PAPER

National LID Atlas: A Collaborative Online Database of Innovative Stormwater Management Practices

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ABSTRACT

Any strategy to protect coastal and marine resources needs to address the issue of polluted runoff, particularly urban runoff generated by development. Low impact development (LID) practices, also known as green infrastructure, have been shown to be very effective in mitigating the impacts associated with stormwater runoff from development. On-the-ground examples of LID implementation, both good and bad, are needed to help local officials and others overcome the natural reticence to embrace new technologies or approaches and encourage or even require their use. The National LID Atlas is an interactive tool that provides these real local examples of LID implementation throughout the country on the Internet in an easy-to-use Google Maps™ Mashup. The members of the National NEMO (Nonpoint Source Education for Municipal Officials) Network and other outreach educators collaboratively built the Atlas and continue to add new projects to it. Local officials, developers, contractors, homeowners, and others can use the site to find examples of LID implementation in their state or region and resources for finding out more detailed information.

Keywords: low impact development (LID), urban runoff, national NEMO network, Google Maps™

Land Use and Coastal Water Quality

America is an urbanizing country. According to the latest estimates by the United States Department of Agriculture (USDA) Natural Resources Inventory (NRCS, 2009), between 1982 and 2007 more than 42 million acres—an area larger than the state of Illinois—were converted to developed land from forest and farmland. Much of this urbanization is occurring in coastal areas. A report from the National Oceanic and Atmospheric Administration (NOAA) reports that the narrow band of coastal counties making up 17% of the nation's contiguous land area is home to more than half of its population (Crossett et al., 2004). The Pew Oceans Commission (2003) reported that the resident population along the coast is expected to increase by 25 million people by 2015.

Urbanization has multifaceted impacts on coastal resources, including dredging and filling of coastal wetlands, habitat degradation, and water quality degradation resulting primarily from urban runoff. According to the latest Water Quality Assessment information compiled by the U.S. Environmental Protection Agency (U.S. EPA, 2010), urban runoff and "unspecified nonpoint source pollution" were among the top 10 probable sources of impairment for bays and estuaries and ocean and near coastal waters; for coastal shoreline, these two sources ranked fifth and second, respectively. Therefore, any strategy to protect coastal and marine resources needs to address the issue of polluted runoff, particularly urban runoff generated by development.

Low Impact Development

Low impact development (LID) practices, also known as green infrastructure, have been shown to be very effective in mitigating the impacts associated with stormwater runoff from development (Dietz, 2007). LID is a site design strategy intended to maintain or replicate a site's natural hydrology through the use of small-scale controls integrated throughout the site to manage runoff as close to its source as possible. LID practices are designed to encourage infiltration of runoff into the soil, and often involve the use of vegetation for the uptake and treatment of pollutants. Common examples of these practices include rain gardens, green roofs, vegetated swales, and porous pavements (see Figure 1 for examples).

Much has been done to promote the use of these practices in new developments, as well as in retrofitting existing

FIGURE 1

Examples of low impact development practices in a residential setting. Seen here are vegetated swales, rain gardens, and pervious pavers.

developments, yet they are still not common practice in most areas. Since land use decisions are primarily made at the local (municipal or county) level, one of the hurdles to wider acceptance of new practices like LID is the natural reticence of local officials to be the first to embrace new technologies[1]. On-the-ground examples of LID implementation—particularly in nearby areas—can help to overcome this barrier. However, providing these examples presents problems of its own, in that it is hardly feasible to organize the number of field trips, conferences, and phone calls needed to publicize these examples.

The National LID Atlas seeks to help communities clear this hurdle by providing real local examples of LID use in a simple and accessible way over the Internet. The University of Connecticut Center for Land Use Education and Research (CLEAR) has a long history of using geospatial technology to provide nontechnical access to data, maps, and other information for local land use officials (Arnold et al., 2000). In recent years, the fusion of geospatial data and applications with Internet technology has created an expansive list of possible applications that can be used to inform better land use (Rozum et al., 2005); the National LID Atlas is the latest such effort of CLEAR.

Developing the Atlas

The National LID Atlas is a Website developed by the NEMO (Nonpoint Source Education for Municipal Officials) programs in Connecticut and California, within the framework of the National NEMO Network. The National NEMO Network is a confederation of 30 outreach programs in 29 states that provide local land use commissioners and other decision makers with education and technical assistance about the connection between land use decisions and natural resource protection. Network programs are adapted from the original Connecticut NEMO program and are coordinated by the CLEAR National NEMO "Hub." NEMO programs work to educate communities about sustainable land use planning and site design, including LID practices.

