Buffers

A buffer is a protective barrier that can exist in natural or managed systems, such as urban areas or agriculture. In the latter, buffers often serve as a landscape design solution to human-made problems like soil erosion, surface water contamination, habitat fragmentation, and biodiversity loss; buffers have the potential to improve the health of human-dominated ecosystems. Obstacles to the use of buffers are primarily economic.

Buffers serve important functions in protecting our natural resources from the negative impacts of human activities. The term *buffer* refers to an entity that serves as a protective barrier, reducing or eliminating the flow of undesirable substances. In natural systems, vegetated buffer zones can protect rivers, wetlands, and other sensitive features from natural disturbances such as fires and floods. In the context of managed systems, buffers represent a landscape design solution that has the potential to reduce the impacts of a number of different anthropogenic problems such as soil erosion, surface water contamination, biodiversity loss, and habitat fragmentation.

Agriculture is one type of land use that can have detrimental impacts on our natural resources. Pesticides and fertilizers used in agricultural systems can be transported to rivers, lakes, and oceans, where they contaminate the water and harm aquatic organisms. Intensive soil disturbance from agricultural activities contributes to erosion and depletion of valuable topsoil. The expansion of agriculture across the landscape has resulted in a net loss of biodiversity, as natural habitats rich with a variety of species are replaced by homogeneous cropping systems. Urban areas, which are also managed systems, are not immune to these problems. In cities, lawns serve as sources of pollutants, building construction contributes to soil erosion, and new development threatens diverse ecosystems. Buffers, when designed and located appropriately, have considerable potential to address these problems, offering a solution that could improve the health of human-dominated ecosystems.

Background

Historically, features such as riparian forests, wetlands, and hedgerows were retained and planted in agricultural landscapes, serving as buffers around cultivated fields and pastures. With the intensification of agriculture over the past 150 years, many of these features were removed and replaced with crops. Without noncrop habitats to divide fields and protect water resources, soil erosion from wind and rainfall became an increasing problem. The 1934 Dust Bowl, a great dust storm that occurred across the farmlands of North America, increased public awareness of the problem. In the years following that event, new soil conservation practices were introduced, including vegetated buffer zones within fields, along waterways, and beside roadways. Not until the 1970s, however, was the term *buffer* used to describe such features. At that time, conservation scientists began to study the effectiveness of buffers in improving water quality.

Today, buffers exist in a wide range of settings, offering a variety of functions depending on their configuration in the landscape and the composition of plant materials. *Riparian and wetland buffers* consist of perennial vegetation, oftentimes forest communities, located directly along water courses. These habitats can play a critical role in protecting water quality in agricultural and urban landscapes. *Wetlands* can themselves serve as very effective buffers, treating contaminated water before it enters rivers, lakes, or oceans. *Field margins* or *hedgerows* are located along the borders of crop fields in agricultural areas, and they serve an important function in reducing soil erosion and offering habitat for wildlife. *Windbreaks* or *shelterbelts* typically contain trees or shrubs to reduce wind erosion and protect crops, livestock, or homesteads from the harsh weather conditions. *Grass filter strips* are designed to intercept contaminants from storm-water runoff before it enters a water body. In urban settings, features such as vegetative swales, rain gardens, and constructed wetlands serve as buffers, if they are located between a source of storm-water runoff and a sensitive water body.

Benefits of Buffers

In the context of managed systems, buffers offer many benefits for the environment and society in general. They have the potential to reduce a number of negative impacts on our natural resources that result from current farming practices and urban development. Buffers reduce soil loss resulting from wind and water erosion, because the perennial plants with extensive root systems help to stabilize the soil and infiltrate water. Taller plantings, particularly trees, reduce the wind current that can carry uncovered topsoil. Buffers also protect water supplies by intercepting fertilizers, herbicides, heavy metals, and other contaminants from storm-water runoff from crop fields, residential lawns, or impervious surfaces. The mechanisms for treating storm water can include physical filtration of sediment-bound materials, chemical or biological transformation of materials in soils, and uptake of materials by vegetation. Performance in removing pollutants, therefore, varies substantially depending on the chemical structure and soil binding properties of the material. Research studies have shown buffers to be effective in capturing significant fractions of nitrogen, phosphorus, heavy metals, soil-bound herbicides, and organic materials.

