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A successful urban Cooperative Extension (Extension) program has been developed by the Rutgers Cooperative Extension Water Resources Program around green infrastructure in New Jersey. The program has gained the trust of the regulators at the New Jersey Department of Environmental Protection, the U.S. Environmental Protection Agency, the nonprofit community, state groups, elected officials, and consultants. This paper discusses the development process of an urban Extension program to work with communities to address their combined sewer overflow issues, including educational programs, partnerships, and funding. Additionally, the paper discusses the implementation of the program in Camden City, New Jersey, and the impacts associated with the program's implementation. Finally, the paper provides a vision for regional collaboration among Land-Grant Universities around green infrastructure.

Keywords: combined sewer overflow (CSO), municipal action team, stormwater runoff, community engagement, partnership development

Introduction

New Jersey is the most densely populated state in the nation with 1,196 persons per square mile (U.S. Census Bureau, 2010). New Jersey is 8,723 square miles in size, and of that, 7,354 square miles are land, and 1,369 square miles are water. According to Nowak and Greenfield (2012), 12.1% of the land in New Jersey is covered with impervious surfaces, which is 1,055 square miles of impervious cover or 675,200 acres. These impervious surfaces prevent rainfall from infiltrating into the ground to replenish the state's aquifers. During a one-inch rainfall event, 18.3 billion gallons of stormwater drains from these surfaces, which is enough water to fill up the New York Giants' stadium 38 times. Limited infiltration of rainwater results in reduced base flow to the local streams that rely on groundwater during the dry summer months. Many of these impervious surfaces are directly connected to our local waterways, meaning that every drop of rain that lands on these surfaces drains directly to a stream, river, lake, or bay. Pollutants accumulate on these impervious surfaces and are washed directly into New Jersey's waterways during storm events. There are 19,704.5 miles of rivers and streams in New Jersey. Of the 96.3% of river and stream miles assessed in New Jersey (18,974.2 miles), 90% are impaired. A total of 5,198.3 miles of rivers and streams are impaired by fecal coliform bacteria, 4,808.7 miles

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by polychlorinated biphenyls (PCBs), and 4,782.3 miles by total phosphorus. Urban-related runoff or stormwater is listed as the probable source of impairment for the 13,690.6 miles of threatened or impaired rivers and streams in New Jersey (U.S. Environmental Protection Agency [USEPA], 2012).

For the 21 communities in New Jersey that rely on combined sewers for stormwater and wastewater management, the picture is much grimmer. These are the very urban centers of the state and have an average impervious cover of 55%. When it rains in these communities, the aged infrastructure of the combined sewer systems often cannot handle the runoff volumes. This results in combined sewer overflows (CSOs) of a slurry of human sewerage and stormwater to local waterways, streets, and basements of the community which creates environmental problems and human health issues for the residents of these CSO communities.

Green infrastructure is one solution to help remediate these problems and issues. Green infrastructure can be used to disconnect some of these impervious surfaces and reduce the impacts of urban-related runoff to water resources. It is an approach to stormwater management that is cost-effective, sustainable, and environmentally friendly (USEPA, 2016). Green infrastructure projects capture, filter, absorb, and reuse stormwater to help restore the natural hydrologic cycle. Major cities across the country have been forced to embrace green infrastructure to comply with USEPA requirements. The USEPA is responsible for enforcing the Clean Water Act to address CSO issues throughout the country.

Communities with CSO systems struggle to better manage the systems, reduce overflows, and upgrade failing infrastructure. The financial investment needed for these "gray infrastructure" upgrades is tremendous. New and larger systems of pipes, catch basins, and treatment facilities are extremely costly. By including green infrastructure in a combined green/gray infrastructure approach, significant cost savings can be achieved. Cohen, Field, Tafuri, and Ports (2012) found the potential cost savings could reach $35 million by using a green/gray combined alternative over a gray-only option in the Turkey Creek Basin of Kansas City, Missouri. Implementation of these strategies has been shown to be just as, if not more, effective at reducing CSO events as gray infrastructure while remaining cost effective. A study of the CSO system in Toledo, Ohio, used a lifecycle assessment to confirm the lower costs of green infrastructure when implementing rainwater harvesting systems (Tavakol-Davani, Burian, Devkota, & Apul, 2016). Green infrastructure was found to be both functional and cost effective. Additional benefits noted were aesthetic value in the case of rain gardens and the use of nonpotable water for watering gardens and flushing toilets in the case of rainwater harvesting.

