The Nelson A. Rockefeller Center at Dartmouth College

The Center for Public Policy and the Social Sciences

Policy Research Shop

New Hampshire Wetlands Buffer Policy

A Political Feasibility Study of a Centralized Wetlands Buffer Policy

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EXECUTIVE SUMMARY

Wetlands buffer zone minimum requirements are currently devolved to local governments in New Hampshire. Each municipality determines its own buffer requirement, and some towns impose no buffer requirement. This policy brief assesses the desirability of continuing to set the buffer zone requirements at the local level versus at the state or federal levels. Although local actors are likely better able to tailor their buffer requirements to the needs of their community, they also often lack the resources necessary to properly assess those needs. Additionally, maintaining a patchwork of regulations requires both increased efforts on the part of local governments to create and maintain the buffer requirements as well as on the developers who must remain knowledgeable about differing requirements in multiple communities.

We have also conducted an analysis of the needs and constraints that will inform the implementation of a statewide buffer requirement. Specifically, we summarize the legal issues surrounding wetlands buffer zones in New Hampshire, buffer policies in other states, and the factors which impact the efficacy of buffer zones. This report uses qualitative and quantitative information to assess the current landscape and policy options available to local, state and federal regulators. Using data from a sampling of New Hampshire towns' buffer policies, combined with literature on wetland buffer sizes in the state and in other parts of the U.S., we describe and analyze the current situation in the state.

1. INTRODUCTION

Wetlands—defined by the US Environmental Protection Agency as "lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface"—are found from the tundra to the topics on every continent except Antarctica.[1] In the U.S., Wetlands are important to fish and wildlife populations—roughly 96 percent of commercially important species of fish are wetlands-dependent and 80 percent of America's bird population relies on wetlands, according to the U.S. Fish and Wildlife Service.[2] Additionally, some species of frogs, toads and salamanders depend exclusively on seasonal wetland areas as their only habitat.

In addition to their importance to wildlife, wetlands are important to humans for water quality purposes. Wetlands perform a variety of water quality functions, including denitrification, preventing large amounts of phosphorous from entering adjacent rivers, preventing erosion and sedimentation, flood control, and groundwater recharge.[3]

Not long ago, wetlands were erroneously believed to be the cause for problems such as disease from insects that lived in these areas. From the mid-1800s until as late as the 1980s, government policies subsidized farmers' conversion of wetlands to cropland.[4] By the mid-1980s, old policies encouraging draining and developing wetlands, in combination with landowners' efforts to do the same things, had reduced U.S. wetland acreage by 117 million acres, roughly halving the area of the nation's wetlands. This resulted in rich new cropland to feed a developing nation and growing economy, but also reduced many of the valuable benefits of wetlands, such as plants, wildlife, and water quality.

Concern over wetland losses led to support for their protection, beginning on a broad scale in the 1970s. Today, government protections cover virtually all wetlands, making them the only type of ecosystem to be comprehensively regulated across all public and private lands in the United States. Government agencies work together to coordinate a variety of programs to acquire, restore and protect wetlands. Some programs incentivize farmers to restore wetlands that were previously converted to cropland, and most programs require developers to obtain permits before building on wetlands.

Despite the policy shift from destroying to restoring wetlands, the regulatory process remains controversial. Landowners and developers often oppose restrictions on developing wetlands, while conservation groups want more controls.

1.1 Benefits of Wetlands

Protected areas adjacent to water resources, offer referred to a "buffer zones," provide a number of functional capacities, such as attenuation of pollutants, aesthetic value, recreation areas and habitat essential to wetland-dependent species.[5] Buffer zones protect wetlands and water bodies from adverse actions (i.e., agriculture, urban development and industrial use) taking place in adjacent upland areas.[6] Well-designed buffers protect and maintain wetland functions by removing sediments and associated pollutants from surface water runoff, removing, detaining or detoxifying nutrient and contaminants from upland sources, influence a water body's temperature and microclimate, and providing organic matter to the wildlife.[7] Buffers also provide and maintain habitat for aquatic, semi-aquatic and terrestrial wildlife, may serve as corridors along local habitat patches, and facilitate wildlife's movement through a landscape.[8]

Local government interests in wetland buffer lands often include concern for stormwater management, avoidance of flooding hazards, protection of water supplies, and protecting property for future hazards that may be associated with local climate change.[9] Vegetated buffers may also reduce the severity of water fluctuations and flooding due to storms, as they increase wetlands' flood storage capacity by better attenuating storm runoff before it reaches the wetland.