While the primary function of buffers is typically to improve water quality by reducing erosion and intercepting pollutants, buffers offer many other environmental benefits. The perennial vegetation in buffers, often consisting of many different species, increases the biodiversity of flora and fauna, while also offering habitat for wildlife. With riparian vegetation, wildlife and aquatic organisms benefit from a more favorable microclimate (regulation of light and temperature), which provides greater access to food and water. Buffers can also serve as corridors to connect natural habitats and support the dispersal of organisms between fragmented patches.

In addition to the environmental benefits of buffers, they provide a range of other benefits for society. The water-quality benefits of buffers, for example, can improve the safety of drinking water and reduce the degradation of recreational waters. Buffers reduce flooding by infiltrating water and retaining flood water within wetlands. The result is a reduced hazard for people and less damage to built structures following flooding events. Trees and shrubs in buffers can also filter dust and unpleasant odors from the air, including around large livestock facilities. When they work as part of a greenway system, buffers can serve as corridors for wildlife as well as for people. They also offer important visual-quality benefits by greening the space, diversifying the landscape structure, and screening views of undesirable features. In addition to protecting recreational features, buffers can themselves provide recreational opportunities such as hunting, hiking, and bird-watching.

Barriers to Buffer Adoption

Despite the extensive benefits of buffers, many obstacles limit their widespread adoption. First is the cost of lost opportunities from competing land uses, many of which offer greater potential for profit. In rural areas, this is typically the yield from crops that would be grown on the area used for a buffer. Some farmers are tempted to use the buffer area for grazing livestock, but this can reduce the integrity of the buffer by compacting the soil, limiting the growth of vegetation, and allowing nutrient-rich manure to be deposited near sensitive sources (i.e., rivers). In urban areas, the values of competing land uses are even greater, with opportunities for residential or commercial development. This issue is particularly critical in the areas surrounding scenic lakes and rivers, where land values are often relatively high. Even in a floodplain, where development is not practical, nearby residents sometimes oppose the establishment of treed buffers because they obstruct the scenic view.

A second barrier to expanding the adoption of buffers is related to the direct costs of establishing and maintaining them. Some buffer types require expensive earth-moving equipment to grade the site to convey or retain water. For many buffers (particularly those located in riparian zones), native trees, shrubs, and herbaceous vegetation must be purchased to develop the appropriate plant community. Initial establishment may also involve labor and materials to install barriers to protect the young plants from grazing and browsing by wildlife. After the buffer is established, additional costs may be incurred by the maintenance of mowing, weed control, and sediment removal. The cost of establishing and maintaining a buffer may need to be covered by public funds, through subsidies to landowners or some other program.

This leads to the third barrier—the role of the government or nongovernmental agencies in allocating funds for buffers, which provide public benefits. In much of North America and Europe, programs have been established to subsidize buffers (along with other conservation practices), particularly in rural areas where agriculture is the dominant land use. Programs such as the Conservation Reserve Program (CRP) in the United States or agri-environmental programs in Europe are designed for this purpose. Agri-environmental programs reward farmers for environmentally friendly management practices such as establishing riparian zones or wetlands, enhancing hedgerows, and conserving areas with high biodiversity. Landowners, however, are often resistant to allowing the government to play a role in the land-use decisions, since the programs often involve multiyear contracts. In many other countries, nongovernmental agencies often play an important role in promoting buffers to protect natural resources by supplying landowners with planning tools, providing labor to help with establishment or maintenance, or even purchasing the land directly to convert to buffers. Even in that situation, landowners (particularly smallholders) may still be skeptical of strategies that appear to allow another organization to control the land-use decisions.

Landscape Design Considerations

The obstacles to expanding the use of buffers may be partially addressed through landscape design by focusing on opportunities to optimize buffer performance, while also considering the preferences of stakeholders. Important factors for buffer design include overall size, placement within the landscape, and selection of plant species. Water quality benefits, for example, will only be incurred if the system is designed to convey water through vegetation or retain water long enough to allow treatment. Riparian zones are often considered to be the best location for treating water before it enters a water course, but if the area of land has been constructed with tile drains, the water may bypass the buffer treatment system altogether. If the primary function of the buffer is to filter odor and dust from the air, the vegetation must be located downwind of the source area. In order to serve as corridors, the buffer should be designed to connect natural habitat areas. Overall, the buffer design will depend to a great extent on the primary functions to be fulfilled.

