Creating a Market for Retreat: Transfer of Development Rights as a Climate Adaptation Tool in Coastal Massachusetts

By

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ABSTRACT

Transfer of development rights (TDR) is a zoning tool that many planning experts have suggested as a potential climate adaptation tool, though it has never been implemented for that purpose. This thesis explores how a TDR program applied as a climate adaptation tool could facilitate a managed retreat program by creating a hypothetical program for the town of Westport, Massachusetts. While the advantage of using TDR for adaptation is that it provides a funding mechanism for managed retreat, its success depends on the program's ability to generate development rights transfers. The Westport implementation is projected to have only partial success at achieving reductions in vulnerability to coastal flooding through buy-outs because of the limited expected demand for TDR credits. However, the Westport implementation has both advantages and disadvantages as an adaptation approach despite its limited success at achieving the primary program goal. These considerations are discussed in detail and are used to generate a set of recommendations for state leaders who may consider promoting the use of TDR as an adaptation approach for other municipalities in Massachusetts.

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INTRODUCTION

Massachusetts' citizens and their property are vulnerable to climate hazards. As a result, the finances of municipalities in Massachusetts are also vulnerable, both because they have to pay for the infrastructure and services that protect the health, safety, and well-being of their residents but also because they rely on property taxes as a revenue source (Shi & Varuzzo, 2020). Recently, the state government has begun to provide funding that supports municipal climate change adaptation efforts and is interested in new forms of municipal support.

This report explores the advantages and disadvantages of using transfer of development rights (TDR) as a climate adaptation tool that reduces exposure to climate hazards, specifically coastal flooding. TDR is a zoning tool that creates a market that allows development rights for real estate to be bought and sold. The structure of the market lets the local government achieve certain policy objectives like open space preservation without direct government spending. One possible TDR program goal could be reducing exposure to future environmental hazards, turning TDR into a tool for climate adaptation. From both the state and municipal government perspectives, TDR could be a win-win solution that is inexpensive, achieves its adaptation objectives, and creates co-benefits for the local community, such as public open space.

However, TDR may not be a perfect solution. This report tries to answer the questions of whether TDR should be used as a climate adaptation tool by municipalities in coastal Massachusetts. TDR has attracted attention in the planning community as an adaptation tool, but no community has implemented it yet with this goal in mind. Before any municipalities try using TDR as part of their climate adaptation strategy or state leadership invests any resources in promoting this new approach, this research will try to determine whether it is possible to set up a functioning market for a TDR program that targets climate adaptation, gauge how effectively TDR might be at reducing hazard exposure and therefore reducing climate vulnerabilities, and identify any negative externalities that could result from this strategy.

This research addresses whether TDR should be used for climate adaptation in four parts. First, it evaluates the governance challenges that climate change has presented to municipalities in Massachusetts, as well as some of the climate adaptation tools available to local officials. Next, it explains how TDR could be applied as a funding strategy for managed retreat, a common but controversial adaptation approach. Then, it reviews some background information on traditional TDR programs like the tool's origins and its use in Massachusetts. Then the research applies a hypothetical TDR program with climate adaptation objectives to the Town of Westport, MA, to explore how the tool could work in the real world. Finally, this report concludes with an evaluation of the Westport application, and a list of factors for government decision-makers to consider before promoting TDR as a municipal climate adaptation tool.

As this research will discuss, the hypothetical Westport program illuminates some flaws in TDR as a form of managed retreat. This implementation was designed as a small buy-out program for around 30 modestly-priced water-front homes. However, its TDR market is only expected to generate a fraction of the TDR credits sales needed to incentivize all of the owners to accept the buy-out. Furthermore, as an

adaptation tool, TDR may produce inequitable outcomes, and using managed retreat for coastal homes may not be the best use of public resources. TDR is not a cost-free program, and its use combined with managed retreat may limit the direct benefits of climate vulnerability mitigation to only a relatively privileged subset of the municipality. While TDR could promote climate adaptation by providing funding for efforts to reduce municipal vulnerability, managed retreat facilitated by TDR may not be the right approach to climate adaptation for Massachusetts' municipalities.

MUNICIPAL RESPONSES TO CLIMATE RISK

Climate change is a governance challenge for municipalities. They are under pressure from citizens and advocates to do something about it but are constrained by the lack of locally accurate climate data, high adaptation project costs, and conflicting local priorities. They also have a limited set of policy tools at their disposal. Land use policy is one responsibility of local government that could be used to promote climate adaptation.

Adaptation in this sense refers to an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (McCarthy et al., 2001, p. 982). TDR could be used to moderate harm by reducing the exposure of some residents to environmental hazards caused by climate change and mitigating the vulnerability of municipal finances to the impact of climate change on their property tax roll. TDR might encourage new development in areas that do not have a major risk from environmental hazards and then leverage value captured from that new development to fund the acquisition of housing in vulnerable areas.

Massachusetts local governments need to plan for numerous natural hazards but flooding may pose the most widespread and damaging threat. Massachusetts' comprehensive State Hazard Mitigation and Climate Adaptation Plan (2018) links thirteen natural hazards to climate change. All of these are projected to have significant impacts on public health, private property, the local economy, government, natural resources, and agriculture in the state. State data from the EEA Municipal Vulnerability Preparedness Program has identified inland flooding as the most common hazard listed in local climate vulnerability plans across the state, while coastal flooding is the most common hazard among coastal communities. Massachusetts' population is clustered around Boston, but municipalities along the coast have much higher populations on average than those in the state's western counties. The 78 coastal communities as defined by the Massachusetts Office of Coastal Zone Management (CZM) have approximately one-third of the state's population. Precise sea level rise scenarios vary geographically due to numerous natural factors, but many coastal communities will see serious impacts from high water levels in the next century (MA EEA, 2017). Coastal flooding is already a threat to some communities and "sea level rise driven by climate change will exacerbate many other existing coastal hazards, like severe storms and storm surge, tidal inundation and salt water intrusion, which could produce billions of dollars of impacts for Massachusetts"(MA EEA, 2017).

TDR could be applied to several of the natural hazards in the state's climate adaptation plan, but this report will focus primarily on coastal flooding. Sea level rise and subsequent coastal flooding will cause extensive destruction in the state and are already a cause for concern for local governments. Coastal areas also may be exposed to more hazards than inland communities. In addition to coastal flooding, erosion and ocean acidification, they are also often challenged by the same hazards facing inland communities like precipitation-induced flooding. The initial focus on coastal flooding is also practical because unlike other climate-impacted hazards, sea level rise projections for the entire state are publicly available. These factors make it a good trial candidate for exploring this TDR as an adaptation tool.

The following chapter will explain how TDR could be used to promote climate adaptation by facilitating managed retreat. However, it will begin with a review of local government climate adaption responses and an in-depth explanation of managed retreat.

CLIMATE ADAPTATION BY MUNICIPALITIES

Coastal municipalities need to plan how they will adapt to climate change, in order to reduce their community members' vulnerability to disaster and to limit the impact that climate change will have on their municipal finances. Sea level rise has generated public attention due to historic coastal flooding incidents like Superstorm Sandy, but that has not yet led to widespread changes in coastal real estate markets (Hino & Burke, 2020), or government action to address flood risk. One recent study found that home prices immediately decline in areas impacted by flooding as the market responds to new disaster information though the prices recover over time as the experience fades (Atreya & Ferreira, 2015). However, local governments may be more responsive than individuals to projections about sea-level rise and its impact on the long-term future of their property tax base. One recent study estimated that properties in US floodplains, including both inland and coastal areas, may be overvalued by $34 billion because current floodplain management policies obfuscate actual risk (Hino & Burke, 2020). When the market eventually corrects for this overvaluation with a decline in floodplain property values, Massachusetts faces a major problem. A decline in value means a decline in the state's tax base, and property taxes "constitute on average 60% of local revenues among its coastal municipalities [based on 2012 census data]" (Shi & Varuzzo, 2020). Compounding this fiscal problem is the likelihood that municipalities will need to spend increasing sums of money on infrastructure maintenance and services like emergency response to deal with their new environmental reality.

STATE AND FEDERAL FUNDING

These climate change related financial risks may motivate local governments to start planning for coastal flooding, but state and federal funding for initial planning and preparedness projects also help motivate municipalities. Massachusetts' Municipal Vulnerability Preparedness (MVP) program, managed by the Executive Office of Energy and Environmental Affairs (EEA), provides grants to assess a city or town's vulnerabilities to local climate hazards and funds local climate adaptation projects. At the federal level, the Federal Emergency Management Agency (FEMA) requires municipalities to have hazard mitigation plans in place to qualify for non-emergency funding, and hazard mitigation planning overlaps with climate adaptation planning (FEMA, 2019b). The State of Massachusetts combined the two concepts in their "State Climate Hazard Mitigation and Climate Adaptation Plan", and this practice is becoming increasingly common in the MVP program. Associating climate change with localized risks to people and property through hazard mitigation planning may inspire more urgency on the part of municipal governments than global climate projections and advocacy campaigns have been able to produce.

LAND USE TOOLS TO LIMIT DEVELOPMENT IN FLOODPLAINS

For municipalities that decide to mitigate risk from sea-level rise, there are many ways to leverage or modify existing land use control processes to limit property vulnerability. These land use tools can be used to prevent individuals from building in at-risk areas or can incentivize adaption of existing construction to higher future sea levels. One option is to use the building code to force new construction to higher

standards that reflect risks induced by climate change. Because of reluctance at the state and national level to recognize climate risks in the code, and an inability for municipalities in Massachusetts to require more strict standards than those in the state code, local governments have to use creative solutions to use this policy lever. One example is the special permits issued for construction in the Town of Hull's Special Flood Hazard Area, which require that buildings meet or exceed flood elevation required by the State Building Code (Conservation Law Foundation, 2019). Incorporating physical resiliency into zoning bylaws can also be done through tweaks like basing setbacks on high water marks at the design end life of new construction, which impacts individual properties, or community-wide assessments and policy changes. Boston's Coastal Flood Resilience Design Guidelines are an example of the former category, though specific recommendations from the guidelines like "revise the zoning code to support climate-ready mechanical systems" and "establish a planning flood elevation to support zoning regulations in the future floodplain" should be formalized in the city's zoning code (Boston Planning and Development Agency, 2019, p. 16). The Town of Chatham has codified resiliency into its bylaws and has banned new residential units in its Conservancy District, defined as its FEMA FIRM 100-year floodplain (Shaw, 2008). This specific bylaw does not prevent construction in areas that will be at future risk because of the migration of the 100-year flood plain caused by climate change, but this flaw could be fixed if the FIRMs incorporate new risks in the future.

Other techniques can be used by municipalities to help residents move out of areas that are too hazardous for future habitation. Buy-outs are a form of land use intervention where government funds are used to compensate owners after property in hazardous areas is moved or demolished (A. Siders, 2013). Land swaps are trades of public land for private land. As part of the New Orleans recovery from Hurricane Katrina, a non-profit organization facilitated trades between private landowners with lots in flooded areas and city-owned lots with less flood risk (M. Nelson, 2014).

CONSTRAINTS AND COMPLICATING FACTORS

For municipalities considering climate adaptation planning and actions including those outlined in the previous paragraph, implementation costs and legal considerations will influence their decision-making. Aspects of Massachusetts' state law, like a municipality's inability to enforce more stringent restrictions than those outlined in the state's building code, limit the power of municipalities to enforce vulnerability reduction at a local level. Other aspects of state law, like the property tax cap known as Prop 2½, may actively undermine efforts to reduce vulnerability to coastal flooding. It may incentivize local governments to authorize high-value coastal real estate development in high-risk areas for coastal flooding since municipalities have a capped property tax rate and ocean-front properties often sell at a premium (Shi & Varuzzo, 2020). Takings are another major consideration for local governments. The Fifth Amendment of the constitution prohibits the taking of private property without just compensation.[1] This constitutional obligation, along with other legal constraints, can limit what the government can do in the public interest because it also has to consider how that action impacts private property rights. For example, compensation for property owners may be required if a municipality's flood mitigation strategy requires

[1] "United States Constitution," § Amendment V.

new public easements on private property, or includes regulations that severely restrict the allowable uses of private land.

Social and political factors also complicate government decision-making regarding climate adaptation. These include physical constraints like a limited quantity of land available for development or redevelopment in areas with low risk of climate hazards. They also include other government priorities like job creation, public health, and education, which compete with adaptation projects for attention and resources. The danger of negative externalities and maladaptation adds another complication to an evaluation of adaptation options. Maladaptation refers to efforts to reduce risk that end up handicapping long-term resilience. It is "a result of an intentional adaptation policy or measure directly increasing vulnerability for the targeted and/or external actor(s), and/or eroding preconditions for sustainable development by indirectly increasing society's vulnerability" (Juhola et al., 2016). A basic example of a maladaptive solution is a sea wall built to protect an individual property, which creates erosion that leads to damage of other properties. A more complicated example would be "growth-based fiscal policies like property taxes to implement adaptation projects"(Shi & Varuzzo, 2020), which could unintentionally intensify development in hazardous coastal areas that are valuable to developers.

Other factors complicating policy-making are related to the nature of climate change as a long-term threat. One local official interviewed for this research commented on their inability to choose a climate scenario as the basis for future planning given the uncertainty associated with climate data. Another challenge is that climate impacts may accelerate over time, disincentivizing near-term action, and worsening potential long-term impacts. A recent study by Shi and Varuzzo (2020) analyzed coastal Massachusetts real estate and projected gradual damages of 3 to 4 billion dollars in damages per foot of SLR up to 4 ft, and then 35 billion dollars in damages between 4 and 5 ft of SLR.

