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Development of Coastal Vegetated Buffer Programs

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This article describes a multiple benefit/multiple use approach to implementing vegetated buffers, using as an example a program adopted by the Rhode Island Coastal Resources Management Program. The multiple benefit/multiple use approach capitalizes on the inherent ability of vegetated buffers to perform multiple functions, such as pollutant removal, habitat protection, scenic improvement, erosion control, and historic/archaeological site preservation. These benefits provide a more robust means for justifying vegetated buffer implementation, and should help develop a broader constituency for the adoption of vegetated buffer policies. Application of vegetated buffers for residential and other developing lands has not been adequately addressed in existing vegetated buffer implementation efforts. We present one solution to implementing vegetated buffers on residential and developing lands. The approach and background information should prove useful for the application of vegetated buffers outside of coastal regions, and promotes a more holistic and integrated view of management practices as well as the concept of management for sustainable ecosystems.

Keywords coastal zone management, habitat protection, residential land use, vegetated buffer, water quality

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A persistent dilemma of natural resources management is the balance that must be maintained between environmental protection and economic development. This problem often becomes exaggerated along coastal regions, where the desire to live and recreate is extremely high, where the pressures for development are often intense, and where a projected 60% increase in population is expected to occur by the year 2010 (Culliton et al., 1990; National Oceanic and Atmospheric Administration [NOAA], 1992).

Our contemporary understanding of the role of nonpoint source pollution in contributing to the degradation of coastal ecosystems, the response of the federal government in the form of Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990, and a continual loss and degradation of coastal habitats from development, has Coastal Zone Management Programs (CZMPs)[1] continually striving to develop more effective management and control measures. One such control measure, endorsed by the U.S. Environmental Protection Agency for the enhancement of water quality (U.S. EPA, 1993), is the vegetated buffer,[2] which is fast becoming a topic for programmatic development in many state CZMPs.

Some coastal states require setbacks[3] in the coastal zone, but these are generally applied as temporary measures to mitigate impacts during the construction process, after which vegetation (if required in the setback) is often removed. Setbacks are therefore not generally useful as a means to achieve long-term goals of habitat protection, pollution abatement, erosion control, and improved visual appeal. Vegetated buffers, when used by state CZMPs, are often times used only in certain coastal regions, such as on agricultural lands, forested areas, or coastal wetlands, where large tracts of open space are available and development pressures are usually limited. Existing state CZMPs rarely have buffer elements that apply to residential development, despite the fact that 40% of all contemporary residential construction has occurred in coastal counties (Culliton et al., 1990; NOAA, 1992). This lack of buffer application in residential areas is understandable, because this form of development poses numerous problems to vegetated buffer implementation. Residential building lots are often small and/or unusually shaped, either of which can severely limit their intended use if the wide buffers typical of other land uses (forested, agriculture, etc.) are implemented. Rapid residential growth in coastal regions presents a serious challenge to coastal managers to control the impacts associated with development. The end result, from a historical lack of adequate control measures, is that much of the coast is developed, or developing, often to the waters edge, providing little means for long-term protection of coastal water quality, shoreline and aquatic habitat, and visual appeal.

Vegetated buffers have been routinely applied in forestry and agriculture to abate nonpoint source degradation of inland water courses, control erosion, and improve aquatic habitat; in wildlife management to provide riparian habitat; and in landscape architecture to provide visual appeal. Recent emphasis has been placed on applying these experiences to the implementation of riparian buffers to move development back from the waters edge along rivers and lakes, thus providing some measure of protection for watershed ecosystems. The research documenting the benefits of vegetated buffers for mitigating water quality impacts due to disruptive land uses and for providing habitat along inland waterways is extensive, and provides reasonable background and justification for implementation of buffer programs in these areas (e.g., see Comerford et al., 1992; Correll, 1993; Desbonnet et al., 1994; Magette et al., 1986; U.S. Army Corps of Engineers [ACE], 1991).

Although the documenting research for actual performance along the coast is relatively meager, the functional mechanisms that apply to inland riparian buffers should similarly apply to coastal buffers. Until such time that research on coastal vegetated buffer function, use, and benefit are better developed, it will have to be assumed that inland buffer information approximates that of the coast. We must use this information to move forward in applying vegetated buffers along coastal regions to better achieve that delicate balance between coastal resources protection and coastal development.

This article briefly reviews some of the major benefits of vegetated buffers. Several approaches are then reviewed with regard to their applicability in coastal regions and their potential for capitalizing on multiple benefits/multiple uses. The Rhode Island Coastal Resources Management Program is used as an example of applying this information to develop criteria for implementing vegetated buffers in developing coastal regions. The intent is to develop some scientific background for adopting a multiple benefit/multiple use approach to designing vegetated buffer programs, as well as to provide an example of implementation given the political realities of the coastal region.

Multiple Benefits of Vegetated Buffers

Pollution Abatement

Vegetated buffers are most effective in pollutant removal by decreasing the flow velocity of surface water runoff, thus allowing sediment to settle out and become trapped in the buffer area (Lee et al., 1989).[4] Since many pollutants are adsorbed to sediments (Karr & Schlosser, 1978), sediment trapping also removes a certain percentage of the pollutant load carried in surface runoff water. Pollutants attached to sediments, and therefore effectively treated by vegetated buffers, are most forms of nitrogen and phosphorus, hydrocarbons, PCBs, most metals, and pesticides (Karr & Schlosser, 1977, 1978; Lake & Morrison, 1977; Lee et al., 1989; Zirschky et al., 1989). Although pathogens can be attenuated while moving through a vegetated buffer, the degree of treatment is generally limited enough that buffers have not been reported to be employed with this as their express purpose.

