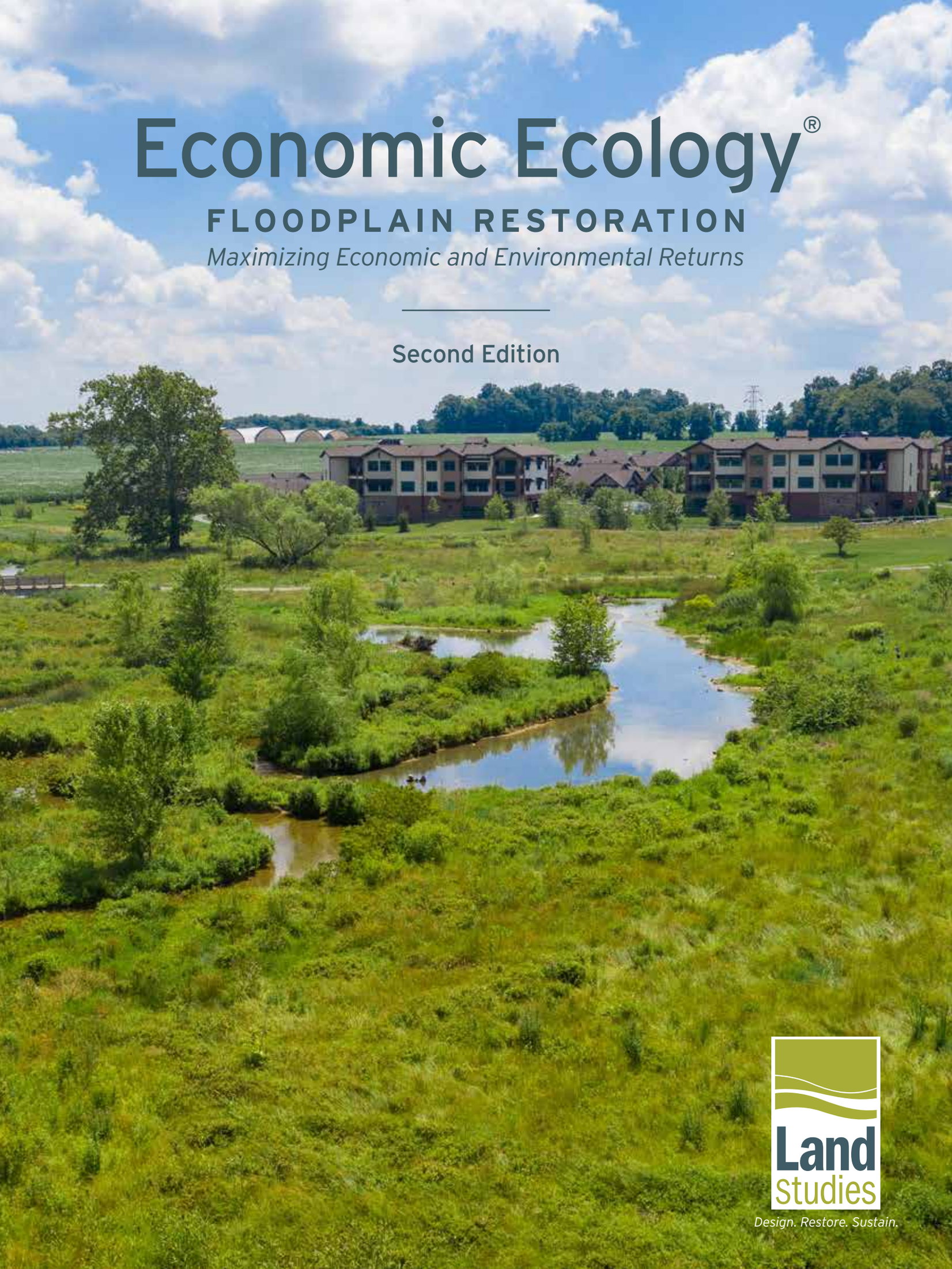
Economic Ecology®

FLOODPLAIN RESTORATION

Maximizing Economic and Environmental Returns

Second Edition



Land Studies

Design. Restore. Sustain.



Letter

FROM THE FOUNDER & VICE PRESIDENT

Since the publication of Floodplain Restoration in 2007, greater attention and concern from state and federal regulatory agencies has focused on water quality and quantity issues. As an applied ecological restoration professional, I have observed, over the last 30 years, efforts to address pollutant removal, flood reduction, and habitat restoration in the mid-Atlantic region, particularly in Pennsylvania and Maryland.

Solving these issues isn't easy. It requires significant resources of time and money to provide the long-term, quantifiable data that regulators use to validate water-quality improvements. And these improvements are measured against performance standards that are based on computer modeling assumptions about the relationship between water, soil, and land. However, the hard numbers need to be blended with qualitative visual observations.

Ideally, we want natural, functional landscapes because they support biodiversity, manage stormwater, filter pollutants, and more. They also work not as independent project sites, but rather as part of a greater regional whole, connected to a larger freshwater system — a watershed.

Conventional methods of addressing water-resource issues are frequently land-intensive and cost-prohibitive. We need landscapes that actually work and that provide economic as well as ecological benefits.

If your town is flooding, or you're struggling to comply with water-quality regulations in a cost-effective manner, or your county or state is trying to meet Chesapeake Bay cleanup requirements, Economic Ecology: Floodplain Restoration is for you. It's intended for community leaders, municipal officials, corporations, real estate managers, economic and land developers, campus managers, sustainable-community planners, policy-makers, and watershed groups.

With 12 case studies, it shows how Economic Ecology, an innovative, regional approach to solving water issues, can maximize both economic and environmental returns on investment. LandStudies has designed, constructed, maintained, and monitored these projects. With up to 20 years of monitoring data on these projects, we can demonstrate their long-term success.

You'll read about cost-benefit analysis, opportunity cost, value proposition, water-quality trading and offsetting, risk management, and mitigation banking — in addition to the compelling ecological benefits of a comprehensive science-based solution.

With Economic Ecology: Floodplain Restoration, I hope, as you work to solve water-resource issues, you are encouraged and challenged to leverage green-infrastructure projects that encourage private and public-private partnerships and that advance economic and environmental benefits to you and the region.



Mark Gutshall,
Founder & Vice President

Introduction

Few can dispute the merits of undertaking projects to repair or prevent environmental damage. The hard truth, though, is that some projects with the best long-term results require a significant initial investment of time and financial resources. Consequently, some view the environmental improvements from these projects as not worth the investment.

LandStudies demonstrates how and why that point of view is changing. Twelve case studies are included to demonstrate the economic rewards of tackling environmental issues on a regional scale. Also included are cost-benefit analyses revealing the true value proposition of an approach we call Economic Ecology that maximizes economic and environmental returns to solve water issues on a regional scale. Understanding Economic Ecology is especially important for those who influence the economic development and vitality of our communities.

Decision-makers who can benefit from reading this publication include officials at all levels of government, bankers, real-estate brokers, developers, land planners, and lawmakers.

Economic Ecology requires that decision-makers depart from more traditional approaches to planning, permitting, and implementation, and it requires some or all of the following to succeed:

- Land planning on a regional rather than local scale.
- Understanding both immediate and long-term costs and benefits.
- Promoting collaboration among diverse stakeholders.
- Public-private partnerships.
- Private sector collaborators (e.g., land developers and commercial and residential builders).



What is Floodplain Restoration?

LandStudies has been a pioneer in advancing floodplain restoration to solve multiple water-resource challenges. Because we have helped restore and protect stream systems for nearly two decades, we have been able to monitor and analyze project results over time. We have discovered that, although floodplain restoration may appear to cost more than certain traditional solutions, it is often the most cost-effective way to achieve a multitude of environmental and economic benefits both immediately and in the long term.

THE PAST

Before we settled the area and altered the stream systems, the stream channel and floodplain were a connected system heavily vegetated with plant species native to the region and adapted to wet conditions. This vegetated network of plants helped slow excess flow and filter pollutants. The soils in the wet floodplains allowed plentiful groundwater recharge, and the riparian plant life housed and nourished a wide variety of native wildlife. Wetland plants also absorbed nutrients such as phosphorus and nitrogen from the water and soils.