The public's relationship to the natural environment may also complicate municipal responses to sea-level rise. Many coastal communities may have their community identity and local economy tied to the ocean and coastal access, through activities like fishing and beach tourism. These require ocean access so risk reduction must be balanced in a way that enables continuity of seaside activities. A second cultural factor is the fact that many people value coastal living and want to live near the water, and may undervalue inland areas at lower risk of climate hazards because they do not offer the same lifestyle and views. This could undermine any effort to shift development away from the coasts and weight municipal decision-making towards adapting to coastal flooding rather than avoiding it entirely through relocation. In summary, while the risk of climate change is clear, local governments have to balance many competing considerations and complicated factors when deciding on an appropriate course of action to address it.

MANAGED RETREAT

Managed retreat is a climate adaptation strategy that helps manage exposure to environmental hazards. In this context, retreat refers to ”the strategic relocation of structures or abandonment of land to manage natural hazard risk”(Hino et al., 2017, p. 364), where the abandoned land is restored or allowed to return to nature (Koslov, 2016). The additional term “managed” contrasts with an unplanned retreat where people are forced to abandon property without any government support, and where the government is unable to capitalize on any of the potential benefits of managing the process (Siders, 2019). Managed retreat does not refer to a goal or final state, but rather an adaptation strategy that can be accomplished with policy programs or zoning techniques. Buy-out programs are the most common tool used to implement managed retreat in the United States (A. R. Siders, 2019b, p. 222).

In the US, retreat facilitated by a buy-out program is often funded by federal programs like the FEMA Hazard Mitigation Grant program and the Department of Housing and Urban Development (HUD) Community Development Block Grant Program (Freudenberg et al., 2016). While funds are provided by these federal programs, state and local governments often manage the implementation (Freudenberg et al., 2016). Property and resident eligibility vary according to the program, as does the compensation requirement though it generally is based on a pre-disaster valuation of the property’s fair market value (Freudenberg et al., 2016). Federally funded buy-out programs in the US have predominately been voluntary (A. Siders, 2013), though the federal government has recently initiated a shift away from this approach. As of this year, the Army Corps of Engineers has informed some municipalities that a new condition of flood mitigation projects is their willingness to use eminent domain if necessary to force homeowners out of hazardous areas (Flavelle, 2020).

JUSTIFICATIONS FOR MANAGED RETREAT

Experts advocate for the use of managed retreat as an adaptation strategy because of its effectiveness at reducing risk and its long-term cost savings compared to other adaptation approaches. It is an effective adaptation strategy because it physically removes people and property from harmful areas. Managed retreat also can produce hazard mitigation co-benefits by creating new open space that can serve as buffers to protect inhabited areas from certain types of hazards. The financial advantage of managed retreat from the federal government’s perspective is that it avoids the need to finance reconstruction after future disasters because homes have already been demolished. From this perspective, managed retreat is also a “far more effective and less expensive means of flood protection than building and maintaining structural defenses, such as levees and seawalls, that will become obsolete as floods worsen and sea levels rise” (Koslov, 2016, p. 363).

ARGUMENTS AGAINST MANAGED RETREAT

There are many criticisms of managed retreat based on politics, negative individual and community impacts, management challenges, and social equity concerns. Despite a federal appreciation for the potential cost savings of managed retreat, local and state governments may oppose the strategy because demolishing housing and relocating people could reduce their property tax base (Koslov, 2016). Individuals or entire communities may oppose it because they do not want to abandon their homes. This attachment to their homes could occur because owners underestimate risk (A. R. Siders, 2019b), are

attached to a place despite its known hazard risk (Simms, 2017), or receive other social and psychological benefits from remaining in their community that outweighs the hazard risk (Simms, 2017). The intangible costs of managed retreat like the loss of place and cultural heritage may be higher with retreat compared to other climate adaptation strategies (Hino et al., 2017). Equity concerns surround these programs and their perceived inability to produce positive outcomes for socially vulnerable populations. According to Siders (2019a, p. 252)"managed retreat is plagued by the dilemma that purposefully relocating low-income communities is socially inequitable and may harm those communities, but not relocating low-income communities…is also socially inequitable and may cause harm". Another major challenge is that people participating in managed retreat programs may not relocate to safer areas. One study of post-hurricane Sandy buyouts found that 20% of buyout recipients moved to areas with equal or greater risk of flooding and almost all moved to an area with a higher poverty rate (McGhee, 2017). Critiques of managed retreat programs include that voluntary programs are still perceived as coercive by residents (de Vries & Fraser, 2012), unintended negative impacts on individuals who decline to participate in a program and are left behind (Purdy, 2019), and concerns about a lack of transparency in decision-making and subjectivity of the cost-benefit analysis used to make major buy-out program decisions (A. R. Siders, 2019a).

Applying TDR to Climate Adaptation

What is TDR?

TDR is a land use planning tool that creates a market to incentivize preservation and guide community development. TDR programs work by designating "sending" areas where property owners can sell unused development rights as TDR credits, and "receiving" areas that can accept additional development enabled by the purchase of TDR credits. Property owners in sending areas receive money in exchange for credits, while property developers generally purchase credits because they enable more density than is allowed by existing zoning. TDR programs are designed to steer future development from one area to another area that the community believes is better suited for it. The goal of TDR differs from program to program but is typically a variant of environmental or historic preservation. Compact development along smart growth principles is a common secondary goal or co-benefit. TDR programs have been implemented to protect urban neighborhood characteristics, as well as to preserve environmental resources and conserve agricultural land (Johnston & Madison, 2007; McConnell & Walls, 2009; A. Nelson et al., 2012). They are a popular tool across the country because they promise the ability to preserve land or buildings without local governments having to purchase those assets directly either through land acquisition or conservation easements.

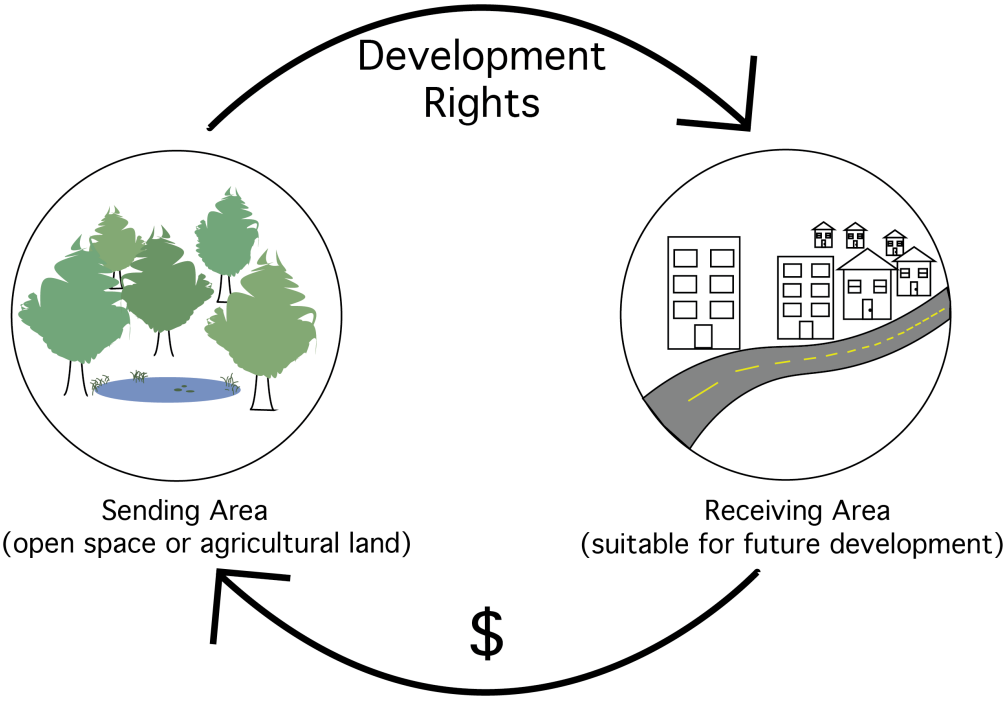

Figure 1: Traditional TDR program characteristics.

TDR AS A CLIMATE ADAPTATION TOOL

TDR has frequently been suggested in planning literature and editorials as a tool to address climate change. One organization promotes the use of TDR as a way to mitigate carbon emissions by encouraging more sustainable development patterns. The Cascade Land Conservancy (2009) highlights TDR's ability to densify development, which they consider to be a climate mitigation technique because increased density can reduce carbon emissions. However, the link between increased urban density and lower carbon emissions has recently been called into doubt (Aldana Cohen & Ummel, 2019).

Other experts recommend TDR as a form of climate adaptation. There do not appear to be any implemented programs in the US with this goal, though at least one is under development in Norfolk, Virginia (Morrison, 2020). While TDR is a popular suggested technique for climate adaptation, opinions differ on the forms such a TDR program might take. Some authors specifically recommend it as a defense against regulatory takings claims if local governments enforce strict development restrictions in vulnerable areas (Sheehan et al., 2018; Straalen et al., 2017; M. A. Walls, 2014). Others like TDR because it provides a way to incentivize individuals to leave vulnerable sending areas, along the lines of a managed retreat program, at very little cost to the government (Cox, 2012; Kopin, 2013; Sheehan et al., 2018). The Urban Land Institute (2017) recommended that in South Florida, TDR could be used to buy out property owners in low-lying stormwater basins who had been rejected by the FEMA buy-out program. The abandoned land could then be used to create adaptive open space that absorbs floodwater as an alternative to grey infrastructure to protect vulnerable areas from flooding. TDR has also been recommended as a funding source for some creative forms of climate adaptation. A thesis by a University of California Berkeley graduate student proposed TDR as a funding mechanism for climate adaptation projects in coastal areas that cannot be abandoned entirely (Plane, 2019). Another creative application proposed using funding generated by TDR to maintain green infrastructure meant to mitigate coastal flooding in New York City (Drake, 2013).

As conceived by this research, a TDR program designed for climate adaptation would use a market for TDR credits to finance a voluntary buyout of development rights in an area vulnerable to climate hazards. It could designate sending districts in places vulnerable to climate hazards to reduce risk to public safety and designate receiving districts in areas that are safer for future construction (see Figure 2). This type of TDR program could be applied to residential property, as well as other land uses with certain program modifications. In theory, the TDR program would decrease the proportion of at-risk housing and provide communities with an opportunity to plan new development that can better respond to future climate risks. It could also leave municipalities with new open space, which in some cases might be restored to provide new recreation value and ecosystem services like natural flood barriers.

Most existing TDR programs focus on redirecting future development from a sending area into a receiving area. By contrast, a Climate Adaptation TDR (CATDR) program could sell development rights that are currently in use in the sending area. The sale of development rights used by existing construction would require demolishing buildings in the sending area as a condition of credit sales in the receiving area. When transferring the rights used by existing construction, TDR acts as a property buy-out program.

Municipalities could benefit from this technique because it would allow them to finance a voluntary relocation program with minimal public expenditure. It would also encourage development within areas of the municipality that are less exposed to climate risks, which could neutralize the negative impact on the municipality's tax roll caused by residents moving out of hazardous areas. The benefits and challenges beyond those directly linked to the program goal are difficult to predict. TDR programs vary greatly from case to case, depending on their precise configuration, the local real estate market, and their specific goal. Consequently, it is also hard to generalize how other community stakeholders might feel about the program as their level of support would likely depend on how the TDR program is configured.

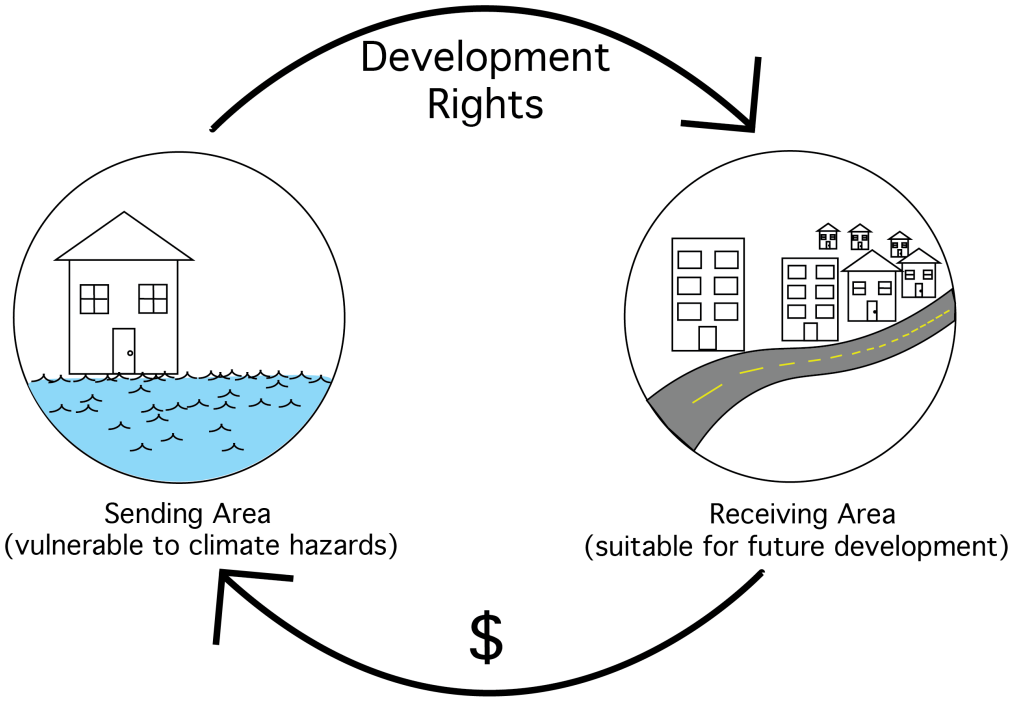

Figure 2: Characteristics of a TDR program for Climate Adaptation.