Green infrastructure is not just applicable in CSO communities, but it can also be applied in municipal separate storm sewer system (MS4) communities to reduce localized flooding. Many green infrastructure practices such as porous pavement and permeable pavers have been shown

to be effective at both capturing runoff and reducing the concentration of pollutants in any runoff they produce (Gilbert & Clausen, 2006). Green infrastructure strategies can also be implemented to capture runoff in brownfields. Brownfields are sites that are abandoned or underutilized and have the potential to be converted into green spaces to provide recreational services, habitat, and climate change mitigation (Mathey, Rößler, Banse, Lehmann, & Bräuer, 2015).

The adoption of green infrastructure can be driven by environmental nonprofit groups (Azadi, Ho, Hafni, Zarafshani, & Witlox, 2011). By involving the public in the incorporation of community green infrastructure, the green infrastructure can provide more than stormwater management and serve as open green space that can benefit residents. Public involvement early in the process also gives the community a sense of ownership that will help sustain the green space that is created (Erickson, 2006). The most successful green infrastructure elements are those where there has been an effort to engage the community (Forest Research, 2010). Many of the green infrastructure programs throughout the nation not only provide funding to improve neighborhood environmental conditions but also provide opportunities to specifically empower disadvantaged communities (Heckert & Rosan, 2016). The long-term success of green infrastructure requires meaningful local buy-in (Lovell & Taylor, 2013; Mittman, Gilliland, Rossman, & Newport, 2014).

This article will discuss the development process of an urban Extension program to work with communities to address their CSO issues, including educational programs, partnerships, and funding. Additionally, the article discusses the implementation of the program in Camden City, New Jersey, and the impacts associated with the program's implementation. The article provides a vision for regional collaboration among Land-Grant Universities around green infrastructure.

Program Development

Based upon work across the nation, it was apparent the green infrastructure movement was in full force everywhere except New Jersey. In both Philadelphia and New York City, an estimated $2.4 billion was being spent on green infrastructure (Philadelphia Water Department, 2011; New York State Department of Environmental Conservation, 2012). The cities where green infrastructure was becoming popular had one thing in common: they were required under an administrative consent order with the USEPA to address their CSO issues in part with green infrastructure. In New Jersey, none of the 21 cities with CSOs had an administrative consent order from the USEPA; all efforts to reduce CSOs were voluntary. If a green infrastructure movement was to begin in New Jersey, it would have to be community-driven and community-based.

Three components were needed to develop a community-based green infrastructure initiative. The initiative would require a strong educational component. While raw sewage overflowing

into local waterways, streets, and basements seems like a basic concept to understand, most of the urban residents did not know that the water they were wading through in the streets was a slurry of human waste and stormwater runoff. The first hurdle was increasing awareness within the community about CSOs and the health concerns associated with CSOs.

The second issue was involving the community in meaningful engagement to begin working collectively to eliminate the health risks associated with CSOs. This required converting a high level of concern to activism with community groups advocating for the elimination of CSOs through the implementation of green infrastructure. Community leaders from across the urban landscape would need to clearly recognize the importance of eliminating CSOs and be willing to dedicate their social and political capital to advocate for green infrastructure and a healthier city.

Demonstrating concern about the problem and advocating for its solution falls short of accomplishing the goal of eliminating CSOs and their health impacts. The community needed technical support on which to base their advocacy. The ability to reference reliable, trusted sources of information strengthens the ability of advocates to sway the naysayers and encourage the believers to move more quickly. Technical support is also needed to help communities implement green infrastructure demonstration projects that can serve as examples of what can be achieved in the highly urbanized environment.