2. METHODOLOGY

The goal of this report is to analyze the potential implementation of a statewide wetlands buffer zone size requirement in the State of New Hampshire. To reach this assessment, this report answers two closely related questions: (1) what are the costs and benefits of implementing a statewide standard and (2) if a standard were to be imposed, what concerns ought to govern its length?

To answer the first question we began by assessing whether or not the towns in New Hampshire had coalesced around a single buffer size on their own. If towns in New Hampshire were already using close to a common buffer size, then a statewide buffer would be easy to implement. We also conducted interviews with local policymakers to further discern the rationale used by towns to set their buffer sizes. If the differences in buffer sizes would were driven by genuine differences in the needs of the communities then a statewide standard would not be appropriate. If instead buffer sizing seems to be more due to random variation, with unclear reasons for why buffers were set at the length they were, then the costs of imposing a statewide standard will be relatively limited.

The second question was addressed by modeling the effect of increased buffer size on pollutant filtration. The gains in purity from increasing buffer sizes demonstrate diminishing returns. The gains from increasing the buffer size from zero to ten feet are much greater than the gains to be made by increasing the buffer size from ninety to a hundred feet. Using this rationale, we conducted a meta-analysis of studies analyzing the effect of buffer zones on water quality in order to identify the point at which increases in buffer size are no longer associated with substantial improvements in water quality.

Finally, we have also considered variations in topology and geology that would impact the size of a buffer required from a given region. In general, this analysis seeks to identify factors that would reduce the speed that water flowed through a certain area to a wetland; the slower the water's movement the greater filtration that is achieved. The flatter the land, the thicker the soil, and the denser the vegetation, the slower the water will move and purer it will be upon reaching the wetlands.

3. CURRENT WETLAND BUFFER REGULATIONS

Wetland areas (tidal marshes, mud flats, swamps, wet meadows, bogs, vernal pools) occur in every community in the state of New Hampshire. Wetlands occupy five to ten percent of New Hampshire's landscape and support almost two-thirds of the state's wildlife in greatest need of conservation.[10] These wetlands are important landscape features, ecologically, economically, and recreationally. According to New Hampshire Senate Bill 19 of 2012, wetlands provide twelve primary functions: ecological integrity, wetland-dependent wildlife habitat, fish and aquatic life habitat, scenic quality, educational potential, wetland-based recreation, flood storage, groundwater recharge, sediment trapping, nutrient trapping/retention/transformation, shoreline anchoring, and noteworthiness. *Prime wetlands* are wetlands that have four of these primary functions, including wildlife habitat, and that are of "substantial significance" due to their size, unspoiled character, fragile condition, or other relevant factors.[11]

3.1 Current Wetland Buffer Regulations in New Hampshire

In New Hampshire, state jurisdiction over wetlands is found in RSA 482-A and NH Department of Environmental Service administrative rules Env-Wt 100-800. Almost all activities that disturb the soils in a jurisdictional area, regardless of size or scale, in or on the banks of a surface water body or in a wetland require a state permit. Projects are classified by their potential for environmental impact — minimum, minor, and major.[12] Wetlands impacts less than 3,000 square feet may be minimum impact; from 3,000 to 20,000 square feet may be minor impact; and impacts greater than 20,000 square feet, or any activity in or within 100 feet or prime wetlands, tidal wetlands, sand dunes, bogs, or natural exemplary communities, or disturbance of more than 200 feet of shoreline, are classified as major impacts. The impact classification determines the amount of information and environmental analysis that the state requires, and the review of an application is commensurate with the size of the project's potential impact.

In New Hampshire, the federal government's jurisdiction over wetlands under Section 404 of the Clean Water Act is administered by the Army Corps of Engineers, which has issued a Programmatic General Permit in the state. Under this, most state wetlands permits are concurrently approved by the Army Corps of Engineers, producing a more streamlined progress with less duplication of effort. The New Hampshire Programmatic General Permit was most recently reissued on June 28, 2007.[13]

For the purposes of policymaking in the state, wetland buffer zones are defined as "naturally vegetated upland area adjacent to a wetland or surface water." In New Hampshire, over 84 towns have wetland buffer requirements ranging from 25-300 feet, the Department of Environmental Services' (DES) mitigation requirements include a 100-foot wetland buffer, and DES Shoreland Protection Standards include requirements for a natural woodland buffer within 150 feet of a water body's reference line. Additionally, the Environmental Protection Agency (EPA) frequently requests vernal pool buffers as part of projects reviewed by the U.S. Army Corps of Engineers.[14]

According to the Department of Environmental Services in New Hampshire, these are the current shortcomings of buffer regulations and research in the state:

- Need data on impacts associated with subdivisions
- Knowing dispersal distance is only one part of the puzzle
- Buffer regulations need to identify reasonable activities (setbacks may do little)
- ZBA's may be granting many variances
- Stream-lined buffer regulations often cannot take site conditions into account
- Engineering considerations often demand variable-sized buffers
- Attorneys can find loopholes in language

- Need to resolve the question of whether a created depression or disturbed wetland should receive the same buffer as a natural system[15]

While state guidance on wetlands buffers is clearly available, this does not preclude local communities from establishing their own local zoning ordinances. There are a number of easily identifiable advantages to local regulation of wetlands, including reviewing potential impacts to smaller wetlands more thoroughly, preventing the cumulative impacts associated with a collection of small projects, reflecting the interests of the community (i.e., to prevent costly water supply impacts or increased flooding), protecting the functions and values of the wetland ecosystem by protecting buffers around the wetlands, and providing local inspection and enforcement.

Under NH RSA 674:16, Grant of Power, municipalities have the right to zone, as the power to adopt a zoning ordinance "… expressly includes the power to adopt innovative land use controls which may include, but which are not limited to, the methods contained in RSA 674:21." "Environmental characteristics zoning" is one of the techniques listed in RSA 674:21.[16]

Accordingly local communities in some parts of the state have taken it upon themselves to regulate development in wetlands. According to the 2007 survey by the NH Office of Energy and Planning (OEP), 111 New Hampshire communities were regulating developing in wetlands via local ordinance, and 62 of those communities were also regulating development adjacent to the wetlands (to put this into context, there are 221 towns and 13 cities in the state; so just under half of the state's towns and cities have local ordinances regulating development in wetlands).

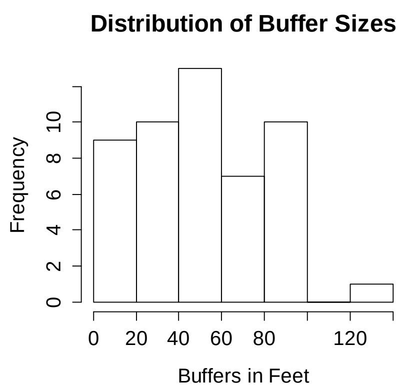
Due to a high degree of variation between local communities, at present, there is a high degree of variability in buffer recommendations and requirements in the state. Interviews with local government officials and review of various towns' ordinances revealed that the reasoning for these variations was nebulous at best, and that specific knowledge of this issue was sometimes lacking at the local level. Consider that the state's draft guidance form, the recommendation is 50 feet for vernal pools, while recommendations in various towns range from no regulation at all to up to 200 feet. For example, in Rye, the buffer requirement is 100 feet, and in Litchfield, it is 200 feet.[17] Meanwhile, other communities have adopted the 100-foot buffer recommended in *Buffers for Wetlands and Surface Waters* (Chase, et al, 1997) as the effective distance for most water quality issues. For communities that have buffer zone policies, the distance from the water's edge over which activities are regulated ranges from 25 to 125 feet, and most communities require that buildings must be set back 50-100 feet from the wetland. Several communities — Auburn, Bow, Rochester, Loudon, and Windham — also address vernal pools in their zoning ordinances.

Many communities allow unregulated removal of vegetation and other potential harmful activities in the buffer zone.[18] However, Lyme's stringent regulations governing wetlands use are a model for other municipalities to follow, if they should so chose. Hewing closely to federal guidelines, Lyme is unique in that its regulations are stricter than those seen in neighboring communities. Within a 100-foot buffer of all wetlands areas in the town, the only permitted uses are activities that do not involve structure or alteration of the land surface.

Just as there are exemplars of local wetlands buffer zone policies, there are also examples of towns that have not developed sufficient — or even any — wetlands buffer zone policies. While it acknowledges wetlands' importance and the impact that development has on their quality, the town of Tuftonboro does not offer any specific regulations on buffer zones' sizes. Instead, its Conservation Commission merely "recommends a buffer zone around all wetlands while maintaining fifty percent natural vegetation within the zone."[19] Antrim, which requires a 25-foot buffer zone parallel to the water's edge, as per the recommendation of the Hillsborough County Soil Conversation Service, is an example of an insufficient policy; a 25-foot buffer zone is significantly below the state's recommendations and best practices seen in most other states.[20]

New Hampshire's decentralized buffer policy, and the resulting wide variation in buffer size regulations across the state, has caused problems for developers seeking to build near wetland areas. Municipal conservation commissions play an important advisory role in the state permitting process, and developers must abide by the local regulations established by these commissions. In interviews, developers noted that the variation in buffer policies is confusing and creates additional transaction costs that impede the process of development.