PRECEDENCE FOR TDR AS AN ADAPTATION TOOL

HAZARD MITIGATION

While TDR has yet to be used as a climate adaptation tool, many existing TDR programs may help reduce municipal vulnerability to climate-related hazards even if they were not specifically designed as a climate adaptation mechanism. TDR has been used by municipalities as a hazard mitigation tool to move development away from areas at risk of hazards like wildfire and avalanches in Pitkin County, Colorado (PlaceWorks, 2017). The scope of these hazard mitigation programs is limited to current hazards and they do not necessarily adapt over time as processes like climate change alter the geography of hazard risk. More importantly, they are not intended to move existing development but rather to guide future development. This limits their usefulness to preventing new development in potentially hazardous locations.

COASTAL FLOODING

One successful TDR program that specifically addresses coastal flooding is from Ocean City, Maryland, and was created in the early 1990s. Ocean City is a densely populated resort community on a barrier island, which sees over 8 million tourist visits annually, as of 2015 (Town of Ocean City, Maryland, 2017). Their TDR program was established as a compensation mechanism to acquire easements required as part of a major dune restoration project (Schechtman & Brady, 2014). The town had to shift its coastal build-to line inland to allow more space for beach and dune construction and therefore had to compensate property owners for the acquisition of easements on land seaward of the development limit (Schechtman & Brady, 2014). The Ocean City program awarded sending area owners a TDR credit for every 500 square feet of land in the sending area. It also awarded a 25% density bonus for receiving area projects built with TDR credits with the receiving areas sited in Ocean City locations with the highest pre-existing density (Schechtman & Brady, 2014). The program did not control the value of the TDR credits and "some property owners received up to $2.5 million for their credits" (Schechtman & Brady, 2014, p. 180). Ocean City's TDR program generated 400 credit transfers as of 2014, and its success may be attributed in part to high local property values, which in turn may be influenced by the booming tourism economy (Schechtman & Brady, 2014).

Other precedents for TDR programs in coastal communities can be found in Florida, such as the Monroe County TDR program that includes the Florida Keys (Stroud, 1994), and in Lee County on the state's southwestern coast. Lee County's Pine Island is a rural, barrier island in Southwest Florida, connected to the mainland by a bridge (Gruss, 2016). The Pine Island TDR program was established by the county in 2015 as a response to takings lawsuits brought because of regulations limiting development on the island (Lee County, n.d.). Much of the island was designated as the sending area, with extra credit units awarded for wetland areas. Credits can be used in a concentrated section of Pine Island, and in large receiving areas on the mainland (Jacob & Rozdolski, n.d.). While the Pine Island TDR program seeks to transition development out of vulnerable coastal environments, it does not attempt to remove existing development on sending area parcels. Like many traditional TDR programs, it is focused on directing future development to areas better suited for greater density.

Environmental Preservation

A TDR program can manifest positive climate change adaptation outcomes, without having climate adaptation as its explicit goal. TDR programs that prioritize wetlands conservation are a relatively common form of hazard mitigation TDR that may make communities more resilient to coastal and inland flooding. For example, the Pine Island program conserves fragile wetland ecosystems that may contribute ecosystem services that mitigate flooding, and concentrates development in an area that might be more easily served by emergency services. Some wetlands preservation TDR programs have been very successful at achieving their preservation objectives, like the well-known Long Island Pine Barrens program in NY (Schechtman & Brady, 2014, p. 135). In addition to preserving a sending area for its ecosystem services like groundwater recharge, biodiversity, and hazard mitigation potential (A. Nelson et al., 2012), municipalities participating in the Pine Barrens program also build resilience by carefully choosing receiving areas that exclude flood-prone locations like coastlines and instead concentrate development in inland and upland areas (Schechtman & Brady, 2014). Unlike the Pitkin County TDR program that tries to prevent the development of dangerous areas like steep hillsides, hazard mitigation is a secondary consideration for the Pine Barrens program though it creates a similar result.

Transferring Existing Development

All of the examples previously mentioned were developed to redirect future development. A major difference between those programs and a CATDR program is that the latter program type could specifically target areas with existing residential development. While a CATDR program might also shift unused development rights, it may have the greatest impact as a way to incentivize people to move away from developed areas with exceptional hazard risk. Traditional TDR and CATDR can result in the same outcome, preserved open space, but might begin with very different development typologies.

The Tahoe Regional Planning Agency's TDR program, in place since 1987, is one example of a program that is designed in part to remove existing buildings from inappropriate sites for development. Inappropriate sites are defined as Stream Environmental Zones, and demolition of an existing building followed by environmental restoration creates two related but separate forms of TDR credits necessary for development in the Tahoe Regional Planning Agency's jurisdiction (A. Nelson et al., 2012). This program is one of the most "innovative and complicated" programs in the US and includes requirements such as sending areas having to be more environmentally sensitive than receiving areas (A. Nelson et al., 2012, p. 179). In this program, environmental sensitivity is determined by its resilience to erosion, and where the most sensitive areas are allowed the least amount of land coverage (A. Nelson et al., 2012, p. 180). This program incentivizes the demolition of existing buildings in sending areas to reduce the overall amount of land coverage available (A. Nelson et al., 2012), and is a compelling precedent for CATDR programs because it recognizes that existing buildings may be sited in inappropriate areas but also provides compensation to landowners when they voluntarily demolish those buildings.

BACKGROUND ON TDR

This chapter provides additional background on TDR. Using TDR programs to facilitate climate adaptation is a new application of the tool that builds on a long history of TDR use in the United States. This chapter explains traditional TDR programs, describes elements that program planners can manipulate when setting up a new program, and concludes with a review of the state and local context of TDR programs in Massachusetts.

TDR HISTORY

Transfer of development rights originated in New York City's original zoning code from 1916, which "allowed landowners to sell their unused air rights to adjacent lots, which could then exceed the new height and setback requirements" (New York State Division of Local Government Services, 2015, p. 3). Later, the TDR program in New York City's historic preservation law was the focus of the influential 1978 Supreme Court case *Penn Central v. City of New York*, where Penn Central challenged the city's TDR zoning provision. The court sided with the city, which gave planning bodies around the United States confidence in the constitutional legality of TDR (A. Nelson et al., 2012). Since then, TDR programs have been used across the country to target different preservation objectives, though not all programs have been able to generate sufficient credit transfers to achieve their preservation or development goals (Bruening, 2008).

Today, TDR is primarily used for two reasons: to preserve historic buildings and development patterns, or to preserve existing open space and agricultural land. The former category of programs is similar to New York's program in *Penn Central v. City of New York.* In this scenario, a local government wants to prevent changes to historic buildings or neighborhoods. To enable this historic preservation, they need to find an alternative economic use for any unused development rights given to historic property owners in the local zoning ordinance. As of 2010, fourteen out of 239 programs across the country focused on this objective (A. Nelson et al., 2012). Many of the remaining 215 programs try to prevent future development to maintain traditional land uses. The most common objectives of TDR programs today are either preservation of valued environmental features such as open space, or prevention of urban sprawl encroaching on agricultural land uses (A. Nelson et al., 2012). Communities have tried using TDR for many other reasons. The Malibu Coastal Zone program tries to prevent new development on steep and remote hillsides to protect the environment and public safety (A. Nelson et al., 2012, p. 185). Others try to influence infrastructure capacity and expansion, like the TDR program in Goshen, New York, which uses TDR to encourage new development where public water and sewage infrastructure is already available (A. Nelson et al., 2012, p. 201). Most programs combine multiple goals into the same program, such as preserving animal habitats and preserving existing rural character (Kaplowitz et al., 2008).

TDR Program Elements

Regional planning agencies, counties, and municipalities have all implemented TDR programs in the United States. TDR programs require significant planning regardless of their jurisdiction, and there are three major program elements for a community to consider during the planning process. The first element consists of program details that structure the market for credits. One of the most important details to determine is the program's policy objective and jurisdiction. The policy objective drives the TDR program's sending and receiving area boundaries. The characteristics of the land included in the program then inform the incentive structure for the TDR credits. Larger programs at the regional or county level sometimes also consider whether TDR credits can be transferred across municipal boundaries, through a process referred to as inter-jurisdictional transfer. To implement TDR, the local zoning code must be updated to establish sending and receiving zones, define the TDR threshold, and allow additional density to be purchased with TDR credits. Ideally, TDR planning occurs in conjunction with a comprehensive plan update. The inclusion of TDRs in the comprehensive plan framework officially links program objectives with broader community goals and incorporates program decisions like new zoning densities with other zoning map and bylaw updates. TDR can be implemented without a comprehensive plan update, as long as strong links can be established between broader community goals and the TDR objectives, there is a community engagement process, and thorough real estate market research is completed. Determining the basic TDR market structure is essential to setting up a TDR program, but programs can be as simple or as complicated as the managing jurisdiction wants and often include many other details.

Best practice guidelines recommend that municipalities create a citizens' advisory committee to develop the TDR program details and manage its planning tasks in conjunction with planning staff (A. Nelson et al., 2012; Pruetz, 2003). This group works with the local planning agency to develop the TDR zoning ordinance, create and assess TDR sending and receiving area scenarios, receive public comments, and recommend a finalized TDR plan (A. Nelson et al., 2012).

Ongoing administration is the second major element of a TDR program. The local government needs to plan a system to educate the public and answer questions about the program, track sales, and complete a variety of other tasks depending on how complicated the program is. Administrative capacity can impact the success of the TDR program, so it is important to ensure that a public agency can manage these tasks on an ongoing basis.

Funding is the third element to consider in the TDR program set-up. In addition to program administration costs, TDR programs can use the funding to maintain a healthy credit market through TDR banks. A bank is not a required component of a TDR program, but it is a relatively common way to manage funding and administration. TDR banks are public entities "officially authorized by the community to buy, hold and resell TDRs" (Pruetz & Standridge, 2009, p. 85).[2] In addition to supplying funds, facilitating transfers, and providing price information, banks can also:

[2] In this context and other quotations throughout this research, "TDRs" refers to TDR credits.

> "provide continuity for a TDR program by promoting the use of TDRs, maintaining lists of potentially interested buyers and sellers, and assisting applicants with the paperwork for executing and recording deed restrictions. The TDR price established by a bank can serve as a benchmark and encourage private transactions that otherwise might not happen due to uncertainty about TDR values."(A. Nelson et al., 2012, p. 90)

TDR banks may contribute to the success of TDR programs because they alleviate temporal gaps between credit supply and demand. In some cases, they provide a way for the government to purchase credits as soon as sellers are ready, regardless of whether a buyer is available at that time. In other situations, they allow local governments to purchase credits at a low price and sell them at a high price. Funding to start a TDR bank needs to be available from third parties like state or federal grants, or local government funds. Some programs with banks can leverage "TDRs resold through the bank [to] generate new revenues to purchase additional TDRs", creating a revolving fund that alleviates the need for an ongoing funding stream (A. Nelson et al., 2012, p. 121).

Each of the three program elements – detail definition, administration, and funding - can be modified in endless ways to suit the community's ability and program needs. However, some configurations seem to work better than others, and TDR experts have compiled a list of qualities shared by the United States' most successful programs. A 2009 study looked at 20 articles about TDR best practices and isolated the 10 factors most often attributed to TDR program success. The authors then evaluated how many of the factors were present in the 20 TDR programs that have preserved the most acreage (Pruetz & Standridge, 2009).[3] Pruetz and Standridge (2009) summarized their findings as follows:

> "We find that all successful TDR programs create receiving areas that fit the community and offer development bonuses that developers actually want. Almost all successful programs also limit the amount of development potential achievable on sending sites, minimize the opportunity to circumvent TDR requirements and allocate TDRs to sending areas at ratios that create adequate compensation for landowners and affordable TDRs for developers." (p. 79)

Appendix A includes the list of success factors from the Pruetz and Standridge study along with commentary on whether each factor is relevant to TDR programs focused on climate adaptation.

[3] In the Pruetz and Standridge (2009) study, effectiveness was judged by the amount of land preserved through TDR credit sales.

TDR Success and Failure

While there are quite a few highly successful TDR programs, some struggle to achieve their program objective. As of 2010, the top five TDR programs in the United States accounted for 84% of total land preserved using TDR (A. Nelson et al., 2012). Forty percent of the total land preserved using TDR in the United States is from a single program belonging to King County, Washington (A. Nelson et al., 2012, pp. 12–13).[4] Acreage preserved is not the only way to measure TDR success as programs also target other objectives like historic preservation but it is a convenient way to compare programs. On the other hand, some cases like the East Cambridge TDR program in Cambridge, MA, have failed to generate any transfers at all (L. Paden, personal communication, October 21, 2019).[5] Nevertheless, planners often like TDR because it promises a win-win situation for the local government. Community assets like open space or historic buildings are preserved, development is concentrated in an area that makes sense for future growth according to the TDR program's designers, and the local government only has to provide minimal planning and start-up funding. However, it is very difficult to set-up a program that generates transfers.