While engaging the community was believed to be crucially important, other groups had to be convinced that green infrastructure was a viable option for managing stormwater runoff in CSO communities. Municipal officials, environmental commissioners, and public works directors needed to be educated. The final group in need of education was the municipal engineers. Many of the engineers were set in their ways and had always looked to gray infrastructure as a solution to stormwater and sewage problems.

Municipal Action Teams

In 2009, the Rutgers Cooperative Extension (RCE) Water Resources Program secured funding from the New Jersey Department of Environmental Protection to implement a stormwater education program in Newark that focused on promoting source controls to reduce stormwater runoff from entering the city's combined sewer system. This project laid the foundation for obtaining a grant from the Camden County Municipal Utilities Authority (CCMUA) to begin a green infrastructure initiative in Camden City. While the RCE Water Resources Program had some success in Newark working with several of the local community organizations, it became clear that a larger city-wide partnership would need to be formed if real progress was going to be made in New Jersey's CSO communities.

The CCMUA's Executive Director clearly understood the importance of addressing the CSO issue and the role green infrastructure could play, but the local community groups were still

unaware of the significance of the problem. The Executive Director arranged several meetings of community leaders and local residents where the RCE Water Resources Program personnel discussed green infrastructure opportunities in the community. These meetings created a level of openness among RCE, the CCMUA, and local community groups, leading to the beginning of trusting relationships needed to move a green infrastructure initiative forward in Camden City.

These meetings brought about the formation of a municipal action team established to bring together local government, utility authorities, and community organizations. This team was designed to foster community engagement and serve as an advocate for green infrastructure in the community. Together, the team members worked to set an agenda for a community-based green infrastructure initiative. The goal of the action team was to foster collaboration and collective action to help the municipality speak with a common voice to achieve a common goal. Members of the municipal action team worked together to define the need and opportunities for green infrastructure, educate residents and community leaders, and leverage funding to design and implement demonstration projects. With a variety of organizations, a range of funding opportunities could be pursued by multiple team members to increase the community's sense of ownership and move a municipality collectively toward adopting a green infrastructure program. This work would help communities protect water quality and improve residents' quality of life.

Camden SMART (Stormwater Management and Resource Training) was the first municipal action team formed in New Jersey. It consisted of six partners: CCMUA, Coopers Ferry Partnership (a local nonprofit organization), New Jersey Tree Foundation (a statewide, nonprofit organization committed to planting trees in Camden City), the City of Camden, the New Jersey Department of Environmental Protection Office of Brownfield Reuse, and the RCE Water Resources Program. Other local community groups were engaged in the Camden SMART initiative as needed for specific projects or events. While Camden SMART met monthly to strategize how to advocate for green infrastructure in Camden City, the RCE Water Resources Program developed a green infrastructure feasibility study for the city that identified 40 sites where green infrastructure could be applied throughout the 20 neighborhoods in Camden City. As the feasibility study was being completed, demonstration projects were constructed throughout the city. The installation of demonstration projects, such as rain gardens and cisterns, helped gain community support and strengthened relationships among Camden SMART partners and the community.

Educational Programs

The municipal action teams not only gave the community an avenue for meaningful engagement but also provided a platform to conduct educational programs. During the development of the feasibility study for Camden City, five community meetings were held throughout the city to obtain input from residents and community leaders. These meetings provided the RCE Water

Resources Program with an opportunity to educate the local community on the issues associated with CSOs and how green infrastructure can be used to not only address CSO issues but also add neighborhood green space. The residents and local community leaders provided firsthand accounts of where flooding occurs and where green infrastructure could be placed.

Build-a-Rain Barrel workshops were also held early in the process to encourage residents to install rain barrels. The Center for Environmental Transformation, a local nonprofit group in Camden City, partnered on many of these workshops. Camden SMART documented the number of barrels distributed and installed. Other educational programs included green infrastructure maintenance training for local organizations that were later hired by the CCMUA to help maintain the rain gardens that were installed throughout Camden City. Green infrastructure design and planning workshops were offered for design professionals like landscape architects and engineers. An annual Camden SMART forum provided an opportunity for the city to celebrate their successes and share their green infrastructure efforts with the rest of New Jersey.

