



EXPLORING THE GREEN INFRASTRUCTURE WORKFORCE

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JOBS FOR THE FUTURE

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NatureWORKS

Launched in 2014, the NatureWORKS study aims to understand the skills, credentials, and potential of the U.S. green infrastructure workforce. NatureWORKS is funded with generous support in part by the U.S. Forest Service’s National Urban and Community Forestry Grant Program as recommended by the National Urban and Community Forestry Advisory Council, NUCFAC.

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INTRODUCTION

There has been a surge of public demand in recent years for “green” innovations that help cities become more environmentally friendly, more pleasant to live in, and more resilient to the hazards of climate change. Expansion of parks, gardens, and other forms of “nature in the city” has transformed urban areas. More recently, there has been growing public interest in using green approaches to address longstanding, costly challenges related to the nation’s aging urban infrastructure—specifically, the hard-to-maintain systems of concrete pipes and other “gray” structures that are intended to manage stormwater and alleviate flooding.

These trends have spurred increased investments in expanding what have come to be called “green infrastructure” initiatives across the country. Studies have documented the economic and other public benefits of green infrastructure.¹ But until now there has been little examination of the workforce needed to install and maintain green infrastructure systems. There is particular interest in understanding the potential to provide employment opportunities for low-income residents and other underserved populations of urban areas.

How many people work in green infrastructure? What are the jobs? What level of compensation do they offer? What are the educational requirements? How much potential is there for job creation as green infrastructure investments increase? How is the green infrastructure workforce within the six U.S. cities examined for this report similar to—or different than—that in the nation as a whole?²

This issue brief attempts to answer these and other questions about current and emerging workforce trends related to the rise in green infrastructure activities. It summarizes the results of research conducted by Jobs for the Future (JFF) as part of NatureWORKS,³ a national initiative to understand the jobs, careers, skills, credentials, and potential of the U.S. green infrastructure workforce. The study was funded by the U.S. Forest Service’s National Urban and Community Forestry Grant Program as recommended by the National Urban and Community Forestry Advisory Council, NUCFAC.

The research focused on occupations involved in the direct installation, maintenance, and inspection (IMI) of the green infrastructure (GI) and their first-line supervisors. This report describes the GI-IMI involvement of occupations whose work includes green infrastructure

activities. It also discusses the emerging movement to certify green infrastructure workers in the stormwater management field as a way to both raise the quality of GI work and promote green infrastructure implementation, thereby expanding the workforce.

It is important to acknowledge a few key findings up front. First, the evolution of some portions of the green infrastructure workforce is still in its early stages—specifically, people who work in green stormwater management, such as those who construct and maintain rain gardens or green roofs. The ability of these projects to spur job creation hasn’t yet reached the level that many advocates had hoped.

Further, many GI-IMI jobs are difficult to isolate using standard occupational codes and classification systems. In fact, it is not yet possible to identify any jobs in the sectors NatureWORKS studied that are exclusively focused on GI-IMI tasks.

Green infrastructure IMI work generally is carried out by individuals who comprise a small proportion of broader, traditional occupation groups, such as construction, landscaping, and water quality protection workers, who often spend most of their time on traditional industry activities.

Installing, maintaining, and inspecting green infrastructure does require discrete skills. However, many of these skills appear to be part of the broader portfolios of skills necessary for success within certain occupations and industries.

This gradual emergence of a workforce for new environmental challenges like green approaches to stormwater management is not unusual. In many ways, characteristics of the green infrastructure workforce mirrors the progression of other “green” sectors in the recent past, such as clean energy. However, it is also likely that, as the number and scope of green infrastructure projects increase, opportunities for developing distinct green infrastructure jobs will increase as well. Already, some contractors have decided to specialize in green infrastructure activity, such as installation of pervious pavement or green roofs, and are building niche businesses.

Further, while the workforce within large industries (e.g., construction, landscaping) that is uniquely devoted to green infrastructure activities is currently relatively small, it represents a valuable opportunity for people seeking good entry-level jobs with some advancement potential. As this report shows, the barriers to entry are low, the wages are in line with other entry-level opportunities, and there are opportunities for career growth within each of the industries that employ green infrastructure workers.

This brief is divided into three sections. The first explores the current workforce, including educational requirements and wages. JFF draws upon both traditional labor market information from the U.S. Department of Labor and the U.S. Census Bureau, as well as online job posting data—known as real-time labor market information—to understand characteristics of employer demand, including skills sought. The second part examines occupational projections to gauge potential job growth; these data are complemented by qualitative findings from an in-depth survey of green infrastructure contractors. The paper concludes with targeted recommendations for policymakers, employers, education and training providers, and other stakeholders interested in expanding GI-IMI job opportunities.

To complement the nationwide analysis in the main body of the report, a series of city profiles is interspersed to provide insight into how cities are implementing green infrastructure approaches and the potential workforce implications of these projects. The profiles highlight the six NatureWORKS focal cities—Ann Arbor, Austin, Charlotte, Denver, Lincoln (NE), and Portland (OR)—as well as Detroit. Together, these cities represent diverse geographies and approaches to green infrastructure. The profiles describe key local drivers of green infrastructure, activities underway, and estimates of the potential green infrastructure workforce. While the precise characteristics of the green infrastructure workforce within these cities is difficult to isolate, the profiles help illuminate the broader factors that drive this work at the local level.

Green infrastructure provides considerable social, economic, and ecological benefit to this Washington, DC neighborhood.

(Photo credit: Phillip Rodbell, U.S. Forest Service)



THE CURRENT WORKFORCE

In order to explore the green infrastructure workforce, it is essential to start by defining terms.

DEFINING 'GREEN INFRASTRUCTURE'

As green infrastructure planning, design, and construction have evolved, the term “green infrastructure” has come to mean somewhat different things to different stakeholders.⁴ For the purposes of this research, JFF developed a definition that encompasses both traditional types of green infrastructure and more recent innovations in green stormwater management—previously considered distinct by some in the field—and combines them under a single umbrella.

JFF defines “green infrastructure” as “a collection of natural lands, working landscapes, and appropriate constructed interventions that conserves ecosystem functions and provides benefits to human populations.” Figure 1 highlights several of the specific green infrastructure systems that are included within this definition. The definition draws on one created by The Conservation Fund, a national nonprofit organization that seeks to save land in ways that balance environmental and economic goals.⁵

Traditional green infrastructure has included parks, urban forests, street trees, large gardens, wetlands, greenways, and other forms of “nature in the city”—all features that existed long before the term “green infrastructure” became commonly used. Cities have been looking for ways to protect and expand these features, as well as to return native ecosystems to the urban landscape, creatively use vacant lots and contaminated brownfields, and restore buffers for creeks, streams, and rivers.

More recent innovations consist of alternative approaches to stormwater management to improve water quality protection and flood control, in the face of climate change and sea level rise. These are known collectively as “green stormwater infrastructure” (GSI).⁶

Public and private investments in GSI are growing across the U.S., driven not only by environmental benefits, but also by federal requirements and incentives regarding handling of stormwater runoff, according to a recent Harvard Law School study.⁷ As a result, instead of installing and maintaining exclusively “gray” physical structures like pipes and storage tanks, a growing number of cities are developing complementary “green”

approaches to reduce stormwater runoff by steering rain to areas where it can infiltrate into the ground. These approaches include rain gardens, green roofs, pervious pavement, bioswales, planter boxes, rainwater harvesting, downspout disconnections, and more.

Some communities have found combining green and gray infrastructure more cost-effective than building gray infrastructure alone, the Harvard Law School study found. And several have committed to major GSI projects in the coming years. Philadelphia, for example, is investing \$1.7 billion in public and private funds through 2036 to reduce stormwater pollution through green infrastructure. New York City has committed \$2.4 billion over the next 20 years.

Smaller cities are also committing to green infrastructure. For example, Portland invested \$55 million to manage stormwater runoff through the use of green infrastructure over five years. However, in many parts of the country, advocates have found regulatory (e.g., conflicting land use policies or property rights) and economic barriers to implementation. In addition, a lack of familiarity with green infrastructure within communities and limited knowledge of the maintenance requirements and costs among municipalities and contractors can also hinder implementation.⁸

Figure 1. Green Infrastructure

GREEN INFRASTRUCTURE is a collection of natural lands, working landscapes, open spaces, and appropriate construction interventions that conserves ecosystem functions and provides benefits to human populations.



DEFINING THE GI WORKFORCE

A significant portion of green infrastructure is on public land, and is managed by local government workers and the private contractors they hire. GI on private land is managed by property owners themselves, through property management companies and/or local contractors. Many volunteers also contribute to this work.⁹

The total GI workforce in any given city can be defined broadly to include the individuals who contribute to the management, design, planning, permitting, finance, regulatory compliance, installation, maintenance, monitoring, and inspection of all of the different types of green infrastructure mentioned above. Some may define it even more expansively to include environmental protection occupations, the full supply chain for green infrastructure-related goods and services, and the research community.¹⁰

For NatureWORKS, JFF narrowed its research focus to a targeted group of activities—direct IMI duties related to green infrastructure and the first-line supervisors of these workers. IMI work was selected because it offers entry-level and middle-skill jobs that represent valuable on-ramps into the sectors deeply involved in green infrastructure work, such as construction and tree care. The broader, professional green infrastructure occupations, such as landscape architects, horticulturalists, hydrologists, and engineers, are not regularly involved directly with the hands-on work of IMI. These positions also require significantly more education and training than entry-level workers, who may choose to pursue these occupations as a longer-term goal.

A GREEN DEGREE

Edmonds Community College in Lynnwood, WA, has responded to Seattle-area demand for green infrastructure initiatives by offering a specialized two-year degree to prepare students for this work. The Landscape and Restoration Horticulture associate degree program blends new skills in ecological landscaping with traditional green infrastructure skills. For example, a prerequisite course in low-impact landscaping introduces the design and installation of green stormwater infrastructure practices such as rain gardens, green roofs, and bioswales, which are becoming popular alternatives to pipes and other common “gray” infrastructure. In addition to typical landscaping techniques, students learn how to do low-volume irrigation and incorporate native plants into designs. Graduates are employed by residential and commercial landscaping companies, as well as municipal agencies that maintain parks, public gardens, and other landscapes and native habitats.

Source: http://catalog.edcc.edu/preview_program.php?catoid=48&poid=9449&returnto=13766

ANN ARBOR, MI¹¹

Providing Financial Incentives for Residents to Expand Green Infrastructure

A relatively small city of about 117,000 people, Ann Arbor is known best as home to the University of Michigan and its more than 40,000 students.¹² Protecting the Huron River, which provides up to 85 percent of the city's drinking water and is a prominent feature of the landscape, is a priority in Ann Arbor's efforts to expand green infrastructure.



Key Goals:

- ▶ Improving water quality in the Huron River, which is negatively affected by stormwater runoff on a regular basis.
- ▶ Reducing stormwater runoff from city streets, which accounts for half of all runoff in Ann Arbor.



Selected Activities:

- ▶ Financial incentives for installation of green infrastructure on private property, such as detention basins, rain gardens, and rain barrels. Residents earn credits toward stormwater utility fees.
- ▶ A county-run program to help residents install and maintain their own rain gardens, or to locate and hire a contractor to assist them.
- ▶ A "Green Streets Policy" that promotes green infrastructure on city right of ways by favoring street construction most likely to meet minimum standards for rainfall infiltration.
- ▶ Maintenance of a significant urban forest, which includes street trees, over 150 parks, and the University of Michigan's Nichols Arboretum and Matthaei Botanical Gardens.



Estimated GI-IMI Workforce:

- ▶ Up to 4 percent of the workforce is potentially involved in the 30 GI-IMI occupations.¹³
- ▶ As many as 9,500 workers are employed across the 30 GI-IMI occupations in the Ann Arbor metro area.*¹⁴
- ▶ There were approximately 1,200 job postings for the 30 GI-IMI occupations across the Ann Arbor metro area in 2015.¹⁵

Ann Arbor has operated its own stormwater management utility since the early 1980s—an expensive and technically challenging operation with an increasingly complex fee structure now based on stormwater runoff measured remotely from each property. Like many cities, Ann Arbor reports insufficient funding for maintenance of green stormwater infrastructure and the need for focused training of city staff and contractors.

**Note: The actual number is likely to be much lower. As discussed later in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

IDENTIFYING THE GI-IMI WORKFORCE

In order to determine the composition of the GI-IMI workforce,¹⁶ JFF worked with stakeholders involved in green infrastructure, such as the Tree Care Industry Association and the National Green Infrastructure Certification Program, to identify a set of core occupations that include individuals doing green infrastructure work and to vet the list with a broad group of green infrastructure professionals and municipal officials.¹⁷

Our research concluded that the GI-IMI workforce includes 30 core occupations found in a relatively small group of interconnected industry sectors. However, only a small percentage of workers in most of the 30 core occupations are involved in GI-IMI activities.