The reasons why TDR programs fail to generate transfers are often attributed to the inverse of the program success factors listed in Appendix A. The fundamental reason for failure is the difficulty in setting up a functioning market. A lack of demand for density enabled by TDR in receiving areas, and the difficulty in creating development credits that have sufficient value for both sending and receiving landowners, are two fundamental challenges (Lane, 1998; Pruetz, 2016). Another challenge is that buyers and sellers may not be ready to complete a sale at the same time, though as mentioned above, this timing challenge can be mitigated with a TDR bank (Stenvenson, 1998). Also, local governments sometimes undermine TDR markets by enabling alternatives to achieving great density without paying for TDR credits, such as density bonuses included as part of inclusionary zoning or through exemptions granted as part of discretionary approval processes (Bruening, 2008; Lane, 1998).

On the other hand, calling a TDR program a success or a failure is often a subjective judgment that depends in large part on the evaluator's goals, and expectations may be too high for TDR (Lane, 1998). If a TDR program contributes any new acreage to a conservation portfolio, the program might already be a success for some communities. This relative success can occur even though some unsold rights may remain, because limited preservation is likely preferred to none at all, and TDR may be a better option for that community compared to other policy alternatives. TDR is one land use tool among many available to communities and should not be expected to achieve all of the community's planning goals (M. Walls & McConnell, 2007). A TDR program's success may be dependent on how well the program is incorporated into the long-term comprehensive planning of a community, and how dedicated the community is to

[4] According to *The TDR Handbook* (2012), the five US TDR programs that have preserved the most acreage are: King County, Washington (135,000 acres); the New Jersey Pinelands, New Jersey (58,500); Collier County, Florida (54,962); Montgomery County, Maryland (52,052); Palm Beach County, Florida (35,000).

[5] The East Cambridge TDR program, implemented in 2001, was designed to prevent new density in existing residential neighborhoods near Kendell Square, and to encourage density near public transit like the Kendell Square Red Line stop (Pruetz, n.d.).

achieving the plan's goals (Lane, 1998). Aside from any preservation resulting from the program, the process of creating TDR programs can benefit local communities by stimulating planning conversations. On the other hand, TDR programs are not cost-free, and program administration can use up limited funding and time that might be used for direct land purchases, grant applications, or the exploration of other land use tools. As part of planning a TDR program, communities should consider instituting a program evaluation process to periodically review the program and ensure that it is still providing more public benefits than costs.

TDR USE IN MASSACHUSETTS

Transfer of Development Rights programs are allowed in Massachusetts through the State Zoning Enabling Act Chapter 40A, Section 9. This section of the act reads:

> "Zoning ordinances or by-laws may provide for special permits authorizing the transfer of development rights of land within or between districts. These zoning ordinances or by-laws shall include incentives such as increases in density of population, intensity of use, amount of floor space or percentage of lot coverage, that encourage the transfer of development rights in a manner that protect open space, preserve farmland, promote housing for persons of low and moderate income or further other community interests; provided, however, that nothing herein shall prohibit a zoning ordinance or by-law from allowing transfer of development rights to be permitted as of right without the need for a special permit or other discretionary zoning approval." (Massachusetts General Laws, Chapter 40A § 9)

To establish a TDR program, a municipality in Massachusetts needs to create a specific ordinance or bylaw establishing the program details, as well as sending and receiving districts. The enabling act specifies several policy goals that the TDR program may address, including "further[ing] other community interests." Addressing municipal vulnerability to climate hazards would likely fall under the "further other community interests" category and qualify as a legitimate reason to establish a TDR program under the Enabling Act. As of 2012, there were fourteen active TDR programs in Massachusetts, with the majority intended to preserve environmental assets or farmland from development (A. Nelson et al., 2012).[6] None of the Massachusetts programs are included in the Pruetz and Standridge (2008) list of the most successful TDR programs because they have preserved relatively little acreage. The reason for this outcome is unclear, but may be attributed to the size, objectives, or program goals of the Massachusetts programs.

TDR programs are difficult for local governments to establish in Massachusetts because of a requirement in the State Zoning Enabling Act.[7] This section requires that any zoning ordinance or bylaw change or amendment be approved by two-thirds of the members of the ruling municipal governing body. TDR programs have to be established through zoning changes, so this super-majority requirement could prevent some programs from being created at all. An additional barrier to TDR programs in Massachusetts may be resistance to multifamily housing within local zoning. A recent study of towns in the Greater Boston area by Amy Dain found that "very little land is zoned for multi-family housing, and what is zoned is often built out to the capacity allowed" (2019, p. iv). TDR programs are designed to concentrate development in the receiving area. If a municipality is opposed to denser forms of development such as multifamily housing, it may be difficult to establish a suitable receiving area where a developer could profitably use TDR credits. While the report found a lot of resistance to rezoning for multifamily developments in neighborhoods already zoned as single-family residential, it also found "support for development in historic centers, former industrial properties, commercial corridors, and the peripheries of municipalities" (Dain, 2019, p. xiv). Due to the lower levels of resistance to new higher-density

[6] It is possible that there are new TDR programs in Massachusetts instituted since 2012.

[7] Chapter 40A, Section 5.

development in these areas, they may have the most potential as receiving areas for new TDR programs in Massachusetts.

The Executive Office of Energy and Environmental Affairs (EEA) sees promise in TDR and is actively promoting it as a Smart Growth tool. It is included as part of an online Smart Growth Toolkit, which touts the benefits of the program as a tool for environmental preservation and lists criteria for successful programs. The EEA has been authorized to establish a state TDR revolving loan fund to help municipalities capitalize local TDR banks, though the fund has not been created yet (Gaertner, 2019). This type of fund would enable local TDR banks to purchase credits without having a buyer ready to build a project in the receiving area (Gaertner, 2019). To receive funding for a TDR purchase, the site selling the TDR credits would need to be preserved in perpetuity with a permanent deed restriction,[8] and the local TDR bank would need to repay the state fund within five years to avoid accruing interest on the loan (Gaertner, 2019). This means that the TDR credit would need to be sold within that time frame or the town would have to finance the loan repayment by some other means. While this revolving fund would facilitate the sale of credits out of the sending area, it places the financial risk on the municipality. However, it also incentivizes municipalities to permit new development that could purchase the banked TDR credits.

[8] Specifically, a conservation restriction.

TDR AS A CLIMATE ADAPTATION TOOL IN WESTPORT, MA

METHODOLOGY OVERVIEW

As discussed in Chapter 3, there are no implemented TDR programs that are specifically attempting to adapt a community to climate change. Therefore, this report cannot evaluate existing programs on their effectiveness. Instead, this chapter will create a hypothetical TDR program for Westport, MA, and then assess how well it reduces hazard risk. Westport, MA, was chosen as the case study community because it is a coastal community with recent planning documentation that can be used as a proxy for the research and community engagement that would be undertaken during TDR program planning.

This exercise is intended to explore whether TDR makes sense for this policy objective at a basic level and to confirm or refute the expectations that planning experts have about CATDR. For that reason, this hypothetical program was not designed to be the optimal version of a TDR program targeting climate adaptation. Instead, a basic TDR program with very modest objectives has been applied to Westport, to reflect the planning constraints that many communities face when designing this type of program. If a simple program is shown to have generally positive outcomes for Westport's overall vulnerability to climate change, then future research can evaluate how to optimize the program and the market design to improve these results.

A few different methods were used to design and evaluate Westport's hypothetical TDR design. Research began with a review of planning documents to collect background information and build a picture of Westport in the absence of site visits.[9] Fortunately, the town recently conducted a Master Plan update, drafted a Housing Production Plan, and has publicized a significant quantity of historical reference material through its historical society. The town is also engaged in the MVP program, which has provided additional documentation specifically focused on the town's climate vulnerabilities and initial climate adaptation planning efforts. GIS methods were used to conduct exploratory research, including an assessment of sea-level rise and its impact on existing buildings. GIS was also used to get a better sense of Westport's real estate market, and how zoning guidelines relate to land value. Appendix B describes the data and methods used to complete the market analysis. This analysis included designating sending and receiving areas for the program, supported by concepts found in Westport's planning documentation. Assessor data was then joined to parcel data in the two TDR areas and was extracted into an Excel model that estimated TDR market metrics, which was loosely based on guidelines from *Beyond Takings and Givings*, a book about TDR best practices (Pruetz, 2003, pp. 119–166). To supplement the GIS assessment and background documentation on Westport, interviews were conducted with two local officials familiar with the Westport planning context, as well as a regional planner experienced in climate adaptation planning and familiar with Westport.

[9] Site visits were not possible due to the COVID-19 outbreak.

RESEARCH LIMITATIONS

There are innumerable details that can be modified in building a TDR program, and ideally, a new program would include a thorough planning stage to discuss how program details might be optimally configured. The planning process for Westport's hypothetical TDR program was simplified and did not include stakeholder engagement, a complete real estate market analysis, or even precise environmental data. Instead of crafting an optimal TDR program, this report develops a basic program model informed by standard TDR best practices but only implementing the best practices that seem relevant to Westport.

Also, the original research design included four case studies to compare how TDR would work across communities with different planning capacities and real estate market typologies. However, the research was narrowed to Westport exclusively to dive deeper into a commentary on the specific challenges and opportunities of TDR at moderating risk and reducing collective vulnerability to climate change. While this approach will not answer questions about the scale of impact that this type of TDR program might have across the state, it will more thoroughly investigate how well this policy solution might achieve its stated objective.

WESTPORT TDR PROGRAM

COMMUNITY BACKGROUND

Westport is a small coastal town in Southeastern Massachusetts that shares its western border with Rhode Island. The town's 2017 population estimate was 15,810, though the town receives a population influx every year from summer tourists (Master Plan Update Committee, 2016; US Census Bureau, 2017). It is primarily a rural community that prides itself on its farming and fishing industries, as evidenced by its town slogan: "The Coastal Agricultural Resource Community of Massachusetts". Residential and commercial development is widely dispersed along the town's major roadways, with limited density clustered around historic village centers.

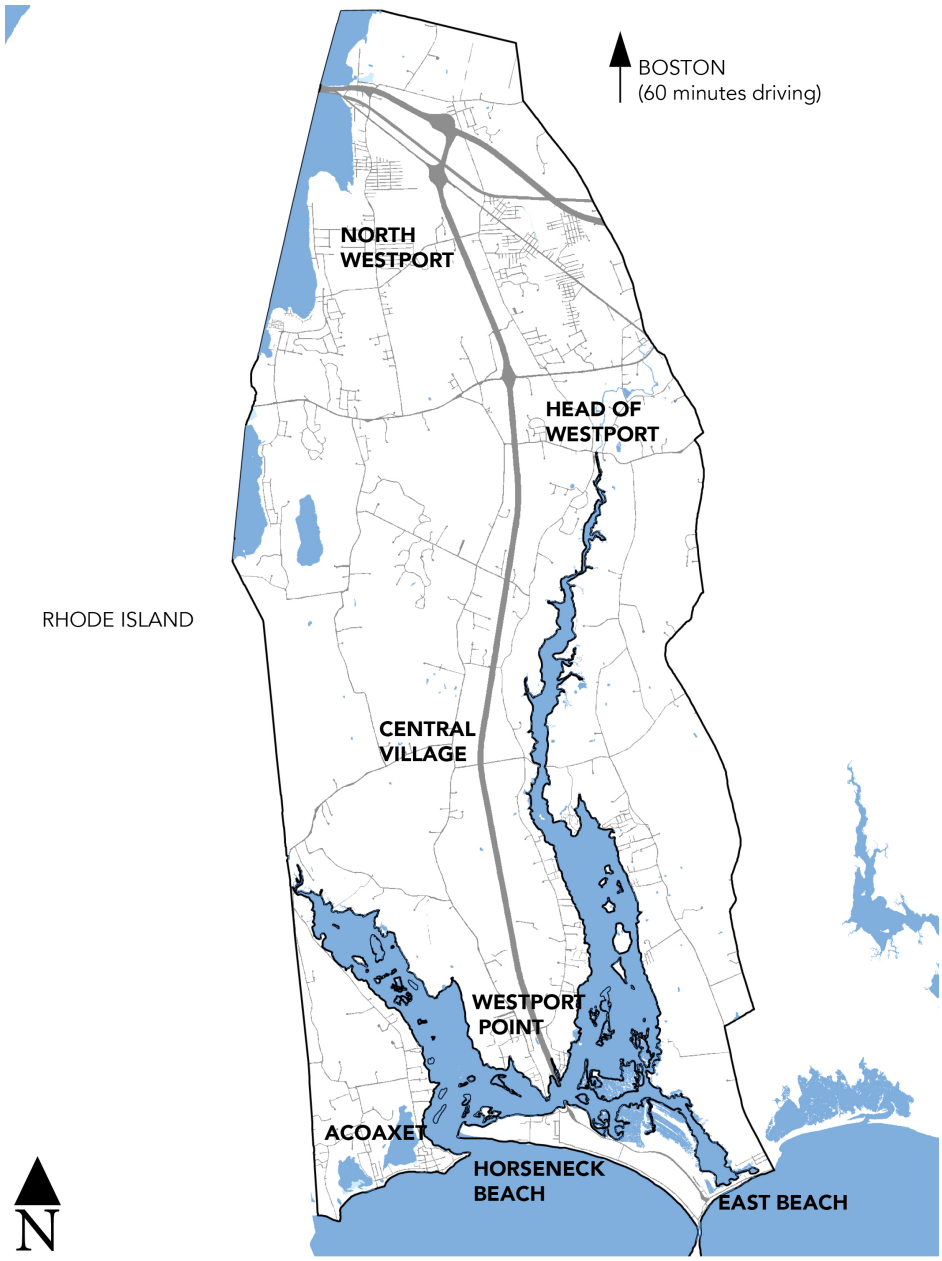

Figure 3: Map of roads, highways, and villages in Westport, MA.

