As shown, Denver can take advantage of both SPP and HAP systems. These systems provide a number of advantages that Denver currently struggles with. Among these advantages are: reduction of heat island effect, water management, reduction of atmospheric carbon, increased natural spaces for residents, and a reduction of energy consumption for cooling during the hotter months. Additionally, due to the financial and other incentives, switching to HAP and SPP systems is well within Denver's reach.

VII. Conclusion

This brief seeks to provide the City of Denver with policy options they can implement in order to increase the urban vegetative landscape. By understanding the interactions between native species, city planners can take cues from the landscape when revegetating the City to maximize the benefits of native plants. As discussed, these benefits include requiring less intensive inputs of water, fertilizer, and maintenance, providing benefits to biodiversity and soil

¹⁶⁵ Yang, *supra*, note 122.

¹⁶⁶ PETE V. DOMENICI U.S. COURTHOUSE LANDSCAPE RETROFIT, LANDSCAPE PERFORMANCE SERIES, <https://www.landscapeperformance.org/case-study-briefs/domenici-courthouse-landscape> (last visited Sep. 28, 2020); BUFFALO BAYOU PARK, LANDSCAPE PERFORMANCE SERIES, <https://www.landscapeperformance.org/case-study-briefs/buffalo-bayou-park> (last visited Sep. 28, 2020); SWOPE CAMPUS PARKING LOT AND ENTRY PLAZA, LANDSCAPE PERFORMANCE SERIES, <https://www.landscapeperformance.org/case-study-briefs/swope-campus-parking-lot-and-entry-plaza> (last visited Sep. 28, 2020).

health, and increasing the overall climate resilience of Denver. With the benefits and importance of native species and natural landscapes in mind, Denver should engage in planning and zoning that incentivizes increasing the footprint of green spaces.

In planning and zoning to increase the adaptive and mitigative benefits of native landscapes, the City should focus on maximizing resilience by implementing regulations that direct the placement of native plants. Additionally, environmental justice considerations should be implemented at every stage of the planning process. One example of how this can be done successfully is through the development of paved spaces using modern vegetative techniques that can reduce the heat island effect and energy consumption while increasing water management and natural spaces. If the City of Denver implements these strategies the City will be healthier and more prepared to face the challenges of climate change.

We hereby certify that the brief for Colorado Law is the product of the undersigned. We further certify that the undersigned have read the Competition Rules and that this brief complies with these Rules.

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