The represented sectors are construction, landscaping, groundskeeping, urban forestry, tree care, ecological restoration, and water/wastewater. The 30 GI-IMI occupations are listed in the table below, broken out across several functional occupation groups (see Figure 2).¹⁸

DRIVERS OF GREEN INFRASTRUCTURE DEVELOPMENT

Green infrastructure initiatives are implemented in response to a number of regulatory and environmental drivers, including:

- ▶ The 1972 Water Quality Act, which gave the U.S. Environmental Protection Agency the authority to regulate the discharge of pollutants into waters.
- ▶ The National Pollutant Discharge Elimination System, which requires polluters—including cities, towns, and counties with over 50,000 people—to obtain a permit for all discharge from their state's environmental agency.
- ▶ Municipal Separate Storm Sewer System (MS4) Permits, which require municipalites to develop stormwater management plans to address runoff due to construction and redevelopment. Cities and states are increasingly integrating green infrastructure into their MS4 permits.

- ▶ Sustainability goals and the desire to create more livable and environmentally friendly cities.
- ▶ Natural disasters, such as Hurricanes Katrina and Sandy, which highlighted the need for flood protection and wetland restoration.

As a result, green infrastructure has become seen as an increasingly attractive strategy to address regulatory requirements and to create vibrant and ecologically viable cities.

To learn more about the drivers of green infrastructure, see: <https://www.epa.gov/green-infrastructure/integrating-green-infrastructure-federal-regulatory-programs#MS4%20Permits>
http://www.sustainablecitiesinstitute.org/Documents/SCI/Report_Guide/Guide_EPA_GICaseStudiesReduced4.pdf

Figure 2. The Green Infrastructure Workforce

Installation, Maintenance, and Inspection Occupations

Architecture and Engineering Occupations

17-3025 Environmental Engineering Technicians

Life, Physical, and Social Science Occupations

19-4093 Forest and Conservation Technicians

Building and Grounds Cleaning and Maintenance Occupations

37-1012 First-Line Supervisors of Landscaping, Lawn Service, and Groundskeeping Workers

37-3011 Landscaping and Groundskeeping Workers

37-3012 Pesticide Handlers, Sprayers, and Applicators, Vegetation

37-3013 Tree Trimmers and Pruners

Fishing, Farming, and Forestry Occupations

45-1011 First-Line Supervisors of Farming, Fishing, and Forestry Workers

45-2092 Farmworkers and Laborers, Crop, Nursery, and Greenhouse

45-4011 Forest and Conservation Workers

Construction and Extraction Occupations

47-1011 First-Line Supervisors, Construction Trades and Extraction Workers

47-2051 Cement Masons and Concrete Finishers

47-2061 Construction Laborers

47-2071 Paving, Surfacing, and Tamping Equipment Operators

47-2073 Operating Engineers and other Construction Equipment Operators

47-2151 Pipelayers

47-2181 Roofers

47-3015 Helpers—Pipelayers, Plumbers, Pipefitters, and Steamfitters

47-3016 Helpers—Roofers

47-4011 Construction and Building Inspectors

47-4071 Septic Tank Servicers and Sewer Pipe Cleaners

47-4091 Segmental Pavers

47-5021 Earth Drillers, Except Oil and Gas

Installation, Maintenance, and Repair Occupations

49-9012 Control and Valve Installers and Repairers, Minus Mechanical Door

49-9071 Maintenance and Repair Workers, General

49-9098 Helpers—Installation, Maintenance, and Repair Workers

Production Occupations

51-8031 Water and Wastewater Treatment Plant and System Operators

Transportation and Materials Moving Occupations

53-7032 Excavating and Loading Machine and Dragline Operators

53-7051 Industrial Truck and Tractor Operators

53-7062 Laborers and Freight, Stock, and Material Movers, Hand

53-7072 Pump Operators, Except Wellhead Pumps

Source: Emsi Analyst. 2016.3 data set. Note: Each occupation is listed by major occupational group and includes both the Standard Occupational Classification (SOC) code and the occupation title.

Involvement in GI-IMI Activities

The occupations involved with GI-IMI work employ nearly 3 million people nationwide, but only a very small percentage are likely to be involved in GI-IMI work now or over the next year, based upon findings from JFF's survey of contractors in industries related to green infrastructure. Further, an analysis conducted by the Institute for Compensation Studies at Cornell University's ILR School, the overall proportion of workers involved in GI-IMI work in the 30 core occupations is about 6 percent of the overall number—roughly 239,000 individuals nationally.¹⁹

This is similar to the proportions in the NatureWORKS focal cities, which range from 4 percent (Ann Arbor) to 6 percent (Lincoln and Charlotte).

The green infrastructure workforce is predominantly male and has a racial/ethnic composition that aligns with that of the nation as a whole. Approximately 12 percent of workers in GI-IMI occupations nationwide are Black and 16 percent are Hispanic. On average, these workers have nearly 14 years of schooling, which corresponds to some college.

Among workers in the 30 core occupations, the estimated level of involvement in GI-IMI work varies significantly. In more than one-third of the occupations, less than 5 percent of workers are involved in GI-IMI activities. Only one of the occupations—tree trimmers and pruners—has up to 75 percent of workers involved in GI-IMI activities.

In other words, most workers in the 30 core occupations are more involved in work which is not related to GI-IMI than in work which is related to GI-IMI.

Based upon a nationwide survey of contractors in the tree care and landscaping industry, and conversations with green infrastructure professionals, JFF estimated the percentage of workers in each occupation group that have some involvement in GI-IMI activities, or can expect to have some involvement in the next few years (see Figure 3). The online survey, which JFF created and analyzed, received nearly 500 responses.²⁰

The data show: In 14 of the 30 occupation groupings, GI-IMI involvement was estimated to be not greater than 5 percent of total workers. These low-involvement GI-IMI occupations include construction laborers, roofers, and paving equipment operators. In another 13 occupations, such as pipelayers, nursery and greenhouse workers, and general maintenance and repair workers, GI-IMI involvement was estimated between 5 and 15 percent.

The three most involved occupational groups work in traditional green infrastructure—tree care and open space. Tree trimmers and pruners were estimated to have up to 75 percent involvement, while the next highest level of involvement was up to 25 percent. Only two occupation groups—landscaping and groundskeeping workers, and forest and conservation workers—were at that level.

Effective, low-maintenance green infrastructure treatments like this sequenced structure in Wilmington, DE, can capture and treat many thousands of gallons of rainwater during each rain event.

(Photo credit: Phillip Rodbell, U.S. Forest Service)



AUSTIN, TX²¹

Weaving Green Infrastructure into Every Part of the City—by Design

The fastest-growing large city in the United States, Austin is a high-tech national hub, a renowned music and cultural center, and home to the flagship campus of the University of Texas.²² Over 930,000 people live in the state capital, which features a vast park system and extensive urban forest, as well as lakes, rivers, and other waterways.²³ Protection and expansion of green infrastructure is a planning priority. Officials want to prove that a big city can “grow green” while growing fast.



Key Goals:

- ▶ Protecting environmentally sensitive areas and integrate nature into the city, making implementation of green infrastructure central to all city planning.
- ▶ Expanding tree cover in every neighborhood, improve watershed health, increase access to parks, and link these resources throughout the city.



Estimated GI-IMI Workforce:

- ▶ Up to 5 percent of the workforce is potentially involved in the 30 GI-IMI occupations.²⁴
- ▶ As many as 58,900 workers are employed across the 30 GI-IMI occupations in the Austin metro area.^{*25}
- ▶ There were approximately 5,400 job postings for the 30 GI-IMI occupations in the Austin metro area in 2015.²⁶



Selected Activities:

- ▶ Officials are making plans to further coordinate green infrastructure activities across the unusually broad range of municipal departments involved in green infrastructure work, which range from Austin Energy to Austin Resource Recovery, Watershed Protection, and Neighborhood Housing and Community Development.
- ▶ The Imagine Austin Comprehensive Plan outlines a set of aligned activities and policies, which include goals to improve or expand green infrastructure through urban forestry, community wildfire protection, integrated water resources, green streets, and parks and recreation.

A big part of maintaining Austin’s growing commitment to green stormwater infrastructure is managing Austin’s natural waterways, engineered channels, drainage pipelines, and stormwater ponds. In practice, this means removing debris that obstructs water flow, stabilizing eroded stream beds, performing landscape maintenance, directly managing over 850 stormwater ponds, and inspecting another 6,300 privately maintained ponds. To assist the public, the city developed a list of local stormwater pond contractors and created a green stormwater infrastructure manual with technical guidance for maintaining rain gardens, biofiltration, and vegetative filter strips.

**Note: The actual number is likely to be much lower. As discussed earlier in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

Figure 3. Estimated Occupational Involvement in GI Installation, Maintenance, and Inspection

5% or less

Operating Engineers and Other Construction Equipment Operators
Roofers
Helpers—Roofers
Helpers—Pipelayers, Plumbers, Pipefitters, Steamfitters
Cement Masons and Concrete Finishers
Construction Laborers
Water and Liquid Waste Treatment Plant and System Operators
Paving, Surfacing, and Tamping Equipment Operators
First-Line Supervisors of Construction Trades and Extraction Workers
Earth Drillers, Except Oil and Gas
Control and Valve Installers and Repairers, Except Mechanical Door
Industrial Truck and Tractor Operators
Laborers and Freight, Stock and Material Movers
Pump Operators, Except Wellhead Pumps

5% to 10%

Segmental Pavers
Excavating and Loading Machine and Dragline Operators
Septic Tank Servicers and Sewer Pipe Cleaners
Forest and Conservation Technicians
Environmental Engineering Technicians
First-Line Supervisors of Agricultural Crop and Horticultural Workers
(This applies only to Horticultural Worker Supervisors)
Pipelayers
Maintenance and Repair Workers, General
Helpers—Installation, Maintenance, and Repair Workers

10% to 15%

First-Line Supervisors of Landscaping and Groundskeeping Workers
Pesticide Handlers, Sprayers and Applicators, Vegetation
Construction and Building Inspectors
Farmworkers and Laborers, Crop, Nursery, and Greenhouse*

15% to 25%

Landscaping and Groundskeeping Workers
Forest and Conservation Workers

25% to 75%

Tree Trimmers and Pruners

**This applies only to nursery and greenhouse workers.
Source: JFF Survey of Contractors (2016).*

CHARLOTTE, NC²⁷

Linking Green Stormwater Infrastructure and Protection of the Urban Forest

An economic hub of the southeastern United States, Charlotte is one of the fastest-growing cities in the country, currently home to more than 827,000 people.²⁸ City officials are expanding green infrastructure initiatives in response to two driving factors—the need to meet federal and state water quality regulations and the desire to improve the quality of life for residents amidst rapid development.



Key Goals:

- ▶ Making all of the city's lakes, streams, and other surface waters safe for swimming and fishing by 2050.
- ▶ Curtailing the rapid loss of trees and restoring the tree canopy to its previous size, covering 50 percent of the city.



Selected Activities:

- ▶ Promoting the use of green stormwater infrastructure approaches instead of (and in alignment with) traditional "gray" stormwater infrastructure consisting of pipes and storage tanks.
- ▶ Instituting a Post-Construction Stormwater Ordinance that requires stream protection and flood control, as well as pollutant reduction for development/redevelopment projects. This ordinance includes a fee-in-lieu provision that funds green infrastructure projects.
- ▶ Capital investment to protect existing street trees and plant new trees.



Estimated GI-IMI Workforce:

- ▶ Up to 6 percent of the workforce is potentially involved in the 30 GI-IMI occupations.²⁹
- ▶ As many as 83,800 workers are employed across the 30 GI-IMI occupations in the Charlotte metro area.³⁰
- ▶ There were approximately 7,900 job postings for the 30 GI-IMI occupations in the Charlotte metro area in 2015.³¹

Charlotte was recognized by the Water Environment Federation and the U.S. Environmental Protection Agency for its green infrastructure work in 2015 and continues to expand green infrastructure systems across the city.³² The city is now working to gather better data about the environmental, economic, and social benefits of green infrastructure in order to sustain strong resident and political support.

**Note: The actual number is likely to be much lower. As discussed earlier in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

The involvement of construction laborers in GI-IMI work is almost exclusively related to green stormwater infrastructure (GSI), especially large projects such as “green streets.” And a large percentage of GSI projects involve some work by construction laborers. However, because these construction activities make up such a small portion of the nation’s total construction work, less than 5 percent of construction workers overall are likely to be assigned to do GI-IMI work.³³ So while there were an estimated 1.7 million construction workers *potentially* involved in GI-IMI activities in the U.S. in 2015, we estimate that less than 84,000 *actually* were involved in green infrastructure work.