3.2 Quantitative Analysis of Current Buffer Sizes in New Hampshire Communities



A quantitative analysis of the current distribution of municipality buffer sizes resoundingly rejects the hypothesis that the municipalities have converged on a common and rationale standard absent state action. The distribution of buffer sizes from a random sample of cities in New Hampshire is presented on the left. The average buffer size is 51 feet and the median buffer size is 50. The maximum buffer zone is 125 feet and the minimum is 0. The standard deviation is 35 feet, and the data displays almost no clustering, with the frequency of each possible buffer size being essentially equal.

There is also little evidence that the variation in buffer sizes is due to variation in geography, topology, or economic pressures faced by the communities. A statistical analysis of buffer sizes across counties showed that municipalities within the same county were no more likely to have a similar buffer size than municipalities not located within the same county. Since towns within the same county would be expected to have similar geological and demographic characteristics, these results suggest that towns may be setting buffer sizes without careful consideration.

3.3 Wetlands Buffer Sizes in a National Context

Many states besides New Hampshire have wetland buffer zone policies. Such states include Massachusetts (100 feet from edges of bordering vegetated wetlands and from the banks of bodies of water), Washington state (variable by environment and county), Maine (100 feet on great ponds and rivers flowing into them, and 75 feet on all other water bodies), Pennsylvania (100-150 feet, depending on the type of riparian area), Florida (variable by local county ordinances, ranging from up to land developers' discretion in Charlotte County to 15-25 feet in Belle Isle, and Georgia (50 feet minimum, with an average width of at least 75 feet in Darien).[21]

Under Section 404 of the Clean Water Act, the federal government also has jurisdiction over wetlands, which is administered by the Army Corps of Engineers.[22] For large-scale developments, the federal government requires developers and others to obtain U.S. Army Corps of Engineers permits to dredge or fill many wetlands.[23]

In the United States today, as many as 5,000 local governments have taken action to protect their wetlands. In some counties and municipalities, local governments have established their ordinances to regulate development and use of buffer zones — an example of this is Sturbridge, Massachusetts, which specifies various regulatory buffer areas greater than the state-required 100 feet (i.e., Sturbridge requires 200 feet for freshwater wetlands) and prescribes minimum non-disturbance areas from 25-200 feet for various types of wetland resources.[24]

Another example of local government tailoring its policies to various types of wetlands is Island County, Washington, which has had an ordinance that takes wetland type, wetland size, and land use zones into account to determine wetland buffer zones since 1984. The County recently revised its ordinance for new development proposals to base buffer distance — which can range from 15 to 300 feet in width — primarily on intensity of surrounding land uses, habitat structure within and around the wetland (as scored by a checklist that landowners may use) and wetland sensitivity. The County requires wider buffers for several carefully-defined wetland types, due to their high ecological value and/or sensitivity. To help developers and others understand how regulations affect various types of land and uses, the County provides a series of tables that show buffer widths required for various combinations of these factors, which is reproduced below as an example of the tailoring that local governments may provide in their wetlands buffer guidelines. These are reproduced below, as printed in *Innovative Land Use Planning Techniques: A Handbook for Sustainable Development*:

Island County, Washington:
This excerpt is based on Island County's *draft ordinance* from November 2007, which reflects a sophisticated use of the matrix approach to buffer distance. The ordinance first prescribes buffers for a few types of particularly sensitive wetlands (especially bogs, coastal lagoons and estuarine wetlands), with wider buffers for more intensive land uses. Then it establishes matrices to calculate buffers for *other* wetlands based on land use intensity, habitat condition, and wetland sensitivity (as predicted by slope and presence or absence of a surface water outlet). Wetlands that lack outlets and are adjoined by steep slopes are presumed to be more sensitive to accumulation of sediment and contaminants, so receive larger buffers. For most wetlands both habitat and water quality buffers are calculated separately and the *larger* buffer (usually habitat) is applied. (The numbers below should be taken as illustrative). The habitat calculation is:

Habitat Buffers					
Land use Intensity	Habitat Functions Score				
	50 or higher	42-48	39-41	32-38	Less than 32
Low	150 ft	125 ft	100 ft	75 ft	Use Water Quality & Slope Tables
Moderate	225 ft	175 ft	150 ft	110 ft	
High	300 ft	200 ft	175 ft	150 ft	

The water quality calculation includes differing buffers based on wetland type (A-E) and whether there is a surface water outlet from the wetland.