In the late 1600s, Europeans first began to colonize our East Coast, establishing farms and towns and industries along the landscape's abundant rivers and streams. Streams were impacted by three important activities that took place concurrently over the years after settlement began, timber harvesting, farming, and mill dam construction

Timber harvesting during settlement and exploration was done without regard for forest regeneration because it seemed as though the forest went on forever. Consequently, hillsides were stripped bare and left to erode. Eroded soils from the deforested hillsides eventually made their way into the lowland stream and river valleys.

Farmers and settlers quickly cleared land in the gentle slopes and bottoms of the stream valleys and often created straight channels along the edges of the valleys to redirect the water into a single stream, leaving the nutrient rich valley soils open for farming. Plowing these fields contributed to the soil erosion affecting the streams, and both animal and human waste contributed to excessive nutrients such as phosphorous and nitrogen. Phosphorus usually attached itself to the eroding sediment particles. Nitrogen more commonly found its way into the groundwater.

The new settlers from Europe were skilled in establishing mills and employing water power to drive them, and they did so rapidly. Throughout the region, one mill after another sprang up on nearly every river and stream. Mill races – long straight channels constructed to direct and control water flow over the mill wheel – diverted water from established channels. Flowing water behind the dams was slowed, becoming more like ponds than streams. It wasn't long before the fine soils and sediments that were finding their way into stream valleys began to drop out in the ponded waters and build up behind the dams. As sediments built up in the ponded areas behind dams, both the channel bed and the floodplain rose. The channel bed, once gravel, now was sediment, also known as legacy sediment.

By the 1950s, several circumstances affecting our stream systems had changed. Wholesale land clearing had essentially ceased. Farm management had greatly improved. Human waste disposal was now largely controlled through municipal sewage waste systems. Water was no longer necessary for power. And industry was not forced to remain along streams. What all of these changes left in their wake was an elevated stream channel, an elevated floodplain, greatly diminished sediment loads coming into the stream valleys, abandoned mills, and crumbling dams.

THE PRESENT

Nature's next step is what we are witnessing today. Through the field work we've done and observations we've made at LandStudies, coupled with the invaluable research of our colleagues, Dr. Arthur Parola at the University of Louisville, and Drs. Dorothy Merritts and Robert Walter at Franklin and Marshall College in Lancaster, we now know that much of the work to repair our streams should first be focused on the floodplains and the "legacy sediments" that have filled them.
LandStudies' approach to floodplain restoration speeds up the process of an unstable stream system working its way back toward stability, and it helps eliminate much of the damage that can occur to our now-occupied land and our infrastructure in the process.

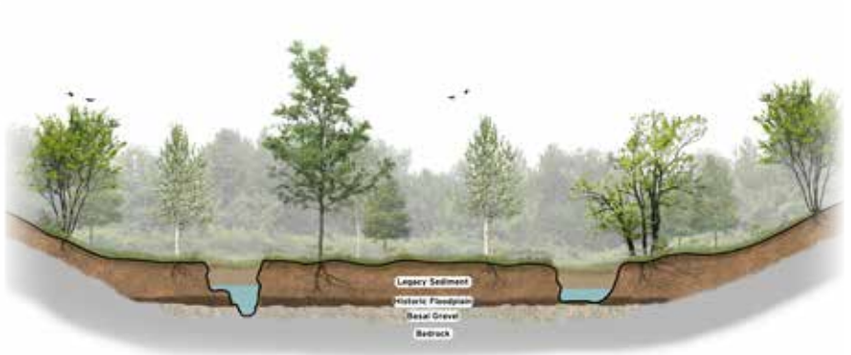
Historical research and keen-eyed field observation help us determine where the stream channel most likely flowed before human intervention changed the landscape. Trenches dug down through the existing terraces show us how deep the sediments are and the depth to the original gravel bed and floodplain. Extensive field research helps us understand the upstream sediment load that will, over the long term, need to move through the restoration site without eroding the restored channel or be deposited in a planned location. The final design considers flow velocities and erosive forces under a range of flood events to ensure that the project will remain stable indefinitely.

FLOODPLAIN RESTORATION METHOD

Legacy sediments are excavated and removed, reestablishing the valley bottom at the elevation of the pre-settlement floodplain, much of which remained intact beneath the historic millpond deposits. The channel and floodplain are designed to allow for both wet and dry zones depending on precipitation and fluctuating groundwater levels.

Pre-Restoration

This section view represents the extent of Legacy Sediment deposition that is typically found in floodplains throughout our region.



Post-Restoration

This section view represents the goal of floodplain restoration and how floodplains looked and functioned for thousands of years prior to colonization.





What is Economic Ecology?

In 2007, LandStudies published Floodplain Restoration, a practical booklet which further explains the history of mid-Atlantic and Northeast stream systems; how land-use practices destabilized most of those systems; how today we are living with the consequences; and the multiple benefits derived from restoration. The booklet also explains the theory behind floodplain restoration, which entails returning an entire system — both stream and floodplain — as closely as possible to its historical, more stable configuration.

By employing a holistic approach that takes the regional watershed into account, LandStudies' method of floodplain restoration addresses the root causes of stream system problems rather than focusing on the symptoms. A multitude of problems are corrected simultaneously, symptoms disappear, and diverse stakeholders benefit from lasting results that require minimal maintenance.

This approach, which optimizes both the environmental and economic benefits of ecological repair and restoration on a regional scale, is appropriately referred to as Economic Ecology. It requires that we look beyond traditional, site-bound solutions to discover a better way that offers a higher value proposition.

Who Benefits?

In theory, every time a stream system is improved or restored, we all benefit because, as the saying goes, "We all live downstream." In practice, a surprising number of constituencies can reap the benefits of one floodplain restoration project:

- Municipal officials
- Communities both around and downstream of the project site
- Individual property owners who live nearby or downstream
- Developers
- Commercial enterprises
- State government
- Financiers
- Farmers
- Sportsmen
- Watershed groups

Floodplain Restoration is available as a free download on LandStudies' website: landstudies.com.

What Are the Benefits?

ONE FLOODPLAIN RESTORATION PROJECT CAN POTENTIALLY ADDRESS THE FOLLOWING:



Water quality

Removes pollutants.



Water quantity

Provides natural stormwater management and flood control.



Wetland creation and restoration

Improves interaction between surface flow and groundwater, which increases infiltration and purification of stormwater.



Water supply

Increases groundwater recharge and purification.



Biodiversity

Improves native plant and animal habitat.



Infrastructure protection

Prevents flood damage to bridges, roads, and buildings.



Regulatory compliance

Meets state and federal requirements.



Smart growth

Enables higher density development and fulfills open-space requirements.



More developable space

Stormwater is managed within the floodplain instead of in detention/retention basins that use up land that might otherwise be used for development.



Comprehensive planning

Municipal and regional.



Mitigation banking

Creates or restores wetlands.



Education

Introduces students and residents to environmental education and stewardship.



Recreation

Creates open space and trails.



Aesthetic improvement

Creates biologically diverse, naturalized open space.



Increased property values

For the benefits listed above.

Stream restoration alone does not restore the integrated functions of the entire system. The initial investment of time and money may be less for a partial restoration, or other more traditional approaches, but such techniques often don't work, don't last, or require ongoing and sometimes costly maintenance. When the floodplain is part of the restoration, benefits are greater and longer lasting.

Common sense tells us that maximum stability is achieved through restoring the integrated system of channel and floodplain. Therefore, the initial cost of a complete floodplain restoration, which can be higher or lower than traditional restoration methods, is a wise and cost-effective investment due to the wide array of long-term and stable benefits for a broad spectrum of people.

Economic Advantages

FLOOD REDUCTION

If floodplain restoration did nothing more than reduce flood damage, it still would be a wise investment. According to the April 2007 issue of Pennsylvania Township News, published by the Pennsylvania State Association of Township Supervisors, "Pennsylvania led the nation with an average of $682 million in flood losses each year between 1955 and 1999."


Photo: Lancaster Liederkranz

A Pennsylvania golf course official cited replacement costs of $45,000 to $60,000 to rebuild a green and $5,000 to rebuild a bunker. A floodplain restoration project on the property may potentially save the course owners several hundred thousand dollars over the long term.