Installation of pervious pavement is another example. Use of pervious pavement on streets, alleys, parking lots, and driveways is an increasingly common part of many GSI projects. Many require the participation of workers in the Paving, Surfacing, and Tamping Equipment Operators occupational group. In 2015, there were an estimated 57,000 such operators; but only 1 percent—or 570 individuals—were likely to be involved in GSI work.³⁴ These operators make up only one part of a workforce that would install pervious pavement; others involved would include project managers, engineers, surveyors, and site safety workers.

In parts of the country where GI-IMI work has been increasing, there appears to be a growing number of contractors that specialize in green infrastructure work—and there may be potential for more businesses

to specialize. It is not possible to estimate how many specialized contractors exist nationally at this time. However, the types of specialty contractors can be seen in the membership of The Green Stormwater Infrastructure Partners, an initiative of the Sustainable Business Network of Greater Philadelphia, whose online directory lists more than 70 firms that advertise work in green roofs, rain gardens, green streets, and other kinds of “green infrastructure” services.³⁵

For most people involved in GI-IMI work, green infrastructure assignments typically amount to a set of activities within their jobs, not entire jobs in and of themselves. However, it is important to note that individual involvement likely varies a great deal. While some people devote just a few hours per week to GI-IMI activities, others may devote all of their time to GI-IMI projects (e.g., an employee of a green roof installer). This indicates there might be emerging green infrastructure occupations—a question worth further exploration.

In sum, the green infrastructure workforce is difficult to isolate and characterize, because GI-IMI work is spread across multiple industries and is carried out by people who have expanded their responsibilities to include green infrastructure activities. They are typically taking on new kinds of work in addition to—not instead of—traditional industry work. As discussed later, green infrastructure workers share a set of cross-industry skills that exist across the major occupation groups involved in green infrastructure.



A “stormwater bumpout” like this vegetated curb extension in Washington, DC, expands the available rooting zone for existing trees and significantly slows rainwater runoff during storm events, while slowing traffic in residential neighborhoods.

(Photo credit: Phillip Rodbell, U.S. Forest Service)

TYPICAL EDUCATION AND TRAINING WITHIN THE GI-IMI WORKFORCE

One of the defining characteristics of occupations involved with GI-IMI work is their typically low educational requirements.

Of the 30 occupations, 28 require high school completion or less—18 require a high school diploma and 10 do not require any formal educational credential. Only two—environmental engineering technicians and forest and conservation technicians—require education beyond high school (an associate degree) to compete for an entry-level position. Most of the occupations have no work experience requirement and if workers take part in on-the-job training, it is either short or moderate term.³⁶

Given the overall entry-level nature of this work, green infrastructure can be an important target for workforce development, especially to increase opportunities for low-income, low-skilled workers currently underrepresented in the workforce.

Employers of GI-IMI workers—whether private contractors or municipal departments—generally seek workers with the knowledge, skills, and aptitudes needed for success on traditional projects. For example, in hiring a paver who will be on a crew that does some pervious paving, most companies or departments seek an individual who has performed typical activities within the paving industry (e.g., leveling surfaces, aligning materials).³⁷ In other words, preparation for GI-IMI is largely the same as preparation for entry-level work in the larger construction, landscaping, tree care, utility, and other related industries.

However, this may be changing as green infrastructure certifications emerge, as discussed under “The Future Workforce” below. Candidates with “green infrastructure” skills or a certification may have an advantage seeking employment with niche contractors that specialize in green infrastructure projects.

PHILADELPHIA:

Growing Green Stormwater Infrastructure and a Workforce to Match

In 2011, Philadelphia launched Green City, Clean Waters, a 25-year program supported by at least \$1.2 billion in public funds that aims to reduce stormwater pollution by 85 percent. This initiative has positioned Philadelphia as one of the national leaders in implementing green infrastructure. Select green stormwater installations added so far include:

- ▶ 742 stormwater tree trenches
- ▶ 268 infiltration/storage trenches
- ▶ 195 stormwater planters
- ▶ 179 rain gardens
- ▶ 49 stormwater bumpouts
- ▶ 48 bioswales
- ▶ 33 downspout planters

For more information, see: Philadelphia’s Green City, Clean Waters Program: http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan and PowerCorpsPHL: <http://powercorpsphl.org/about-us/>

Source: JFF phone interview with Gerald Bright. June 18, 2015.

To meet workforce needs related to this initiative, the Philadelphia Water Department oversees a diverse team of city workers, contractors, and trainees/volunteers. Gerald Bright, manager for green infrastructure maintenance in the Office of Watersheds, notes that the city currently employs a team of 7 individuals for green stormwater management maintenance; their work is complemented by approximately 40 contractors, including AmeriCorps trainees from PowerCorpsPHL. Bright anticipates that this current workforce will be able to meet the city’s green infrastructure needs, though some upskilling may be necessary to ensure effective long-term maintenance of green infrastructure systems.

DENVER, CO³⁸

A Voluntary Approach to Expanding Green Stormwater Infrastructure

Named “the best place to live in the United States” in 2016 by *U.S. News and World Report*, Denver is growing rapidly and is currently home to more than 683,000 people.³⁹ Denver lies within the South Platte River Valley and borders the front range of the Rocky Mountains. Unlike many other U.S. cities investing in green stormwater infrastructure, Denver faces no U.S. Environmental Protection Agency compliance orders to reduce stormwater runoff, but instead chooses to implement green stormwater infrastructure practices voluntarily.



Key Goals:

- ▶ Maintaining over 20,000 acres of parks and more than two million trees.
- ▶ Using open spaces, drainage ways, and floodplains to mitigate the effects of the city’s concrete and rooftops.
- ▶ Extending the tree canopy to cover more than the current 20 percent of the city.
- ▶ Developing a system that uses green infrastructure to manage stormwater, while balancing strict limitations (common in western states) on uses of surface water with the irrigation needs of Denver’s semi-arid climate.



Estimated GI-IMI Workforce

- ▶ Up to 5 percent of the workforce is potentially involved in the 30 GI-IMI occupations.⁴⁰
- ▶ As many as 91,700 workers are employed across the 30 GI-IMI occupations in the Denver metro area.^{*41}
- ▶ There were approximately 14,300 job postings for the 30 GI-IMI occupations in the Denver metro area in 2015.



Selected Activities:

- ▶ Ambitious \$30 million “River Vision” initiative to connect green infrastructure projects and parks that stretch along three miles of the South Platte River—developing an area that was once considered a sewer and dump into a premier outdoor recreation destination.
- ▶ A 2016 *Ultra-Urban Guide* that identifies green stormwater infrastructure practices that are particularly well suited to the city’s dense, urban environment, such as street-side and bump-out stormwater planters, green gutters, green alleys, and tree trenches.
- ▶ A city requirement for licensure of companies providing tree care assures quality; over 170 companies that serve Denver are currently licensed.

Denver’s semi-arid climate is hardly conducive to sustaining thriving green infrastructure systems: rainfall is infrequent but intense, and there are more than 200 freeze/thaw cycles each year. Denver has less experience than other cities in designing, installing, and maintaining green stormwater infrastructure, and officials acknowledge a bit of trial and error. But they are collaborating at all levels to make it work, as well as to train staff and find funding for maintenance.

**Note: The actual number is likely to be much lower. As discussed earlier in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

A Skills Analysis

In today's economy, employers are looking for workers with a mix of skills both technical (those specific to doing the work at hand)—and employability (those that are needed to perform effectively in any job). As noted earlier, there are no occupations that are strictly involved in green infrastructure for us to use to define the needed skills, so what are the skills that could be considered core to GI-IMI work?

A NatureWORKS analysis by Cornell University researchers provides some insight into this question. Their study drew on skill information from the O*Net database that details skills across occupational groups.⁴² Compared to similar occupations that are not involved in green infrastructure, GI-IMI jobs require higher levels of the following skills (listed by greatest level of importance):

- ▶ Equipment maintenance
- ▶ Repair
- ▶ Operation and control
- ▶ Troubleshooting
- ▶ Equipment selection
- ▶ Quality control analysis
- ▶ Installation

These skills reflect the core competencies necessary across IMI occupations.

In addition, for greater insight into the specific skills that are relevant to green infrastructure work within these occupations, JFF analyzed job posting data, which allowed researchers to examine job postings for the 30 GI-IMI occupations that explicitly included green infrastructure keywords, such as “rain garden” or “downspout disconnection.”⁴³ This analysis helps refine our understanding of the specific skills and qualifications employers are seeking when they hire for green infrastructure-related work.

Several of the specialized skills that emerged from the real-time analysis align with those highlighted by Cornell, such as repair and machinery (see Figure 4). Other specialized skills in high demand for GI-IMI workers were found to apply specifically to GSI work, such as water quality and water treatment skills.

Another interesting finding of the real-time LMI analysis is the top baseline skills—also called employability skills—sought by employers (see Figure 4). It shows that employers are also looking to hire workers with strong communication, writing, mathematics, and other general employability skills. This finding was supported by conversations with staff people representing the employers associated with the National Green Infrastructure Certification Program, the Tree Care Industry Association, the Center for Watershed Protection, and the National Association of Landscape Professionals.⁴⁴ This finding is not unique to these employers. Nationally, employers—regardless of industry—emphasize the importance of these skills when hiring.⁴⁵



“Green roofs” use vegetation to help absorb stormwater, insulate buildings from extreme temperatures, and moderate urban heat islands.

(Photo credit: Shutterstock)

Figure 4. Key GI-IMI Skills, Based upon Job Posting Data

Top Skills for IMI Occupations Nationwide (with GI Keywords) June 2015–May 2016	
Baseline	Specialized
Physical Demand	Repair
Communication Skills	Inspection
Writing	Water Quality
Troubleshooting	Water Treatment
Mathematics	Scheduling
Supervisory Skills	Machinery

Source: Burning Glass Technologies. Labor Insight.

Compensating the GI-IMI Workforce

National median wages for occupations involving GI-IMI work are typical of other entry-level occupations, though there is some variation across the 30 occupations (see Figure 5). Roughly one-third paid a median wage of less than \$15 per hour in 2015; one third paid \$15 to \$20 per hour; and the remaining third paid \$20 to \$26 per hour.

The 2015 median hourly wages range from a low of \$11.50 per hour for landscaping and groundskeeping workers to a high of over \$26 for construction and building inspectors. Annualized, full-time pay ranges from \$21,300 to \$55,000. In many parts of the country, these annualized wages may provide an artificially high estimate, as certain types of GI-IMI workers—such as landscaping and groundskeeping—are employed seasonally, not year-round.

Compared to the overall U.S. workforce, workers in occupations involved in GI-IMI earn approximately

\$6.44 less per hour, according to the Cornell study. And compared to the overall U.S. workforce, workers in those occupations are 41 percent less likely to be female and have lower levels of education (2.7 fewer years). However, compared with workers in similar occupations, the pay differential narrowed to just over 1 percent.⁴⁶ A 1 percent pay differential is, of course, small. However, workers in occupations related to GI-IMI do earn slightly less than individuals in similar—but non-green infrastructure-related occupations.

The Cornell analysis also examined a broader definition of compensation that included employer-provided health care. Nationwide, workers in GI-IMI occupations are approximately 1-2 percentage points more likely to receive employer-provided health care than those in non-green infrastructure occupations.⁴⁷ This indicates that despite lower-level wages, GI-IMI workers may be compensated through other forms of rewards.