Water Quality Buffers						
Land Use Intensity	Wetland Category					
	Wetland Outlet	A	B	C	D	E
Low	Yes	40 ft	35 ft	30 ft	25 ft	20 ft
	No	75 ft	50 ft	40 ft	35 ft	25 ft
Moderate	Yes	90 ft	65 ft	55 ft	45 ft	30 ft
	No	105 ft	90 ft	75 ft	60 ft	40 ft
High	Yes	125 ft	110 ft	90 ft	65 ft	40 ft
	No	175 ft	150 ft	125 ft	90 ft	50 ft

The water quality value is then adjusted for slope:

Slope Adjustment	
Slope Gradient	Additional Buffer Multiplier
5-14%	1.3
15-40%	1.4
>40%	1.5

This matrix approach is more complex than a single number, but can better reflect scientific understanding, particularly with diverse wetland types and land use conditions in a locality. With appropriate public outreach and technical support, a matrix-driven buffer can gain public support and achieve good results.

4. ESTABLISHING BUFFER REGULATIONS

What factors might be the most important when considering the establishment of buffer zone lengths? And what key factors might New Hampshire keep mind when deriving an optimal buffer size for New Hampshire? Answering these questions requires a consideration of best practices, costs, and the possibility relying on federal guidelines. It also requires a consideration of how these questions might be tailored for New Hampshire's needs.

4.1 Considering Options

Below, we briefly consider the main issues to keep in mind when establishing buffer regulations. We review the best practices, consider the costs, and briefly discuss using federal standards for statewide regulations.

4.1.1 Best Practices for Establishing Buffer Regulations

While determining ideal buffer zones is a multivariable process, there are some best practices and considerations that are key to determining buffer zones. To begin with, the EPA notes that in much of the country, buffers' benefits can be amplified when they are managed in a forested condition.[25]

Furthermore, the EPA suggests 10 key criteria to consider when establishing a stream buffer:

1. Minimum total buffer width
2. Three-zone buffer system
3. Mature forest as a vegetative target
4. Conditions for buffer expansion or contraction
5. Physical delineation requirements
6. Conditions where buffer can be crossed
7. Integrating stormwater and stormwater management within the buffer
8. Buffer limit review
9. Buffer education, inspection, and enforcement
10. Buffer flexibility.

The EPA suggests a 100 feet minimum width to provide adequate stream protection and a three-zone buffer system (inner, middle, and other zones) as an effective technique for establishing a buffer. In a three-zone buffer system, the zones are distinguished by function, width, vegetative target, and allowable uses. The inner zone, consisting of a minimum of 25 feet of wetland and critical habitats, protects physical and ecological integrity. Its vegetative target is mature forest, and its allowable uses are very restricted (flood controls, utility right-of-ways, and footpaths). The middle zone, which is typically 50-100 feet depending on stream order, slow, and 100-year floodplain, provides distance between upland development and the inner zone. Its vegetative target is managed forest, and usage is restricted to some recreational activities, some stormwater BMPs, and bike paths. Finally, the outer zone, which is at least 25 feet wide, is the first zone to encounter runoff. While forest is encouraged for this zone, its vegetative target may also be turf-grass. This zone's uses are unrestricted, and may include lawn, garden, compost, yard wastes and most stormwater BMPs.[26]

When designing buffers, it is important to take design and environmental factors into consideration, as they may either reduce or enhance performance. These are provided in the table below:

FACTORS THAT ENHANCE PERFORMANCE	FACTORS THAT REDUCE PERFORMANCE
Slopes less than 5%	Slopes greater than 5%
Contributing flow lengths <150 feet	Overland flow paths over 300 feet
Water table close to surface	Ground water far below surface
Check dams/level spreaders	Contact times less than five minutes
Permeable, but not sandy, soils	Compact soils
Growing season	Non-growing season
Long length of buffer or swale	Buffers less than 10 feet
Organic matter, humus, or mulch layer	Snowmelt conditions, ice cover
Small runoff events	Runoff events >2 year event
Entry runoff velocity less than 1.5 feet/second	Entry runoff velocity more than 5 feet/second
Swales that are routinely mowed	Sediment buildup at top of swale
Poorly drained soils, deep roots	Trees with shallow root systems
Dense grass cover, 6 inches tall	Tall grass, sparse vegetative cover

4.1.2 Costs of Establishing Buffer Zones

For local or state governments, the costs of instituting a buffer program include extra staff, plan review training, technical assistance, field delineation, construction, and ongoing buffer education programs. A community seeking to implement a stream buffer program will need to adopt an ordinance, develop technical criteria, and invest in additional staff resources and training. Buffer programs also require an investment to train plan reviewers and consultants. To explain the new requirements to stakeholders and land developers, communities will need to provide manuals, workshops, seminars, and direct technical assistance.