One of the major objectives of the Network is to be a forum for the sharing of innovative research, educational practices, and outreach and training techniques among member programs. The National LID Atlas is a recent example of the power of this type of collaboration. The Atlas grew out of Connecticut NEMO's statewide Low Impact Development Inventory, a searchable online database of LID projects, first developed in 2005. With California NEMO leading the way, various members of the NEMO Network were interested in expanding Connecticut's Web tool without duplicating the same technical effort for each of the 30 state programs. The goal was to make a user-friendly resource for sharing information about existing LID projects that would be nationwide but also serve to reach local decision makers with information on local LID projects in their county, watershed, or state.

The LID Atlas is a mapping "mashup"—it combines two or more tools, applications, or data sources to create a new separate, but integrated, product. In this case, the Atlas combines information from an online database of LID projects with free imagery and base maps from Google Maps™, using the Google Maps application programming interface or "API." An API is a set of data structures, protocols, and tools for accessing a Web-based software application such as Google Maps. In simpler terms, it is a utility that allows one program to interface and interact with the code of another program. It ensures that other software programs utilize the application correctly. The Google Maps API allows other programs to access Google Maps data and functionality for use in a third-party application.

In addition to free map data from Google, the software programs used to build the Atlas are open source, which mean they are free and open to the development community. The Atlas pulls information in real time from a MySQL database, an open source online relational database program that runs on a Web server and allows multiple users to access it.

The original version of the Atlas was designed by educators from the California and Connecticut NEMO programs and programmed by the Ohio NEMO program. A CLEAR

[1]This finding is a result of the authors' observations based on a collective 60 years of experience working with local officials on land use planning and water resource issues.

technology volunteer, working with the National NEMO Hub, has revised the Atlas to improve functionality (see below).[2]

The benefits of this technological approach are many. First, all of the various programs utilized to build it are free and/or open source, helping to reduce the costs of production. Also, by utilizing programming APIs, you are able to pull together preexisting functions and data to build a tool rather than recreate the functions from scratch. This provides tremendous time and cost savings.

From an end-user's perspective, a mapping mashup like this deploys the information in an increasingly common interface—that of an online/digital mapping program. These interactive mapping applications are now pervasive on Websites, mobile phones, and GPS devices. Websites with embedded mashups are also increasingly common, with over 350,000 Websites incorporating Google-based mapping mashups alone.[3] The increasing familiarity of these interfaces helps reduce the amount of training required to make use of the end product. Furthermore, adding a spatial element to your information helps to individualize your data and connect it back to the user.

Of course, there are also limits. To be able to deploy these technologies effectively, knowledge of computer programming, Web development, and Web design are needed. In addition, because mashups are reliant on various other programs or functions, they are also subject to any conditions placed on their use by the developer/owner. These conditions may hinder what can be done or, in some cases, prevent people from utilizing them all together.

Navigating the Atlas

As discussed above, one of the benefits of a mapping mashup is the familiar interface and ease of use to locate information. The Atlas consists of a series of place markers or points tied to a specific geographic location in Google Maps. Each place marker is color coded to match the type of LID project (e.g., yellow markers for rain gardens, brown for permeable pavements, etc.). Clicking on those points brings up a "balloon" of information about a particular LID installation at that location. Each balloon includes a project summary, location information, type of LID practice, land use type (residential, civic, and commercial), a photo of the installation, and links to more detailed project information or resources (installers, monitoring results, etc.) (Figure 2).

Users can employ Google Maps built-in navigation tools to pan and zoom around the map to explore areas they are interested in. Because the Atlas utilizes Google imagery, users can change the underlying map to the base map, satellite imagery, terrain, or a hybrid map. If the Google satellite imagery is good enough in a particular location, users can zoom in close enough to view the LID project—for instance, a large green roof (Figure 3).

Recent improvements in the Atlas allow it to also be filtered and/or searched in a variety of ways. Users can filter what projects appear on the map by state, type of practice, land use type, or any combination of the three. For example, if someone is looking for examples of rain gardens in North Carolina, they can filter the Atlas so that just examples meeting those criteria appear. There is also a keyword search that allows users to search the entire database for a particular word or phrase.