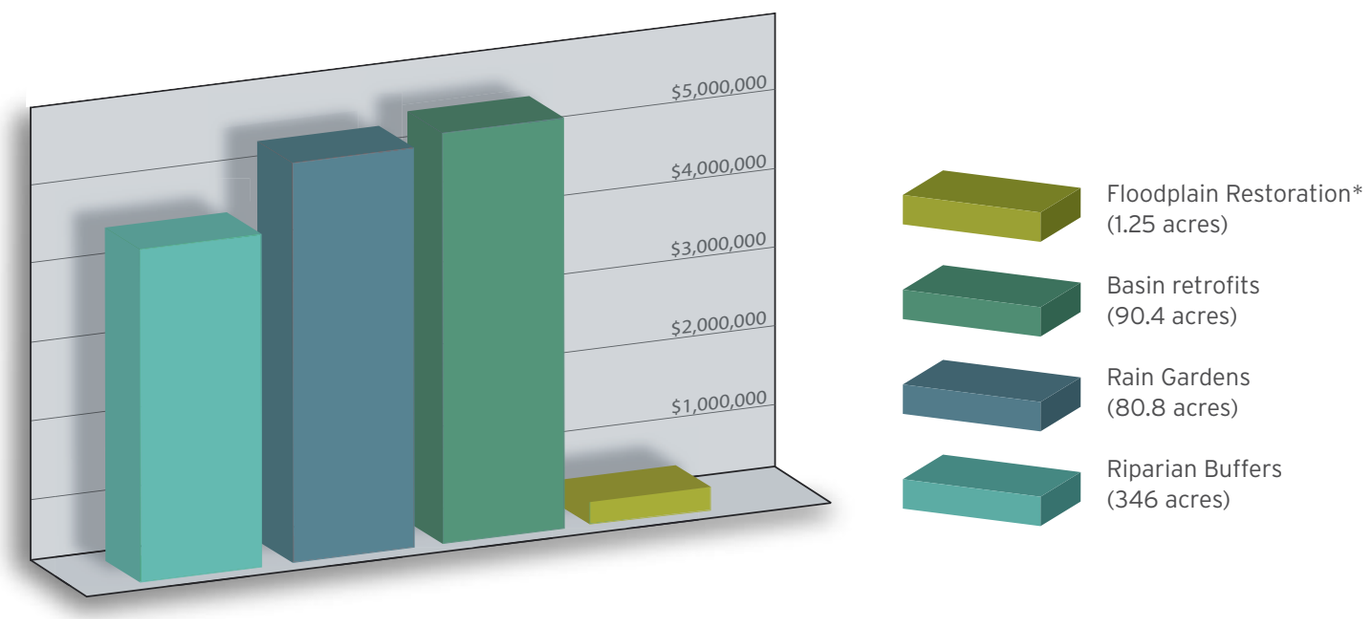
In 1990, the Federal Emergency Management Agency (FEMA) implemented a voluntary and financially beneficial Community Rating System (CRS) through its National Flood Insurance Program (NFIP). Under the program, flood insurance premiums are discounted to reward community actions that reduce property damage from flooding and develop a comprehensive approach to floodplain management. Floodplain restoration achieves exactly that, especially when targeted to problem areas throughout a watershed.

Discounts for complying communities begin at five percent. As a participating community's CRS rating improves, its premium discount grows by five percent for each rating class.

As of March 2014, according to the FEMA fact sheet on CRS, "Nearly 3.8 million policyholders in 1,296 communities participate in the CRS by implementing local mitigation, floodplain management, and outreach activities that exceed the minimum NFIP requirements."

Cost to Reduce 100,000 Pounds of Sediment

(Including Amount of Each BMP to Achieve Reduction)



**Floodplain restoration data is based on the Brubaker Run at Lime Spring Square project.*

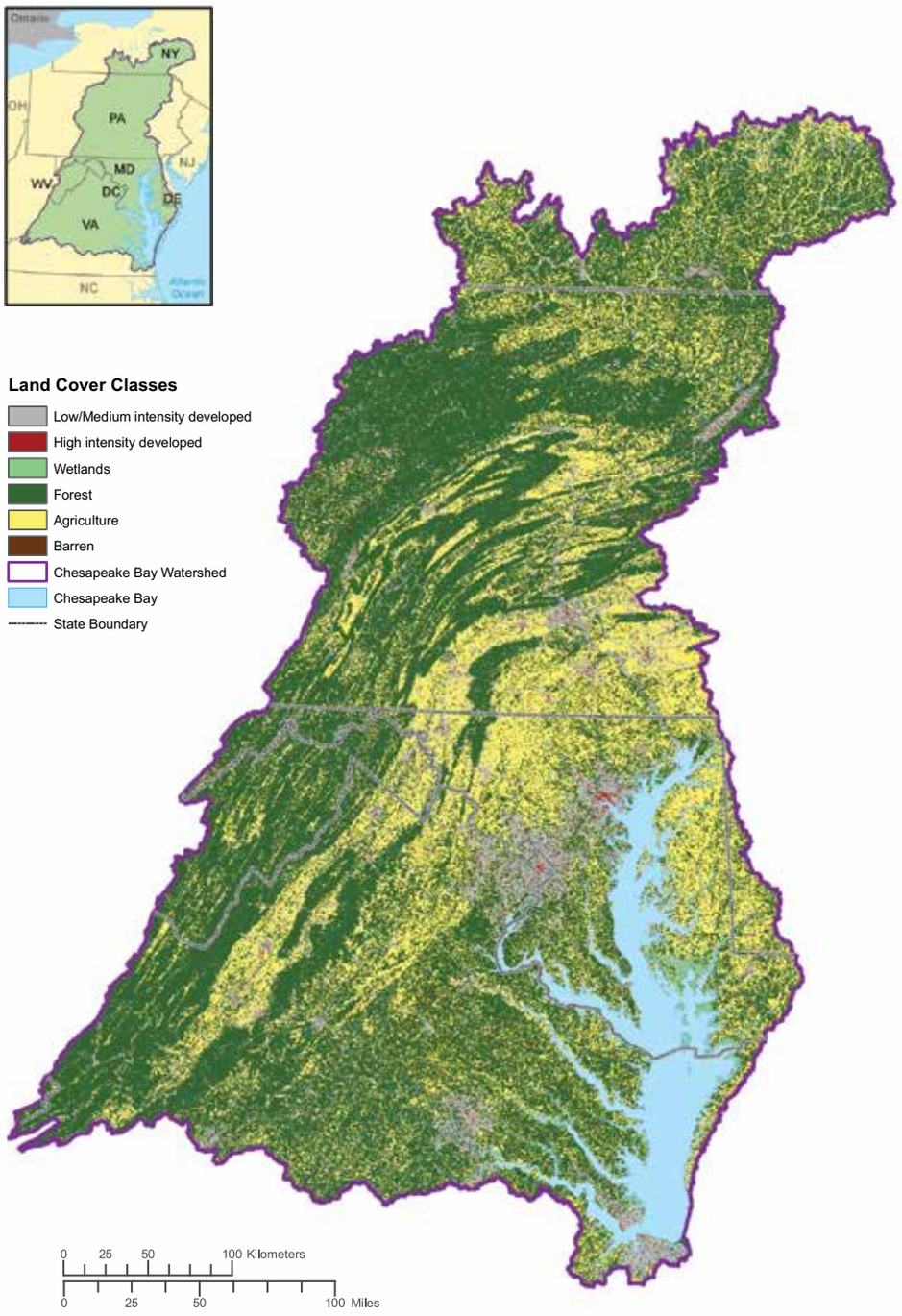
WATER-POLLUTION REDUCTION

The previously mentioned publication, Floodplain Restoration, explains in detail how floodplain restoration reduces sediments and nutrients from channel flow immediately upon removal of the legacy sediments that were deposited on top of the historical floodplain. Floodplain restoration also helps capture much of the sediment and nutrients washed from upstream during high flows.

Nitrogen, which is particularly difficult to capture through other techniques, is reduced through the creation of an anaerobic environment in the saturated soils of functional wetlands. Bacteria that thrive in that environment use the oxygen from nitrates (NO_3^-) for metabolism. The resultant harmless nitrogen gas is released into the air, and nitrates are removed from groundwater.

That's good news for Pennsylvania, which has until 2017 to implement best management practices (BMPs) that reduce nitrogen loads in its streams and rivers by 10 million pounds and sediment loads by 212 million pounds. The Commonwealth fell short of meeting the 2013 milestones for nitrogen and sediment reductions, according to the U.S. Environmental Protection Agency (EPA). If the 2017 milestones aren't met, EPA can impose additional reduction requirements directly on wastewater-treatment plants and controls on farmland and stormwater runoff. These wastewater-treatment plant upgrades and stormwater BMPs cost more per pound of sediment and nutrients removed than floodplain restoration.