Lastly, buffers need to be maintained. Resources should include systematic inspections of the buffer networks before and after construction, as well as increasing resident awareness about buffers.

For developers, compliance with buffer ordinances may be costly when it reduces developable land, or prevents them from building in desirable areas. One way to relieve some of the significant financial hardships for developers is to provide flexibility through buffer averaging. Buffer averaging allows developers to narrow the buffer width at some points if the average width of the buffer and the overall buffer area meet the minimum criteria. Variances can also be granted if the developer or landowner can demonstrate severe economic hardship or unique circumstances that make compliance with the buffer ordinance difficult.

4.1.3 Limitations of a Federal Approach to Wetlands Buffer Regulations

As previously discussed, current federal regulations require developers and others to obtain permits from the U.S. Army Corps of Engineers to dredge or fill many wetlands. From this, one might believe that federal regulation and guidance on wetlands buffer zones might be ideal — it would avoid creating a regulatory patchwork, and establish standards in states that currently lack wetlands buffer zone regulations.

However, there are a number of limitations to the federal government's ability to regulate wetlands. For example, many activities that affect small acreages, or that involve particular kinds of construction or development activities, are authorized under generic "general permits" or "nationwide permits" with minimal security and standard conditions.[27] Furthermore, some types of wetlands are not subject to federal jurisdiction. These include some isolated wetlands and wetlands that lack sufficient connection to navigable waters and tributaries, which may be federally un-regulatable under Supreme Court decisions in *SWANCC v. U.S. Army Corps of Engineers* (2001) and *Rapanos v. United States* (2006).

Additionally, federal regulations may not be sufficient to protect upland habitats surrounding wetlands. In a study of freshwater turtles' nests and habitat on land at a Carolina bay, researchers from the Savannah River Ecology Laboratory found that federal regulations protected none of the turtles' nesting and hibernation sites.[28]

4.2 Alternatives for New Hampshire

What are some of the key factors to consider in deriving an optimal buffer size for New Hampshire? The sections that follow consider this question from multiple perspectives. The current system is analyzed to see whether trends can be detected, and factors that would affect the establishment of a state-wide buffer are considered.

4.2.1 Estimating an Optimal Statewide Buffer Size

Using a meta-analysis of purification achieved by different buffer zone sizes we created estimates of the expected purity achieved by an increased buffer. The table below displays the estimates for sediment purity achieved. This metric of purity was chosen because it displays the most direct relationship between buffer zone size and purity; however, the filtration rates of other pollutants show a similar pattern.

Buffer Size	Purity
0	.24
10	.77
50	.82
100	.84
500	.89

This analysis suggests that large environmental benefits can potentially be gained by implementing even a small state buffer requirement. Half of New Hampshire municipalities sampled currently impose a buffer that is less than 50 feet and a quarter sampled have no buffer zone requirement at all. In these municipalities, even a small buffer would yield dramatic increases in the health of the wetlands. Similarly, communities that impose buffers above 100 feet are not gaining substantial increases in wetlands protection.

It is worth noting that while the benefits from an increased buffer zone requirement decrease as the buffer size increases, the costs of increasing it increase. This occurs because the amount of area needed to increase the buffer along a curved boundary one foot will be greater at a hundred feet than at zero feet. This stems from a basic geometric property of curved objects. The amount that the area of circle increases for a one unit increase in radius is larger when the radius is five than when the radius is one. Towns which are imposing a requirement that is greater than 100 feet are incurring larger economic costs for little to no gain in wetlands purity.

4.2.2 Factors Impacting Buffer Efficacy Other than Size

While buffer zone size is certainly the largest factor in determining the purity of water that also reaches the wetlands, other features of the buffer zone may also have an effect. In general, characteristics of the buffer zone that slow down the movement of water through the buffer will result in improved purity, while characteristics that speed up the movement will reduce purity. Specifically, the slope, soil type, and vegetation of a buffer zone will impact the level purification the buffer contributes. One county's evaluation of the significance of these various factors is presented in table in section 3.3.

The slope of a buffer zone is the largest factor impacting the level of purity. Steep slopes cause water to move very quickly through the buffer zone and provide less purification than flat buffers. There are two ways that the grade of the land can be built into the buffer requirements. One is to create a formula for buffer sizes so that the size of the buffer increases with the grade of the land included within it. This solution is the most sound environmentally, but also the most difficult to implement. A second option is simply to exclude land of an especially steep grade from counting towards the requirement. Finally, although steeper land does not provide as good of filtration as flat land, it still provides some benefits, and a valid option is to simply impose a statewide minimum buffer size, regardless of the slope of the land in the buffer. Although this does not provide as large a benefit environmentally, the ease of implementation may justify the trade-off. It is worth noting that land with a very steep grade is often of marginal utility, so the cost of imposing a larger buffer requirement on steep land will be less than that cost might otherwise be.