The relationship between pollutant removal and buffer width is nonlinear and can be expressed as an inverse exponential relationship between increasing buffer width and the percentage of pollutants removed. Ever greater buffer width is therefore required to achieve ever smaller increases in pollutant removal efficiency (Karr & Schlosser, 1978; Wilson, 1967; Wong & McCuen, 1982). Optimal buffer efficiency occurs at about 80% removal, in general, after which overly large additions of buffer width are required to increase pollutant removal efficiency by even a few percent (Table 1). The buffer widths and removal effectiveness values presented in Table 1 are representative of "average" buffers, although actual buffer effectiveness varies from site to site. Average pollutant removal effectiveness was determined by deriving the relationship for a best fit line through data reported in the literature for a given pollutant. The data used in deriving these relationships were used regardless of geographical region, season, pollutant source, soil type, or vegetation type, but excluded those data for wetland systems and where slope was greater than 20% grade (see Desbonnet et al., 1994, for details).

Sediment is the most readily removed pollutant of those given in Table 1, with a 25-m wide buffer removing 80% of the sediment load. Total suspended solids (TSS) are removed more slowly than sediments because of their smaller size, with 80% generally being removed by a 60-meter buffer. Nitrogen and phosphorus are also readily removed from surface waters by vegetated buffers, with 80% generally being removed within 60

Table 1
Estimated Percent Removal of Various Pollutants
According to Vegetated Buffer Width

	Buffer Width (m)			
% Removal	Sediment	TSS[a]	Nitrogen	Phosphorus
50	0.5	2	3.5	5
60	2	6	9	12
70	7	20	23	35
80	25	60	60	85
90	90	200	150	250
99	300	700	350	550

[a]Total suspended solids.
Source: Adapted from Desbonnet et al. (1994).

and 85 m of buffer width, respectively. Nitrogen and phosphorus, in addition to being removed through binding with sediments, are also biologically incorporated into vegetation in the buffer, and this removal is reflected in the table values. Nitrate–nitrogen can be removed through plant uptake in vegetated buffers, but the dominant mechanism of removal is through the denitrification process (Groffman & Tiedje, 1989; Groffman et al, 1992; Simmons et al., 1992), which is more dependent on soil and water table conditions than on vegetated buffer width. Buffer width is therefore not a useful indicator of buffer potential to remove nitrate–nitrogen.

Habitat Protection

Ringold and Clark (1980), using 1971 data, reported that only 60% of total U.S. coastal miles (excluding Alaska and Hawaii) remained in an undeveloped state, and that 75% of total U.S. coastal miles were privately owned. Considering the trend toward an increasing human coastal population (Culliton et al., 1990), the percentage of coastline still undeveloped is undoubtedly lower now. This is a reasonable assumption because local and state regulatory programs tend to control development and growth rather than prohibit it except under certain conditions (e.g., in wetlands). Increased development of coastal regions therefore poses a serious threat to maintaining and preserving coastal habitat and its ecological integrity. Protection of wildlife habitat, however, is a well-documented benefit of vegetated buffers.

Table 2 provides a summary of reported vegetated buffer values as wildlife habitat. Even relatively small vegetated buffers of 15 m in width have value as habitat, the value increasing with buffer width. Although vegetated buffers less than 15 m wide do not provide ideal habitat,[5] they may provide resting and feeding areas for a variety of species, particularly bird life. Application of vegetated buffers can promote plant and animal diversity in the ecologically important coastal ecosystem, preserve valuable shoreline habitat for both aquatic and upland species, and protect near-shore aquatic habitat from greater exposure to nonpoint source pollutants and disturbance. Furthermore, vegetated buffers can be applied around significant ecotypes, such as wetlands, of which

50% have been lost since industrialization of the continental United States (estimated from data in Ringold & Clark, 1980, and Tiner, 1991). Vegetated buffers provide a barrier to disturbance, provide at least a fringe of uplands, and better preserve the integrity of these valuable coastal ecosystems.

Aesthetic Improvement

Aesthetic and visual appeal are a third major benefit of vegetated buffers. These benefits are not as readily quantified as pollutant removal and habitat value. An assumed value may therefore have to suffice, unless specific studies are performed in the buffer implementation area. The assumption is that greater visual diversity equates to greater aesthetic and visual appeal (Forman & Godron, 1986; Mann, 1975; Simeoni, 1979). A vegetated buffer with a diversity of vegetation types will therefore have greater aesthetic value than a single species buffer or no buffer at all.

Erosion Control

Twenty-four percent of the U.S. coastline (44% if Alaska is excluded) has had or is experiencing significant erosion problems, with approximately $109 million spent on erosion control projects between 1971 and 1978 alone (Ringold & Clark, 1980; U.S. ACE, 1971). Costs, if not miles of eroding coastline, have certainly increased since that time, suggesting that coastal erosion is a serious national problem. Vegetated buffers help to control erosion by stabilizing the soils. The root mass of the vegetation that comprises the buffer area binds soils, reducing the tendency of the soil to wash away during rainfall or storms. Furthermore, the vegetation itself acts as a barrier to the flow of runoff water, reducing flow velocity and further limiting erosion in areas downstream of the buffer.