Westport is built around two branches of the tidal Westport River (Town of Westport, MA, 2018). The town has experienced recent flooding from severe storms, which have damaged buildings, overwhelmed culverts, and have caused access and evacuation challenges (Town of Westport, MA, 2018). The town's MVP workshop report cites "coastal storms, sea-level rise, and increasing temperature" as climate change-induced hazards that are already impacting the town (Town of Westport, MA, 2018, p. 2). An additional challenge Westport faces is the demand for water-front living, which has led to the conversion of many summer holiday homes into year-round residences, increasing property values and intensifying the use of properties that may be at high flood risk (Master Plan Update Committee, 2016).

The town has a few planning problems in addition to climate-related hazards. Westport residents have a strong preference for low-density, single-family residential development, but this desire conflicts with other housing and environmental needs (Master Plan Update Committee, 2016). The 2016 Master Plan mentioned the lack of rental units, and the critical need for new multi-unit, elderly, and affordable housing. There is currently a high demand for summer rentals and this has contributed to the low-availability of year-round rentals, which had a zero percent vacancy rate in 2015 (Master Plan Update Committee, 2016). As of 2012, Westport needed to nearly triple the number of affordable housing units available to meet the state's Department of Housing and Community Development's 10% affordable quota (Master Plan Update Committee, 2016, p. 5–2). Multi-family housing development might help alleviate the need for affordable and rental housing, but "virtually the entire town is uniformly zoned for single-family or duplex dwellings on 60,000 square foot or larger lots" (Master Plan Update Committee, 2016, p. 5–1). In the past, the town successfully re-zoned areas for specific projects like an overlay zone that accommodates 54 units of mixed-income multi-family housing, and a 48-unit age-restricted apartment building near Central Village. However, the lack of broad support for denser development, and the existing land use and dimensional restrictions, handicap the town's ability to meet the housing goals of its Master Plan. Denser forms of development in Westport are also constrained by the "lack of public water and sewer systems [which] tend to limit new development to standard subdivisions, driving housing costs higher" (Master Plan Update Committee, 2016, p. 5–1).

The housing section of the 2016 Master Plan recognized the limitations of Westport's existing development patterns and called for developing new nodes of density in the town as a way to continue growing without promoting sprawl. However, the planning board has yet to redraw any zoning maps to allow for additional density in certain areas.

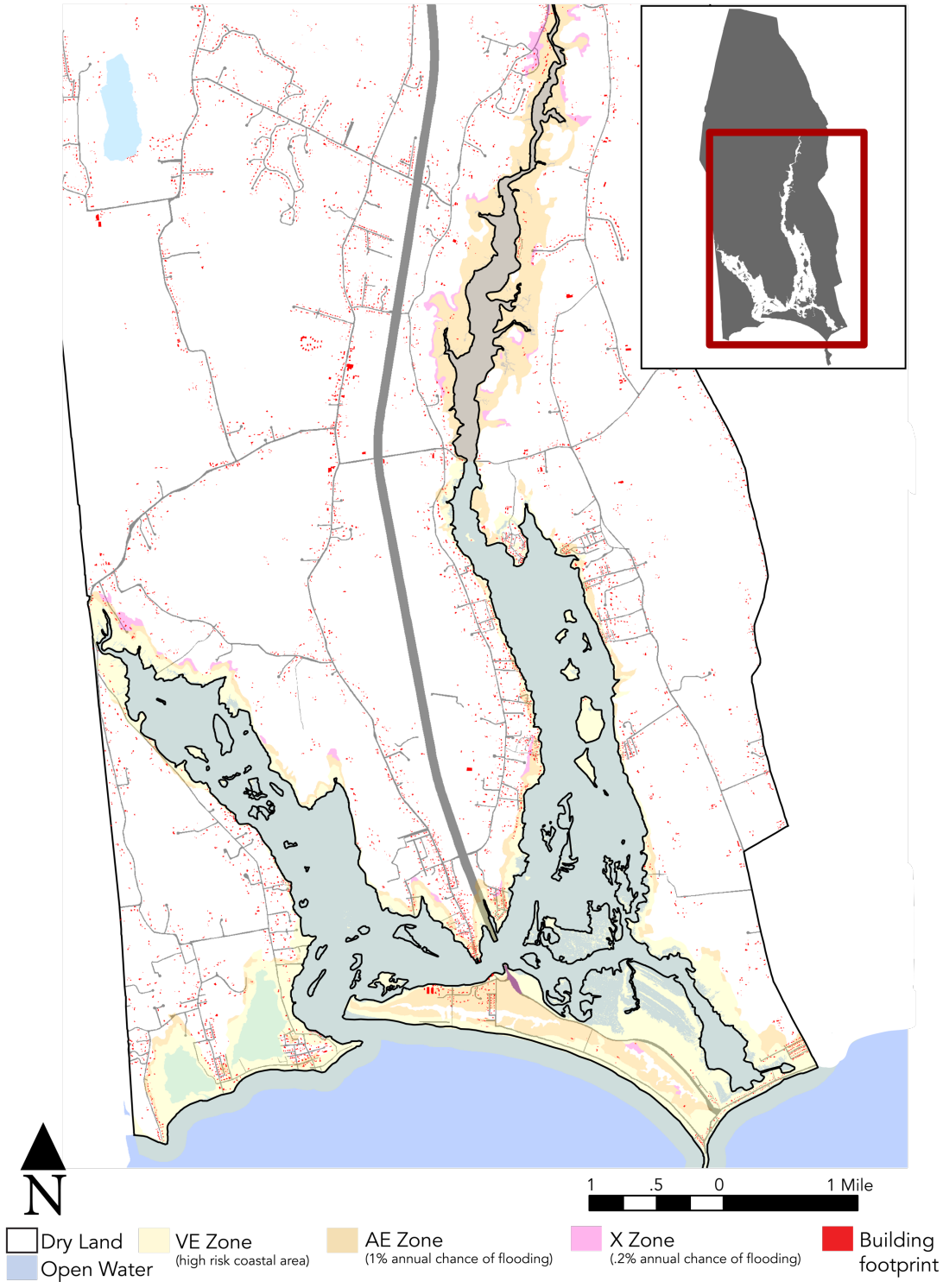

Figure 4: Map of existing FEMA flood zones and building footprints in Westport, MA. The FEMA flood zones incorporate risk from storm surge but do not factor in change over time due to sea-level rise caused by climate change.

TDR Program Description

The primary goal of the hypothetical TDR program for Westport is to move full-time residents out of East Beach, the area of town that is most difficult to defend from sea level rise. The Westport TDR program has been designed as a voluntary buy-out program that incentivizes residential homeowners to leave the sending area. The town will be responsible for managing the program but will benefit from reduced emergency management risk in the East Beach area, and from the ability to capture incremental value from increased density in the receiving area. The TDR program in Westport is designed to be administratively simple and easily managed by municipal staff. TDR credits can only be used in the designated receiving area, which is also within town limits.

Owners of property in the sending area will be allocated credits based on the assessed values of existing buildings. This allocation scheme reflects the differences in assessed value amongst the properties. However, the TDR credit price will vary based on demand in the receiving area and there is no mechanism to guarantee a minimum credit sale price for sending area owners. The variable TDR credit sale price is intended to facilitate transfers that might be prevented by a mandatory price floor. The TDR program is intended to provide sending area owners with some compensation if they move before their homes are permanently flooded. It is an alternative to a federal buyout program, and allows residents to be proactive in managing their flood risk without investing thousands in elevating and floodproofing their homes.

Receiving area property owners are incentivized to participate in the program by the potential for profit from the increased density enabled by TDR. With the use of a TDR credit, a 60,000 square foot lot in the receiving area could double its density to one unit per 30,000 square feet. An owner of a typical 60,000 square foot residential lot could net over $50,000 in profit after doubling their lot density with a TDR credit.

The TDR sending area, receiving area, and credit market will be discussed in further detail in the following sections.

Coastal Flooding Program Assumptions

TDR programs modify many different program parameters. When the goal relates to climate change, one of the parameters could be the climate change scenario that the program is based on. This program uses 5 feet of sea-level rise as the basis for designating the sending area. Sea level rise (SLR) data was sourced from the National Oceanic and Atmospheric Administration (NOAA), which projects that five feet of sea-level rise (from the year 2000 baseline) is possible in Newport, Rhode Island, by 2063, according to the most extreme Global Mean Sea Level Rise scenario (National Oceanic and Atmospheric Administration, n.d.).[10] This sea-level rise height is possible by the year 2100 according to three of the six SLR projections produced by the NOAA (National Oceanic and Atmospheric Administration, 2017b). This SLR height was chosen because it is likely to have a significant impact on the built environment in coastal Massachusetts,

[10] Newport is the closest NOAA data collection point to Westport, so is used as the reference data for this analysis.

including Westport. It makes sense to use a long-term planning scenario rather than a flooding scenario that is more likely to happen in the near-term because TDR is a long-term planning solution.

The NOAA SLR data is an imperfect representation of future flood impacts on Westport but is the best data publicly available at present. This model is based on a "bathtub approach" that shows land as flooded if its elevation is lower than the estimated water level, but does not account for local flood mitigation strategies like elevated building foundations, or "future changes in an area's hydrodynamics" like erosion or subsidence (Massachusetts Office of Coastal Zone Management, 2017). Thus, it can only approximate whether areas will be flooded due to sea-level rise. It also only displays future mean sea levels and does not include storm surge, which would cause much more extensive flooding than is projected by the NOAA SLR scenarios. Further assessment that incorporates local elevation measurements, wave dynamics, and potential flood pathways should be conducted before sea-level rise projections are used as part of real-life adaptation planning in Westport.

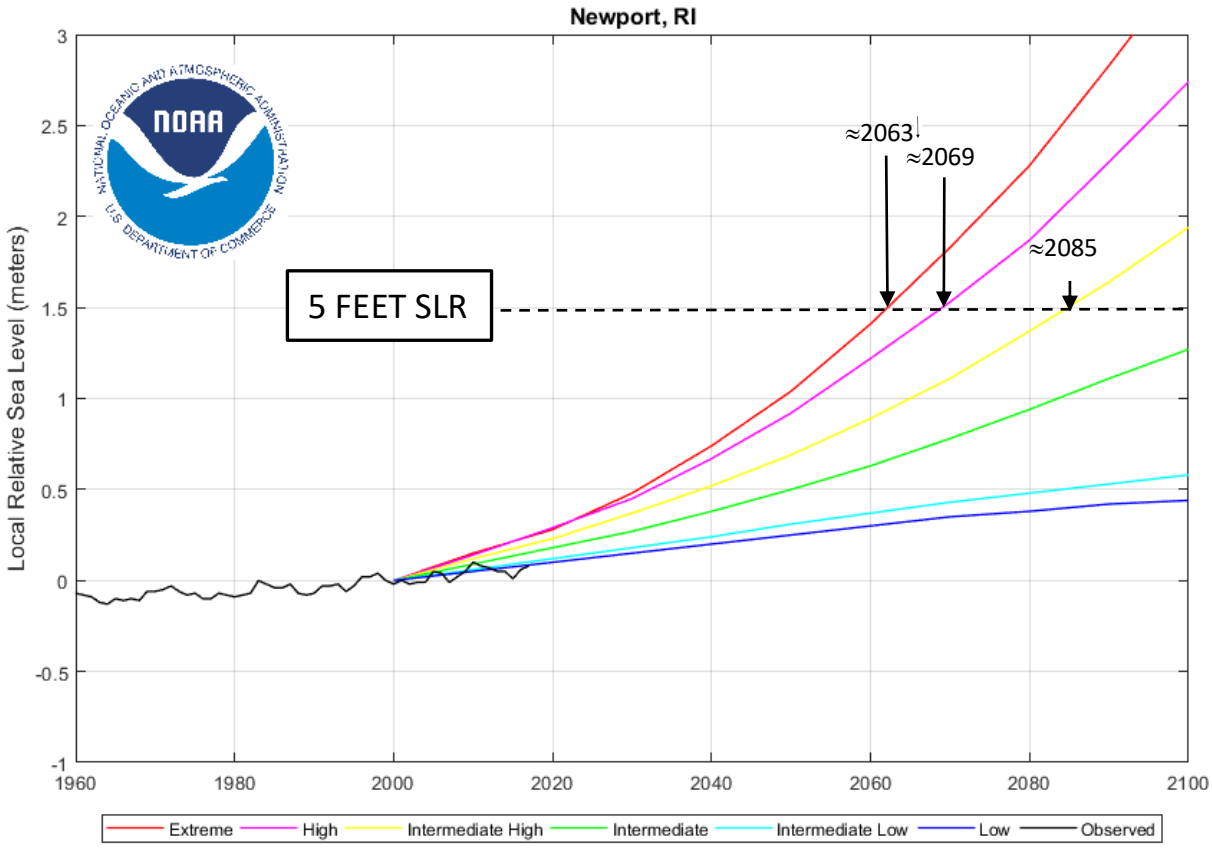

Figure 5: Newport, Rhode Island, sea-level rise scenarios produced by NOAA. a Relative sea-level rise of 5 ft is possible as soon as approximately 2063 for the Extreme Global Mean Sea Level Rise scenario. Source: National Oceanic and Atmospheric Administration (NOAA).