The soil type can also have an impact on the filtration quality. In general, tighter packed clay soils will provide better filtration than granular, sandy soils. Although the difference in purification is non-negligible, the benefits are small enough and the implementation difficult enough that it is likely not necessary to take this into account in constructing a state-wide buffer requirement.

The effects of different types of vegetation are significant, but often in conflicting directions. For example, densely vegetated grasslands will often provide a better filtration quality than forested areas, but forested areas do a better job keeping the water cold. There is no clear way that vegetation type could be factored into a statewide buffer requirement.

5. POLICY OPTIONS

The state government is faced with two questions, the answers to which dictate distinct sets of policy options: first, should a statewide buffer zone requirement be imposed and second, it is imposed, how should this requirement be set? The first question presents two clear-cut options. The second presents a more nuanced set of policy options.

To answer the first question, policymakers might weigh the costs and benefits of imposing a statewide requirement against the costs and benefits of allowing the current devolution of buffer zone sizes to municipal governments to continue. Our research has uncovered two main benefits of imposing a statewide buffer zone requirement. First, state officials are likely to be better able to determine the optimal buffer zone size for the given conditions than their local counterparts because municipalities may not possess the resources or local expertise that is necessary to conduct a thorough study of the buffer size needed for their area. Determining the optimal buffer zone for an area requires a comprehensive analysis of the soil type, topology, and economic needs of the area that local policymakers are ill equipped to conduct. For example, several towns have failed to establish any buffer requirements at all. Since it seems unlikely that many towns' optimal buffer size deviates this greatly from the EPA's recommended 100 foot buffer, the choice to require no minimum buffer size is most likely an oversight rather than a decision stemming from a thorough evaluation of the costs and benefits of applying a minimum buffer zone size.

Second, there are administrative and economic benefits from having standard buffer sizes. Maintaining a patchwork of local regulations imposes a cost on developers who must discover multiple buffer requirements when they want to begin a new development.

Local control of buffer zone sizes presents the benefit of allowing local policymakers to tailor their buffer zone sizes to their area's needs. A statewide buffer zone is by definition unresponsive to local concerns, and meaningful differences in topology, geology, vegetation, and value assigned to maintain clean wetlands may dictate differing buffer zone requirements in different areas.

If the state government decides to impose a statewide buffer requirement, the next step is to decide what form that requirement should take. Although there are obviously a large number of ways that this requirement can be imposed, three main classes of options stand out. The simplest is to impose a single statewide minimum buffer zone requirement. This option has the advantage of simplicity but it also lacks flexibility. Since topology varies from town to town, it is likely that the optimal buffer zone does as well.

The most complicated option would be to develop a formula that would dictate the size of the buffer under given conditions. For example, a formula could be created such that the size of the buffer required would increase with the grade of the land that it encompasses. This solution would provide the most adjustment to local conditions, but would also be difficult to develop and implement.

Finally, a compromise solution is to generate a statewide buffer requirement, but exempt certain types of land from counting towards that requirement. For example, land with a grade of over thirty degrees could be excluded from counting towards the requirement. This solution allows some amount of adjustment to local conditions, but is also easy to interpret and straightforward to implement.

6. CONCLUSION

The devolution of setting wetlands buffer zones in New Hampshire presents numerous options to policymakers. Namely, state policymakers can choose to impose a new state wide minimum buffer size or they can allow the current devolution to continue. Although the current devolution allows local communities the maximum level of flexibility to adapt their buffer requirements to the needs of their community, local policymakers may not be well situated to determine what those needs are. Qualitative and quantitative assessments of the distribution of minimum buffer sizes in the state suggest that the variation in buffer sizes outstrips the variation that would be expected from the variation in geography. It also shows that on average, buffer requirements in New Hampshire are lower than the EPA suggested size of 100 feet. A statewide buffer requirement may be necessary in order to ensure that a minimum buffer requirement large enough to adequately protect the health of New Hampshire's wetlands. Maintaining a patchwork set of local buffer requirements also creates economic costs because it forces contractors to adapt to a wide variety of different rules. Moreover, it forces towns to do (often duplicative) research to determine the optimal buffer size for their area.