Table 2

Range of Habitat Values for Various Widths of Vegetated Buffer

Width (m)	Objective
15–23	General avian habitat
15–30	Protect wetland habitat from low-intensity disturbances
30	Wildlife travel corridor
30–45	Protect wetland habitat from high-intensity disburbances
60	General wildlife habitat
60	Breeding site for fragment-sensitive birds
60–100	General wildlife habitat
67	Small mammal habitat
91.5	Protect significant wildlife habitat
178	Wetland habitat protection
200	Diverse songbird community
<200	For all but large mammals
600	Protect significant critical species

Source: Adapted from Desbonnet et al. (1994).

Approaches to Buffer Implementation

Vegetated buffers, when implemented or proposed for implementation, are often touted as providing a single benefit—habitat or species protection. Vegetated buffers have been shown to have multiple uses and to provide multiple benefits (Desbonnet et al., 1994), yet vegetated buffer programs are rarely "advertised" in this fashion. Promoting a new regulatory program on a single benefit, wildlife habitat preservation, for example, is akin to sitting on a one-legged stool—it works, but it can be fairly unstable. If you add a few more legs to the stool—nonpoint source pollution control and erosion control—you have a much more stable structure upon which to seat a new program. Building constituencies to support coastal management programs has been shown to be a major factor in their successful promotion and adoption (Olsen, 1993). Promotion of vegetated buffer programs according to their multiple benefits should serve to build a broader constituency of support. Promoting the application of vegetated buffers on even the two most well-documented benefits—pollutant removal and habitat protection—provides the possibility of attracting greater support than if promoted on a single benefit.

Furthermore, multiple benefits can be used as justification for the implementation of vegetated buffers along a variety of coastal features. It could be argued that a vegetated buffer is inappropriate to control erosion when placed inland of a sandy beach, which generally is more affected by near-shore physical dynamics than by overland runoff. It could further be argued that the sandy beach itself, because of its surface porosity, is sufficient to remove sediment-bound pollutants and therefore a buffer is unnecessary. Using a multiple benefit approach, however, it could be persuasively argued that a vegetated buffer is indeed appropriate in this instance because it will have value as habitat, will provide aesthetic appeal, and will remove sediment-bound pollutants before they reach the sandy beach and are moved into near-shore benthic sediments through near-shore physical processes. Although this approach does not guarantee that buffers will be universally applicable in coastal regions, it does provide a mechanism that promotes giving full consideration to all the benefits derived from the implementation of vegetated buffers. In doing this, it becomes difficult to disregard the use of a buffer simply because one of the suite of benefits does not fit in a given circumstance. Finally, utilizing the multiple benefit approach for the use of vegetated buffers in coastal regions promotes taking a more holistic view of both problems and solutions and furthers the concept of management for sustainable coastal ecosystems.

Table 3 provides guidance with regard to two major, well-documented vegetated buffer benefits—pollutant removal and habitat provision. This table was developed based on the values provided in Tables 1 and 2, but aligned in such a way as to show the benefits and uses of both according to width of the vegetated buffer to be implemented. Although not implicitly stated, both aesthetic improvement and control of erosion can be assumed in the tabled benefits, the benefit increasing with increasing vegetated buffer width. The values in Table 3 provide a starting point from which to devise policy and begin implementation of multiple benefit/multiple use vegetated buffer programs for coastal regions, including residential and previously developed areas.

Fixed-Width Buffers

A fixed-width buffer approach has been used by several coastal states (e.g., Maine, Maryland, North Carolina, Virginia). The primary asset of this approach is clarity—it is acknowledged that a single buffer width is expected throughout the entire coastal re-

Table 3
Summary of Pollutant Removal Effectiveness and Wildlife Habitat Value for Given Widths of Vegetated Buffer

Buffer Width (m)	Pollutant Removal Effectiveness	Wildlife Habitat Value
5	Approximately 50% or greater sediment and pollutant removal	Poor general habitat value; useful for temporary activities of wildlife
10	Approximately 60% or greater sediment and pollutant removal	Minimally protects stream habitat; poor general habitat value; useful for temporary activities of wildlife
15	Greater than 60% sediment and pollutant removal	Minimal general wildlife and avian habitat value
20	Approximately 70% or greater sediment and pollutant removal	Minimal general wildlife habitat value; some value as avian habitat
30	Approximately 70% or greater sediment and pollutant removal	May have use as a wildlife travel corridor as well as providing minimal to fair general wildlife habitat
50	Approximately 75% or greater sediment and pollutant removal	May have use as a wildlife travel corridor as well as providing minimal to fair general wildlife habitat
75	Approximately 80% sediment and pollutant removal	Fair-to-good general wildlife and avian habitat value
100	Approximately 80% sediment and pollutant removal	Good general wildlife habitat value; may protect significant wildlife habitat
200	Approximately 90% sediment and pollutant removal	Excellent general wildlife value; likely to support a diverse community
600	Approximately 99% sediment and pollutant removal	Excellent general wildlife value; supports a diverse community; protection of significant species

gion. For example, a vegetated buffer of 20 m width could be required bordering all coastal waters. This approach, according to Table 3, would provide approximately 70% overall removal of sediment and pollutants and provide minimal general wildlife habitat. Along some coastal regions, however, a 20-m vegetated buffer may have serious limitations, such as making some developable lots unusable due to site constraints, particularly in residential settings. Furthermore, a 20-m buffer often may not give sensitive resources adequate protection. Increasing or decreasing the width of the fixed buffer alleviates problems at one end of the spectrum while creating them at the other (e.g., less infringement on lot usage but reduced habitat value, and vice versa).