Technical Support for Green Infrastructure Planning, Design, and Implementation

Professional staff of the RCE Water Resources Program provided technical support to Camden SMART. The design professionals of the RCE Water Resources Program identify potential sites for green infrastructure. Engineers and landscape architects work closely together to design green infrastructure practices that can be used to retrofit existing development to capture, treat, and infiltrate stormwater runoff before it enters the combined sewer system. The design process has three components. The first is to develop a concept plan of the green infrastructure practice that shows the location of the proposed practice and often includes an artistic rendering of the practice. The rendering is typically used to entice the landowner to allow the practice to be installed on their property. The next component is to complete a preliminary design based on engineering calculations. The last component is the final construction plan that includes the design details for building the practice.

The RCE Water Resources Program completed the green infrastructure designs and helped oversee the construction of the designs. To construct the designs, the RCE Water Resources Program helped identify a contractor and worked with local project partners, such as the municipality's department of public works, to build the project. Undergraduate students from Rutgers University were involved in the process, from identifying potential sites for green infrastructure to designing practices to working with local volunteers to build the projects. Each project that was constructed showcased green infrastructure and encouraged others to build similar projects. These demonstration projects were used by city officials as examples for new construction or redevelopment projects and served as examples to other CSO communities.

Partnerships

As seen in initial efforts in Newark, New Jersey, effective partnerships are the key to success for implementing green infrastructure. In Newark, the projects that moved from concept plans to construction were those that had a local champion who worked with the RCE Water Resources Program to implement the project. The RCE Water Resources Program provided the technical support while other partners contributed in a different fashion. Since the project partners are embedded in the community, their local contacts were instrumental in gaining access to potential project sites, and their trust among the community helped encourage early adopters to move forward with green infrastructure projects. Other project partners provided direct funding, such as the CCMUA and New Jersey Department of Environmental Protection. The nonprofit project partners tended to have access to sources of funding (e.g., private foundation funding) that is not typically available to Rutgers Cooperative Extension, CCMUA, or New Jersey Department of Environmental Protection. Together, the partners leveraged their resources to achieve the collective goal of green infrastructure implementation for the elimination of CSOs.

Funding

In 2010, the first year of a six-year annual contract, the CCMUA provided the RCE Water Resources Program funding to begin the green infrastructure effort in Camden City. In all, the CCMUA has provided more than $430,000 to the RCE Water Resources Program with some of this funding being passed through to Camden SMART partners for their green infrastructure efforts in Camden City. Two years after the start of the Camden City green infrastructure initiative, the New Jersey Department of Environmental Protection awarded the RCE Water Resources Program $300,000 to implement green infrastructure practices in Camden City. A year later, they awarded an additional $40,000 to RCE to develop a community-based green infrastructure maintenance program.

The success of the green infrastructure work in Camden City allowed the CCMUA to apply for low interest loans from the New Jersey Environmental Infrastructure Trust. To encourage the implementation of green infrastructure projects in CSO communities, the state offered 50% principal forgiveness on New Jersey Environmental Infrastructure Trust loans for green infrastructure projects. Camden City has taken advantage of this program for each of the last three years, and the RCE Water Resources Program prepared the green infrastructure designs for the New Jersey Environmental Infrastructure Trust applications. The success of the green infrastructure program has also attracted the attention of private foundations. The Surdna Foundation has provided the RCE Water Resources Program with $770,000 to expand the program beyond Camden City into other CSO communities throughout New Jersey. These private foundation funds allow for flexibility in programming typically not provided with state and federal funds and provide additional opportunities for leveraging funding resources. Table 1

illustrates the funding that has been secured for the Community-Based Green Infrastructure Program. In addition to these funds, the RCE Water Resources Program helped four CSO communities apply for more than $7.4 million in New Jersey Environmental Infrastructure Trust loans that have 50% principal forgiveness.