SENDING AREA: "EAST BEACH"

The initial TDR sending area in Westport will consist of residential parcels along East Beach and Eastern Horseneck Beach in Southeastern Westport. East Beach and Horseneck Beach are part of a barrier island system near the outlet of the Westport River. While the entire barrier system, including around 80 homes, is at risk from hazards induced by climate change like coastal flooding, East Beach is already challenged by severe winter storms that overwash the beach (Town of Westport, MA, 2019). East Beach is also more isolated, and less densely settled than the other low-lying coastal communities in Westport like Westport Point and Acoaxet. Severe hurricanes in the early 20th century decimated the summer village of East Beach, and since then ecological changes have shifted the water line landward as shown in Figure 8 (Westport Historical Society, n.d.-c). Today, the main road through East Beach is "only a few feet above current monthly higher high tides" (Town of Westport, MA, 2019). Complete overwash of the beach could mean the loss of one of the barrier system's two evacuation routes, as well as "the total loss of power and the telecommunications and potentially a secondary opening of the Westport River to the ocean with the resulting risk to its ecology" (Town of Westport, MA, 2019). The area was noted as an especially vulnerable area in the town's MVP report, and in 2019 the town was awarded a $75,000 MVP Action Grant for an East Beach Corridor Vulnerability Assessment (Executive Office of Energy and Environmental Affairs, 2019). The vulnerability assessment is still in progress, so its final recommendations are unknown.

Figure 6: East Beach today in the summer. The primary land use is "seasonal use", which allows portable trailer homes. Source: www.milburyre.com.

Historically, East Beach was a community of summer cottages and a small commercial strip, which catered to working-class vacationers from nearby towns. Today, the area is primarily used to park trailer homes in the summer months and has very few permanent dwellings. Of the 157 parcels included in the sending area boundary, only 32 parcels are classified with residential land use, including five lots with multiple units on a single parcel. 103 of the remaining 125 parcels are classified as seasonal camps and are used to park trailer homes, with the remaining parcels classified as unbuildable, vacant, or are owned by state agencies. The 32 residential parcels will be the only properties eligible for TDR credits because they have permanent structures and can be used as year-round residences. Full-time residence in East Beach imposes a risk to the area's residents, and a burden on the municipality in provisioning basic services like road maintenance, utility access, and emergency response. Several of the residential building footprints appear to be flooded in the 5 feet of sea-level rise scenario, along with many of the trailer footprints (see Figure 7**Error! Reference source not found.**). However, the NOAA SLR data is based on the elevation of the land, so flooding estimates do not take local adaptation measures into account. Some of the residential homes appear to be elevated (see Figure 9 for an example), though this may be irrelevant to their future livability as most of the lots will also be flooded under normal tidal conditions in the 5-foot SLR scenario. Of the 32 residential parcels, only seven appear to be their owner's primary residence according to public tax assessment data. The remaining 25 are either used as rentals, or as second homes.

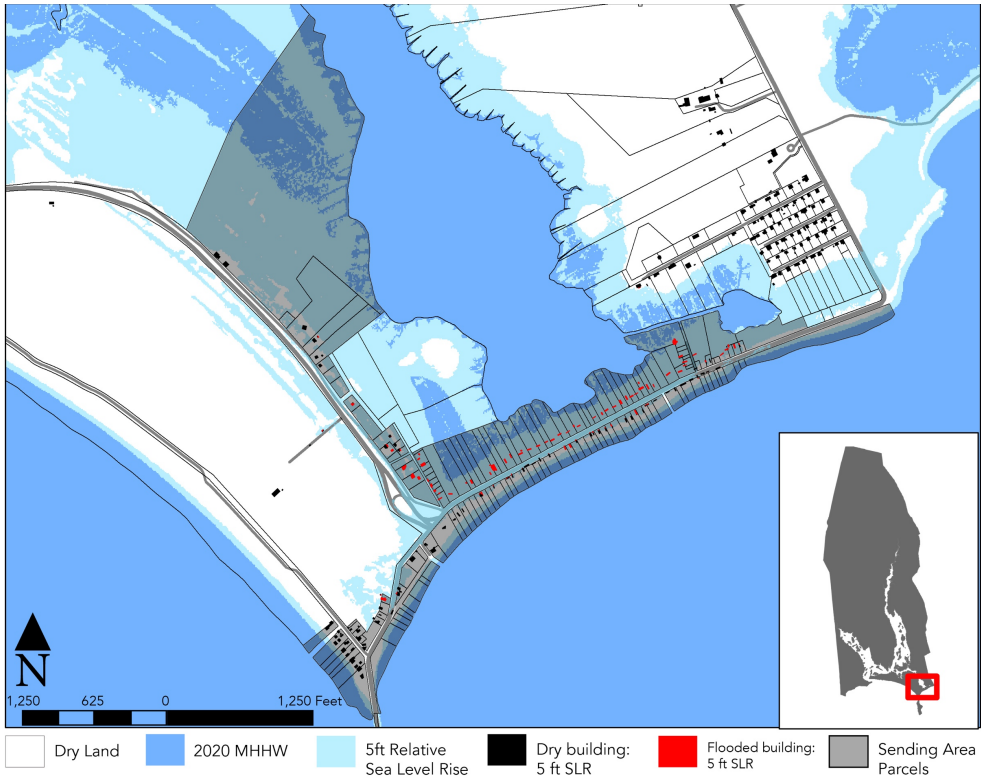

Figure 7: East Beach Sending Area parcels with 5 feet of sea-level rise (light blue) and today's mean tidal elevation (dark blue). Neither water elevation includes storm surge, which is likely to impact all non-elevated buildings East Beach based on boundaries show on the current FEMA VE zone (see Figure 4). Buildings flooded in the 5 feet SLR scenario are shown in red, while dry buildings are shown in black.

Figure 8: Today's coastline along the eastern section of East Beach, with building outlines pre-dating the 1938 hurricane shown in yellow. Source: Westport Historical Society.

Figure 9: Foundation elevation in progress for a home in East Beach. Source: Regional planning official, 2020.

Figure 10: Two images of East Beach road after it was overwashed by flooding during Hurricane Irene in 2011. Source: https://buzzardsbay.org/enjoy-buzzards-bay/weather/storms-hurricanes/tropical-storm-irene-buzzards-bay/.

Since seasonal camps are the predominant existing land use in East Beach, the Westport TDR program will allow owners of sending parcels to choose to retain the title of their land and rezone it as a seasonal camp or to deed the land to the municipality. In either case, the sending area landowner will be responsible for demolishing any structures on the sending parcel and properly disposing of the debris within 12 months of the TDR credit sale. To enforce compliance with this provision, Westport could hold 25% of the TDR credit purchase value until it verifies that demolition has been completed. If the land is deeded to the municipality, they can decide whether to pursue ecological restoration on it, but sending area owners will not be expected to do so. It is expected that as sea levels rise, sending area landowners will increasingly decide to deed their property to the town, as water levels may make many lots unviable even for portable trailers. The potential retention of the land for seasonal use justifies the approximately $110,000 discount that the owner will see when comparing their current assessed value to the estimated credit value they will receive. While the municipality would still need to maintain the East Beach road and utilities if residents continue to use the area for seasonal use, transitioning the area's land use to only seasonal occupation might alleviate some of the emergency management burden for the town government. Encouraging occupation only in the summer months by forms of housing that can be evacuated at short notice would reduce the physical vulnerability of East Beach landowners while enabling the area to continue contributing to the town's seasonal economy.

The thirty-two residential parcels in the receiving area have a combined property value of approximately $11 million. Based on the estimated pricing of TDR credits,[11] 131 credits are expected to be needed to induce all residents to leave the area. This TDR design choice assumes that residents would need to be compensated with at least the present fair market value of their homes to participate in the program. Reference Appendix B for a full discussion of the calculation methodology.

Market Factor	**Definition**	**Sending Area TDR Scenario**
Number of parcels	Total parcels included in scenario.	14
Total asking value	The total assessed value for all parcels in the sending area minus each parcels' potential land value associated with seasonal land use.	$11,107,162
TDR credits needed	The expected number of TDR credits needed to meet the total asking value. The estimated number of credits is based on the TDR credit price of $85,191.	131

Table 1: Westport Sending Area Parcels.

[11] The estimated TDR credit price is 60% of the estimated TDR credit value: $85,191. The estimated TDR credit value is based on the estimated development value of a parcel suitable under Westport's existing zoning for one residential unit in the receiving area: $141,986.

RECEIVING AREA: CENTRAL VILLAGE

Westport is a low-density community. There is no traditional downtown or main street neighborhood, and no specific districts where the town is actively trying to encourage new density. However, there are a few nodes of residential and commercial activity where the town could promote new density in the future, including around highway US-6 and historic villages. Central Village is one of the historic village centers and will be designated as the TDR receiving area.

Figure 11: Central Village from the perspective of Main Road. The area is a mix of historic buildings, auto-centric commercial developments, homes, and open space. Source: Google Maps.

As the name suggests, Central Village is centrally located along both the north-south and east-west axes of the town. It has access to both sides of the Westport River. Municipal buildings, a graveyard, historic structures, and some existing commercial development are all clustered along Main Road. According to the local historical society, it is the "unofficial town center" of Westport (Westport Historical Society, n.d.-b). It is known within the town as a commercial area, where residents can do their basic shopping from small local businesses (Pateakos, 2012). Like much of Westport, it is not designed to be walkable and is not served by public transportation. Residential land use, protected open space, and land zoned for multiple uses are interspersed with and surround the commercial parcels. Much of the land zoned for multiple uses in this area appears to be farmland.

As previously mentioned, the 2016 Westport Master Plan supports increased density in this area of Westport. A summary of public input sessions proposed a potential goal of increasing density of housing in Central Village, while another section of the document affirmed that Central Village surrounding Main Road should be the "primary location for new residential development" in the town (2016, pp. 5–4, 9–3). The Master Plan also stated that:

> "The review and revisions of zoning by-laws should continue, particularly for Central Village, where a mix of desirable types of businesses and private residences should be encouraged on available land just outside the existing business zoning where further economic development appears feasible."(2016, pp. 3–2)

There is an opportunity for the town to use TDR to build density. TDR enables landowners to build above the density normally allowed by zoning. Instead of rezoning the area to allow higher densities by right, the town could enable denser residential development only with the use of TDR credits. The new Central Village receiving zone would apply to lots with existing residential zoning or lots designated as buildable for residential construction. It would maintain the existing by-right zoning density of one unit per 60,000 square feet but TDR usage would enable a developer to double the number of units allowed to one-unit per 30,000 square feet. At one-unit per 30,000 square feet, each house would be on a lot over half an acre in size. This analysis assumes that doubling the lot density to one unit per 30,000 square feet also doubles the lot value, as there seems to be a low premium on residential land in Westport aside from its value as a building site.[12] However, new construction involves additional costs like septic system installation, and a landowner purchasing a TDR credit will want to make some profit off of their investment, so the price of a TDR credit has been adjusted to 60% of the expected incremental value of increased density in the receiving area.

The ability of developers to construct at greater density without purchasing TDR credits impacts the likely demand for credits. The town's zoning bylaws allow for some additional ways that landowners can build residential units on smaller lots without purchasing TDR credits. Non-conforming parcels that were created before 1982 are exempted from the one unit per 60,000 square feet minimum (Westport Zoning By-laws, Article 7.5). Also, the articles for Assisted and Independent Living Facilities (Article 11), Inclusionary Housing (Article 13), and Open Space Residential Developments (Article 18), all enable smaller minimum lot requirements under specific conditions. Demand for credits in the hypothetical TDR could be negatively impacted by these alternative means of securing exceptions to the minimum lot requirements.

The likely demand for credits is also influenced by several factors that may limit the construction of additional residential units in the Central Village area. They include the lack of municipal sewage and water systems, and the associated environmental regulations for installing septic tanks and wells (Master Plan Update Committee, 2016, pp. 6–1). Residential lots are required to have at least 30,000 square feet of contiguous upland to be considered buildable for a single unit, ostensibly to limit construction in ecologically valuable and vulnerable wetland areas (Westport Zoning By-laws, Article 7.0). As seen in Figure 13, many lots include areas of wetland in the Central Village area. The environmental limitations inherent in some of the receiving area lots are embedded in the "Likely Units" with and without TDR

[12] The premium on residential land across Westport was estimated by comparing the land value small non-conforming residential lots (up to 25,000 square feet) with larger lots zoned for a single-family home (between 55,000 and 80,000 square feet). The average difference in value was only $28,000, which represents the additional value attributed to a much larger backyard. This is only a rough estimate as it ignores all other variables that might impact the relative price of land like location, environmental characteristics, and scenic value.

estimates. These figures attempt to estimate the number of buildable units on the parcel based on how much land is suitable for building. The assessed land value for each parcel is divided by the estimated land value associated with as-of-right zoning for a single residential unit to understand the number of units likely to be built under current zoning, and the total buildable square footage for each lot. These series of calculations assume that the assessed land value is negatively impacted by factors like the existence of wetlands that limit how much of a parcel's square footage is reasonably buildable.[13]

A final limiting factor is potential resistance from owners with existing units, who may be hesitant to sub-divide their lot because of an unwillingness to welcome neighbors, or who may be unable to do so because of other zoning regulations like minimum frontage requirements.