The Chesapeake Bay Watershed



Map: Land Cover: Chesapeake Bay Watershed (2008). Author: Emma Andrews. Accessed May 5, 2015 from http://www.chesapeakebay.net/maps/map/land_cover_chesapeake_bay_watershed.

Because pollutant removal and flood reduction (only on sites where flooding is a problem and given specific site constraints) are the overriding benefits that result from virtually all floodplain restoration projects, Pennsylvania can improve water quality and meet its Chesapeake Bay milestones with this innovative, cost-effective BMP.

OPPORTUNITY-COST RECOVERY

Strict regulations against encroaching on the floodplain as well as into wetlands prevent floodplain acreage from being developed. Regulatory requirements for stormwater management and open-space areas traditionally have rendered even more acreage undevelopable.

Since 2006, the Pennsylvania Department of Environmental Protection (DEP) has recognized floodplain restoration as a stormwater best management practice. In 2014, Rock Lititz* was the first floodplain restoration project to be accepted by DEP to satisfy the overwhelming majority of the site's stormwater management requirements.

The image below shows the Rock Lititz master plan campus. Five out of seven of the planned or existing buildings could not be developed if traditional stormwater management methods were used, rather than a floodplain restoration.



Existing or portions of proposed buildings that would be eliminated to make room for conventional stormwater basins.

* View the full Rock Lititz case study on page 16

By utilizing floodplain restoration, stormwater management and open-space requirements can be fulfilled within the restored floodplain. This results in more available acres for development and the potential for commercial and residential developers to recover a substantial opportunity cost, which can be worth millions of dollars.

ECONOMIC SUMMARY

A floodplain restoration project saves money in numerous ways:

- The completed restoration reduces the risks of flooding and water pollution, improves the appearance of the riparian zone, and potentially increases property values nearby and downstream through the addition of improved recreational open space.
- Private landowners, commercial developers, municipalities, and state governments can satisfy numerous regulatory requirements within the scope of one floodplain restoration project.
- Property owners gain more developable land by using floodplain restoration for stormwater management, recovering what would otherwise be a significant opportunity cost.
- The newly naturalized area requires reduced maintenance, and the documented stability of the restoration over time reduces or eliminates the need for further financial investment.

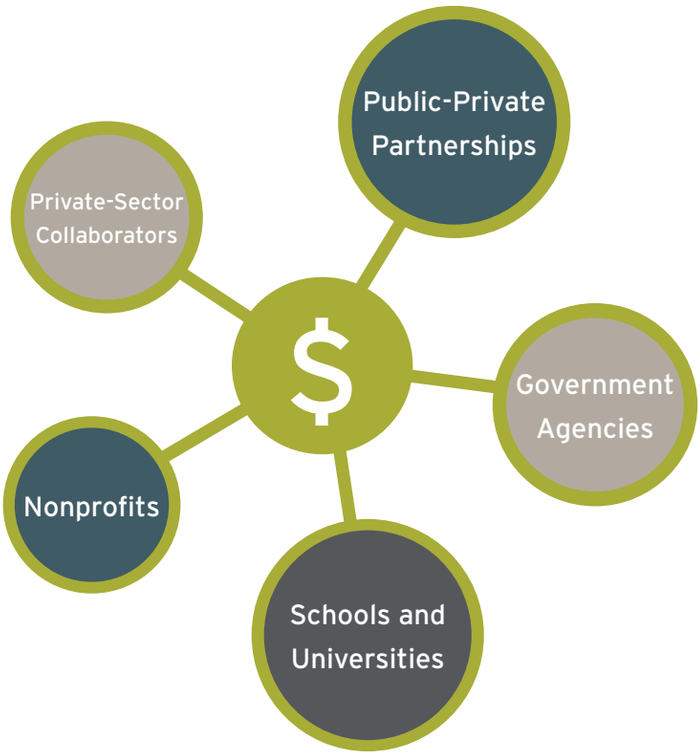


ADVANTAGES OF COLLABORATION

Because floodplain restoration benefits numerous groups and individuals for both economic and environmental reasons, it lends itself readily to collaborative efforts. Collaboration among stakeholders, especially when it involves public-private partnerships, encourages its own economic advantage.

Cooperative Efforts From Diverse Stakeholders Creates Opportunities and Divides Costs

Collaborative efforts typically are viewed favorably by funding sources, especially when the resultant project benefits are numerous, widespread, and relatively permanent and when cooperating stakeholders are diverse. Not only are funding opportunities increased, but also any remaining costs can be divided among the stakeholders.



See Economic Ecology in Action

ATTEND A HEALTHY WATERSHEDS TOUR

As part of LandStudies' commitment to applied learning and spreading the word about Economic Ecology and floodplain restoration, those who are interested can sign up to attend a Healthy Watersheds Tour. The tour includes some of the projects featured in this book.

To learn more, go to landstudies.com





CASE STUDY 1

Lititz Run Watershed
(OVERVIEW)

POST-RESTORATION

PROJECT HIGHLIGHTS

Challenge
A variety of man-made changes to the landscape had led to flooding and water-quality issues in the Lititz Run watershed.

Economic Ecology Solution
- Regional, watershed-based solutions featuring floodplain and stream restoration implemented at several sites
- Reduced flooding, improved water quality along 5 miles of stream and floodplain corridor
- 15 acres of native wetland habitat created

Collaborators
- Donegal Chapter of Trout Unlimited
- Lititz Run Watershed Alliance
- Warwick Township
- Lititz Borough

Awards
- EPA National Showcase Watershed
- Governor's Award for Environmental Excellence
- Outstanding Planning Award, Pennsylvania Planning Association
- Merit Award, Pa./Del. Chapter of the American Society of Landscape Architects
- Platinum Certified Sustainable Municipality, Sustainable Pennsylvania Community Certification program

A Community Improving Its Water Quality

More than 20 years ago, Lititz Borough and Warwick Township began implementing a regional planning model to improve water quality and reduce flooding in the Lititz Run watershed. Community involvement was encouraged and nurtured from the beginning. The restored health and public enjoyment of the watershed has become a source of pride for local residents; hundreds have volunteered their time and donated money to help improve their watershed.

The regional effort quickly gained national attention. In 1999, it won various national and state awards and distinctions. It is one of only 12 watersheds in the country chosen to be part of EPA's National Showcase Watershed. A high point came in 2009, when the stream's designation was elevated from a Warm Water Fishery to a Cold Water Fishery, indicating its improved water quality.

Cooperating partners in the municipal projects have included the local watershed association and the Donegal Chapter of Trout Unlimited. Warwick School District, as well as other districts, has used floodplain restoration areas in their curriculum for middle school and high school students. Millersville University also has used the watershed in its science curriculum.

Stakeholders are moving watershed planning to the next level with the implementation of a **watershed-based permit**. This permit synchronizes efforts from multiple sectors with common goals based on the quality and health of all natural resources.

A **stormwater utility** has been developed that views stormwater resources infrastructure no differently than sanitary sewer or other common utilities. This designation allows municipalities to benefit from credits and offsets from stormwater utilities.

To date, floodplain restoration projects have helped reduce flooding and improve water quality along five miles of stream and floodplain corridor and created 15 acres of wetlands. Funding has come through state and federal grants as well as through private donations. Five projects in the Lititz Run Watershed are described in greater detail in the following pages.

A Letter From the Municipality

Warwick Township, Lititz, PA

ECONOMIC ECOLOGY IN PRACTICE FOR OVER 20 YEARS



There is often a desire to be green and make environmental improvements, but the knowledge of how to go about it and limited financial resources can be a challenge.

Warwick Township's goal is to address those challenges and guide development and other kinds of projects in a direction that provides long-term sustainability. For projects that are close to Lititz Run or one of its tributaries, we look to see if we can incorporate watershed improvements. By doing that, we're able to provide greater benefits to our community and to the larger region.

We've worked with LandStudies on a number of sites, both residential and commercial. Many of these projects have exceeded regulatory requirements. But they also promote development, economic growth, and jobs. Lititz Run is much cleaner today than it was 20 years ago. We do the monitoring and have the data to show that. Yet our community has grown substantially. Warwick Township is living proof that environmental benefits and economic benefits don't have to be mutually exclusive. It's possible to have both.