Table 1. RCE Water Resources Program Funding for the Community-Based Green Infrastructure Program, July 2009–December 2016

Date	Funder (CSO City)	Amount
7/09-6/13	NJDEP (Newark)[a]	$200,000
7/10-present	CCMUA (Camden)	$430,898
3/12-2/15	NJDEP (Camden)	$340,000
7/12-6/16	NJDEP (Newark)	$320,000
3/13-present	Passaic Valley Sewerage Authority[b]	$508,908
4/14-present	Surdna Foundation[c]	$770,000
5/15-present	NJDEP (Perth Amboy)	$489,156
1/16-present	NJDEP (Paterson)	$500,000
	TOTAL	**$3,558,962**

Note: (a) NJDEP is the acronym for New Jersey Department of Environmental Protection; (b) Passaic Valley Sewerage Commission has 48 municipalities in its sewer service area, eight of which are CSO communities; funds were to complete green infrastructure feasibility studies for all the 48 communities, both CSO and MS4 municipalities; (c) Surdna Foundation funding was provided to expand CSO efforts into all 21 CSO municipalities in New Jersey.

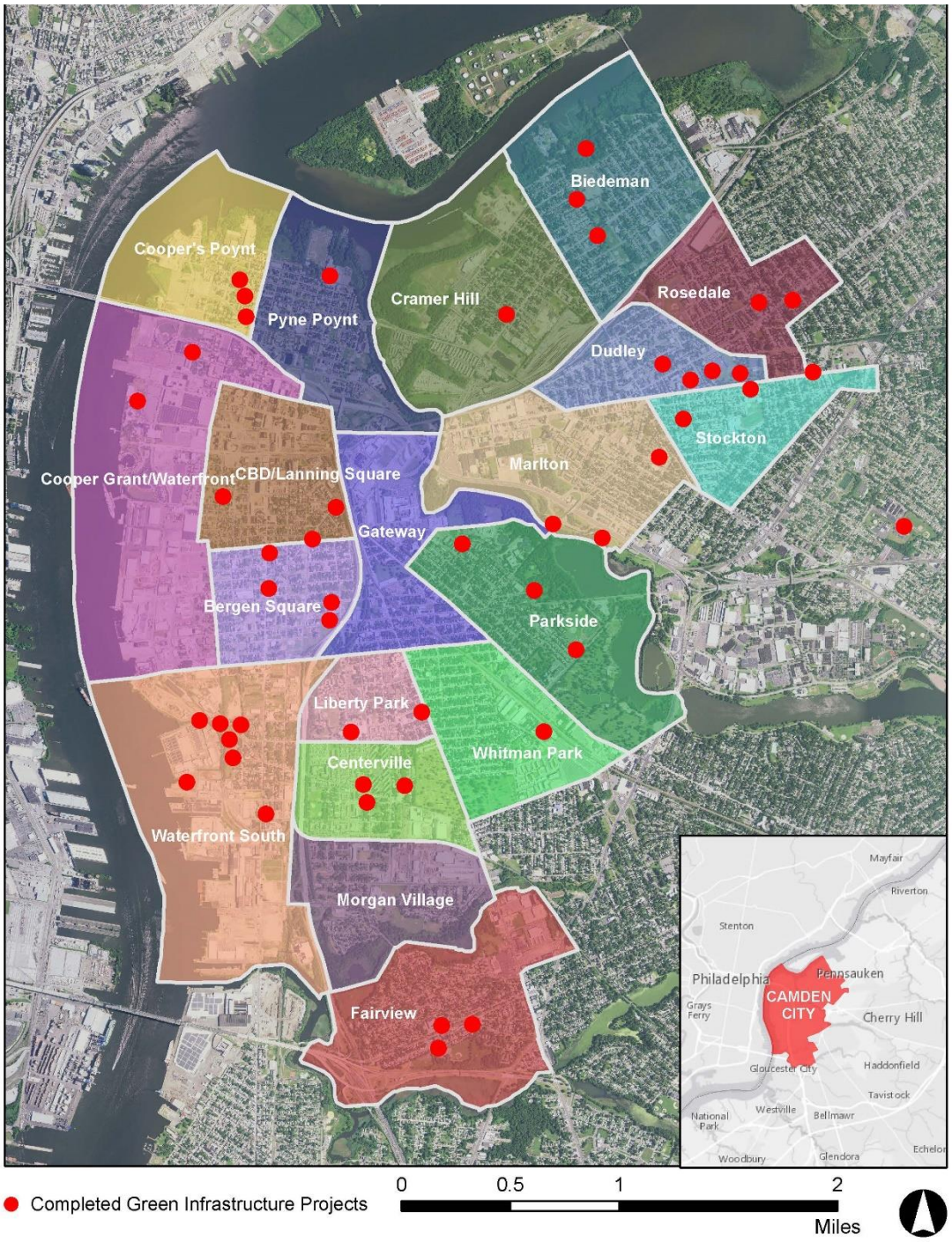
Impacts

Since 2010 in Camden City, 49 green infrastructure projects have been completed (see Figure 1), 1,458 trees planted, 223 rain barrels distributed, 4,000 residents engaged, more than 40 partnerships created, and more than 61 million gallons of stormwater captured (Camden SMART Initiative, 2017). More than $5 million were invested in Camden City from 2011 to 2016. Similar green infrastructure initiatives have been launched in Newark, Perth Amboy, Paterson, Jersey City, Trenton, and Gloucester City. Municipal action teams have been formed, and the impacts in these cities are beginning to be realized as well.

While there is potential for other impacts (e.g., economic, health, and social), these impacts have yet to be quantified. By reducing the occurrence of overflows into basements, streets, and parks of the neighborhoods, the health risks from exposure to pathogens are expected to decrease. Additionally, most of the green infrastructure systems incorporate vegetation which can help improve air quality as well as sequester carbon to help combat climate change. Green infrastructure construction in Camden City has also resulted in the creation of pocket parks, social spaces that reconnect neighbors (Cassidy, Newell, & Wolch, 2008; Newell et al., 2013).

Local workers are also hired to maintain the green infrastructure systems, and at times, to help build the practices, which can be viewed as job training and job creation. Additional research will be needed to document these impacts.

Figure 1. Completed Projects in Camden City as Part of the Community-Based Green Infrastructure Program



Regional Collaboration