A variation of the fixed-width vegetated buffer approach, which is not currently in use by any state CZMP, was proposed in a booklet describing implementation of riparian buffers (Welsch, 1991). In this approach, a vegetated buffer has a minimum width of 28 m and consists of three zones. The zone closest to the water is of a fixed width of 5 m and allows for no alteration within that zone. The second or middle zone has a minimum width of 17 m but can be expanded based on local or site-specific conditions, or to achieve a given effect (e.g., rare species protection). Limited use, such as selective harvest of timber, may be allowed in this zone of the buffer area. The third, most inland zone abuts a developed or disturbed area and possesses a minimum width of 6 m that can also be expanded based on local conditions. This inland zone might consist of lawn in a residential setting or hay field in an agricultural setting.

This approach, advocated by the U.S. Forest Service, alleviates some problems by allowing greater buffer widths to be applied as needed to protect sensitive resources, but it still may be too restrictive in its applicability in areas where residential development is occurring or where development already exists. The Forest Service approach was developed for implementation along non-structurally developed areas, and its use may be most appropriate in instances where agricultural, forested, state owned, or federally owned lands border the coast. Although a minimal buffer width expected for implementation is clear in this approach, the actual buffer that may be required is not initially clear to those who might propose the utilization of lands that fall within the buffer implementation area. The fixed-width approach, despite its limitations in certain land use situations, is very amenable to incorporating the multiple benefit/multiple use approach. A fixed-width buffer can be determined, based on multiple benefit/multiple use goals, and then implemented in order to work toward achieving those goals.

Site-Specific Buffers

Another approach to vegetated buffer implementation is to tailor buffer width to each site. This approach typically uses a model that determines an appropriate buffer width based on a variety of site-specific data to provide a site-specific goal. Several site-specific vegetated buffer delineation models exist (Nieswand et al., 1990; Nilson & Diamond, 1989; Palmstrom, 1991; Phillip & Phillips, 1988; Roman & Good, 1985), but none are reported to be in use by any state CZMP. The site-specific approach is often data intensive, but it can result in a given buffer width that can better approximate a specific performance standard. High quality data for use in a model will often be expensive and time consuming to collect, which may limit its overall practicality for general use in agency resource management programs.

Many of the existing buffer delineation models were developed to mitigate site-specific construction impacts, generally for the control of a single factor (e.g., sediment movement) during site disturbance, and therefore may not be readily applicable in establishing multiple benefit/multiple use vegetated buffers, unless performed after the fact. Because the models typically depend on site-specific physical characteristics, the resulting buffers on adjoining lots have some probability of taking on a "saw-tooth" pattern, which may reduce the overall habitat value and/or aesthetic appeal of the buffer. Furthermore, buffer width has a high probability of varying by lot, dependent on site-specific characteristics, and the requirement of a wide buffer on one lot but not on others of a similar size has the appearance of being unfair to the landowner who gets stuck with the wider buffer.

Despite the validity of the site-specific, single-benefit model, this approach may cause considerable resentment simply because it appears to be unfair if it applies variable buffers on similar sized lots. This could result in efforts to repeal the buffer program, or it may simply result in noncompliance in maintaining the width of the applied buffer, converting it to lawn or other use over time. It will also be entirely unclear to developers and landowners what is expected for buffer width until agency staff run the model. Site-specific buffer implementation approaches have a high probability of success when applied to large tracts of undeveloped land, or where agriculture or forestry are the predominant land uses. Such approaches are highly impractical in already developed or developing areas, such as is commonly found in coastal regions.

Incremental Buffers

A more practical approach to vegetated buffer implementation, particularly in developing or developed areas, is to set a realistic minimum standard vegetated buffer width. Buffer width could be based on lot size and/or land use and allowed to expand according to increases in lot size or proximity to significant resources. This approach is different than preceding approaches in that it provides a mechanism by which buffers can effectively be implemented while incorporating the realities of existing land use patterns. Furthermore, this approach allows vegetated buffer requirements to be made available to developers and landowners prior to actual permit application. They can be incorporated into site plans at the start of the landscape design process, and they can be standardized statewide.