Figure 5. Nationwide Median Wages of GI-IMI Occupations, 2015

Occupation	Median Hourly Earnings
First-Line Supervisors of Construction Trades and Extraction Workers	\$28.22
Construction and Building Inspectors	\$28.00
Control and Valve Installers and Repairers, Except Mechanical Door	\$26.57
Environmental Engineering Technicians	\$23.55
Operating Engineers and Other Construction Equipment Operators	\$22.54
Water and Wastewater Treatment Plant and System Operators	\$22.48
First-Line Supervisors of Farming, Fishing, and Forestry Workers	\$21.86
Earth Drillers, Except Oil and Gas	\$21.85
Pump Operators, Except Wellhead Pumpers	\$21.17
Excavating and Loading Machine and Dragline Operators	\$20.33
Paving, Surfacing, and Tamping Equipment Operators	\$20.03
Cement Masons and Concrete Finishers	\$19.26
Pipelayers	\$18.72
First-Line Supervisors of Landscaping, Lawn Service, and Groundskeeping Workers	\$18.52
Maintenance and Repair Workers, General	\$17.90
Roofers	\$17.58
Septic Tank Servicers and Sewer Pipe Cleaners	\$17.49
Forest and Conservation Technicians	\$16.89
Industrial Truck and Tractor Operators	\$15.75
Tree Trimmers and Pruners	\$15.64
Construction Laborers	\$15.47
Pesticide Handlers, Sprayers, and Applicators, Vegetation	\$15.39
Segmental Pavers	\$14.26
Forest and Conservation Workers	\$14.21
Helpers—Pipelayers, Plumbers, Pipefitters, and Steamfitters	\$14.06
Helpers—Roofers	\$13.42
Helpers—Installation, Maintenance, and Repair Workers	\$12.99
Laborers and Freight, Stock, and Material Movers, Hand	\$12.40
Landscaping and Groundskeeping Workers	\$11.95
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	\$10.56
GI-IMI Median Wage	\$15.78

Source: Emsi Analyst. 2016.3 data set.⁴⁸

LINCOLN, NE⁴⁹

Growing a High-Tech Green City on the Nebraska Prairie

The state capital of Nebraska with nearly 280,000 residents, Lincoln earned the nickname “Silicon Prairie” for its growing high-tech sector and receives national accolades for its quality of life.⁵⁰ Most residents live within walking distance of one of 125 public parks—more parkland per capita than any other U.S. city.⁵¹ Most of the city lies within the watershed of Salt Creek and its tributaries, including Antelope Creek, Deadman’s Run, and Little Salt Creek.



Key Goals:

- ▶ Improving water quality, reducing stormwater runoff, and facilitating infiltration. For example, protecting the 5,000-acre Antelope Creek watershed, which covers much of Lincoln’s downtown, by expanding rain gardens, native grasses, pervious pavement, and other green infrastructure practices.
- ▶ Integrating green stormwater infrastructure with parks and recreation needs.



Estimated GI-IMI Workforce

- ▶ Up to 6 percent of the workforce is potentially involved in the 30 GI-IMI occupations.⁵²
- ▶ As many as 9,000 workers are employed across the 30 GI-IMI occupations in the Lincoln metro area.^{*53}
- ▶ There were approximately 1,200 job postings for the 30 GI-IMI occupations in the Lincoln metro area in 2015.⁵⁴



Selected Activities:

- ▶ Development and implementation of multiyear watershed basin management plans that incorporate green stormwater infrastructure practices and guide city decision making.
- ▶ Offering grants and cost-share incentives for installation of green infrastructure on private property, including up to \$2,000 for rain barrels, rain gardens, native landscaping, and pavement removal.
- ▶ Passage of a voter-approved \$6.3 million Stormwater Improvement Bond Issue that will include many green stormwater infrastructure practices.

Lincoln’s primary challenge is the maintenance of its many green infrastructure projects, as there is currently no designated public funding for maintenance. To keep costs down, city officials are considering simpler plantings, which require less ongoing care. For example, past installation plans included requirements that plants flower in three seasons, without staff to maintain them. More recently, the city often has selected planting schemes that require lower levels of ongoing maintenance.⁵⁵ The city is also considering the need for additional training for construction and maintenance workers regarding green infrastructure installation and maintenance activities.

**Note: The actual number is likely to be much lower. As discussed earlier in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

THE FUTURE WORKFORCE

Precise projections of GI-IMI job growth are not possible to calculate, because of the lack of discrete GI-IMI jobs. However, it is worth considering overall trends within the broader 30 occupations that have GI-IMI involvement, as this provides the best available estimate of growth within these jobs. This study also examines job postings to understand current demand for GI-IMI workers among employers across the nation.

JOB GROWTH PROJECTIONS

In fact, projected growth in these occupations is positive, and for some it is very strong, based on traditional labor market data. Projection data takes into account both net new hires as well as anticipated growth due to replacements (retirements, churn, etc.).

Several occupational groups expect double-digit growth; almost two-thirds of the occupational groups are projected to see growth of 5 percent or higher (see figure 6a).

UNDERSTANDING THE WORKFORCE IMPACT OF A MAJOR GREEN STORMWATER INFRASTRUCTURE INITIATIVE

Lessons from Philadelphia's Green City, Clean Waters

The Sustainable Business Network of Greater Philadelphia (SBN) is a nonprofit membership organization that leads Green Stormwater Infrastructure Partners, an initiative focused on advancing local green stormwater infrastructure (GSI) industry and innovation across the city. As part of this initiative, SBN completed a 2016 study to better understand the economic impact of Philadelphia's Green City, Clean Waters program during its first five years. This study provides one of the first analyses of actual and probable job support from a major metropolitan GSI program that includes several years of supporting data from both contractors and municipal employees. The study found that Green City, Clean Waters supports approximately 1,000 jobs annually and that installing GSI systems can advance social equity. However, the total number of new IMI jobs supported by Green City, Clean Waters is likely to be quite small since the total estimate of 1,000 jobs includes the direct,

indirect, and induced jobs across a much broader range of occupations (e.g., planners, bookkeepers, accountants, information technology workers). This suggests that existing training programs that offer on-ramps to installation, maintenance, and inspection jobs within Philadelphia are likely prepared to meet much of the increased demand for these workers that results from the Green City, Clean Waters initiative.

Read the full study: [http://www.sbnphiladelphia.org/images/uploads/Green%20City,%20Clean%20Waters-The%20First%20Five%20Years\(1\).pdf](http://www.sbnphiladelphia.org/images/uploads/Green%20City,%20Clean%20Waters-The%20First%20Five%20Years(1).pdf)

To learn more about the Sustainable Business Network of Greater Philadelphia, visit: <http://www.sbnphiladelphia.org>

Note: Material for this profile comes from interviews with Emily Hauth, Maria Jimenez, Jennifer Karps and her staff, Ricardo Moreno, and Jason Schmidt. JFF conducted these interviews 2015-2016.

Figure 6a. Nationwide Projected Growth for GI-IMI Occupations, 2015–2020

Description	2015 Jobs	2020 Jobs	2015–2020 % Change
Septic Tank Servicers and Sewer Pipe Cleaners	28,685	31,786	11%
Helpers—Roofers	11,051	12,131	10%
Helpers—Pipelayers, Plumbers, Pipefitters, and Steamfitters	58,743	64,142	9%
Environmental Engineering Technicians	17,572	19,184	9%
Tree Trimmers and Pruners	61,429	66,174	8%
Landscaping and Groundskeeping Workers	1,258,251	1,348,696	7%
Roofers	148,162	158,240	7%
Pesticide Handlers, Sprayers, and Applicators, Vegetation	31,578	33,656	7%
Helpers—Installation, Maintenance, and Repair Workers	129,984	137,988	6%
Cement Masons and Concrete Finishers	175,776	186,439	6%
Laborers and Freight, Stock, and Material Movers, Hand	2,556,448	2,702,552	6%
Maintenance and Repair Workers, General	1,452,611	1,532,707	6%
Construction and Building Inspectors	100,360	105,735	5%
Industrial Truck and Tractor Operators	551,202	578,705	5%
Forest and Conservation Workers	13,356	14,011	5%
First-Line Supervisors of Landscaping, Lawn Service, and Groundskeeping Workers	143,789	150,778	5%
Construction Laborers	1,288,038	1,349,757	5%
Water and Wastewater Treatment Plant and System Operators	114,460	119,921	5%
Pipelayers	46,316	48,404	5%
Paving, Surfacing, and Tamping Equipment Operators	53,316	55,701	4%
Operating Engineers and Other Construction Equipment Operators	375,702	390,383	4%
Segmental Pavers	1,466	1,523	4%
Control and Valve Installers and Repairers, Except Mechanical Door	42,513	44,035	4%
Earth Drillers, Except Oil and Gas	21,194	21,692	2%
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	785,106	800,153	2%
First-Line Supervisors of Construction Trades and Extraction Workers	627,322	637,099	2%
Pump Operators, Except Wellhead Pumpers	13,921	13,977	0%
Excavating and Loading Machine and Dragline Operators	56,972	57,089	0%
Forest and Conservation Technicians	32,405	32,376	0%
First-Line Supervisors of Farming, Fishing, and Forestry Workers	51,032	49,268	(3%)
GI-IMI TOTAL	10,248,760	10,764,299	5%

Source: Emsi Analyst. 2016.3 data set.

Note: Projected job change in parentheses indicates a decline in the total number of jobs within that particular occupation.

PORTLAND, OR

A National Leader in Green Stormwater Infrastructure

Oregon's largest city is home to about 632,000 people,⁵⁶ many drawn to its extensive network of parks, urban forest, and open space. Located between the Willamette and Columbia rivers, the city sits within several watersheds, has more than 240 miles of waterways, and is known for wet weather, raining almost every other day on average. Portland's long history of green infrastructure projects began in the 1990s and the city remains a national leader today.



Key Goals:

- ▶ Securing sufficient funding to maintain a significant base of green stormwater infrastructure on public and private property, including over 2,000 rain gardens, hundreds of green roofs and roof gardens, and thousands of other installations.
- ▶ A targeted "Tabor to the River" program launched in 2010 aims to plant 3,500 trees, add 500 green streets, and build 100 private stormwater projects to decrease sewer backups and flooded streets from the neighborhood of Mount Tabor to the Willamette River.⁵⁷



Estimated GI-IMI Workforce:

- ▶ Up to 5 percent of the workforce is potentially involved in the 30 GI-IMI occupations.⁵⁸
- ▶ As many as 72,900 workers are employed across the 30 GI-IMI occupations in the Portland metro area.^{*59}
- ▶ There were approximately 10,600 job postings for the 30 GI-IMI occupations in the Portland metro area in 2015.⁶⁰



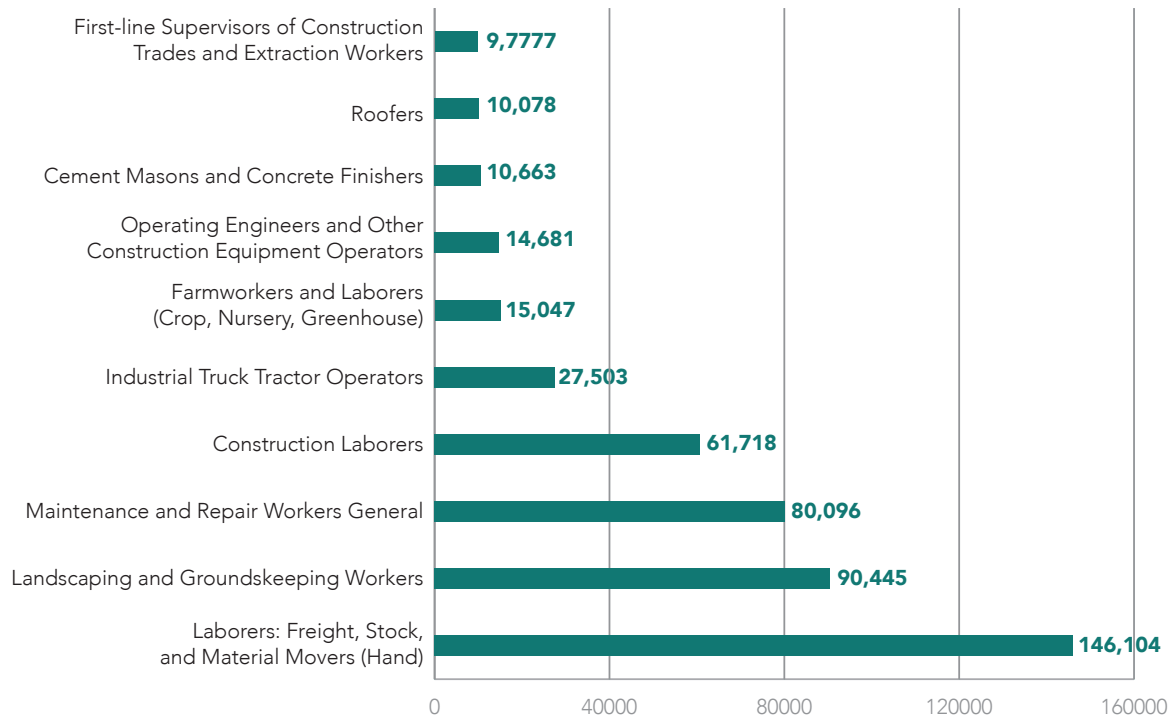
Selected Activities:

- ▶ A Clean River Rewards program created in 2006 offers discounts and credits to customers for managing stormwater with green infrastructure practices.
- ▶ The Green Streets program created in 2007 is a core part of the city's green infrastructure approach. The Green Street Steward program trains and supports volunteers to help maintain them.
- ▶ Integrating green stormwater infrastructure activities into the city's already extensive green infrastructure network of parks, forestland, and gardens.

