Lessons Learned: The North Carolina Backyard Rain Garden Program

Mitch Woodward, Area Specialized Agent, North Carolina State University, College of Agriculture and Life Sciences, North Carolina Cooperative Extension.

William F. Hunt, Ph.D., PE, Assistant Professor & Extension Specialist - Urban Stormwater Management, North Carolina State University, College of Agriculture and Life Sciences, Biological and Agricultural Engineering Department.

Wendi Hartup, Natural Resources Area Extension Agent, North Carolina State University, College of Agriculture and Life Sciences, North Carolina Cooperative Extension.

Abstract: Research conducted at the North Carolina State University and elsewhere has determined that bioretention practices are very effective in reducing polluted stormwater runoff from urban areas. Smaller residential bioretention areas, also known as rain gardens, have proven to be an effective means of removing metals, nutrients, sediment and fecal coliform provided that they have been designed, sited, constructed and maintained properly. The university, local and state governments have been promoting the installation of rain gardens and other stormwater practices in Phase I and II communities for many years; however, very few homeowners and commercial landscape contractors have a working knowledge of the benefits of rain gardens, their installation or their maintenance requirements. To help promote rain gardens and address these needs, the North Carolina Backyard Rain Garden Program was implemented during the summer of 2006 in a six-county pilot area. Funded as an EPA 319(h) project, the program (1) developed an education program by conducting homeowner workshops in each county, (2) installed more than 40 residential demonstration rain gardens, and (3) developed educational and reference materials making them available at the following website: www.bae.ncsu.edu/topic/rain garden. More recently, an assessment was performed to determine:

- How many rain gardens continued to function properly
- What, if any maintenance had been performed
- Common traits among the cooperators with successful rain gardens.
- Education needs for homeowners and installers.

A Rapidly Growing State

North Carolina is the ninth-fastest-growing state in the nation and the tenth most populous. Raleigh, the state's capital, is currently growing by nearly 100 new residents each day. Across the state, nearly 300 acres of pervious woodlands and farms are replaced by developments each day, creating an immediate need for residential stormwater management, and in particular, for effective retrofit practices that can be installed in existing developments to help protect local streams and water quality.

Research conducted at the North Carolina State and other universities have concluded that bioretention practices are effective at reducing peak flows, delaying flow peaks, reducing the outflow volume, and reducing pollutant loads (Davis 2008, Hunt et al., 2006, Hunt et al., 2008). A bioretention area captures runoff from an impervious surface and allows that water to infiltrate through the soil media. As the water infiltrates, pollutants are removed through a variety of mechanisms including adsorption, microbial activity, plant uptake, sedimentation, and filtration. Suspended solids, nitrogen, phosphorus, copper, lead, and zinc concentrations have all been reduced. Some of the incoming runoff is temporarily held by the soil of the bioretention area and later "leaves" the system by way of evapotranspiration or exfiltration to the ground water.

Backyard Rain Garden Program Implementation

One of the challenges in accelerating the adoption of these practices is that very few homeowners or commercial landscape contractors understand or have a working knowledge of rain garden installation and even fewer understand and institute maintenance activities regularly once the practices are installed. There is a need to provide homeowners with a step-by-step set of instructions and residential demonstration sites that will facilitate the homeowners' understanding of effectively dealing with stormwater runoff on their residential lots.

In response, a partnership was formed in 2006 between North Carolina State University, Department of Biological and Agricultural Engineering; North Carolina Department of Environment and Natural Resources, Division of Water Quality; and North Carolina Cooperative Extension to develop training materials that would be available on the internet that would better explain: (1) why water quality and quantity is a problem, (2) how to best site these best management practices (BMPs) on their property, (3) step-by-step construction instructions, (4) vegetative selection, and (5) required maintenance activities.

Funded as an U.S. Environmental Protection Agency (EPA) 319 project, the objective of the North Carolina Backyard Rain Garden Project was to support local county efforts to provide homeowners, installers, and county Extension educators with materials, instruction, and demonstration sites. The result of the project was to support local efforts to properly plan, site, install, and maintain small residential rain gardens. The initial focus of the project was to identify at least 30 installation opportunities in the pilot counties; however, more than 40 rain gardens were eventually installed.