Organizations can also embed a smaller version of the Atlas in their own Website that displays only examples of LID from a particular state or region. The embedded version of the Atlas has the same navigation and search functions as the national version but adds the option to search for installations by town/city. Users can also search neighboring states or the entire country if they like from within the embedded version.

Because these localized versions pull from the same database as the national version, when a site is added to the Atlas or edited it is automatically updated on any embedded, localized versions. NEMO programs from six states (CA, CO, CT, NC, RI, SC) have embedded a localized version of the Atlas on their Websites.

Organizations interested in embedding the Atlas in their Website should contact the hub (nemo@uconn.edu) for step-by-step instructions on adding a custom version of the Atlas to their Website. It should be emphasized that the Atlas is not intended to be a complete or exhaustive compilation of all LID practices in the country. While the developers at CLEAR and the NEMO Network would like as many data points as possible, the Atlas is an educational tool, not a tracking system.

Collaboratively "Growing" the Atlas

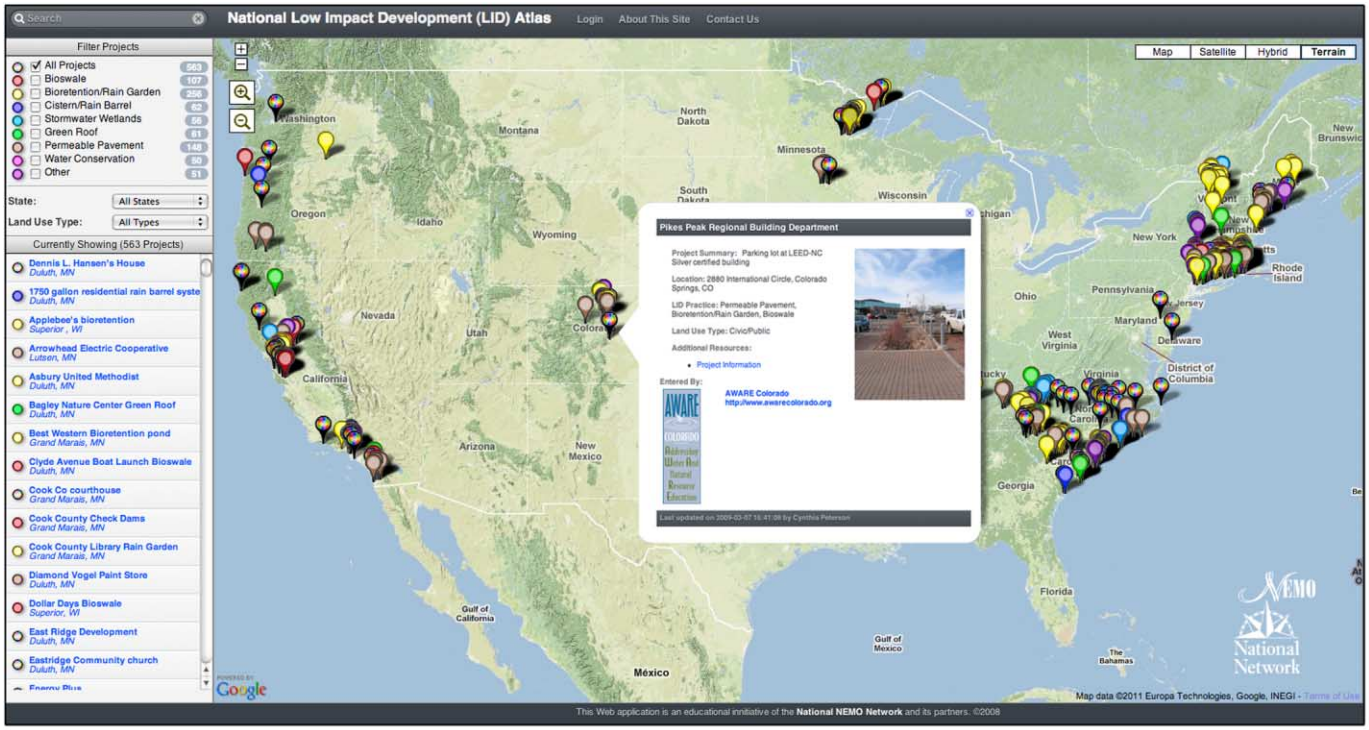
The Atlas is a dynamic, collaboratively built tool. Individual NEMO

[2]John Rozum & Kate Woodruff (CT NEMO), David Dickson (NEMO Hub), and Dr. Timothy Lawrence (CA NEMO) designed the Atlas. John Ray at The Ohio State University did the programming. Mark Hensel is the technology volunteer who completed the revision of the Atlas.