The vegetated buffer guidelines given in Table 3, even when applied to small lots in high-density residential areas, can produce some benefit for pollutant removal, habitat provision, erosion control, and aesthetic appeal, while not inordinately restricting use of property. Vegetated buffer width applied to a given lot can then be expanded as individual lot size increases to provide greater benefit without overly restricting use of private or public lands. An example of applying the lot-size dependent, incremental approach to vegetated buffer implementation is that adopted by the Rhode Island Coastal Resources Management Program.[6]

The Rhode Island Approach

During the spring of 1993 the Rhode Island Coastal Resources Management Program (RICRMP) began the process of redesigning its coastal buffer program element, which was originally established in 1983.[7] The RICRMP authority applies to all activities in tidal waters, at shorelines abutting tidal waters or coastal ponds, or within 200 ft. landward of coastal features, such as coastal beaches, dunes, wetlands, cliffs, bluffs, embankments, rocky shores, and artificial shorelines (RICRMP, 1990). The revised buffer program was initiated to eliminate the variability inherent in determining the width of each buffer associated with residential development based solely on the best professional judgment of agency staff on a site-by-site basis. The overall goals in developing the new vegetated buffer policies for the coastal zone were that they be consistent, defensible, equitable, easily applied for routine permit purposes, and assist in fulfilling the RICRMP mandate to ". . . preserve, protect, develop, and where possible, restore coastal resources. . ." (RICRMP, 1990), while considering existing land use patterns.

Buffer width requirements were established based on three components: (1) consistency with RICRMP mandates to balance coastal resources use and development with protection of water quality, habitat, and shoreline stability; (2) estimated value in removing pollutants from surface water runoff and provision of wildlife habitat; and (3) the reality of implementation along coastal Rhode Island given existing land uses and lot sizes.

Policy Development

With regard to the first component, consistency, it was decided that any vegetated buffer policies developed must not be so restrictive as to totally, or nearly so, prohibit development in coastal regions. With regard to buffer value, the second component, it was agreed that the goal should be to provide for 80% removal of total suspended solids (TSS), for consistency with Section 6217 (U.S. EPA, 1993), and that at least minimal habitat should be provided in all coastal regions. From Table 3, the minimal vegetated buffer to achieve these goals would be 60 m in width. Incorporating the third component, reality, made it clear that a 60-m vegetated buffer would be impractical throughout much of the Rhode Island coastal region because small lots were common, a remnant of when summer beachside cottages were a typical use of the coastline. It was realized that despite the pollutant removal benefits that would be achieved from the application of vegetated buffers, the benefits that could be gained in residential areas of the Rhode Island coast were not sufficient to meet Section 6217 requirements on their own. Other nonpoint source pollutant controls would need to be considered in achieving mandates of the Coastal Zone Management Act, as amended in 1990.

It was readily apparent that a fixed-width 60-m vegetated buffer was not a viable alternative for implementation along the Rhode Island coast, and a site-specific approach was not desirable for many of the reasons previously outlined. It was therefore decided that an incremental approach to applying vegetated buffers in Rhode Island provided the greatest opportunity and flexibility in achieving the desired goals of the new vegetated buffer program.

Buffer width was tied to residential lot size, which was felt to be the most equitable approach to buffer implementation given existing coastal land use patterns. Narrow buffers would be applied to small lots, with buffer width increasing as lot size increased. Although this would result in not meeting desired buffer benefit goals in most residential development circumstances, the realities of existing land use patterns along the Rhode Island coast required some give and take. The alternatives were to mandate the desired goals and then risk program rejection by the public, or to reduce the overall goals of the buffer program (i.e., something less than 80% TSS removal and minimal habitat provision). Neither option was desirable from an agency perspective, and so the buffer to be applied to a given range of lot sizes was determined by estimating the greatest buffer width that could be applied to the smallest lot in that range, such that on average, residential development would not be prohibited on these small lots. Once a buffer width was derived for a given lot size, it was hypothetically applied to several typical lot configurations to test its applicability in practice. The range of lot sizes applicable to a given buffer width closely resembled those of local government zoning but was not directly tied to local zoning because of small differences and nuances particular to local zoning standards. Using lot size to determine buffer width avoided localized differences in zoning, yet provided an equitable and consistent base from which to determine buffer width statewide along the coast.

Rhode Island Vegetated Buffer Policy

Table 4 summarizes the new policy for determining vegetated buffer widths within RICRMP jurisdictional areas. Predefined vegetated buffer widths were developed only for residential lands because the majority of permit applications reviewed by program staff involve single-family residential development. This approach to vegetated buffer implementation provided the greatest streamlining of routine permits, removed any capriciousness from that portion of the decision-making process, and would result in consistent application by staff throughout the coastal region of the state. The vegetated buffer policies apply specifically to new development requiring a permit from the RICRMP.

Existing development is not subjected to the new buffer policies until such time that they undergo significant alteration and expansion requiring a permit, such as changing the footprint of the existing structure. The developed policies meet the twin goals of 80% TSS removal and minimal habitat provision only on residential lots greater than 4.5 acres in size (200,000 sq. ft.) that border conservation and low intensity use designated waters. Lots greater than 1.5 acres in size (60,000 sq. ft.), however, provide greater than minimum habitat value in their buffers.