Master Gardeners, a volunteer organization associated with North Carolina Cooperative Extension (and other extension services across the U.S.) were targeted as an initial core group of potential trainees to help both advertise the program and identify additional cooperators interested in installing a demonstration rain garden on their property. A "rain garden team" was assembled in each county consisting of a faculty member from Biological and Agricultural Engineering (BAE), at least one BAE student, and a county-based environmental extension agent. The team advertised and conducted a total of 13 "How To Rain Garden" training workshops, 11 for homeowners and 2 for Master Gardener volunteers in the six targeted counties (Brunswick, Craven, Henderson, New Hanover, Transylvania and Wake – see Figure 1).

At the conclusion of the workshops participants were offered the opportunity to sign up for a rain garden site visit from the rain garden team. The team visited each site, ranking them based on site-related issues, their potential as an education-demonstration site and willingness of the homeowner to help. Cost share was provided by the program in the amount of $50 per garden to cover costs of mulch and plants. Actual construction (digging) of the rain gardens was provided free of cost to the property owner by the rain garden team.

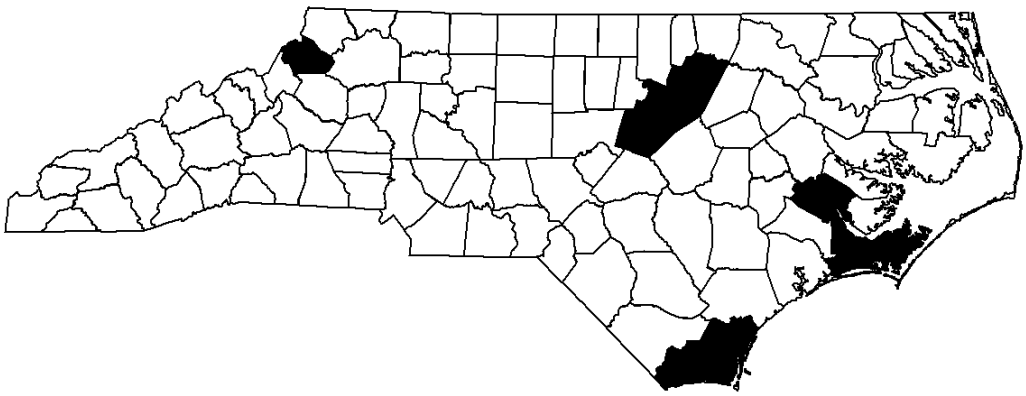

Figure 1 – Map of North Carolina showing counties where the backyard rain garden project was piloted.

Program Results

The rain garden team completed 73 site assessments and installed 40 demonstration rain gardens. These sites have been used in numerous local and regional education events, featured in media broadcasts, and in at least one county, were used to train homeowners and landscape professionals who are obligated to install these practices to meet pervious area requirements. County Extension Agents working with a campus Extension associate and specialist developed training and reference materials available on line at: http://www.bae.ncsu.edu/topic/raingarden/.

The materials developed include: Stormwater Management for Homeowners; How to Site and Build a "Backyard Rain Garden"; Plant Selection for Rain Gardens and Wetlands; and Maintaining your Rain Garden.

More recently, a post-installation assessment of the condition and functioning of the rain gardens was completed two years after initial installation (Table 1). To facilitate the analysis, those who had received a rain garden were organized into several 'rain gardener types' based on their gardening knowledge and motivations for installation: (1) avid gardeners (2) environmentalists (3) direct connection to water resource (4) flooding issues (5) required by law and (6) educators/schools. Each rain gardener type is explained in subsequent paragraphs.

Rain garden sites were re-visited approximately two years after installation and the condition of the garden was judged to be Good, Fair or a Failure. Good condition meant the practice was functioning as designed; maintenance activity was obvious, plants were cared for and thriving, and adequate storage volume had been maintained. Fair condition indicated little or no maintenance had been performed; plants showed some

stress, needed pruning, or needed replacement. A "fair" rain garden, however, retained at least some treatment function. A Failure indicated the garden was either abandoned or had no maintenance performed; plants were dead or dying, mulch was absent and the rain garden was no longer capturing and treating runoff. Images of prototypical rain gardens in each category are presented in Figure 2.