"Lititz Run is much cleaner today than it was 20 years ago. We do the monitoring and have the data to show that. Yet our community has grown substantially. Warwick Township is living proof that environmental benefits and economic benefits don't have to be mutually exclusive. It's possible to have both."



Daniel L. Zimmerman
Township Manager
Warwick Township

CASE STUDY 2

New Street Park Nutrient Trading Pilot Project

(LITITZ RUN WATERSHED)

POST-RESTORATION

PROJECT HIGHLIGHTS

Challenge

A pilot project was needed to help establish nutrient-pollution trading parameters in the Conestoga watershed. The New Street Park ecological restoration provided additional flood storage, improved water quality, and protection of downstream bridges from flood damage.

Economic Ecology Solution

- 750-foot straightened section of stream restored to 950-foot section of meandering stream channel
- 15.6 million pounds of sediment removed
- ~ 8,900 pounds of phosphorus removed
- ~ 26,000 pounds of nitrogen removed
- 1.5 acres of wetlands created

Collaborators

- Pfizer
- Lititz Borough

Award

- Governor's Award for Environmental Excellence

Benefits

The New Street Park ecological restoration in Lititz Borough was a cost-effective way to rejuvenate an existing community park, and at the same time, provide additional flood storage, improve water quality, and protect downstream bridges from flood damage and debris.

Excavation during the floodplain restoration removed 15.6 million pounds of sediment, about 8,900 pounds of phosphorus, and about 26,000 pounds of nitrogen.

The New Street Park ecological restoration helped to pilot nutrient-pollution trading parameters in the Conestoga watershed (in which Lititz Run is a subwatershed) in Lancaster County, Pennsylvania.





In addition to removing a substantial amount of sediment and nutrients from the stream system, the New Street Ecological Restoration also created fully functional wetland areas and incorporated plantings of native plants, shrubs, and trees along the length of the restored corridor.

The New Street Ecological Restoration project won the coveted Governor's Award for Environmental Excellence. It remains a model of floodplain restoration through a heavily populated residential area, and the restoration area has become a favorite feature for local residents who use the park.



CASE STUDY 3

Banta Property Floodplain Restoration

(LITITZ RUN WATERSHED)

At the Banta property in Warwick Township, the Lititz Run channel had been moved to the side of the deep, narrow valley, straightened, and dammed for a historical mill operation. Because of its artificial configuration, the channel and banks were unstable, eroding both laterally and downward, creating a channel that was too deep and too wide.



The floodplain restoration involved 2,250 linear feet of stream and floodplain. The channel was moved back to the lowest and most stable elevation in the valley. Cross vanes and rock vanes were installed in the channel specifically to improve trout habitat. Sediments in the floodplain were removed and wetlands were created along the length of the restoration area. The stream, floodplain, and wetlands now interact with groundwater and each other.

The restoration site was planted with native species, and they are flourishing. Trees were planted as young seedlings and have grown to heights ranging 25-30 feet. More interesting, perhaps, was the discovery that other native wetland plants were sprouting and thriving in abundance during the first growing season after the restoration was completed. The historical floodplain seed bank, buried for centuries, had been uncovered with the excavation, and the long-dormant seeds began to grow.

Reproducing trout have been observed through electrofishing, and macroinvertebrate and trout surveys indicate these communities are healthy and increasing in number.

A monitoring study conducted several years after the project was completed revealed that, in spite of enduring a number of severe flood events and high-flow periods, the channel and floodplain have remained stable.

PROJECT HIGHLIGHTS

Challenge

A historical mill dam had altered the section of Lititz Run that flows through the Banta property, leading to streambank erosion and stream-channel instability.

Economic Ecology Solution

- 2,250 linear feet of stream and floodplain restored
- Native wetland habitat created
- Sediments in floodplain removed

Results

Over the years, in spite of enduring a number of severe flood events and high-flow periods, the channel and floodplain have remained stable. Trout communities are thriving and long dormant native wetland plant seeds were excavated and now growing.

Collaborators

- DEP Growing Greener
- Warwick Township, Pa.

Benefits

CASE STUDY 4

Santo Domingo Water Quality Facility

(LITITZ RUN WATERSHED)



PROJECT HIGHLIGHTS

Challenge

Lititz Run and its tributaries, including the Santo Domingo Creek, were listed by DEP as impaired due to high sediment loads. The Lititz Run Watershed Alliance and Warwick Township sought innovative ways to reduce the sediment load in this watershed.

Economic Ecology Solution

A settling basin and constructed wetland were created to divert sediment-laden storm flow from the Santo Domingo Creek, slow the water down and filter it through wetland vegetation, and return cleaner water to the stream.

Collaborators

- Warwick Township
- Lititz Run Watershed Alliance

Benefits

The Santo Domingo Water Quality Facility, the first of its kind in Pennsylvania, demonstrates a regional alternative to traditional on-site stormwater management.



Sediment build up is being removed from the pretreatment settling basin.

As Santo Domingo Creek, a Lititz Run tributary, flows into Warwick Township's Linear Park, excess stormwater is diverted into a forebay pond, a water pretreatment settling basin, where stream flow velocity is slowed and sediment settles out. The reduced-sediment stormwater flow then moves through a three-acre wetland where even more sediment settles out and nutrients can be absorbed through the metabolic processes of thousands of wetland plants. Then, the clean, filtered water is discharged downstream.

Created in 1998, the Santo Domingo Water Quality Facility demonstrates a biologically sound solution to riparian management on a regional scale, as well as the community's willingness to think outside the box, and their ability to recognize the worth of a nontraditional approach. Residents in the surrounding development consider the open-space facility a highly valued asset, and the lots adjacent to the site sold at a premium.



Water in the pretreatment settling basin (circled area) is brown with sediment. In the wetland above it, the water is noticeably cleaner.



CASE STUDY 5

Butterfly Acres CARA Restoration

(LITITZ RUN WATERSHED)

The Butterfly Acres site is a stormwater drainage swale that flows through a development in Lititz Borough, Pennsylvania, that had become severely degraded. There had been significant erosion, and undesirable invasive plants had dominated the site. When the Susquehanna River Basin Commission, during the course of their 2005 Northern Lancaster County Groundwater Study, identified Butterfly Acres as a Critical Aquifer Recharge Area (CARA), it became especially important to find a way to restore the site.



Educational signage along the walking trail helps inform the public about how the regional bioswale works and why it is so important.

Results from field surveys, geoprobes, and electromagnetic logging studies to check for susceptibility to sinkhole formation evolved into a four-phase Master Plan to restore the site's function as an aquifer recharge area. Because the site runs through a residential development and features a walking trail, the plan included the establishment of a healthy native plant community to improve the aesthetics and to increase enjoyment for the residents and others who use the site.

All four phases were completed over four subsequent years on behalf of the borough and through the generous contributions of private community businesses. Monitoring is ongoing, and visual observations indicate that the goal of restoring the infiltration and groundwater recharge function has been realized in this critical area. Educational signage on the site helps inform the public about how the regional bioswale works and why it is so important.

PROJECT HIGHLIGHTS

Challenge

A degraded drainage swale running through the Butterfly Acres development had significant erosion, was dominated by invasive plant species, and was not infiltrating and filtering stormwater runoff.

Economic Ecology Solution

- Native plant and wildlife habitat created
- Function of aquifer recharge area restored through enhanced infiltration
- Recreational opportunities (e.g., walking trail) and aesthetics enhanced
- Stormwater conveyance improved and localized flooding and infrastructure damage reduced

Collaborators

- Lititz Borough
- Private Community Businesses

Award

- Smart Growth Leadership Award

Benefits

CASE STUDY 6

Rock Lititz Floodplain Restoration

(LITITZ RUN WATERSHED)



POST-RESTORATION



PROJECT HIGHLIGHTS

Challenge

The Santo Domingo Creek, a tributary to Lititz Run located on the Rock Lititz site, had been significantly altered by historical human activities, leading to streambank erosion and streambed degradation that caused nutrient-rich sediment to affect downstream water quality.

Economic Ecology Solution

- 3,136 linear feet of stream restored by removing legacy sediment from the valley bottom and increasing floodwater storage potential
- Stormwater managed within the floodplain, increasing available land for development by 9 acres

Collaborators

- Warwick Township
- Clair Global
- TAIT Towers
- Atomic Design
- Derck & Edson Associates

Benefits

Rock Lititz is a landmark floodplain restoration project. It is the first time DEP has permitted floodplain restoration to provide the overwhelming majority of stormwater management for a large commercial site. This designation is economically important for a number of reasons.