Land-Grant Universities, working in collaboration, can help urban communities in the Northeast address stormwater issues. Rutgers, Penn State, University of New Hampshire, University of Rhode Island, University of Vermont, and University of Connecticut are all engaged with many local communities in their states to provide education on green infrastructure strategies for stormwater management. These universities also provide various levels of technical support to the communities. Furthermore, these universities are conducting research on the effectiveness of green infrastructure practices and their impacts on a watershed scale. Working collaboratively and sharing program ideas and research knowledge across state lines enables communities in the Northeast to enhance their ability to deal with stormwater management issues. A critical obstacle to overcome with green infrastructure is not the technology and the maintenance issues themselves but the human dimension involved with community decision making. A survey conducted in New Jersey indicated that, while many communities are not averse to installing green infrastructure, these communities had not taken advantage of grant programs to help them move forward with installation (Rowe, Rector, & Bakacs, 2016). Often, new technologies, such as green infrastructure, can take years to implement as the adoption of new technologies lags behind their actual development. Land-Grant Universities can play a key role in establishing the relationships needed to maximize all benefits associated with green infrastructure, and through research, provide sound science to decision makers considering green infrastructure applications.

Conclusions

The RCE Water Resources Program identified the health and water quality impacts of CSOs as an emerging issue in New Jersey. A community-based green infrastructure program was developed to address this issue. The ability of RCE to engage the local community and build robust partnerships has helped this program become a great success. The program has measurable impacts and has received funding from local and state sources. Additionally, private foundations have seen value in the program and have provided financial support. This community-based green infrastructure initiative is an example of a successful urban Extension program that can serve as a model for the rest of the country.

While much of the CSO elimination efforts throughout the nation are being driven by administrative consent orders with the USEPA, this program has demonstrated that a community-based program can be effective at implementing green infrastructure practices that can keep stormwater out of the combined sewer system. While Camden City was the example presented in this paper, the same program is being successfully implemented in other cities throughout New Jersey. The Extension model of community engagement that has worked so well through the years with agricultural producers and rural communities has proven equally beneficial in these urban areas and has been shown in this program to have the capacity to generate substantial funding to create and maintain an impactful program for more than seven years.

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