[3]http://blog.programmableweb.com/2010/10/19/google-maps-api-now-serving-350000-websites/.

FIGURE 2

A screenshot of the National LID Atlas. Note navigation options within the map and filtering/search options on the left. Clicking on the icons in the map will open more detailed information about the LID project at that location.



educators and/or their partners around the country add all of the projects in the Atlas. The Atlas includes a login area that allows authorized users to fill out a simple online form. Upon completion, projects are automatically added to the Atlas. Projects can be edited or added anytime by logging back into the site.

In addition to adding projects individually, it is possible to fold entire databases into the Atlas all at one time. As long as the database can be exported into a spreadsheet format that matches data to the Atlas fields and it includes a valid address or latitude/longitude coordinates, the projects in that database can be added as a batch into the Atlas. This can be very useful for states with existing spreadsheets or databases of projects. A spreadsheet template for bulk uploads of projects to the Atlas has been developed and distributed to authorized users.

The batch upload option can also be an efficient way to collect examples of projects and quickly add them to the Atlas. For example, South Carolina solicits LID examples on its Website via a Google form. The information being collected can then be exported into a Google spreadsheet, verified, and sent to the NEMO Network Hub for inclusion in the Atlas. Google forms and spreadsheet are both free software programs available at: http://docs.google.com.

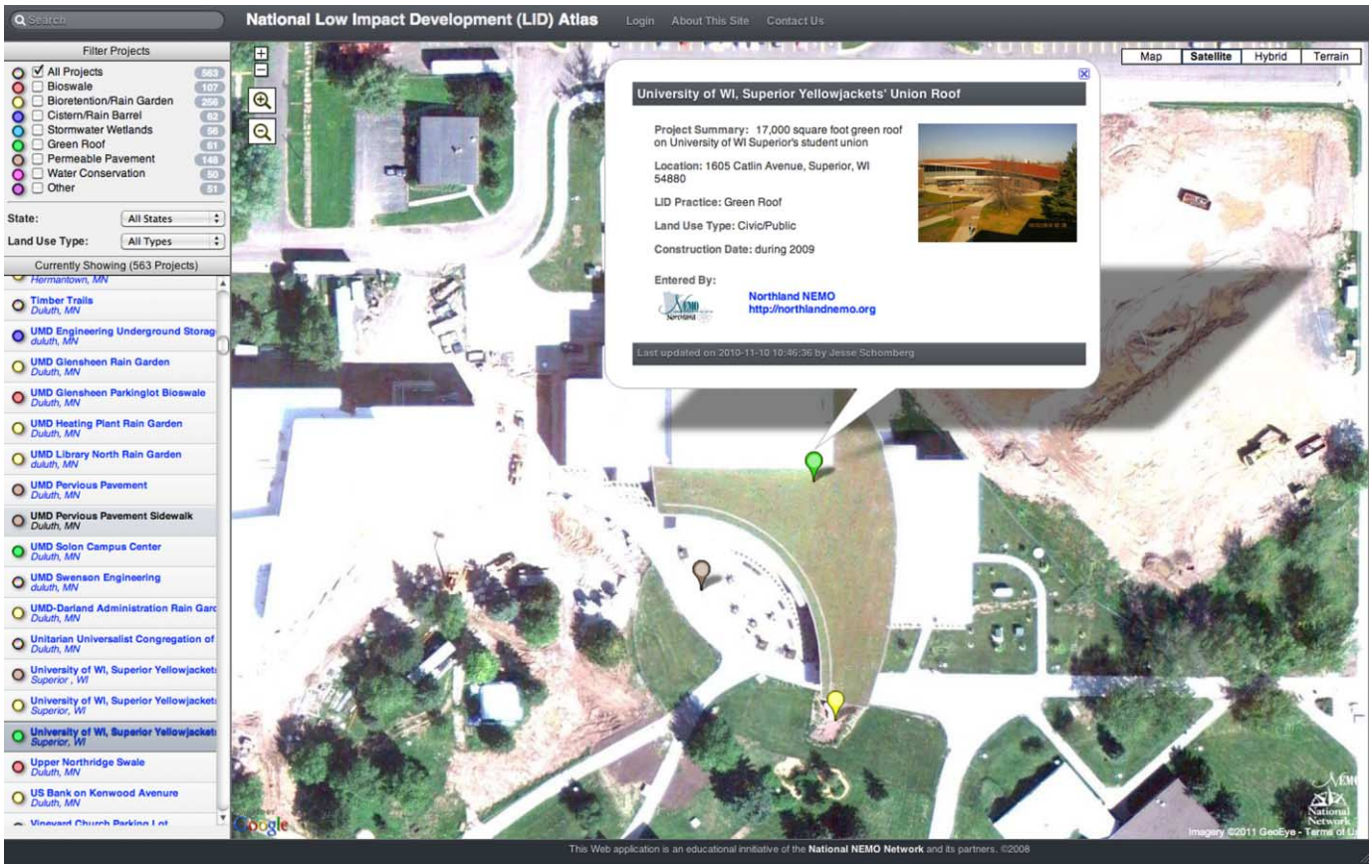
The Network Hub held two webinars, in March 2010, on how to use the site, add projects, and embed a local version of the Atlas. The webinars were recorded and have been placed on Youtube as a reference. The videos can be found on the NEMO Hub's Youtube channel at: http://www.youtube.com/nemohub.