PRE-RESTORATION

Rock Lititz is one of Lancaster County's newest and most far-reaching and important enterprises. The company provides facilities for the training, preparation, coordination, and rehearsals needed for musical acts from all over the world.

Santo Domingo Creek, a Lititz Run tributary, flows through the Rock Lititz property. The channel and floodplain occupy 17 of the 96 acres and cannot be developed. Conventional approaches to land development would have set aside additional acreage for stormwater management, open space, and building setbacks – as required by local land development, stormwater management and zoning ordinances, and state stormwater management requirements. The traditional approach would have allowed only 47 of the 96 acres to be developed – less than half the site.

An alternative option that would maximize land use was needed. After careful consideration, Rock Lititz chose to fund a floodplain restoration on the portion of Santo Domingo Creek that runs through its property.

The restoration project is expected to provide *annual* pollutant reductions of 248,000 pounds of sediment, 1,010 pounds of nitrogen, and 173 pounds of phosphorus.



The Rock Lititz floodplain restoration project, more than any other to date, was thoroughly researched in terms of its economic value to Rock Lititz. A detailed cost-benefit analysis is available from LandStudies.

The results of that analysis provided an eye-opening picture of both direct and indirect benefits to Rock Lititz and the surrounding communities, which further reveals why the greater up-front investment for floodplain restoration pays off financially and environmentally.

With floodplain restoration, Rock Lititz regains **nine** acres of land for development that could have been lost to conventional stormwater-management systems and detention basins, resulting in a **182%** return on investment based on implementation of floodplain restoration and a $3.1 million value of the recaptured nine acres. The developable portion of the site went from 47 to 56 acres.

The floodplain restoration is helping Warwick Township to meet MS4 and total maximum daily load (TMDL) requirements, and it's helping Lancaster County to meet Chesapeake Bay cleanup obligations. By looking beyond traditional ways of developing and permitting, the Rock Lititz floodplain restoration project has set a new standard for cost-effective development.



The central green area in the plan above indicates the floodplain restoration project.
Image: Derck & Edson

Economic Ecology By the Numbers

9
MORE ACRES OF DEVELOPABLE LAND

182%
RETURN ON INVESTMENT*

$3.1 Million
VALUE OF RECAPTURED LAND

* *Based on implementation of floodplain restoration and value of recaptured land.*

CASE STUDY 7

Landis Homes Floodplain Restoration



POST-RESTORATION

Photo: RGS Associates



PROJECT HIGHLIGHTS

Challenge

An expansion to the Landis Homes Retirement Community required additional stormwater management. The client's goals were to improve stream function of Kurtz Run and the aesthetics of the community while minimizing the area devoted to stormwater management so that area available to construct resident housing could be maximized.

Economic Ecology Solution

Eleven additional residential units could be added as a result of the land-use savings from the floodplain restoration. The floodplain restoration approach was more cost-effective for Landis Homes compared to other approaches relying on conventional detention basins. The following charts compare common BMPS to the economic ecology approach of flood plain restoration. The cost includes design, permit, construction, monitoring ($226K) and maintenance ($51K) for 5 years.

Annual sediment removal: 150,000 pounds per year.

Solution	Cost
Economic Ecology	$1.1 Million
Rain Gardens (requiring 121 acres)	$7.6 Million
Urban Forested Riparian Buffer (requiring 518 acres)	$6.4 Million

Annual nitrogen removal: 800 pounds per year.

Solution	Cost
Economic Ecology	$1.1 Million
Rain Gardens (requiring 42 acres)	$1.1 Million
Urban Forested Riparian Buffer (requiring 94 acres)	$1.1 Million

Annual phosphorus removal: 130 pounds per year.

Solution	Cost
Economic Ecology	$1.1 Million
Rain Gardens (requiring 50 acres)	$1.3 Million
Urban Forested Riparian Buffer (requiring 148 acres)	$1.8 Million

This project also achieved significant aquifer recharge with a runoff volume reduction nearly four times greater than required by the NPDES permit.

Collaborator

Landis Homes Retirement Community

Benefits

Additional stormwater management facilities were a requirement for a residential expansion at Landis Homes Retirement Community. Because stewardship is an important component of Landis Homes' mission, management wanted to find a sustainable yet financially astute way to increase housing while environmentally and aesthetically improving the site. Floodplain restoration along Kurtz Run, which flows through their property, provided the solution.

Kurtz Run, like so many other streams in the area, had been a source of sediment and nutrients due to streambank erosion.



PRE-RESTORATION


POST-RESTORATION

A floodplain restoration project met management's high standards for appearance and functionality, managing stormwater, removing pollutants, and capturing and filtering stormwater naturally.

The return on investment for the project was significant. The floodplain restoration provided the additional stormwater management required and freed up enough space on the 114-acre parcel to seek permitting for building 11 more cottages— on acreage that otherwise would have been used for traditional stormwater management structures. Landis Homes is awaiting final approval of the permit, which is in its final stages with DEP.

Approximately 27,500 cubic yards of sediment were removed from the floodplain and spread on adjacent fields or stockpiled for future use.

A pond was restored to a wetland full of native plants and now attracts wildlife and helps filter water during storm events.

Applying a holistic ecosystem approach has paid off in many ways for Landis Homes and for the environment both on site and downstream. Management has more than met their obligation to control stormwater rate, quantity, and quality. The community has been able to maximize its utilization of limited land area and at the same time, decrease outdoor maintenance. Residents are enjoying the natural beauty of more plants, color, wildlife, and walkable areas.


Photo: Landis Homes

The Friends of the Woods and Wetlands is a group of residents that volunteer at Landis Homes. The group's activities include reestablishing native species; controlling invasive species; studying environmental issues and making recommendations based on their findings. They encourage involvement from other residents at Landis Homes and provide environmental education to residents and the broader community.



CASE STUDY 8

Brubaker Run at Lime Spring Square Floodplain Restoration

PROJECT HIGHLIGHTS

Challenge

Efforts to clean up the Chesapeake Bay have intensified in recent years, resulting in an increased level of regulation for governments and private industries. Many companies, municipalities, and business operations have less money available to address these issues due to the economy, associated government spending cuts, and smaller operating and capital expenditure budgets.

Economic Ecology Solution

- By reconnecting the stream channel with the floodplain and restoring 4,750 linear feet of stream length, 8.4 additional acres of emergent wetlands and native plant communities were created that provide water quality benefits.
- Approximately 38,500 tons of legacy sediment had been removed from the floodplain.
- Annual sediment removal: 800,000 pounds per year.
- Annual nitrogen removal: 5,773 pounds per year.
- Annual phosphorus removal: 254 pounds per year.

Collaborators

- Oak Tree Development Group
- East Hempfield Township

Benefits





PRE-RESTORATION

Lime Spring Square contains a mix of industrial, commercial, retail, office space, and a community park. For this project to become a reality, the 98-acre development had to satisfy Post Construction Stormwater Management requirements. Oak Tree Development Group, a Lancaster-based real estate development company, partnered with East Hempfield Township to not just meet regulatory requirements but to undertake an expansive water quality initiative to realize regional flood and nutrient benefits for the project site as well as patrons and resources downstream of the 2.25 square mile watershed which include the Little Conestoga Creek, Susquehanna River and Chesapeake Bay.

A floodplain restoration project was designed to remove legacy sediment from the floodplain and restore an active, connected, and functional floodplain. This restoration approach meets or exceeds the stormwater management requirements of the development, provided an additional 8 acres of buildable space for the land developer, and helped East Hempfield Township meet a majority of their Chesapeake Bay Pollutant Reduction Plan (PRP) goals at no cost to taxpayers.


POST-RESTORATION


POST-RESTORATION

This project provided a unique opportunity for local and state governments in Pennsylvania to join forces with the private sector to maximize funding sources and create substantive water quality benefits that can be applied to Environmental Protection Agency (EPA) mandated water quality improvements for the Commonwealth. The project had the support of elected officials throughout the planning process, which was important, as this is just the third floodplain restoration in the county that directly gives its municipality credit on state and federal scorecards for reducing pollution of the Bay.