Finally, parcels with preserved open space have been excluded from the receiving area entirely.

[13] This is an important factor to include in the market calculations. Some of the lots in the receiving area are much larger than others but have a relatively low assessed land value. There are many factors that may influence land value, but this analysis assumes that potential development value is the primary influence.

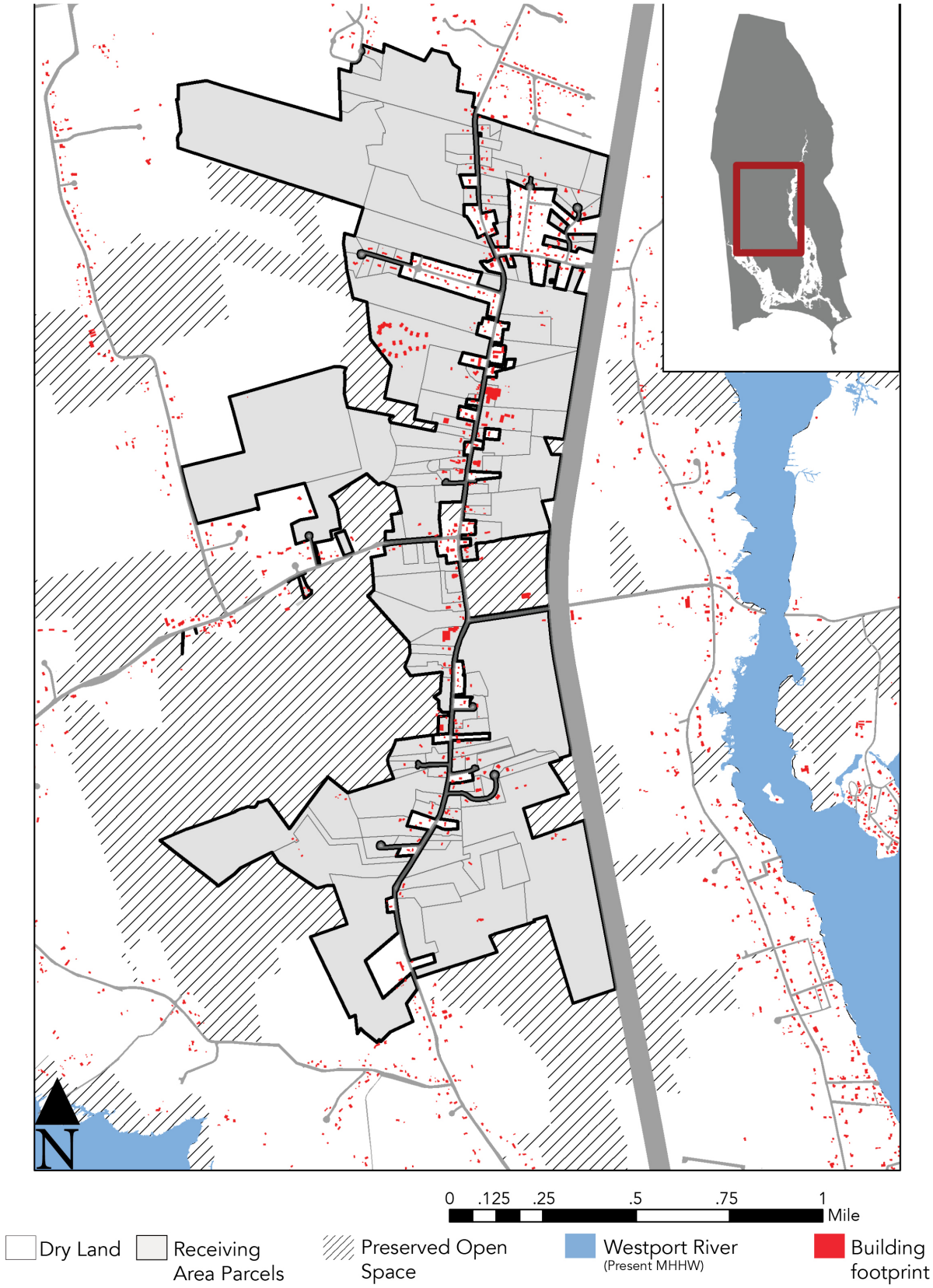

Figure 12: Map of Central Village TDR Receiving Area.

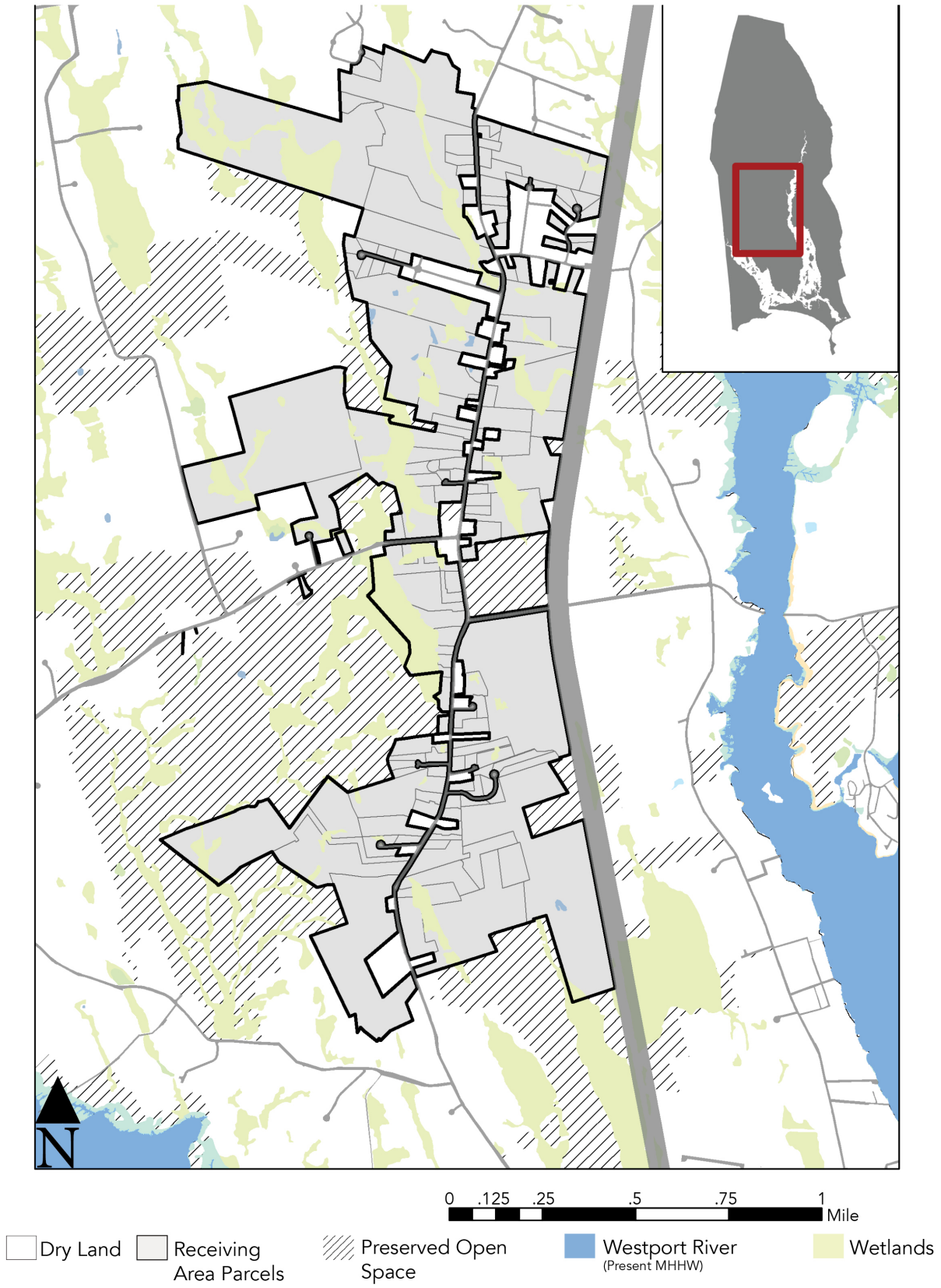

Figure 13: Wetlands in the Central Village receiving area.

Receiving Area Demand Scenarios

Limitations on TDR demand is shown by the difference between the two receiving area scenarios used in the TDR market analysis. Scenario 1 only includes only parcels classified as vacant but buildable according to the land use code in the property assessment database. There are only a few of these parcels in the receiving area, but the landowners may be more likely to want to participate in the program. Scenario 2 includes the vacant but buildable parcels from scenario 1 but also includes an additional 65 parcels that have existing single-family residential units. Landowners in scenario 2 may be less likely to want to purchase TDR credits because they are satisfied with their land's existing zoning. The possible TDR demand for each scenario varies because much more land area is included in scenario 2. Scenario 1 may be the more realistic demand outcome for Westport's hypothetical TDR program given the expected attitude of landowners in the sending area.

Market Factor	**Definition**	**Scenario 1: Only Buildable Parcels, Excluding Existing Residential Land Use**	**Scenario 2: Buildable and Existing Residential Parcels**
Number of parcels	Total parcels included in scenario.	14	79
TDR threshold	Minimum lot area requirements in existing residential zoning.	1 unit / 60,000 sq. ft.	1 unit / 60,000 sq. ft.
Max. density with TDR	The new minimum lot area allowed with the use of a TDR credit.	1 unit / 30,000 sq. ft.	1 unit / 30,000 sq. ft.
Max. theoretical increment	The density that a land owner gains by using a TDR credit.	1 unit / 30,000 sq. ft.	1 unit / 30,000 sq. ft.
Likely units without TDR	The number of units that are estimated to be built under existing zoning, assuming that some land may not be well-suited for development.	17	93
Likely units with TDR	The number of units that are estimated to be built with TDR credits.	28	143
Existing units	The number of existing residential units on parcels.	0	63
Possible TDR demand	The maximum expected demand for TDR credits from parcels included in the scenario.	11	40

Table 2: Receiving Area Demand Scenarios.

WESTPORT TDR EVALUATION

TDR programs do not always work as well as their planners hope they might. The following section examines the hypothetical Westport TDR program in detail to assess whether the program design and local real estate market are likely to yield credit transfers that would significantly reduce the permanent population of East Beach. However, the program's intended result of moving residents out of East Beach will also be evaluated in detail to assess whether the advantages of this strategy benefit or detract from the town's overall climate resilience. The goal of this section is to determine whether TDR for climate adaptation is a policy that Westport should consider implementing in reality.

PRESENCE OF TDR SUCCESS FACTORS

The following section will discuss the hypothetical Westport TDR program in the context of the ten TDR success factors from the 2009 Pruetz and Stanridge study "What Makes Transfer of Development Rights Work?: Success Factors From Research and Practice", which are listed in Appendix A. They are used to prompt commentary on how the program is structured, and are not a set of required characteristics for the Westport program as some are less relevant for a TDR program that is not focused on environmental asset preservation.

DEMAND FOR BONUS DEVELOPMENT AKA REAL ESTATE DEMAND

It is unclear whether there would be demand for single-family residential lots sized at 30,000 square feet in Westport. While 60,000 square feet lots are the current minimum lot size for residential zoning, many smaller non-conforming lots exist in North Westport so smaller lots are not an unfamiliar typology for the area. A local official noted that recently the town has seen 60 to 80 residential building permits per year, almost exclusively for single-family residences, and primarily on "large" lots.[14] The new construction is not concentrated in any particular area of town. The town's most recent Housing Production Plan indicates that building growth is likely to slow in the near-term due to a leveling off of population growth in the town, estimated at 1.4 percent between 2020 and 2025 (Town of Westport, MA, 2017, p. 26). However, it is unclear how Westport's population dynamics and the real estate market might change in the longer term. It may be some time before sending area residents feel compelled by rising sea levels to sell their TDR credits, so the uncertainty of long-term real estate demand is a major risk for this program.

CUSTOMIZED RECEIVING AREAS

The TDR receiving area for this program was chosen based on comments in the town's 2016 Master Plan, which indicated in multiple instances that this area of town should be targeted for future development. Central Village already contains a major road, easy access to all regions of the town via MA-88 and Hix Bridge, and significant existing commercial facilities. Additionally, drinking water and wastewater have to be handled on-site, so the construction of and investment in new municipal infrastructure does not appear to be a major barrier to additional development. However, the Master Plan did not specify the boundaries of Central Village, nor the type and intensity of development that should be promoted so the proposals

[14] The interviewee did not explain what they mean by "large" but may have used that term as a differentiator from smaller, non-conforming residential lots.

of the TDR program may not align with what the plan's authors intended. Also, without community engagement, it is unclear whether existing property owners would be interested in purchasing TDR credits or would even support additional density in their neighborhood.

Strict sending area zoning

In traditional TDR programs, strict sending area zoning can prevent owners of properties in the TDR sending area from being able to achieve development densities that might incentivize them to build on their land rather than sell their development rights. If TDR credits are an incentive for land preservation, strict sending area zoning is a disincentive for land development. This success factor is less important for CATDR programs, where the sending area is a populated shoreline that is already near its maximum density. In Westport's case, the sending area has only five vacant parcels and all are publicly owned. Since Westport is trying to limit vulnerability on Each Beach, these parcels are unlikely to be developed.