Not only are the ecological functions important to consider, but cultural and social functions might also be supported by good buffer design. These functions might include recreation, visual quality, education, artistic expression, and historic preservation. Recreational opportunities can be supported by integrating trails or pathways through buffers, and by establishing vegetation that would draw in birds and other wildlife for bird-watching or hunting. Buffers designed to support the visual quality preferences of the landowners, nearby residents, and other stakeholders might be more widely adopted and protected for the long term. Where scenic views are important, for example, the buffers might be designed with openings consisting of short shrubs or herbaceous plants, allowing taller vegetation to frame the views. In agricultural landscapes, farmers and other landowners often prefer buffer designs that demonstrate an ethic of stewardship, with well-managed vegetation that reflects the organization of the cropping systems. Educational, artistic, and historic components might be integrated into the design, particularly in urban areas where it is important to have the support of many user groups to establish and maintain buffers. The cultural functions will depend to a great extent on the local landowners and residents, as well as the context of the site.

The regional context of buffers can play a very critical role in the success of the design, so consideration should be given to the primary environmental issues, competing land uses, and preferences of stakeholders. In tropical regions, for example, deforestation drives a very specific need to reduce erosion and protect water resources, particularly for vulnerable rural communities. There the focus is often on reestablishing stream corridor vegetation. In Africa, buffers have been used to reverse some problems created by land degradation from deforestation and improper use of herbicides, while at the same time trying to optimize systems so they do not compete with production of valuable food resources. In regions where much of the native vegetation was replaced with introduced species, such as parts of New Zealand, the interest in reestablishing native plants along streams and wetlands in urban and urban fringe areas has driven the design and establishment of buffers. Some regions have tied the establishment of buffers directly to locally important endangered species. Buffers have been promoted in the US Pacific Northwest to improve habitat and reduce pesticides that harm salmon, which are a highly valued species—both economically and ecologically. In Europe, hedgerows and other buffer types have been recognized and promoted for the positive impact they have on the aesthetics of the countryside landscape, which impacts agritourism in the region. Around the world, buffers have been used regularly to protect water resources, but their implementation is often more successful when tied to other specific goals that fit with the interests and preferences of the people living there.

Outlook for the Future

Several trends are likely to impact the adoption and design of buffers in managed systems in the future. First is the growing interest in developing landscapes to be sustainable and multifunctional. Buffers should be considered as a standard layer of rural and urban landscape planning. Even the design of individual buffer features can be conceived in a way that supports many more functions and synergizes conservation goals. Tree and shrub species in buffers, for example, might be selected to offer edible fruits and nuts that can be harvested by the landowner or users of the site. Increasingly, the interest in integrating biofuel production in the more sensitive and less productive areas has been considered. This strategy could be appropriate if the biofuel crops are native perennial plants with very low likelihood of invasiveness, and they would not be replacing another important plant community.

A second trend with buffers is to improve their performance (typically related to water quality) using advanced technologies such as specialized filters containing materials that have a high capacity for absorbing pollutants. Recycled steel slag, for example, has been used to remove high levels of phosphorus through subsurface-flow constructed wetlands. As new technologies for water treatment become available, they are likely to be integrated into the design of buffers. Finally, future strategies to increase the adoption of buffers will probably encourage greater participation from a wide range of stakeholders, including coordinated efforts among multiple landowners. Participatory planning approaches have been shown to encourage commitment from stakeholders, increase satisfaction with results, build trust in the process, and create more realistic outcomes. These trends, taken together, could have a significant, positive impact on the contribution buffers make in protecting our natural resources.

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See also Agricultural Intensification; Agroecology; Biodiversity; Biological Corridors; Boundary Ecotones; Community Ecology; Edge Effects; Habitat Fragmentation; Hydrology; Irrigation; Landscape Architecture; Landscape Planning, Large-Scale; Rain Gardens; Stormwater Management; Tree Planting; Viewshed Protection

Further Reading

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