Although Portland's GI-IMI workforce is still relatively small, the expansion of public and private projects provides opportunities for local businesses, including nonprofit groups and social enterprise corporations. For example, Verde Landscaping, a private contractor, has operated a training program for low-income, primarily Latino residents since 2006, and now provides skilled labor to other contractors. Training is integrated into the regular work day and participants are paid; the program covers all fees associated with exams and certifications. Verde hires graduates for both permanent and part-time positions.

**Note: The actual number is likely to be much lower. As discussed earlier in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

Figure 6b. Top GI-IMI Jobs Nationwide, Based upon Projected Employment Increase from 2015–2020



Source: Emsi Analyst. 2016.3 data set.

There is very little overlap between the occupations with the largest net growth, based on numbers of jobs (Figure 6b), and those with the greatest percentage of growth (Figure 6a), except for roofers and landscaping and groundskeeping workers. Roofers and landscaping and groundskeeping workers are the only occupations that have high growth, according to both metrics.

Additional evidence about employer demand comes from online job posting data, which has been found to be a leading indicator for hiring.⁶¹ There were 778,000 postings for the 30 target GI-IMI occupations nationwide in 2015, which represents approximately 3 percent of postings activity overall.⁶² One reason for the relatively small number of postings is that many of the industries studied, such as construction, tend to hire entry-level workers by informal means, such as word of mouth, rather than by posting ads online. Posting activity generally is higher for professional and middle-skill positions, including green infrastructure occupations such as civil engineers or landscape architects.⁶³

JFF researchers included a set of green infrastructure keywords (e.g., “bioswale,” “rain garden”) to refine this analysis and to better understand the demand for workers to fill positions that require work on green infrastructure systems or interventions.⁶⁴ When the keywords are

included, there were only 2,900 postings annually, which represents a mere 0.4 percent of overall postings within the target occupations.

Overall, employer demand for IMI workers is highest for the following titles (listed with the number of total postings):

- ▶ Water and Wastewater Treatment Plant and System Operators (254)
- ▶ Maintenance and Repair Workers (232)
- ▶ Maintenance Technicians (210)
- ▶ Construction Inspectors (195)
- ▶ Service Technicians (134)
- ▶ Forest and Conservation Technicians (120)

Overall, these findings support evidence from stakeholder interviews with city officials and contractors that employers rarely hire specifically for green infrastructure skills or competencies. Instead, they primarily search for effective construction, tree care, landscaping, or first-line supervisors in their hiring. However, further research is necessary to confirm these findings because job posting activity is relatively low in the industries most involved in GI-IMI work, as noted above.

EMPLOYER PERSPECTIVES ON HIRING AND TRAINING

Landscape and tree care contractors engaged in GI-IMI activities report that hiring can be difficult and many current employees need skill upgrades, according to a JFF survey of employers within the tree care and landscaping industries.⁶⁵ However, survey responses indicate that there is currently at least some unmet demand for GI-IMI workers within landscape and tree care contracting companies.

Further, it may be necessary to pay a premium to secure workers with the necessary skills (e.g., tree trimmers/pruners, landscaping/groundskeeping workers, first-line supervisors of landscaping/groundskeeping workers, and first-line supervisors of horticultural workers). These

findings are encouraging signs that career preparation that focuses on GI skills may provide trainees with an advantage in the landscaping or tree care industry marketplace.

Survey respondents were shown a list of 21 green infrastructure activities, including many related to green stormwater infrastructure, such as bioswales, green roofs, and rain gardens, and asked to indicate whether they are involved in providing this service. The answers showed that the respondents were primarily involved in ecological landscaping, gardens and urban agriculture, street trees, rain gardens, and bioswales—not in all GI interventions.

USING SECTOR STRATEGIES FOR GI-IMI WORKFORCE DEVELOPMENT

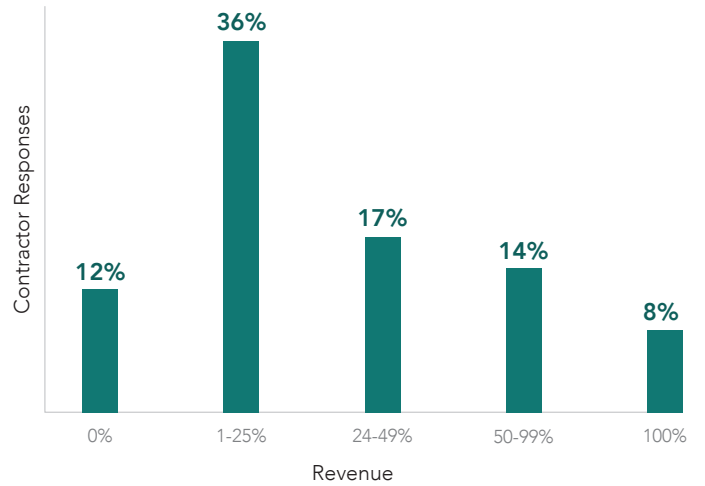
The Tree Care Industry Association recently launched a sector partnership initiative to address a shortage of tree care workers, build a long-term talent development pipeline within tree care, and professionalize the industry. TCIA has launched a marketing campaign to attract high school students, veterans, and job-seeking adults into arboriculture and developed a career pathway model for arborists. Through its regional partnership in Denver, TCIA is collaborating with Front Range Community College to develop a short-term training program with industry certifications that can lead to an associate degree. While many TCIA-supported sector partnerships are gaining momentum, it is unclear whether the construction, landscape, paving, roofing, stormwater, and tree care industries that collectively employ GI-IMI workers can realistically organize as a “sector” in any major labor markets.

To learn more about TCIA's sector partnership development, visit: <http://www.tcia.org>

Respondents were asked to estimate the percentage of revenue their company earned from all green infrastructure activities listed in the survey. The results show that only 22 percent of the respondents reported receiving between 50 and 100 percent of their annual revenues from GI-IMI activities (see Figure 7).

Respondents were asked whether they felt that “have to pay a premium” to secure people with green infrastructure skills from some of GI-IMI SOC codes. For four occupations, over 50 percent of respondents answered “yes” (see Figure 8).

Figure 7. Contractor Revenue Percentage from GI-IMI Activities



Source: JFF Survey of Contractors (2016). Note: Percentages based upon 478 total responses. 13% of contractors surveyed did not respond to this question.

Figure 8. Employers Willing to Pay a Premium for Selected GI-IMI Workers



Source: JFF Survey of Contractors (2016). Note: Percentages based upon 478 total responses.

Figure 9. Employers Reporting Need for GI-IMI Skill Upgrades in Various Occupations



Source: JFF Survey of Contractors (2016). Note: Percentages based upon 478 total responses.

As a way of assessing the need for skill upgrades among different GI-IMI occupations, employers were asked: “To take on more green infrastructure projects, would your workers in this occupation need to upgrade their green infrastructure skills?” For six occupation groups, over 50 percent of employers responded with a “yes” (see Figure 9).

Finally, the survey asked: “How difficult do you find it to hire for this occupation?” and the answers showed a high rate of difficulty across most GI-IMI positions (see Figure 10). These are the occupations in highest demand, according to the contractor survey. Except for landscaping workers and nursery and greenhouse laborers, these positions have median wages above \$15 an hour and tend to be for slightly more experienced workers within the relevant industries.

Figure 10. Employers Reporting Difficulty Hiring for Selected GI-IMI Occupations



Source: JFF Survey of Contractors (2016). Note: Percentages based upon 478 total responses.

CERTIFICATION PROGRAMS

A potential vehicle for job growth is developing and promoting certification programs, particularly for green stormwater infrastructure work. At least 18 green infrastructure certification programs already exist, with content ranging from a single technology, such as rainwater harvesting, to a broader focus on sustainable landscaping practices in general.⁶⁶

So far, there is wide variety in program types, duration, and oversight. One common element among many programs, including the five sponsored by national organizations that are accepted by multiple states (e.g., EnviroCert, StormwaterONE), is that none meet the standards for a professional certification program, which requires candidates to pass a formal certification exam. Advocates say this highlights the need for a single “robust certification program” to raise the level of professionalism in the industry and provide job portability.⁶⁷

“At present, GI certifications are typically operating in very small markets and have not achieved wide acceptance or driven demand for either GI or for certified GI workers,” the Harvard Law School study states.⁶⁸ One factor is the lack of widely accepted standards for green infrastructure technologies.

The exceptions are pervious pavers and green roofs. For example, the Pervious Concrete Contractor program offers three levels of certification—technician, for a general audience; installer, the basic certification for pervious concrete workers; and craftsman, which requires much more work experience.⁶⁹ Nearly 9,000 professionals were certified in 2014.

Multiple levels of certifications for workers to access at different points in their careers are often referred to as “stackable” credentials. These may be “especially attractive to workers, as they generally present workers with a low barrier to entry, while providing a transparent track for career advancement,” according to the Harvard study.⁷⁰

The National Green Infrastructure Certification Program

Some advocates are optimistic that current industry-led efforts to develop the first national certification program will help increase GI development, the quality of work performed, and the number of IMI jobs.

The National Green Infrastructure Certification Program is expected to cover at least six specific IMI activities, including bioretention (e.g., rain gardens, stormwater planters), permeable pavements, rainwater harvesting (e.g., rain barrels and cisterns), rooftop detention practices (e.g., green roofs), dry wells, and stormwater wetlands.⁷¹

The potential implications are significant for overall GI-IMI workforce development because it represents a specific strategic approach from a partnership of prominent industry and municipal leaders in green infrastructure. The certification will verify that IMI workers “have the required knowledge, skills, and abilities to support long-term performance and sustainability of these systems,” according to a press release announcing the program.⁷²

The joint effort of the nonprofit Water Environment Federation and DC Water (the District of Columbia’s water and sewer authority) is intended to support a legal agreement between the district and several federal agencies to decrease combined sewer overflows (and the accompanying pollution) to the area’s primary waterways by 96 percent. DC Water set a goal of 51 percent of new jobs created by the project to be filled by district residents.

A national coalition of stormwater management leaders is contributing to the development of the certification.⁷³ The certification test is expected to be offered for the first time in 2017, and certification nationwide is expected to be available in 2018. If successful, it will provide much-needed guidance to education and training providers, including community colleges, career and technical high schools, students, and jobseekers.

The Water Environment Federation argues that the certification would have benefits for employees and employers alike. In addition to ensuring competent workers, it also would provide “livable wages, professional growth, and job portability,” according to its 2015 report on the subject.⁷⁴ This could be a significant step toward providing a pathway to family-supporting jobs and possible career advancement in the field.

Increasing portability would be a big benefit to incumbent and potential workers in green infrastructure. While some certifications are employer specific, only recognized by certain employers, “portable” certifications demonstrate that the holder has skills that meet a widely accepted standard and are recognized by employers across the industry.

Rain barrels, such as this one, capture and store rainwater that drains from a roof, thereby reducing runoff and the load on water treatment systems.

(Photo credit: Shutterstock)



DETROIT, MI⁷⁵

Replacing Traditional Gray Infrastructure with Green Innovations

Home to nearly 680,000 residents, Detroit is a Great Lakes city that has struggled with public disinvestment following the 2008 recession.⁷⁶ Facing a \$1.2 billion price tag for a seven-mile underground tunnel, Detroit took an entirely different approach to managing the billions of gallons of untreated sewer and rain overflows that pollute local rivers and cause millions of dollars in property damage. The city plans to invest at least \$50 million in green stormwater infrastructure activities by 2029 and aims to turn its challenges into opportunities to become a national leader in implementation.



Key Goals:

- ▶ A comprehensive green stormwater infrastructure plan focuses on the creation of new policies including incentives for private property owners, development of prototype demonstration projects, continued implementation of planned activities, monitoring of long-term performance, and stakeholder and community engagement.
- ▶ Development of a new post-construction stormwater ordinance offering alternative options for compliance (e.g., offsite mitigation), stormwater design and maintenance manuals, standards for green streets, and tracking changes in impervious cover.
- ▶ Creation of a credit system offering property owners opportunities to reduce the fees they pay to the city based on how well they reduce their stormwater runoff.
- ▶ Convene a broad array of public agencies and private partners in support of green infrastructure, which includes leadership from the Detroit Water and Sewerage Department as well as the Detroit Land Bank Authority, the Detroit Public Schools, the University of Michigan Water Center, The Greening of Detroit, The Erb Family Foundation, Wayne State University, and community groups across the city.