(a) Rain garden in "Good" condition.

(b) Rain garden in "Poor" condition.

(b) Rain garden in "Fair" condition.

Figure 2. Example rain gardens described as (a) "Good," (b) "Fair" and (c) "Failure."

During the training workshops all participants received advice on proper site selection, soils, construction, plants and maintenance requirements. In addition, all had access to the 'Backyard Rain Gardens' Web site as well as county Extension staff to answer any remaining questions or to fix problems. Yet, not all rain gardeners were equally successful. As expected, the 'avid gardener' group had a high rate of success. We anticipated this would be the case based their gardening experience, knowledge level, expectations of the garden and possibly their original motivations and enthusiasm for working with and learning about new plants and how they function in the challenging conditions (wet/dry) that rain gardens create. The cause of the one failure in the group (of the 14 installed by "avid gardeners") was attributed to a condensation line from an air conditioner unit that provided more water than anticipated into the rain garden. This made the garden and surrounding area too wet, making it behave more like a wetland.

The constantly wet condition was unacceptable to the homeowner and the garden was replaced with a turf-lined drainage swale.

A second group that maintained their gardens relatively well was those with a 'direct connection' with the resource being protected. This group, while not the most experienced or knowledgeable gardeners, all owned homes that surrounded a lake that served as the focal point of the community. Most of the owners could see the lake from their properties and, therefore, had a vested interest in keeping the lake free of sediment and nutrients that can cause algal blooms. As a result, there was a lot of interest and perhaps some peer pressure to maintain their gardens in good condition. In fact, as a result of the original group's success, other homeowners in the community have installed at least four more rain gardens, receiving help and advice from the original group that was trained.

Two other groups, the 'environmentalists' and the 'required by law' group generally had rain gardens that continued to function but could not be rated as highly as the avid gardeners or the direct connection groups due mainly to maintenance issues and relative lack of plant care, mulching, and general maintenance. The self-described 'environmentalists," while being enthusiastic about the prospects of protecting water quality, generally lacked gardening experience and, therefore, were less likely to know how to manage dead or dying plants, apply the correct amount of mulch, or to attend to berm erosion problems. None of the 8 rain gardens installed by or for "environmentalists" failed, however.

The "required by law" group was not originally part of this study. They have been included here because they do provide an interesting contrast to the rest of the gardeners who installed the rain gardens voluntarily. Because they were constructing homes in a jurisdiction that enforces impervious area limits on individual lots, this group was forced to install rain gardens or other practices in order to receive their building permit. It is important to note that the owners received instructions on maintenance from our website and that, once installed, the gardens are subject to annually inspection.

Overall, this group seemed to be maintaining their gardens mostly in the fair range, which is the minimum requirement to avoid receiving a notice of violation. Many were in need of some minor maintenance, most either needing mulching or replacement of dead plants. It is important to note that a number of these gardens failed when they were installed due to sediment being directed into the garden during rainfall events. This was due mainly to the installation of the garden occurring too soon in the construction sequence, when the site was still unstable and earth-moving activities were still underway. This has been found to be the most common cause of failure for larger, commercial bioretention installations in North Carolina (Hunt and Lord, 2008). Our study indicated very few failures as a result of sedimentation in more stable, mature landscapes with no erosion issues.

Across all groups that are actively maintaining their gardens, the two most common problems are plant issues and the over application of mulch (Table 2). It is understandable that plant issues would predominate, given the extreme nature of the moisture conditions the plants experience. It is clear that the experienced gardeners where more capable of identifying stressed plants and taking corrective action.

Over mulching can decrease the storage volume of the unit and impact its effectiveness, especially during larger runoff events. This particular issue does not seem

to be a problem in the larger commercial bioretention cells because of the cost of mulching (Hunt and Lord, 2008). Interestingly, the gardens in the required-by-law group, as a whole, were maintained at least as well as the environmentalist group. This is presumably because of annual inspection performed by the county and the possibility of being fined for a non-functioning garden.