Buffer width was also tied to RICRMP water use designations (see Table 4), developed in 1983. These designations essentially zone the coastal waters of the state of Rhode Island. They range from Type 1, conservation areas, where houseboats, dredging, and shoreline abutments are prohibited, to Type 6, industrial/commercial waterfronts, where development and modernization of water-related facilities are encouraged. Water use designations are not to be confused with water quality classifications, which pertain to the chemical constitution of the water column as defined by the U.S. EPA (e.g., SA, SB). The intent of a water use designation is to better guide land-based growth to be compatible with the use and resources of adjacent waters, to control in-water impacts, and to provide a greater degree of protection for significant aquatic resources in those areas where they are still most abundant. Designation of water use for conservation and low-impact activities limits structural modification of the shoreline and in-water habitat to mitigate, for instance, erosion. Wider buffer widths are therefore applied to lands adjacent to conservation and low-impact activity waters of the coast, which comprise approximately 80% of all coastal waters in Rhode Island. The wider buffers will assist the program in protecting shoreline and aquatic habitat, water quality, and visual appeal. Conservation and low-impact activity use waters have been noted to be of great cultural, economic, and ecological importance to the state of Rhode Island, and therefore the RICRMP strives to provide greater protection to these resources. Standard buffer widths are applied to waters designated for marinas, ports, industry, and other high-intensity uses. These waters and their adjacent shorelines generally have previously developed.

Table 4

Required Vegetated Buffers for Single-Family Residential Development, Based on Lot Size and Water Use, in the Rhode Island CRMP

Residential Lot Size (sq. ft.)	Water Use Category[a]	
	Type 1 & 2	Type 3, 4, 5, & 6
<10,000	25 ft.	15 ft.
10,000–20,000	50 ft.	25 ft.
20,001–40,000	75 ft.	50 ft.
40,001–60,000	100 ft.	75 ft.
60,001–80,000	125 ft.	100 ft.
80,001–200,000	150 ft.	125 ft.
>200,000	200 ft.	150 ft.

[a]Type 1—conservation; Type 2—low intensity boating; Type 3—high intensity use; Type 4—multipurpose; Type 5—commercial and recreational harbors; Type 6—industrial waterfronts and commercial navigation channels.

structurally engineered methods employed to protect the shoreline from erosion and other impacts associated with their designated uses. Furthermore, the development occurring along such waters is often not of a residential nature, and, if not, will be reviewed in a different manner to determine appropriate buffer widths.

Additional buffer width may be required on lots that border designated critical and sensitive habitats or designated areas of special scenic, historic, or archeological significance. The intent is to provide a greater degree of protection to those coastal resources that require it. Because buffer width is nearly maximized according to a given lot size, however, adding extra buffer width to lots that border critical or sensitive areas or conservation and low-intensity activity waters, increases the risk of the lot becoming unusable. In these cases a variance will have to be sought by the permit applicant, and a decision, based on the potential impact to critical or sensitive resources, will be made by RICRMP staff.

Determination of vegetated buffer widths for all permits other than for single-family residential development was to be determined by program staff on a case-by-case basis. This allowed program staff the flexibility to determine buffer widths appropriate for the protection of coastal resources based on the intensity of the development and its potential impacts. Staff could make a more detailed assessment of the development proposal in light of site-specific criteria. The site-specific approach, as previously noted, often allows for greater specificity in determining impacts and the buffer required to mitigate those impacts. The approach also allows staff to require other management practices in those cases where a buffer is an inappropriate tool to fully mitigate the impacts of the development being proposed.

Rhode Island Buffer Management and Maintenance Guidance

Design and implementation of a coastal vegetated buffer zone program that disregards human use of the coastal region, however, is bound to meet both resentment and resistance. This backlash could potentially be great enough to force the abandonment of this important management tool for preserving and protecting coastal resources. Implementing agencies need to develop management and maintenance guidelines for homeowners with buffers on their property. The guidance should clearly outline what is permissible within the buffer, what maintenance is needed to keep the buffer healthy and functional, and some general information that explains to the homeowner what a vegetated buffer is, what it does, and what benefits it provides. Once the homeowner understands the uses, benefits, and proper care of vegetated buffers, cooperation in maintaining a functional buffer should increase. Castelle et al. (1992), in an assessment of implemented buffers in Washington state, found that 95% of the buffers suffered from abuse and/or alteration from their original purpose. Several other authors report similar findings from other regions (Cooke, 1991; Heraty, 1993). Castelle et al. (1992), however, did note that buffers that were on the property of landowners who had an understanding of the use, benefit, and functions of the buffer were generally unaltered from their original design. These authors suggest that the difference is due to the education of private property owners who have buffers on their lands.

With this in mind, RICRMP staff developed a "Coastal Buffer Zone Management Guidance" document, which outlines permitted uses, benefits of buffer application, and long-term maintenance procedures to keep the buffer functioning as originally intended (RICRMP, 1994). Some of the activities allowed within the buffer zone are pathways to the water, development of view corridors, placement of picnic tables and other nonpermanent structures, and limited vegetation removal. Procedures for the control of weed (e.g., Poison ivy) and exotic (e.g., Autumn olive) species are also outlined. This document is provided to all permit applicants so that permitted uses and long-term management can be incorporated into initial site design plans. The management guidance developed by the RICRMP has resulted in better compliance with buffer regulations, as well as in more cooperation between agency staff and landowners in ensuring long-term success of the implemented buffers (David Reis, personal observation).