Selected Activities:

- ▶ Repurposing vacant lots as rain gardens, parks, wetlands, and urban agriculture, and removing buildings and driveways from these lots to reduce heavy stormwater runoff and foster stormwater retention and infiltration.
- ▶ Implementing park projects, which include bioretention gardens and extensive bioswales, to capture runoff and keep it out of storm drains on nearby streets.
- ▶ Using pervious asphalt and pavers, providing assistance for property owners to disconnect downspouts that send stormwater directly into pipes, planning for properties of the Detroit Public Schools, and a street and park tree program that has planted more than 7,000 trees.



Estimated GI-IMI Workforce:⁷⁷

- ▶ As many as 102,300 workers are employed across the 30 GI-IMI occupations in the Detroit metro area.^{*78}
- ▶ There were approximately 11,700 job postings for the 30 GI-IMI occupations in the Detroit metro area in 2015.⁷⁹

Detroit's growing green stormwater infrastructure is expected to create or support a modest number of IMI jobs, and the city is developing a training program to ensure contractor quality. Training for landscaping firms, for example, will include use of native plants, design with attention to soil quality, and underground installation that facilitates stormwater retention and infiltration. A list of graduates will be available to potential commercial, industrial, and residential customers.

**Note: The actual number is likely to be much lower. As discussed earlier in this brief, many of the workers across the 30 GI-IMI occupations have low involvement (or no involvement) in green infrastructure work, though the estimated percentage of involvement varies by individual occupation. As a result, this number represents the upper bound of workers who may be involved in green infrastructure work.*

CAREER PATHWAYS

Career pathways describe education and training programs that offer a clear sequence of education and training courses that end in credentials. Career pathways are often built around sector strategies to align with the skill needs of a particular industry sector, stackable education and training options that are recognized by the industry, and multiple entry and exit points.⁸⁰

There are some existing career pathways that focus on GI-IMI jobs that have been developed by industries and associations involved in green infrastructure work. For example, the Tree Care Industry Association and International Society for Arboriculture created a career pathway flowchart for arboriculture. In addition, the California Landscape Contractors Association has outlined potential career pathways for installation, maintenance, and administrative work within the industry.⁸¹

Nevertheless, despite efforts to develop a national certification program, career pathways are clear for broader occupations (e.g., landscaper) that include GI activities, but not always for GI-IMI-specific jobs. There is also a need for more robust pathways for young people and potential workers to help them better understand the wages, specific skills, and opportunities for advancement across these jobs.

Advancement beyond the entry level is often based on development of leadership and business skills as much as additional technical skills, because higher-level opportunities are available primarily in supervision, management, or business ownership. These positions also require workers to acquire and demonstrate general employability skills, such as communication and time management abilities, as a first step.

THE CORPS NETWORK

The Corps Network offers a national training model to prepare youth and young adults facing barriers to employment for conservation-related work, including GI-IMI jobs. Structured as comprehensive youth development programs, each local Corps partners with municipal government agencies to offer job training, academic instruction, leadership skill development, and additional supports through projects that improve both communities and the environment. Following nine months of classroom instruction and paid work-based learning opportunities, graduates typically earn industry credentials and/or certifications of value in the labor market.

Cities with Corps programs specifically focused on GI-IMI skill development include Detroit, Baltimore, Chicago, and Philadelphia.

For more information, see: www.corpsnetwork.org.

RECOMMENDATIONS

As the field of green infrastructure continues to emerge and evolve, there are clear opportunities for stakeholders to promote the development of a strong GI-IMI workforce. The recommendations below target education and training providers, employers, policymakers, philanthropists, and others interested in expanding GI-IMI job opportunities. They focus on organizing strategically to share information about green infrastructure (including GI-IMI occupations), coordinating efforts to develop and disseminate potential career pathways, and contributing to the professionalization of the GI-IMI workforce.

Green Infrastructure Community at Large

The green infrastructure community as a whole would benefit from more structured connections and collaboration around current and future workforce opportunities in local labor markets. In many regions, the public workforce development system is well positioned to lead such efforts because of its existing cross-sector relationships and its ability to convene stakeholders across education, training, business, government, and policy arenas to address current and future workforce needs. Philanthropy can play an important role. Specifically, each local community should coalesce to:

- ▶ **Identify a regional intermediary to convene cross-sector stakeholders** and foster dialogue around current and anticipated workforce challenges and opportunities.
 - ▶ While the scale of demand for GI-IMI workers in most regions may not currently warrant development of new programs or initiatives, establishing a forum for collaboration among GI-IMI industry sectors, education, and government can help stakeholders ensure long-term alignment between workforce supply and demand.

- ▶ **Help educate policymakers, legislators, and government leaders about the broad array of community benefits of green infrastructure systems** and the many types of workers involved (both professional and IMI).
 - ▶ In particular, these conversations can serve as an opportunity to emphasize the value of these jobs for residents and community members seeking high-quality entry-level opportunities, even if the total number of local jobs is relatively small.

The philanthropic community can play a valuable role in advancing these efforts, both nationally and locally. Through grant making, philanthropy can help individual communities better understand the diverse benefits of green infrastructure and publicize examples of success. Further, philanthropy's strong convening power could help spur increased coordination and alignment among stakeholders to address education and workforce development challenges related to green infrastructure. For example, a collaboration with a city interested in adopting a comprehensive approach to green infrastructure credentialing could provide evidence of benefits—and any potential drawbacks—of this approach.



(Photo credit: Shutterstock)

Education and Training Providers

The education and training community can play a critical role in preparing young people and adults for careers in sectors that install, maintain, and inspect green infrastructure systems. In addition, these stakeholders can provide insight into the specific on-ramps and advancement opportunities related to these jobs as well as the cross-sector skills and competencies that can enable green infrastructure workers to advance within their respective industries and in their own careers, more broadly. The education and training community should:

▶ **Develop clear career pathway maps and lattices that articulate connections between GI occupations and related professions.**

- ▶ These pathways should highlight the education and skill requirements (both technical and employability skills) for workers to progress from entry-level to middle-skill jobs and on to more advanced positions.
 - ▶ These pathways should explicitly connect to the broad range of career and technical education and volunteer opportunities related to green infrastructure to highlight potential on-ramps.
 - ▶ Relevant portable and stackable credentials should be embedded within these pathways and highlighted to offer students and workers insight into potential strategies for advancement and career development. While several basic career pathways that include GI-IMI jobs exist (e.g., from the International Society of Arboriculture), there is an opportunity to make them more robust with the inclusion of information on skills and wages, and clarification of the credentials and skills necessary for both advancement and lateral movement.
- ▶ **Engage employers across sectors that employ GI-IMI workers to review curricula and programs as they are developed and/or refined.**
- ▶ Discuss with employers their sector-specific and company-specific demands for both new hires and incumbent workers. These conversations can help education and training providers remain attuned to shifts in work related to GI-IMI and to calibrate the scope and size of their programs accordingly. When possible, it is often effective to vet labor

market information (e.g., occupational and industry projections, job descriptions) with employers to gain a more granular understanding of demand and any current gaps they are experiencing.

- ▶ Collaborate with employers to develop work-based learning experiences, such as internships, to both high school students in career and technical education and adult learners. Work-based learning can offer valuable on-ramps to the workforce for many individuals. Work-based learning also can serve as a low-risk recruitment tool for businesses seeking to expand their workforce in jobs related to green infrastructure, ultimately creating a more effective talent pipeline.
- ▶ **Target training opportunities to specific underserved communities** (e.g., people with disabilities and individuals returning from correctional facilities) that can take advantage of their potential as entry points into the workforce.
- ▶ The Corps Network (described in the box on page 31) provides one strong example of how training for GI-IMI jobs can be targeted to young adults, veterans, and others who face barriers to employment. With integration of on-the-job training and classroom instruction in academic and employability skills, the Corps Network's model offers an effective strategy for green infrastructure employers to partner with community-based organizations and nonprofits to diversify the workforce.
- ▶ **Raise awareness around workforce opportunities related to green infrastructure. Community colleges are in a unique position to do this.**
- ▶ The SEED Center report *A Guide to Climate Resiliency and the Community College* can serve as a strong example of how community colleges can coordinate a regional approach to education/training, develop clear curricula and career pathways, help prioritize community needs, and facilitate partnerships.⁸²

Employers

The employer community includes both private employers and the municipal governments that employ workers who contribute to green infrastructure projects. Both types of employers can play an important role in helping to professionalize and diversify the green infrastructure workforce. There is an important opportunity for municipal government to lead the way by setting strong positive examples through their hiring practices for other employers. Specifically, employers should:

- ▶ **Actively seek out collaborations and partnerships with the education and training community** to meet workforce demands for green infrastructure workers. These partnerships may take place on the local level or at the regional/national level through employer/industry associations (e.g., arboriculture, tree care), which allow workforce needs to be aggregated and distilled across a broader context. In addition, such partnerships can:
 - Articulate the potential career pathways and relevant skills and competencies required to work in occupations related to green infrastructure and the broader industries in which they are found. When applicable, these efforts should link to professional-level green infrastructure occupations and/or linkages to management or entrepreneurial opportunities for long-term career growth and development. The sector partnerships led by the Tree Care Industry Association (see [box on page 26](#)), have helped bring together multiple local tree care employers and community colleges to collaboratively develop and vet curricula in arboriculture. While many of TCIA's partnerships are relatively new, they provide insight into how one industry involved in green infrastructure can establish strong relationships with the education and training community.
 - Facilitate the identification, evaluation, and validation of industry-recognized credentials to

ensure that they have market value. In addition to national certifications such as HAZWOPER, First Aid/CPR, and OSHA safety certifications, employers can also provide insight into state or local certifications or courses (e.g., Chicago Wilderness Prescription Burn Class) that are particularly relevant for GI-IMI jobs within a particular industry.

- Offer incumbent worker training for GI-IMI workers on cross-sector competencies, such as employability skills and business/management skills. Whenever possible, training programs that aim to upskill incumbent workers should be structured so that they build toward an associate degree and include portable, stackable credentials.
 - Provide work-based learning and volunteer opportunities for both high school students and adult learners to learn about GI-IMI occupations. Critically, these opportunities should be connected to efforts to diversify the green infrastructure workforce by recruiting through community-based organizations and programs that recruit local residents.
- ▶ **Serve as a public advocate for green infrastructure:** support state incentives to spur collaboration with education/training organizations and model these practices within individual companies and municipal departments. As with the LEED certification, municipal employers could play an important role in shifting green infrastructure certification from a niche designation into the mainstream by:
- Offering preferential hiring for individuals with green infrastructure credentials.
 - Developing explicit goals for hiring certified green infrastructure professionals.

Policymakers

The recommendations for policymakers emphasize the role that they can play in expanding both the knowledge and implementation of green infrastructure at the county, municipal, and regional levels.

► **Accelerate national momentum among policymakers for green infrastructure projects.**

- Use existing networks and organizations such as the U.S. Conference of Mayors, National League of Cities, National Governor's Association, regional planning associations, and large-scale regional partnerships based upon Forest Preserves and/or Water Reclamation Districts to advance green infrastructure development as a priority issue among policymakers. While the installation of green infrastructure is an important first step, policymakers should also emphasize the full range of maintenance and inspection activities that are critical for the long-term success of green infrastructure projects.

- Encourage the expansion of local stormwater agencies/utilities and the adoption of ordinances that incentivize onsite management of stormwater and the use of green infrastructure projects.
 - Support the development of comprehensive "green infrastructure plans" at the metropolitan, regional, and/or watershed level.
 - Urge local policymakers to take advantage of existing green infrastructure information and technical resources (e.g., from the U.S. Environmental Protection Agency).
- **Support the diversification and professionalization of the GI-IMI workforce within state and local government programs and projects.**
- Set explicit goals for involvement of minority and woman-owned business enterprises.
 - Provide incentives to businesses that hire local residents for green infrastructure IMI.
 - Mandate that a certain percentage of contractors' workers have NGICP certification.



This parking lot uses a mix of vegetation and permeable pavement to absorb stormwater and reduce the amount that flows into the sewer system.

(Photo credit: Shutterstock)

REFERENCES

APPENDIX A

ADVISORS AND CONTRIBUTORS

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APPENDIX B

METHODOLOGY

This section provides an overview of the data sources and analytical methods used by JFF in the NatureWORKS study. A brief description of key data sources is offered in addition to details on the specific methods that JFF used to identify the GI-IMI occupations code, conduct the labor market analysis, analyze wages and compensation for GI-IMI jobs, understand employers' perspectives on current and future needs related to green infrastructure through a large-scale survey, and develop the city profiles.

Background: Data Sources

To provide insight into the GI-IMI workforce, JFF drew upon data from several different sources, including data from two labor market information vendors, Emsi and Burning Glass Technologies.