The last two groups, homeowners with flooding issues and rain gardens installed at schools generally received the lowest levels of maintenance and had the highest failure rate. Flooding issues are a concern in North Carolina, and the workshops attracted a substantial number of homeowners looking to solve their drainage issues. After learning that rain gardens would not remedy their flooding problems, many elected not to participate in the program further. However, some homeowners did adopt rain gardens, but none of them were kept in good condition and three of the five failed. We did offer some homeowners the option of establishing small wetlands. To our knowledge, only one of the "backyard wetlands" was installed. This was not surprising, given that many perceive that wetlands produce mosquitoes and attract snakes. Also, several counties in the area have mosquito control ordinances that do not permit areas to have any standing or stagnant water for more than five days.

Rain gardens installed as demonstration sites at schools apparently suffered during summer breaks, when the school grounds were emptied of teachers and students. While many were initially looked after, there seemed to be a "forgetfulness" of faculty and students after the summer, and nearly all the gardens fell into disrepair.

Table 1. Summary of Preliminary Analysis of Raingarden Condition, 2 Years after Installation.

Rain gardener Type	Rain garden Condition*		
	Good	Fair	Failure
Avid Gardener	10	3	1
Environmentalist	2	7	
Direct Connection To Resource	4	4	
Flooding Issues		2	3
Required by Law	8	15	8**
Educators / Schools		1	5

*Good: Maintained well, functioning as designed.
Fair: Maintenance not evident, still provide some treatment
Failure: Not maintained, not functioning.

** Initial rating just after construction was completed. All sites were stabilized and rain gardens replaced as a requirement to receive building certificate of occupancy.

Table 2. Summary: Rain Gardens Maintenance Issues 2 Years after Installation. (A total of 60 rain gardens were evaluated.)*

Maintenance Issue	Number of Rain gardens Affected
Berm / Weir Failure	6
Plants / Planting	49
Soils / Drainage	10
Sedimentation / Clogging	8
Mulching	38
General Neglect / Abandoned	9

*Summary of all maintenance issues identified. Several rain gardens had more than one maintenance issue that affected performance.

Conclusion

Homeowners, engineers and installers will continue to need educational programs, research information and demonstration sites that will facilitate their ability to understand and effectively deal with stormwater runoff. While rain gardens and other stormwater treatment practices appear to be simple to install and maintain, many questions remain about their longevity. If small site scale stormwater management and low impact development practices are to gain broader acceptance among engineers and regulators as treatment devices, and among property owners as welcome additions to their landscapes, they must remain both aesthically pleasing and functional after the initial installation. Few homeowners or commercial landscape contractors understand or have a working knowledge of rain garden installation and even fewer understand and institute maintenance activities regularly once the practices are installed. On-going educational and regulatory programs emphasizing inspection and routine maintenance will be critical to success.

References

Davis, A.P. 2008. “Field Performance of Bioretention: Hydrology Impacts.” *Journal of Hydrologic Engineering*, 13(2): 90-95.

Traver, R.G. , A.P. Davis, and W.F. Hunt. 2007. “Bioretention and Bioinfiltration BMPs: Three Researchers’ Experience.” Stormwater March 2008.

Hunt, W.F., A.R. Jarrett, J.T. Smith, and L.J. Sharkey. 2006. "Evaluating Bioretention Hydrology and Nutrient Removal at Three Field Sites in North Carolina." *ASCE Journal of Irrigation and Drainage Engineering* 132(6): 600-608.

Hunt, W.F., J.T. Smith, S.J. Jadlocki, J.M. Hathaway, P.R. Eubanks. 2008. Pollutant Removal and Peak Flow Mitigation by a Bioretention Cell in Urban Charlotte, NC. *ASCE Journal of Environmental Engineering* Vol 134 (5): 403-408.

Hunt, W.F., and W. Lord, 2008. "Stormwater Best Management Practice Inspection and Maintenance Certification Workshop." North Carolina State University, College of Agriculture and Life Sciences, North Carolina Cooperative Extension. Raleigh, NC.