If state policymakers choose to end the devolution of buffer zone requirements, the state will have to determine how to set the new statewide buffer zone requirement. In general, the more slowly water moves through a buffer zone, the greater the level of purity achieved will be. Large, flat buffer zones will provide the greatest levels of purification. Small, steep buffer zones will provide less purity. Soil type and vegetation have some effect on purity levels, but the size of the effect is small compared to the importance of slope and buffer zone size. There are three main options for how to take this variation in buffer efficacy into account. The most complicated solution is to generate rules and formulas to determine the buffer requirement for a given area. The policies of Island County, Washington provide an example of this approach. Although this approach provides more adaptation to local conditions it also dramatically increases the difficulty associated with creating and implementing the requirements. The simplest is a flat requirement that does not vary in response to environmental factors. Although determining the optimal statewide buffer size is beyond the scope of this report, the EPA suggested minimum is 100 feet. A compromise option is to establish a single, constant requirement for the entire state, but to exclude certain types of land (such as areas with a slope of greater than 15 percent) from counting towards it. This option maintains some of the responsiveness to local geography of the first option, but also some of the simplicity of the second.

APPENDIX A: STATISTICAL METHODS

Two main pieces of statistical analysis were presented in this policy brief. The first assessed the level of dispersion in minimum buffer zone requirements in the state of New Hampshire. The second used regression techniques in order to project the level of purity achieved by different buffer zone sizes. This appendix will provide more details regarding the analyses undertaken to answer both questions.

Current Distribution of Buffer Zone Sizes

Two questions were addressed regarding the current distribution of buffer zone sizes. The first was whether towns have converged on a common buffer zone requirement independent of state action. If this were the case, state requirements might be unnecessary. Two pieces of statistical evidence suggest that this has not occurred.

First, the buffer sizes show a very high level of dispersion. The interquartile range of buffer zone sizes sampled is 50 feet, which is nearly half the entire range. The ratio of the standard devation to the mean is roughly .25, which is also quit large. Second, the distribution of towns presents fat tails which indicates that many towns have very large deviations from the mean buffer size. The Anscombe-Glynn test of kurtosis rejects the null hypothesis that the data is normally distributed. (Anscombe, F.J., Glynn, W.J. (1983) Distribution of kurtosis statistic for normal statistics. Biometrika, 70, 1, 227-234)

We also attempted to assess whether or not this high level of dispersion was due to meaningful changes in the geography and topology of the state. To do this, we used a linear regression model which tested whether or not towns in a county were more similar to each other than to towns elsewhere in the state. The reasoning being, that towns in the same county are likely to have similar vegetation, soil types, and slopes and so if the differences in buffer zone sizes are because of differences in these features then towns in the same county will have similar minimum buffer sizes.

To test this, we used a linear regression which used the county of a town as the independent variable and the buffer sizes as the dependent variable. These results fail to reject the null hypothesis that buffer zone sizes do not depend on the county. The only statistically significant effect observed is for Sullivan County, which only had two towns that were sampled and where the difference is likely to be due solely to chance.

	Coefficient
Baseline (Belknap)	62.50***
	(13.78)
Carrol	-32.50
	(20.44)
Cheshire	-62.50
	(36.46)
Coos	-50.00
	(27.56)
Grafton	-4.17
	(17.79)
Hillsborough	-4.38
	(18.23)
Merrimack	7.50
	(20.44)
Rockingham	-6.79
	(18.78)
Strafford	-2.50
	(20.44)
Sullivan	-62.50*
	(27.56)
R^2	0.27
Adj. R^2	0.11
Num. obs.	50

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Statistical models

Predicting Purity Levels

Purity levels were projected using data acquired from a metanalysis of studies of the effect of buffer zone sizes on riparian water quality conducted for the state of New Hampshire. Missing data was imputed from the measures of the pollutants. The regression results are presented in the following table.

	Sediment	**N**	**P**	**TSS**	**N03**
(Intercept)	0.75***	0.54***	0.52***	0.27	0.56***
	(0.03)	(0.06)	(0.08)	(0.14)	(0.06)
√Buffer	0.01*	0.01	0.00	0.03	0.00
	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)
R^2	0.13	0.03	0.00	0.06	0.00
Adj. R^2	0.11	0.01	-0.02	0.04	-0.02
Num. obs.	51	51	51	51	52

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Statistical models

The model's performance is not very good. The effect is only statistically significant for sediment (which is used as purity in the body of the report), although the coefficients are in the correct direction for the others. R squared values are also quite low which suggests that the predictive power of the model is not high. The relatively poor fit could be due to the choice to model the relationships as a square root relationship (as opposed to using another radical), a relatively small sample size, and the large number of other factors that impact wetlands quality.

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