Emsi aggregates data from more than 90 state, federal, and private sources. Federal sources include the U.S. Department of Labor, National Center for Education Statistics, and the U.S. Department of Commerce. In addition, Emsi uses state industry projections as well as data for smaller geographies within states (e.g., workforce areas, metropolitan statistical areas), when available. Emsi applies proprietary methods to remove suppressions and provide a more comprehensive picture of the workforce than that available from other sources.⁸³ Additional information on Emsi may be found at: <http://www.economicmodeling.com>

Burning Glass Technologies' Labor Insight tool provides real-time labor market information from online job posting data. Burning Glass aggregates job postings from over 40,000 sources daily, deduplicates these postings, and then codes them so that they may be parsed by occupation, industry, education level, and relevant skills. Additional information on Burning Glass is available at: <http://www.burning-glass.com>

In addition, JFF drew directly from several federal data sources, including the U.S. Department of Labor's O*NET OnLine database. O*Net OnLine provides detailed descriptions of each occupation, including work activities, knowledge, skills, and abilities needed to perform the work; required education and credentials; wages and employment data; access to current job openings; guidance about related fields and the relationships between an occupation and potential skills; and strategies for transitions to other occupations. Additional information may be found at: www.onetonline.org

The identification of GI-IMI occupations was based upon SOC codes, which are used across federal agencies, including the Bureau of Labor Statistics, to classify workers into occupational groups at the two-, three-, five-, and six-digit levels. All workers are classified into one of 840 detailed occupations, each of which is given a unique code (for example, the code for Tree Trimmers and Pruners is 37-3013). To learn more about SOC codes, visit: <http://www.bls.gov/soc/>

The wage and compensation study conducted by Cornell University's ILR School analyzed data from the Integrated Public Use Microdata Series (IPUMS). These data are drawn from the U.S. Census Bureau's American Community Survey. The data are provided through the University of Minnesota's Minnesota Population Center; more information is available at: <https://usa.ipums.org/usa/>

Identification and Confirmation of GI-IMI SOC Codes

JFF focused its research for this study on a targeted group of professions and occupations we have identified as “Green Infrastructure-Installation, Maintenance, and Inspection” (GI-IMI) workers. Individuals within these occupations perform direct installation, maintenance, and inspection duties in the field or are “first-line” supervisors of those workers.

To select the SOC codes that make up the GI-IMI workforce, JFF researchers engaged in a multi-step process in which they:

- ▶ Reviewed existing research on green infrastructure jobs.
- ▶ Drafted a preliminary list of SOC codes that constitute the GI-IMI workforce.

- ▶ Vetted the list for review and comment with representatives from national organizations with expertise in this work, including the National Green Infrastructure Certification Program (<http://www.ngicp.org>) and Ecotrust (<https://ecotrust.org>). JFF also compared the draft list with the occupational data provided by officials from the six focal cities to ensure that the core occupations involved in green infrastructure work were included in the final list. (Additional information on these lists of occupations is provided below in the discussion of the focal city research.)
- ▶ Reviewed O*Net OnLine profiles to confirm that the selected occupations include workers whose normal occupational duties would likely touch on GI-IMI work, based on review of job titles and descriptions that were determined by employers to be GI-IMI jobs.
- ▶ Finalized a list of 30 GI-IMI occupations analyzed in this study.

Labor Market Analysis

Current workforce data was analyzed using Emsi Analyst. JFF examined the overall number of workers in GI-IMI occupations and specific characteristics of these workers (e.g., job count, occupational projections, demographics), both nationwide and within the focal cities during 2015. These data include both employees as well as self-employed workers.

To complement this analysis, real-time labor market information (RT LMI) from job postings was used to better understand the characteristics of employer demand within GI-IMI occupations, both nationally and within the NatureWORKS focal cities. The RT LMI analysis utilized the most recent full-year data available (2015) and included all 30 target GI-IMI occupations.

In addition, JFF conducted a RT LMI analysis within these occupations using a group of green infrastructure keywords to identify the extent to which green infrastructure skills and competencies are prioritized by employers as they seek new employees.

These keywords were identified by NatureWORKS researcher Kevin Doyle, based upon his knowledge of the field; they include:

- ▶ Green infrastructure
- ▶ Alternative stormwater management
- ▶ Green stormwater infrastructure
- ▶ Green stormwater management
- ▶ Urban forestry
- ▶ Urban tree care
- ▶ Permeable surfaces
- ▶ Permeable paving
- ▶ Green roofs
- ▶ Arboretums
- ▶ Parkland management
- ▶ Parkland maintenance
- ▶ High-performance streets
- ▶ Cisterns
- ▶ Rain barrels
- ▶ Rain catchment
- ▶ Rain gardens
- ▶ Stormwater volume reduction
- ▶ Ecological lawn care
- ▶ Ecological landscaping
- ▶ Urban farming
- ▶ Low-impact development

Wage and Compensation Study

Cornell University's ILR School led the wage and compensation portion of this study. Researchers from the ILR school drew upon the American Community Survey, single-year surveys from 2010-2013 available through IPUMS. The sample was restricted to include only individuals 16 to 64 years old who indicated that they participated full time in the labor force for the full year during the previous year. These data were merged with SOC code data from O*NET to analyze critical employment skills for the GI-IMI occupations. Only 27 of the 30 SOC codes were included, as several did not have sufficient data for analysis.

Those not included in the analysis were:

- ▶ Forest and Conservation Technicians (SOC: 19-4093)
- ▶ Environmental Engineering Technicians (SOC: 17-3025)
- ▶ Construction and Building Inspectors (SOC: 47-4011)

In total, the dataset contained information on 2,922,920 individuals. The Cornell ILR team created subsamples to understand pay differentials in the Ann Arbor, Austin, Charlotte, Denver, Lincoln, and Portland metro areas.

Focal City Research and Development of City Profiles

The six NatureWORKS local cities were selected to provide a cross-section of the nation and to incorporate urban areas of different population sizes, geographies, ecological conditions, and different approaches to green infrastructure.

NatureWORKS researchers conducted in-person interviews and/or focus groups with municipal officials in Ann Arbor, Austin, Charlotte, Denver, Lincoln, and Portland, OR. JFF also conducted secondary research on each of these cities, as well as Detroit, to better understand the specific initiatives and other green infrastructure activities taking place within each city. These interviews provided insight into how each city is building and maintaining all forms of green infrastructure. Sample interview questions included:

- ▶ To what extent is the city involved in green infrastructure? Which specific green infrastructure projects has your city undertaken (e.g., wetland restoration, "green" streets, rain barrels)?
- ▶ What were the occupations / job titles of workers involved in these projects? What were the wages of these workers?
- ▶ Do any of these activities involve contractors? Please provide the contractor name and contact information, if available.
- ▶ What else should the research team know about current green infrastructure projects/initiatives, any current workforce needs, or relevant education and training programs?

To complement this qualitative data, JFF also asked city managers and staff to provide a list of the public-sector occupations that each city considered to be a GI "installation, maintenance, and/or inspection" worker. Managers from city human resource departments then assisted JFF in organizing the lists and providing the minimum educational qualifications and wages (or wage ranges) for each.

This data, along with relevant labor market information, was drawn upon to create the city profiles that are included throughout the report.

Employer Survey

From April to June of 2016, JFF fielded an online survey (via SurveyMonkey) to understand various employers' involvement in different forms of green infrastructure work and to discuss the level of ease or difficulty they were having in securing workers. The survey was not designed to produce statistically significant results but to assist JFF in gaining general employer feedback from those with an interest in discussing GI-IMI workforce needs. Sample survey questions include:

- ▶ Please estimate the percentage of your firm's revenue related to green infrastructure projects in the last one to two years.
- ▶ How would you characterize the short-term (one- to two-year) growth prospects for your firm related to green infrastructure design, installation, and maintenance?
- ▶ For relevant green infrastructure occupations:
 - How many workers does your firm employ in this occupation?
 - Among workers in this occupation, what percent of their annual work hours are spent on green infrastructure activities?
 - How difficult do you find it to hire for this occupation?
 - Relative to most workers in this occupation, do you have to pay a premium to secure green infrastructure skills?
 - To take on more green infrastructure projects, would your workers in this occupation need to upgrade their GI-IMI skills?

Employers in the landscape and tree care industries were prioritized, as landscaping and tree care occupations showed the highest concentration of GI-IMI work involvement among the 30 identified SOC codes. Many organizations helped to distribute and encourage responses to this survey; they are listed in Appendix A.

JFF received 478 unique responses. Approximately 70 percent of respondents were from the landscaping industry.

Additional Information

Please contact Sara Lamback (slamback@jff.org) with questions on any portion of this study's methodology, data sources, or to request copies of interview protocols or survey tools.

ENDNOTES

1. Alliance for Community Trees. 2011. *Benefits of Trees and Urban Forests: A Research List*. Nebraska City, NE: Arbor Day Foundation. While the title suggests an exclusive focus on trees and urban forests, the research listed includes many kinds of green infrastructure, including green stormwater infrastructure. Benefits noted (in addition to economic benefits) include reduction of stormwater runoff; improvement in the quality of air, water, and soil; reduction of carbon emissions; improvement in physical and mental health; increased property values; and improvement in “quality of life.” See http://www.actrees.org/files/Research/benefits_of_trees.pdf
2. The six U.S. cities examined for this report are Ann Arbor, MI; Austin, TX; Charlotte, NC; Denver, CO; Lincoln, NE; and Portland, OR. The report includes brief profiles of each city’s approach to urban green infrastructure and information about its GI-IMI workforce. The report also includes information about Detroit and Philadelphia.
3. This report is one product of the NatureWORKS initiative, which also includes online content, webinars, conference presentations, and videos. See www.jff.org/initiatives/natureworks/
4. Low Impact Development (LID), is a set of activities within green infrastructure, though LID is typically understood to be on a smaller scale (e.g., on a particular site), while green infrastructure refers to watershed- or community-level approaches to stormwater management and conservation. In this report, the terms are used interchangeably. See: University of Connecticut, Center for Land Use Education and Research (CLEAR). 2013. “LID vs. Green Infrastructure.” Available at: <http://blog.clear.uconn.edu/2013/12/10/lid-vs-green-infrastructure/>
5. McDonald, L.A., W.L. Allen III, M.A. Benedict, & K. O’Conner. 2005. “Green Infrastructure Evaluation Plan Frameworks.” *Journal of Conservation Planning*. Vol. 1, No. 1. 6-25.
6. This report uses the acronym “GSI” when referring specifically to stormwater management best practices, as a way of emphasizing that the term “green infrastructure” is not limited to these practices.
7. Emmett Environmental Law & Policy Clinic and the Environmental Policy Initiative, Harvard Law School. 2014. *Certifications for Green Infrastructure Professionals: The Current State, Recommended Best Practices, and What Governments Can Do to Help*. Cambridge, MA: Author. The report notes the Clean Water Act and its regulations, which regulate stormwater discharge, and the U.S. Environmental Protection Agency, which has encouraged incorporation of green infrastructure into Clean Water Act compliance plans.
8. Additional information on barriers to green infrastructure is available here: U.S. Environmental Protection Agency. 2016. “Overcoming Barriers to Green Infrastructure.” Accessed at: <https://www.epa.gov/green-infrastructure/overcoming-barriers-green-infrastructure#developers>
9. Cornell University ILR School. 2016. Analysis for JFF. Nationwide, three-fourths of workers involved in GI-IMI activities are employed in the for-profit sector, 17 percent work in the public sector, and 8 percent work for nonprofit organizations. Community volunteers also perform some green infrastructure work, particularly tree planting and rain garden installation and maintenance. Volunteer programs serve many purposes. They can build community pride and a sense of ownership in the greening of city neighborhoods; they also serve as a form of environmental education.
10. Many observers would also include those who conduct scientific and technical research; educate and involve the public; advocate for more and better green infrastructure; train and educate new and incumbent workers; map the location and health of trees and natural features; and create and enforce policies, rules, ordinances and regulations. Some might argue that estimations of the GI workforce should also include the larger environmental protection workforce involved in the enforcement of laws and regulations regarding clean water, clean air, hazardous waste and materials, solid waste, and public/environmental health generally. Finally, a comprehensive definition of the green infrastructure workforce could also incorporate occupations engaged in the supply chain of goods and services needed to keep the green infrastructure enterprise going, such as those who supply and work at the nation’s greenhouses, nurseries, and garden centers.
11. Material for this profile comes from interviews with City of Ann Arbor officials, led by Jennifer Lawson, water resources manager, October 24-26, 2015, and from Lawson’s JFF webinar presentation on December 2, 2015.
12. U.S. Census Bureau. n.d. “Quick Facts: Ann Arbor city, Michigan.” Available at: <http://www.census.gov/quickfacts/table/PST045215/2603000>
13. Cornell University, ILR School analysis for JFF.
14. Emsi Analyst. 2016.4 data. Extracted by S. Lamback. There were 9,519 employed and self-employed workers in 2015 across the Ann Arbor metropolitan statistical area.
15. Burning Glass Technologies. Labor Insight. Data analyzed by S. Lamback. There were 1,179 postings for the 30 GI-IMI occupations across the Ann Arbor metropolitan statistical area during 2015.