As of mid-December 1994, about 7 months after the vegetated buffer program was implemented by the RICRMP, 197 permit applications have been reviewed subject to the new buffer requirements. Of this total, 52 applications were specifically for permit alterations within the buffer in accordance with management and maintenance procedures. The remaining 145 permits filed were for new development or expansion of existing residences. RICRMP staff report a high number of variances to buffer requirements being sought (approximately 60%), but note that many were of a very minor nature and did not request massive reductions of required buffer width. Most of the variances have resulted from oddly configured lots that, once the required buffer is applied, become unusable for residential development. A variance is therefore sought in order to build on that lot.

Existing State Coastal Vegetated Buffer Programs

Of the 23 state programs summarized in Table 5, four—Maine, New Jersey, New Hampshire, and Rhode Island—have buffer programs applying to the entire state coastline as an element of their CZMPs. Four other states—California, Maryland, North Carolina, and Virginia—have buffer elements that pertain to certain portions of the coast, for instance, along wetlands. Nearly all states have some form of mitigation procedure that could be applied during the permitting process to establish vegetated buffers along the coast on a case-by-case basis.

Construction setbacks, which could be used to establish vegetated buffers, are reported by most states, although many have been established by town rather than state regulations. The setbacks generally have the specific intent of mitigating or controlling sediment movement from the construction site. These measures are often intended to be temporary, generally being required only during the construction process, with vegetation often removed once site disturbance is completed (i.e., the setback area may be converted to lawn or other use).

The various setbacks and buffer policies being used by state CZMPs range from 15 to 300 ft. (4.5 to 91 m) of buffer width (excluding the possibility of no buffer). This represents a range of buffer effectiveness (from Table 3) of 50% pollutant removal and poor habitat value to 80% pollutant removal and good general wildlife habitat value. The four states with programs that apply to their entire coast can establish vegetated buffers ranging from 15 to 200 ft. (4.5 to 61 m), providing from 50% pollutant removal and poor habitat provision to 75% pollutant removal and fair habitat provision. No state program that applies to the entire coast has policies or regulations that provide 80% pollutant removal, the optimal buffer width to pollutant removal ratio and the goal of the reauthorized Coastal Zone Management Act, and none provide buffer widths in the category considered excellent as wildlife habitat, although either or both could potentially be achieved during case-by-case buffer development.

Vegetated buffers are underutilized as a resource management tool along coastal regions of the United States. Only 35% of all coastal states have provisions that can

Table 5
Vegetated Buffer Elements and Setback Widths in Existing State CZMPs (Excluding the Great Lakes), According to State Program Policies and Jurisdictional Authorities

State	Buffer Width	Status[a]	Setback Width	Status[a]	Comments
Alabama			40 ft.; only along Gulf Coast	M	For dune protection
Alaska			100 ft. city/state lands; 66 ft. private property	M	Applies only to timber harvest operations
California	100 ft. around wetlands	R			For habitat preservation
Connecticut					Local ordinances only
Delaware	May be case by case		50 ft. from mean high water	M	For wetland protection
Florida	May be case by case				Mainly by local ordinances
Georgia	No CZMP at present				
Hawaii			40 ft. from shore vegetation line; 20 ft. if hardship shown	M	Applies to all islands in the Hawaiian islands group
Louisiana	May be case by case				Mainly by local ordinances
Maine	75 ft. along entire coast; 250 ft. along sensitive wetlands	M			Also has a buffer management program
Maryland	100 ft. along Chesapeake Bay	M			Case by case on non-Chesapeake Bay shores
Massachusetts	May be case by case				In process of developing new buffer program

Mississippi	May be case by case				Applies to wetlands only
New Hamsphire	100 ft. along wetlands	M			Wetlands includes the entire NH coast
New Jersey	0–300 ft. on a case by case basis	R			Along designated sensitive areas only; local zoning supersedes state
New York	May be case by case		75 ft. from wetlands (30) ft. in New York City)	M	Vegetation not required
North Carolina	30 ft. around significant waters	M			Vegetation not required; may be case by case
Oregon					Through local ordinances
Rhode Island	15–200 ft according to residential lot size	M	50 ft. from the coastal feature	M	Also has a buffer management program
South Carolina	May be case by case		Variable, according to erosional rates	R	Coastal dunes only; vegetation not required
Texas	CZMP being developed				
Virginia	100 ft. along Chesapeake Bay	M			Not required along other state coastal areas
Washington					Local ordinances only

[a]M, mandatory; R, recommended.
Source: Adapted from Desbonnet et al. (1994).

provide long-term or permanent vegetated buffers along the coast. Many of these states, however, have vegetated buffer policies that do not pertain to the entire coast. In Virginia, for instance, the vegetated buffer policies apply to Chesapeake Bay shores only, and implementation of buffers in urban and residential areas is optional, dependent on local governments' willingness to adopt the buffer policies.

Only 17% percent of all coastal states have vegetated buffer programs that apply to their entire coast. Some subset of this percentage, however, recommend rather than require the vegetated buffers. New Jersey, for instance, despite a well-developed buffer policy in the state CZMP, cannot enforce it because local-level rule supersedes the state program. In the final analysis, only 13% of all coastal states have vegetated buffer policies that are both mandatory and apply to their entire coastal region.