The amount of sediment pollution removed each year by the project will equal that of approximately 64 miles of forested buffers installed on both sides of the stream, which would have cost the public as much as $5.6 million. Both the Oak Tree Development Group and the Township benefit from using floodplain restoration. Furthermore, Oak Tree has gained as much as 100,000 square feet of additional leasable space on the project site. The Township gained an 11-acre recreational park in addition to the MS4 pollution reduction credits beyond Oak Tree's permit obligations.

By looking beyond traditional ways of developing and permitting stormwater Best Management Practices (BMPs), land development provides a significant opportunity for both economic and environmental gains for the private and public sectors. The private sector may have the financial resources to fund the implementation of floodplain restoration as part of the land development planning, permitting, and construction process, while benefiting from the additional developable space that would otherwise be required to implement traditional stormwater BMPs. Local and state governments benefit from the pollution reductions and the community benefits from cleaner water, additional wildlife habitat, and enhanced aesthetics.




PRE-RESTORATION



CASE STUDY 9

Bedford Springs Resort Floodplain Restoration

PROJECT HIGHLIGHTS

Challenge

A Bedford Springs Resort golf course was being threatened along Shober's Run by flooding and erosion, and it was contributing to nonpoint source pollution.

Economic Ecology Solution

- 6,800 linear feet of stream and floodplain restored
- In-stream structures installed for grade control, bank protection, and improved aquatic habitat
- 12 acres of wetlands created

Collaborators

- Bedford Springs Resort
- Forse Design (www.forsedesign.net)

Awards

- Affinity Award for Best Environmental Project, Golf Course Industry Magazine
- Renovation of the Year, Golf, Inc.

Benefits





The golf course at the historic Bedford Springs Resort in Bedford, Pennsylvania, was still being used, but many of the course features were being threatened or damaged by flooding and erosion along Shober's Run, which runs through the property. A new golf course was planned for the site, which was being restored in its entirety. However, something had to be done to prevent the stream from causing costly damage to the new course.

The solution was a floodplain restoration along 6,800 feet of Shober's Run. The floodplain was excavated to its historical elevations. A floodplain corridor at least 80 feet wide was created to accept and diminish the forces of high flows and to provide flood storage and infiltration. In-stream structures further stabilized the channel through grade control and bank stabilization and improved the aquatic habitat. Twelve acres of wetlands were created along the length of the restoration site, including several acres to mitigate wetlands disturbed during the restoration of the Victorian era Bedford Springs Hotel.

Post-construction monitoring, which ended seven years after project completion, indicated that the entire project — channel, floodplain, new wetlands, and mitigation wetlands — is functioning as DEP required and is remaining stable over the long term.

Flood reduction and pollutant removal, as well as improved aesthetics and wildlife habitat, are among the valuable assets of the newly renovated resort and golf course and downstream town of Bedford.

Upon completion of the project, the floodplain restoration of Shober's Run received two awards from the golfing industry: the Affinity Award for Best Environmental Project and Renovation of the Year.



CASE STUDY 10

Western Pennsylvania Stream and Wetland Mitigation Banking

POST-RESTORATION

A watershed-scale stream-restoration project in Washington County, Pennsylvania, will become Pennsylvania's largest mitigation bank associated with a stream and floodplain restoration. The project represents a cost-effective approach to meeting local, state, and federal regulatory requirements for the energy industry and other economic development in western Pennsylvania while improving regional environmental and ecological functions that will benefit many people.

As with most other floodplain restoration projects that address the root causes of environmental problems on a regional scale, the direct benefit (in this case, creating a permitted mitigation bank) is accompanied by numerous other indirect benefits – stormwater storage and infiltration, groundwater recharge and filtration, and reduced damaging flood flows, all of which can affect the region both ecologically and financially.

The restoration will take place across 552 acres in West Finley Township, in the Robinson Fork watershed, where land was undermined, deforested, and farmed. The project is designed to restore nearly 47,500 linear feet of stream, enhance 41,890 linear feet, and preserve another 53,508 linear feet. Legacy sediments in the stream valley will be removed, and the entire channel will be relocated to its historical elevations, creating a functional, stable, and healthy stream and wetland complex while providing suitable compensatory mitigation for unavoidable disturbances to streams and wetlands as a result of activities authorized by local, state, and federal levels of government.

Along with developing a re-integrated stream and wetland complex, the project will restore local groundwater aquifers, greatly improve both plant and animal habitat, and create a riparian system that will remove pollutants from the stream and reduce damaging flood flows both on site and downstream.

Restoring a regional riparian system to its historical, most stable configuration to reconnect stream flow, wetlands, and groundwater is, in the long term, the most cost-effective approach. The area's energy industry and everyone in the surrounding municipalities will reap both direct and indirect benefits through the re-establishment of a historically degraded system to a long-term stable system that will essentially maintain itself.

PROJECT HIGHLIGHTS

Challenge

Mined, deforested, and farmed land in what will be a large mitigation bank suffers from legacy sediments and an altered floodplain and stream channel within a steep wooded system.

Economic Ecology Solution

- Detailed plan to feature stream and floodplain restoration and wetland creation

Collaborators

- RES
- Riverine Systems

Benefits





PRE-RESTORATION

CASE STUDY 11

Big Spring Run Floodplain Restoration

POST-RESTORATION
Photo: Nic Hertzler, F&M



PHOTO: NICK HERTZLER

PROJECT HIGHLIGHTS

Challenge

Big Spring Run was characterized by severe streambank erosion and streambed degradation, resulting in the release of nutrient-rich sediment that impacted downstream water quality.

Economic Ecology Solution

- Wetland-meadow valley bottom complex created
- 22,000 cubic yards of legacy sediment removed
- 1,500 linear feet of valley restoration
- 3,100 linear feet of stream restoration
- Five years of monitoring

Collaborators

- Franklin & Marshall College
- U.S. Geological Survey
- The Friends School, Baltimore
- Elizabethtown College
- Millersville University
- EPA
- DEP

Benefits





PRE-RESTORATION

Under the auspices of the Pennsylvania Environmental Council, the Big Spring Run floodplain restoration project in southern Lancaster County, Pennsylvania, helped establish Chesapeake Bay protocols for defining reductions in pollutant loads through individual floodplain restoration projects.

Big Spring Run is a headwater tributary of the Conestoga River. Historical land-use practices and the imposition of 19th century mill dams on the stream system generated a nutrient-rich sediment load that, over time, had filled in the stream valley. Analysis indicated that streambank erosion in Big Spring Run under pre-restoration conditions accounted for 63 percent of nutrient-laden sediments suspended in the stream flow.

The restoration, which is part of a research project led by Franklin & Marshall College scientists Robert Walter, Ph.D., and Dorothy Merritts, Ph.D., was designed to return the bottom of the stream valley to its historical condition, creating a wetland-meadow valley bottom complex. Restoration construction activity removed


POST-RESTORATION

approximately 22,000 cubic yards of legacy sediment. Included in the restoration were 3,100 linear feet of stream channel and 1,500 linear feet of stream valley.
The restoration has improved water quality on site and for downstream portions of the watershed, created additional storage capacity for flood waters, increased groundwater-recharge capabilities, and restored and improved both aquatic and terrestrial wildlife habitat.

Several videos of the project are available on YouTube: http//www.youtube.com/channel/UCorgwKIsH03jLRuTSF-3Wxzg. Detailed information on the restoration project is available at www.bsr-project.org.