In a collaboratively built tool like the Atlas, one of the challenges is quality control over what gets added to the database. By limiting entries to a few authorized users in each state, we are able to provide some quality control. Each entry identifies who entered it, so follow-up in the case of errors or erroneous information can be made. Another level of quality control is whether the practices identified are actually working. Because we believe failed installations can be as instructive as successful ones, we have chosen not to limit entries based on effectiveness of the implementation of the LID practice.

To date, primarily NEMO program coordinators have been authorized to add projects to the Atlas. However,

FIGURE 3

A screenshot of a sample LID project balloon. Note that by using Google's satellite imagery you can actually view the green roof on this building.



other organizations are encouraged to add LID projects to the inventory either on their own or through the NEMO program in their state. Interested organizations should contact the NEMO Network Hub at nemo@uconn.edu.

Impact

Because the Atlas is still relatively new, it is too early to try and gauge the impact it is having at the local level. In addition, there are other reasons why measuring impact is difficult. The National NEMO Network hub compiles impact reports every several years, documenting examples of how NEMO programs help communities to change their land use plans, regulations, and on-the-ground development practices (Dickson & Arnold, 2008). As impressive as these examples are, due to the complex nature of local land use decision-making, they cannot be portrayed as direct cause-and-effect events. Rather, NEMO programs take credit for being the *catalyst* for local officials to make changes. Evaluating an individual tool like the Atlas further compounds the problem, in that a NEMO program's work with a town often involves an integrated approach that includes outreach education, technical tools, and facilitation. Isolating the impact of one program element in these instances becomes difficult.

In absence of a short-term ability to tease out Atlas-specific data, University of Connecticut CLEAR is tracking general usage of the tool. On average, the National Atlas receives 450 visits per month, and the six localized state versions of the Atlas receive 550 per month, for a total of just over 1000 visits. This number is expected to grow as more projects are added (see "Growing" above), and more states and organizations add a localized version of the Atlas to their own Websites. In the future, additional data will be gathered on who is visiting, not just how many are visiting.

Conclusion

The National LID Atlas is intended to help share information on innovative stormwater management practices around the country and, by doing so,

help to overcome local reluctance to try these new approaches. Recent advances in the interplay between geospatial technologies and Internet technologies have made tools like this possible. The Atlas is just one application that demonstrates the vast potential of this technology for education and outreach focused on protection of our ocean and coastal resources.

The Atlas is also an example of a dynamic, collaboratively built, open source resource that can be constructed for relatively little cost, given modest access to the programming know-how required. And, while the Atlas is a somewhat advanced use of mashup technology, it is relatively easy for non-technical audiences to make simple mashups to display research results, photos, videos, documents, and other information related to a specific geographic site. CLEAR currently has a national project, funded by the USDA/National Institute of Food and Agriculture (NIFA) Water Quality Program, to conduct mashup training around the country for Land Grant and Sea Grant audiences.

The Atlas currently contains over 500 examples, and the National NEMO Hub hopes to greatly expand this number, as LID takes hold across the country and the number of organization contributing to the Atlas continues to grow. The Atlas is at: http://clear.uconn.edu/tools/lidmap.

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