16. Researchers and professionals have not yet settled on firm definitions for how to define and label the “green infrastructure installation, maintenance, and inspection” workforce.
17. Other stakeholders JFF consulted include the National Ready Mixed Concrete Association, the Center for Watershed Protection, Green for All, Pacific Institute, and researchers at EcoTrust. A detailed explanation of the methodology is in Appendix B.
18. Standard Occupational Classification (SOC) codes are used by the U.S. Bureau of Labor Statistics and other federal agencies to classify workers into occupational categories. All workers are classified into one of 840 occupations. To learn more, see: <http://www.bls.gov/soc/>.
19. Cornell University, ILR School analysis for JFF.
20. See additional description of the methodology in Appendix B.
21. Material for this profile comes from an interview with Matt Hollon, environmental program manager, Planning and GIS, Watershed Protection Department, August 19, 2016.
22. Imagine Austin website. n.d. “About Imagine Austin.” Available at: <http://www.austintexas.gov/department/about-imagine-austin>
23. U.S. Census Bureau. 2015. “QuickFacts: Austin city, Texas.” Available at: <https://www.census.gov/quickfacts/table/PST045215/4805000,00>
24. Cornell University, ILR School analysis for JFF.
25. Emsi Analyst. 2016.4 data. Extracted by S. Lamback. During 2015, there were 58,925 employed and self-employed workers across the Austin-Round Rock metropolitan statistical area.
26. Burning Glass Technologies. Labor Insight. Data Analyzed by S. Lamback. There were 5,375 postings for the 30 GI-IMI occupations across the Austin-Round Rock metropolitan statistical area during 2015.
27. Material for this profile comes from interviews with City of Charlotte officials, including Marc Recktenwald, water quality and environmental permitting program manager, September 15, 2016, and from Recktenwald’s JFF webinar presentation on December 2, 2015.
28. U.S. Census Bureau. 2015. “QuickFacts: Charlotte city, North Carolina.” Available at: <https://www.census.gov/quickfacts/table/PST045215/3712000,3128000,4159000,4805000,00>
29. Cornell University, ILR School analysis for JFF.
30. Emsi Analyst. 2016.4 data. Extracted by S. Lamback. There were 83,753 employed and self-employed workers in these occupations in 2015.
31. Burning Glass Technologies. Labor Insight. Data extracted by S. Lamback. There were 7,913 job postings for the 30 GI-IMI occupations in the Charlotte-Concord-Gastonia metropolitan statistical area during 2015.
32. Water Environment Federation, Stormwater Institute. 2015. “National Municipal Stormwater and Green Infrastructure Awards Program.” Available at: <http://wefstormwaterinstitute.org/ms4awards/>
33. To estimate a precise percentage, JFF contacted GSI leaders associated with the National Green Infrastructure Certification Program. NGICP estimated the percentage of involvement in GI-IMI at no more than 5 percent of all construction workers, which comes to nearly 84,000 individuals.
34. Interview with Philip W. Kresge, vice president of local paving, National Ready Mixed Concrete Association, July 30, 2016.
35. Green Stormwater Infrastructure Partners. n.d. “An SBN Initiative.” Available at: http://www.sbnphiladelphia.org/initiatives/GSI_Partners/
36. Within the 30 GI-IMI occupations, only first-line supervisors of construction trades and extraction workers, and construction and building inspectors require five years or more of experience. Source: Emsi Analyst. 2016.3 data series.
37. O*NET OnLine. 2016. “Summary Report for: 47-4091.00—Segmental Pavers.” Available at: <http://www.onetonline.org/link/summary/47-4091.00#AdditionalInformation>
38. Michael Bouchard, South Platte River vision project manager, Department of Parks and Recreation, City of Denver, JFF webinar presentation, December 2, 2015.
39. *U.S. News and World Report*. n.d. “Best Places to Live.” Available at: <http://realestate.usnews.com/places/rankings-best-places-to-live>; Population data is for the City of Denver: U.S. Census Bureau. 2015. “QuickFacts: Denver city, Colorado.” Available at: <https://www.census.gov/quickfacts/table/PST045215/0820000,00>
40. Cornell University, ILR School analysis for JFF.
41. Emsi Analyst. 2016.4 data. Extracted by S. Lamback. There were 91,678 employed and self-employed workers in 2015 across the Denver-Aurora-Lakewood metropolitan statistical area.
42. O*Net is the United States’ primary source of occupational information. The O*Net database provides information on hundreds of occupations, including the skills, knowledge,

- and abilities associated with a particular job. Available at: <https://www.onetonline.org/>
43. A full list of the green infrastructure keywords included in the real-time labor market information analysis can be found in the methodology in Appendix B.
 44. Chuck Bowen, *Lawn and Landscape* magazine, phone conversation and email follow-up, September 6, 2016; Sandra Giarde, California Landscape Contractors Association, phone conversation, September 2, 2016; James Ingram, Bartlett Tree Experts, phone conversation, July 20, 2016; Mark Noark, Davey Resource Group, phone conversation, May 30, 2016.
 45. Burning Glass Technologies. 2015. *The Human Factor: The Hard Time Employers Have Finding Soft Skills*. Boston, MA: Author. Available at: http://burning-glass.com/wp-content/uploads/Human_Factor_Baseline_Skills_FINAL.pdf
 46. To do so, researchers compared those in our target SOC codes (e.g., pipelayers with SOC code 47-2151) to other occupations in the construction trades workers group (47-2). This latter group includes boilermakers, carpenters, and cement masons.
 47. Cornell University ILR School. 2016. Analysis for JFF.
 48. Emsi is a labor market research tool that aggregates data from a variety of federal, state, and local sources. Additional information on Emsi is available here: <http://www.economicmodeling.com/analyst/>
 49. Material for this profile comes from interviews with city officials including Ben Higgins, watershed manager, Department of Public Works, August 26, 2016.
 50. U.S. Census Bureau. 2015. "QuickFacts: Lincoln City, NE." Available at: <https://www.census.gov/quickfacts/table/PST045215/3128000,4159000,4805000,00>
 51. City of Lincoln Parks & Recreation. n.d. "Parks & Facilities." Available at: <https://lincoln.ne.gov/CITY/parks/parksfacilities/index.htm>
 52. Cornell University, ILR School analysis for JFF.
 53. Emsi Analyst. 2016.4 data. Extracted by S. Lamback. There were 8,992 employed and self-employed workers in these occupations in 2015.
 54. Burning Glass Technologies. Labor Insight. Data extracted by S. Lamback. There were 1,204 job postings for the 30 GI-IMI occupations in the Lincoln, NE, metropolitan statistical area during 2015.
 55. Drawn from a presentation by Lincoln city official Ben Higgins, Lincoln Watershed Management Division, as part of a JFF webinar, December 2, 2015.
 56. U.S. Census Bureau. 2015 estimate. "QuickFacts: Portland city, Oregon." Available at: <https://www.census.gov/quickfacts/table/PST045215/4159000,4805000,00>
 57. City of Portland, Oregon, Environmental Services. 2016. "Tabor to the River Program." Available at: <http://www.portlandoregon.gov/bes/index.cfm?c=47591>
 58. Cornell University, ILR School analysis for JFF.
 59. Emsi Analyst. 2016.4 data. Extracted by S. Lamback. There were 72,853 employed and self-employed workers in these occupations in 2015.
 60. Burning Glass Technologies. Labor Insight. Data extracted by S. Lamback. There were 10,630 job postings for the 30 GI-IMI occupations in the Portland-Vancouver-Hillsboro, OR-WA metropolitan statistical area during 2015.
 61. Carnevale, A.P., T. Jayasundera, & D. Repnikov. 2014. *Understanding Online Job Ads Data: A Technical Report*. Washington, DC: Georgetown Center on Education and the Workforce. Available at: https://cew.georgetown.edu/wp-content/uploads/2014/11/OCLM.Tech_Web_.pdf
 62. During the same time period, there were approximately 27,000,000 job postings nationwide, according to data from Burning Glass Labor Insight.
 63. Carnevale, Jayasundera, & Repnikov. *Understanding Online Job Ads Data: A Technical Report*.
 64. A full list is in the methodology in Appendix B.
 65. It is important to note the survey did not include construction contractors, because its focus was on industries with occupations in the higher ranges of GI-IMI involvement. Landscaping companies were 70 percent of survey respondents.
 66. Emmett Environmental Law & Policy Clinic and the Environmental Policy Initiative, Harvard Law School. *Certifications for Green Infrastructure Professionals*.
 67. DC Water & Water Environment Federation. 2015. *The Need for National Green Infrastructure Training and Certification*. Washington, DC: Authors. Available at: <http://ngicp.org/wp-content/uploads/2016/07/White-Paper-The-Need-for-National-Green-Infrastructure-Training-and-Certification.pdf>
 68. Emmett Environmental Law & Policy Clinic and the Environmental Policy Initiative, Harvard Law School. *Certifications for Green Infrastructure Professionals*. 7.
 69. Emmett Environmental Law & Policy Clinic and the Environmental Policy Initiative, Harvard Law School. *Certifications for Green Infrastructure Professionals*.
 70. Emmett Environmental Law & Policy Clinic and the Environmental Policy Initiative, Harvard Law School. *Certifications for Green Infrastructure Professionals*. 18.

- 71.** DC Water & Water Environment Federation. 2016. *National Green Infrastructure Certification Program: Body of Knowledge*. Washington, DC: Authors. Available at: http://ngicp.org/wp-content/uploads/2016/07/NGICP_Body-of-Knowledge-1.pdf
- 72.** National Green Infrastructure Certification Program. 2016. "DC Water and the Water Environment Federation launch development of a National Green Infrastructure Certification Program." Available at: http://ngicp.org/2016/03/16/ngicp_launch/
- 73.** In addition to DC Water and the Water Environment Federation, these include the Department of Environmental Protection; the Milwaukee Metropolitan Sewerage District; the Metropolitan Sewer District of Louisville, KY; the San Francisco Water Power Sewer; the Boston Water and Sewer Commission; and the Metropolitan Water Reclamation District of Greater Chicago, among others.
- 74.** DC Water & the Water Environment Federation. *The Need for National Green Infrastructure Training and Certification*.
- 75.** Material for this profile came from interviews with Jacob Koch of Bloomberg Associates, Devon Buskin and Fai Foen of The Greening of Detroit, and Palencia Mobley of the City of Detroit, September 16-23, 2016.
- 76.** U.S. Census Bureau. 2015. "Quick Facts: Detroit city, Michigan." Available at: <https://www.census.gov/quickfacts/table/PST045215/2622000,0820000,00>
- 77.** Detroit was not included in Cornell's analysis for JFF. As a result, the estimated proportion of workers within the city potentially involved in green infrastructure work was not available.
- 78.** Emsi Analyst. 2016.4 data. Extracted by S. Lamback. There were 102,333 employed and self-employed workers in these occupations in 2015.
- 79.** Burning Glass Technologies. Labor Insight. Data extracted by S. Lamback. There were 11,708 job postings for the 30 GI-IMI occupations in the Detroit-Warren-Dearborn metropolitan statistical area during 2015.
- 80.** JFF. 2012. *The Promise of Career Pathways Systems Change*. Author: Boston, MA. Available at: http://www.jff.org/sites/default/files/publications/CareerPathways_JFF_Paper_060112.pdf
- 81.** International Society of Arboriculture. 2016. "Careers in Arboriculture Flowchart." Available at: <http://www.isa-arbor.com/students/careersInArboriculture/index.aspx>; California Landscape Contractors Association. 2016. "CLCA Career Path." Available at: <http://clca.org/careers/career-path/index.php>
- 82.** White, S. & T. Cohen. 2014. *Preparing Students, Strengthening Communities: A Guide to Climate Resiliency and the Community College*. American Association of Community Colleges, Center on Wisconsin Strategy, & The SEED Center. Available at: http://theseedcenter.org/Resources/SEED-Resources/SEED-Toolkits/AACC-Report--A-Guide-to-Climate-Resiliency---The-C/Resiliency-Report/COWSSEED_ResiliencyReport_1014_web.pdf
- 83.** Suppressions are data collected by the federal government (e.g., through the Quarterly Census for Employment and Wages) that are not released to the public in order to protect confidentiality of individual companies. This issue typically arises when analyzing labor market information for a small geographic area, such as a county, that may be dominated by a single employer.



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