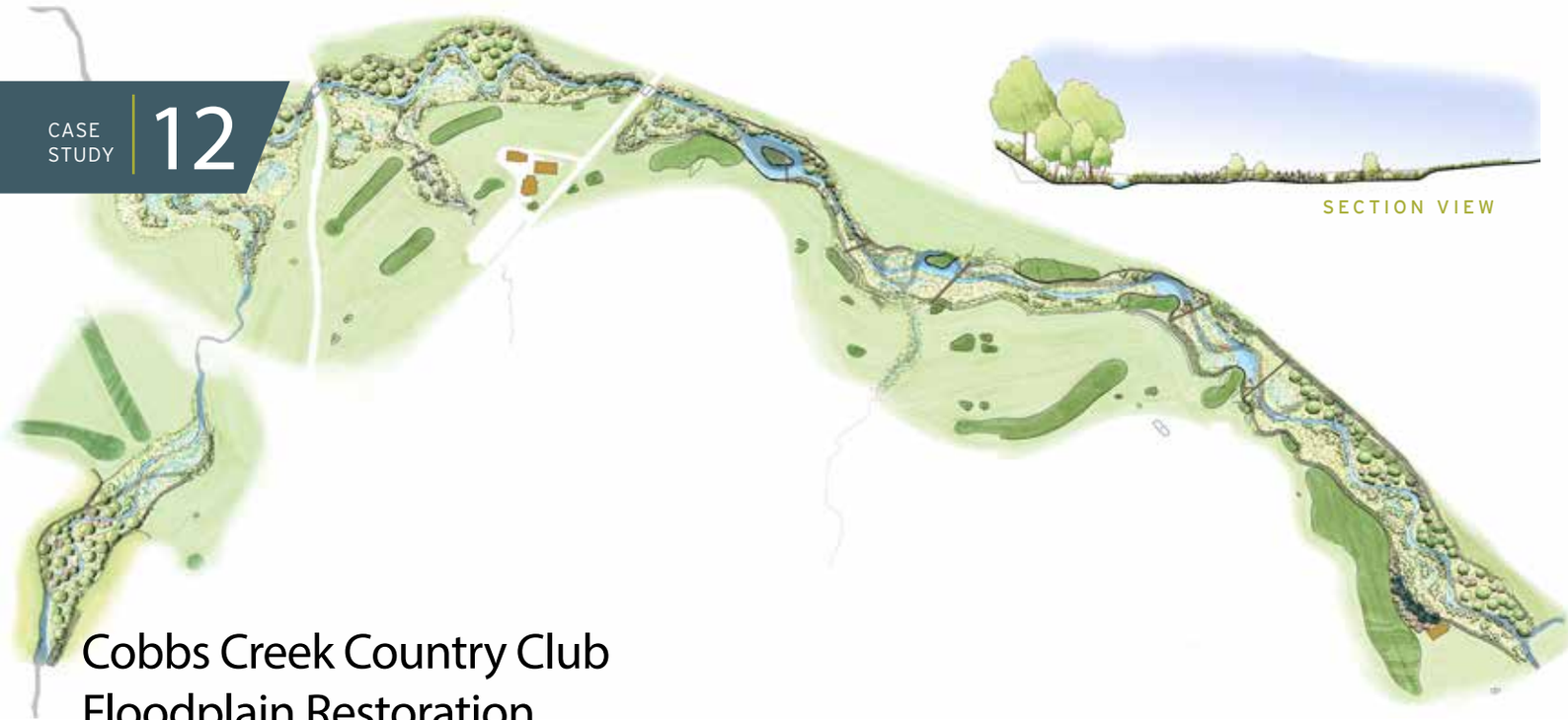
Hyporheic Exchange and Stream Temperature

One of the leading topics of discussion over the years regarding stream health and water quality is stream temperature. It is commonly accepted that the most effective way to regulate stream temperature is by blocking incident solar radiation by shading with riparian vegetation. However, data from Landis Homes floodplain restoration has indicated that reestablishing the connection to groundwater has a greater impact on stream temperatures than shading. Hyporheic exchange, defined as the mixing of surface and groundwater, can provide additional benefits to stream systems, such as sustained temperature buffering, especially during the early stages of vegetative growth.



Source: http://forestry.oregonstate.edu

CASE STUDY 12



SECTION VIEW

MASTER PLAN

Cobbs Creek Country Club Floodplain Restoration

PROJECT HIGHLIGHTS

Challenge

Cobbs Creek provides a unique feature to the golf course, but frequent flooding and channel degradation makes it unsafe and an environmental hazard to the community.

Economic Ecology Solution

- Proposed approximately 12,000 linear feet floodplain restoration
- Proposed 25-40 acres of wetland creation

Collaborator

- Cobbs Creek Foundation

Benefits

The golf course's name sake, Cobbs Creek, is the centerpiece of this course on the edge of Philadelphia. The stream provides a unique amenity, but frequent flooding and channel degradation coupled with poor maintenance makes it more of a nuisance and eyesore.

In the early 1900s, golf was growing in popularity, and the Golf Association of Philadelphia, City Counsel and Mayor's office sought to create a public course for its community. Cobbs Creek first opened in May 1916 and went on to host the PGA Tour, the Daily News Open ad other national championships. In the 1950s, impacts of the Cold War began a slow decline for the golf course. Cobbs Creek was also negatively effected during this time period and began to overflow and cause flooding on the property. Despite setbacks over the past several decades, the Cobbs Creek Golf Course is getting a second chance. The Cobbs Creek Foundation has committed to rehabilitate, restore and maintain the golf course.

The floodplain restoration design maximizes flood storage potential and creates a stable, natural floodplain that protects the primary golf features (greens, tees, fairways, etc.) and enhances the character and strategy of each hole. The restored floodplain will be a significantly more stable system that supports a variety of plants and wildlife, but the benefits go far beyond looking better. The restoration will provide multiple regional benefits, including water quality improvement, flood storage, reduced erosion, reduced maintenance (especially bridge repairs), extensive functional wetlands that can be used as a banking opportunity and improved and enhanced wildlife habitat.





PRE-RESTORATION

Further Reading

The following resources provide more information about floodplain restoration, economic ecology, and the case studies in this book.

BSR Project. Acquatic Ecosystems Restoration Research. Big Spring Run, Lancaster, PA. http://bsr-project.com/

Chesapeake Bay Foundation. "The Economic Benefits of Cleaning Up the Chesapeake." CBF Reports. http://www.cbf.org/EconomicBenefits

Delaware Valley Regional Planning Commission and the GreenSpace Alliance. "Economic Value of Open Space." http://www.dvrpc.org/openspace/value/

EPA. "Cost-Benefit Resources." Water: Green Infrastructure. http://water.epa.gov/infrastructure/greeninfrastructure/gi_costbenefits.cfm

Fleming, Patrick M., et al. "Legacy Sediment Erosion Hot Spots: A Cost-Effective Approach for Targeting Water Quality Improvements." Journal of Soil and Water Conservation, vol. 74, no. 4, 2019, doi:10.2489/jswc.74.4.67a.

Gutshall, Mark, LandStudies, and Diane Huskinson. "The Future of Watershed Restoration: Landis Homes Expansion Project Meets Needs of Business, Community and Environment." Catalyst, Spring 2014. http://digital.graphcompubs.com/publication/?i=205226&article_id=1685945&view=articleBrowser

LandStudies, Inc. Floodplain Restoration. Lititz, PA: LandStudies, 2007.

Walter, Robert C., and Dorothy J. Merritts. "Natural Streams and the Legacy of Water-Powered Mills." Science, January 18, 2008.

CREDITS

Writing:
Shelby Chunko
Diane Huskinson, Huskinson Communications

Editing & Production Management:
Diane Huskinson, Huskinson Communications
Kelly Gutshall, LandStudies, Inc.
Lindsey Bofinger, LandStudies, Inc.
Leslie Hendricks, Landstudies, Inc.

Design & Layout:
Caroline Chen, Chengraphix
Lindsey Bofinger, LandStudies, Inc. (*second edition*)

Contributors:
Mark Gutshall, LandStudies, Inc.
Daniel L. Zimmerman, Warwick Township

Cover Photo:
RGS Associates

Photography:
Bob Ingraham
Eric Lyons
Lancaster Liederkranz
Landis Homes
Landscape Architecture Magazine
Larry LeFever
Melody McFarland Photography
Nic Hertzler, F&M
RGS Associates
Scott Kreider Photography
CHAR co.

Our thanks to Gregg Robertson of Conewago Ventures, who contributed his time and insights.

Economic Ecology is a registered trademark

First Edition 2015
Second Edition 2020

Economic Ecology

Economic Ecology maximizes both economic and environmental returns to solve water issues, such as pollutant removal and flood reduction, at a regional scale. It is defined by ecological principles that are validated by engineering measurement and performance standards. It is proactive rather than reactive, addressing the causes of problems and not merely symptoms. By employing the principles of Economic Ecology, planners and decision-makers can reduce wasteful spending and more effectively meet regulatory requirements for stormwater, flooding, and more. Economic Ecology also involves the formation of partnerships with government, public, nonprofit, and private organizations to share costs and increase benefits throughout an entire region or watershed.

LandStudies, Inc.

315 North Street
Lititz, PA 17543
landstudies.com
717 627 4440