Summary and Conclusions

The application of vegetated buffers along coastal regions can be a flexible and beneficial tool for coastal resources managers. Well-documented benefits of vegetated buffers are abatement of nonpoint source pollutants, protection of wildlife habitat, erosion control, and aesthetic and visual improvement. These benefits address what are most often the foremost concerns in the mind of the general public when considering major threats to our nation's coastal regions, as well as addressing documented national coastal concerns. Furthermore, the application of vegetated buffers can assist state CZMPs in meeting federal mandates, such as those of Section 6217 of the reauthorized Coastal Zone Management Act, and the state mandates of the overall CZMP.

Vegetated buffer benefits can be estimated, according to their width, and adapted by coastal state CZMPs for use in developing vegetated buffer policies. Buffer benefits can be derived for even small buffers that are often the only ones that can practically be applied in residential areas, an element not effectively addressed in most coastal state buffer programs, when one is in place.

Despite the multiple uses and multiple benefits inherent in the application of vegetated buffers, they are typically underutilized in existing state CZMPs, with only 13% of all coastal states having mandatory buffer policies that apply to their entire coastal region. Furthermore, when developed, they are not advertised as providing multiple benefits, generally limiting their proposed use as single purpose. This greatly understates the value of vegetated buffers and potentially limits backing by those constituents who feel the stated purpose of the buffer program is not a priority issue. By building and promoting vegetated buffer programs on multiple benefits, a greater constituency for its adoption can be built, thus promoting wider general acceptance.

The Rhode Island program is the most progressive program to date in addressing the application of vegetated buffers in residential areas, as well as in developing a multiple benefit/multiple use approach and applying this to the entire coast. This program will provide a good test of vegetated buffers to control the impacts of converting existing coastal land uses to residential use, as well as for rehabilitating residential land uses undergoing significant alterations. The Rhode Island CRMP was put to public notice in January 1994 and was adopted by the RICRMP on 22 March 1994. Essentially no opposition was voiced by either environmental or development constituencies or by the general public during the development and public comment phases. Engineers and architects have commented on the adopted program, stating their appreciation of the up-front nature and consistency of the buffer widths, giving them the ability to incorporate vegetated buffers into original design plans, saving them and their clients time and money (David Reis, personal observation).

Although we acknowledge that the new buffer policies in Rhode Island have been in place only a short time, and that more time is needed to determine the program's effectiveness in achieving its goals, the program has so far proven to be efficiently implemented by agency staff and complaints about the program have been minimal. The experiences with the buffer program adopted into the Rhode Island CRMP suggests that multiple benefit/multiple use vegetated buffer program development, with an attendant buffer management program, is worthy of further consideration and application by other state CRMPs considering, or in the process of, the development of coastal zone vegetated buffer programs.

Notes

1. Discussion throughout this article is in reference to states with coastlines abutting saltwater seas or estuaries. Therefore, the terms "coastal state" and "Coastal Zone Management Program," for the purposes of this article, refer only to those states that have coastal areas bordering saline water bodies. This description excludes any reference to those states having coastlines that border the Great Lakes, although methods presented may be applicable to those areas as well as others.

2. The term vegetated buffer, as used in this article, refers to naturally vegetated areas containing native species that have been, or are being, permanently set aside along the coast. The vegetation in the buffer may be comprised of grass, brush, or trees, or some combination of these, provided they are species native to the region. When reference is made to designing vegetated buffers where natural and/or native vegetation is lacking, the intent is to develop a vegetated area that mimics native vegetation appropriate to the same locale.

3. Setbacks are generally defined as areas of undisturbed land between a place of disturbance (e.g., construction site) and an area of concern (e.g., water body). Although the term setback is often used synonymously with the term buffer, the key differences, as defined for purposes of this article, are that setbacks often are not required to be vegetated and are often temporary, whereas vegetated buffers are both permanent and vegetated.

4. Reduced flow velocity of surface water runoff also allows for water to infiltrate the soil layer, contributing to both pollutant removal and flood control. The degree of infiltration will be highly dependent on the permeability of the soils within the buffer area. See Desbonnet et al. (1994) for a more thorough discussion of the factors affecting pollutant removal effectiveness of vegetated buffers.

5. There is considerable debate about the overall value of vegetated buffers as wildlife habitat because of the effects of habitat "edge." The basic argument is that habitat edge does not provide good living conditions for resident species, and that buffers, unless they are extremely wide, consist of all edge and therefore are of questionable habitat value. Readers interested in this aspect of vegetated buffers are referred to the diverse ecological literature pertaining to "edge effect," or "fencerows," as they are more commonly termed in the European literature.

6. The Rhode Island Coastal Resources Management Program (RICRMP) was enabled through Rhode Island General Law 46-23-1 in 1977. A council of 17 members set policies for the program, which are implemented by program staff. The council reviews permit applications for major development proposals that have the potential for significant public or environmental impact. Program staff review all other applications and permit activities within the area of their authority.

7. In the Rhode Island policies, "vegetated buffer" is an area usually comprised of natural vegetation and always of native vegetation. In all cases, vegetated buffer width is applied inland from the inland edge of a coastal feature, as described in the text. Implementation of a buffer for new development means keeping the existing, natural, native vegetation in its existing state (unless the vegetated area has been altered previously, in which case it may need to be replanted with native species). In cases where a buffer is to be implemented in existing development where no natural or native vegetation occurs, the buffer area will need to be replanted with native

species approved by permitting staff and as outlined in the RICRMP "Coastal Zone Buffer Management Guidance" document.

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