Landowners in this area are also relatively restricted in what they can do on their land due to the coastal location. While no specific regulations are preventing the development of coastal areas in Westport's zoning bylaws, the entire East Beach area is in FEMA's Coastal VE zone. This designation means that new construction or significant improvements to existing buildings must comply with heightened building code requirements. For example, all new construction and substantial building improvements must be elevated to keep the entire bottom floor above the wave height of a base flood storm surge (FEMA, 2019a). The heightened building code requirements for this area may disincentivize the redevelopment of existing buildings and encourage landowners to sell TDR credits rather than pay for flood-proof construction.

Alternatives to TDR

Westport's zoning bylaws enable some alternative ways to increase density other than through TDR credit purchases. They include relaxed intensity restrictions for assisted and independent living facilities (Article 7.2.1), Inclusionary Housing (Article 13), and Open Space Residential Development (Article 18). For Inclusionary Housing projects of 10 or more units where at least 10% of the units are affordable, the Planning Board (also known as the SPGA – Special Permit Granting Authority) may grant up to "two market rate units for each affordable unit provided as part of compliance with this By-Law"(Article 13.5.5). Open Space Residential Development (OSRD) is a method for subdividing lots of at least 5 acres, clustering development on the parcel, and then preserving the original parcel as open space. OSRD reduces the minimum lot size for single-family construction to 20,000 square feet of upland (Article 18.7). The combined use of Inclusionary Zoning and Open Space Residential Development can produce a net increase in housing units up to 50% of the original property yield before the application of density bonuses (Article 13.5.5).

Seventeen of the lots in the receiving area are greater than five acres and thus might qualify for OSRD. The minimum lot requirements for Inclusionary Zoning are unclear, though, given the minimum area requirements, lots eligible for Inclusionary Zoning may overlap with those eligible for OSRD. In any case, either bonus density option is likely to compete with TDR credits and allow minimum lot sizes that are smaller than those enabled through the use of TDR.

MARKETABILITY INCENTIVES

The Westport TDR program uses an enhanced transfer ratio. Each sending area parcel is awarded approximately one credit per $85,191 of existing value above the approximately $110,000 in land value that each parcel is expected to maintain after the lot is converted to seasonal use. With each credit estimated to sell at $85,191, this ratio attempts to ensure that sending area landowners receive credits that are proportionate to the current fair market value of their property.

ENSURING DEVELOPERS CAN USE TDR

Westport's planning governance consists of a Planning Board and a Board of Appeals. The Planning Board is the special permit granting authority for many of the other specialized development bylaws like Assisted and Independent Living Facilities, Flexible Frontage for Reduced Density, Medical Marijuana Treatment Centers, Noquochoke Overlay District,[15] and Inclusionary Housing. However, Section 2.5.0 in the by-laws states that "A special permit shall be required for all uses and for all exceptions to dimensional regulations, which are designed in this By-Law as requiring a special permit before the Inspector of Buildings may issue a building or occupancy permit"(Zoning By-Laws, 2017).

Ideally, Westport would carefully craft the TDR section of their bylaw when designing the program so that the Planning Board could be Special Permit granting authority. This would ensure that projects are promptly approved, provided that the proposed development meets the requirements included in the by-law.

STRONG PUBLIC SUPPORT FOR PROGRAM GOAL

Westport's MVP report indicates that the town might support a buy-out program for East Beach and Horseneck Beach in the future. The report referenced receptivity to abandoning areas likely to repeatedly flood, citing the working groups' "openness to a changing landscape" and the fact that "all three [workshop] groups recorded the vulnerability of East Beach Road to flooding, storms, and sea-level rise as a medium to high priority" (Town of Westport, MA, 2018, p. 3). Furthermore, the report stated that "residents expressed willingness to abandon this access road to Horseneck Beach and Gooseberry Island if a future cost-benefit analysis indicates that to be the town's least costly scenario…Participants expressed fatigue from troubleshooting this and similar highly vulnerable infrastructure (i.e. Atlantic Ave) year after year"(Town of Westport, MA, 2018, p. 3).

Conversations with local officials indicated that while public officials are beginning to plan for the town's future in the context of climate change, there is a general lack of public concern about sea-level rise. One local official stated the topic of climate change comes up in every Planning Board meeting but the town has yet to move forward with any adaptation projects beyond the East Beach Vulnerability Assessment. However, another official commented that there is a general disinterest towards coastal flooding among the general public, especially amongst full-time residents. They stated that no town residents have moved

[15] The Noquochoke Overlay district is roughly 30 acres in East-Central Westport that were rezoned in 2009 to enable affordable housing development (*Noquochoke Village to Celebrate with Ribbon Cutting*, 2019). According to a local planning official, the site is now fully built out.

recently because of flooding, and the town has not pursued or publicly discussed relocation as an adaptation technique to date. Nevertheless, public opinion may likely shift in the future, especially due to the high number of homes along the waterfront. Both branches of the Westport River are lined with homes, along with coastal areas like Westport Point, Acoaxet, and the barrier islands (see Figure 4**Error! R eference source not found.**). Because a significant portion of residents' homes will likely be impacted by flooding in the long term, public support for municipal climate adaptation is only likely to grow with time. While officials are already incorporating climate adaptation into town planning conversations, it is unclear how soon the general public would support a more radical adaptation strategy like TDR-funded buy-outs.

SIMPLICITY

The Westport TDR program is designed to be relatively simple. Its credits can only be used within the town's boundaries, and the town's Planning Board will be the only official body that has to approve projects using the credits. The credits can be used for only a single, specific purpose: reducing the minimum residential lot dimensions from 60,000 to 30,000 square feet. While the initial program requires significant upfront planning, the program could be simpler for the town and residents to navigate than the FEMA Hazard Mitigation Grant Program process, which is the predominant form of buyout assistance in the US today (A. Siders, 2013).

TDR PROMOTION AND FACILITATION

Westport may face some challenges administering the TDR program, based on the fact that the MVP report cites the town government's perceived lack of ability to enforce regulations as a potential challenge. Westport has also not implemented a TDR program before, so it would be a new concept for the municipal government and landowners, and this learning curve might slow its adoption. This may be mitigated by the relatively small size of the sending and receiving areas because it limits the number of landowners who need to understand the program to participate. At a minimum, Westport needs to be able to devote staff time to the on-going administration of the TDR program. Given the small size of the town's planning department, which consists of a Town Planner and an Assistant Planner, setting aside staff time to facilitate this program may be a challenge.

TDR BANK

Westport's hypothetical TDR program does not include a TDR bank. Fully capitalizing the TDR bank may be too difficult for a small town like Westport. Additionally, it might be difficult to predict how long the bank would need to hold onto credits before finding a willing credit buyer in the receiving area, so Westport would need to be willing to tie up funding for extended periods.

TDR Market Analysis, Assumptions and Limitations

WESTPORT TDR PRICE & SALES		
TDR credit price	Expected TDR Sales for Scenario 1	Expected TDR Sales for Scenario 2
$85,191	$937,106	$3,407,657

Table 3 Expected TDR Credit Price and Sales.

The estimated TDR credit price is derived from the estimated TDR credit value, which is based on the estimated development value of a parcel suitable under Westport's existing zoning for one residential unit in the receiving area: $141,986. This figure was calculated by averaging the land value of buildable but vacant parcels in Central Village that are currently zoned for a single residential unit.

The expected TDR credit price of $85,191 is 60% of the expected additional value TDR receiving owners can gain by purchasing a credit. Discounting the TDR credit price leaves receiving area landowners with a potential profit margin of 40%, though overhead expenses like permit fees and road construction would reduce that amount.

In a conservative scenario where landowners of vacant buildable parcels in the receiving area opt to purchase TDR credits, the TDR program generates $937,106. In the more ambitious scenario where buildable and residential receiving area lots over 60,000 square feet are TDR credit purchasers, the TDR program generates $3,407,657. As mentioned previously, the conservative scenario is more likely because owners of parcels with existing residential construction may not want to create new lots near homes constructed with Central Village's original minimum lot requirements.

To purchase all of the sending area credits available and remove all residential buildings from the sending area, an aggregated credit value of $11,107,162 is needed. Neither of the two scenarios examined as part of the receiving area analysis will generate enough credits to purchase all of the parcels in the TDR sending area. The number of credits sold in the more aggressive scenario would need to more than triple for the program to generate enough funding to purchase all of the sending area credits.

Impacts of Sea Level Rise on TDR Market

The aggregated TDR sales value may go further than projected by this analysis. It may take a while for sending area owners to decide to take advantage of the TDR program. They may wait until coastal real estate prices start falling as potential buyers recognize the risk of flooding that sea-level rise poses to these properties, or FEMA reforms the NFIP and prices policies to reflect actual risk. At this stage, sending area owners might be willing to accept less than the 2018 assessed value. This willingness of sending area owners to accept lower prices for their credits is not necessarily a good thing as it would reflect desperation and greater coastal flood risk, but lower prices would allow more sending area landowners to participate in the TDR program.

In another alternative scenario, East Beach properties could be flooded in a future storm, and owners might decide to rebuild and elevate, investing more money into their properties. This could make them

more reluctant to leave, and increase the amount of money needed to incentivize them. Also, the estimated sending area value does not factor in the subjective values that people might associate with their property like memories tied to their family beach home, which could undermine the use of money as an incentive (Nadler et al., 2008).

Sea-level rise is a long-term phenomenon. The uncertainty surrounding sea-level rise timing and its long time-horizon will also impact the program in ways that are difficult to predict. A sea-level rise of 5 feet, which is depicted on the maps used in this report, will not happen for decades, and its timing depends on many factors including yearly global carbon emissions. Much could change in the future economy, local and national politics, and public opinion about risks from climate change. The uncertainty surrounding these factors also makes it difficult to predict the relative success or failure of this hypothetical TDR market.

Assumptions

The receiving area TDR credit price is built on assumptions. The incremental value gained by doubling the density of a 60,000 square foot lot may be more or less than the $142,000 estimate. TDR credit price assumes that home buyers in Westport are interested in 30,000 square foot lots. However, perhaps people move to Westport because they want to be surrounded by nature and do not want a lot of interaction with their neighbors, and therefore value parcels for their lower building density. It is also possible that the Westport real estate market does not need more single-family homes on large lots, but would see demand for even higher density around Central Village.

Limitations

This analysis is limited by its inability to include several factors that could impact the TDR market. First, it does not account for other building restrictions in the Westport zoning bylaws like minimum setback requirements. This could further restrict the number of lots that are buildable at a higher density with a TDR credit. Similarly, it does not account for other ways that the zoning bylaw incentivizes increases in density, like Open Space Residential Developments. Second, in designating the sending and receiving areas, the hypothetical TDR program ignores other climate hazards that should limit the buildable land in Westport. Based on a conversation with a local official, inland flooding from stormwater is a major concern for the town. As seen in Figure 13, the receiving area includes a lot of land currently classified as wetlands. These wetland areas may shift or expand over time as the local ecology is impacted by changes in precipitation induced by climate change, limiting the land that is considered buildable (Commonwealth of Massachusetts, 2018). The analysis uses a rough mathematical calculation to estimate how much land on each lot is suitable for building, but it would be difficult to verify the accuracy of this calculation. Third, as this is a hypothetical TDR program, the sending and receiving areas were chosen without any community engagement with area landowners. If these individuals buy into both the purpose and expected impact of the program on the town's built environment then they may be unwilling to participate as credit buyers and sellers, or lobby to prevent the zoning bylaw changes necessary to enable the program.

ADAPTATION EVALUATION CRITERIA:

The preceding section discussed whether the TDR market in Westport could generate enough transactions to accomplish the program's goals. While a functioning TDR market must generate transactions, it is also important to consider how well the TDR program accomplishes its policy goal. In this case, the primary goal of TDR as a climate adaptation tool is a reduction in exposure to coastal flooding for residents in the sending area. However, exposure is only one factor in a person's or community's vulnerability.

Vulnerability is a term that is frequently used in conversations about climate change and is defined here as "the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard, either a perturbation or stress/stressor" (Turner et al., 2003). Exposure, sensitivity, and adaptive capacity are the three attributes that compose vulnerability (Bennett et al., 2016). Social vulnerability refers to the vulnerability of individuals or groups, but vulnerability can also refer to physical objects like buildings. The related term, vulnerable populations, refers to social vulnerability and may be shorthand for the Center for Disease Control's Social Vulnerability Index (SOVI). SOVI is a tool that uses criteria from census data to estimate a community's general vulnerability. Factors that influence but do not necessarily determine social vulnerability include age, economic status, gender, and race (Cutter et al., 2003; *Mapping Risks and Vulnerabilities to Increase Resilience Planning*, n.d.). Vulnerability is not a static characterization but is instead something that can change over time and responds to different drivers including adaptation responses (Bennett et al., 2016; van den Berg & Keenan, 2019). It is also not something that is necessarily determined by someone's demographic or socio-economic characteristics. Individuals, or populations, are "vulnerable to" a force or event but are not inherently weak or unable to cope with their environment as might be implied by the term "vulnerable population".

The following evaluation criteria include other factors that impact Westport's communal sensitivity and adaptive capacity to climate change: prioritizing resources for the most vulnerable; the estimated net impact of the TDR program on the town's housing stock; and the potential for producing environmental co-benefits. The goal of looking at all of these criteria is to build a more holistic picture of how TDR could impact Westport's vulnerability, which might be missed with a narrow focus on exposure or risk reduction.

PRIMARY GOAL: REDUCTION IN EXPOSURE TO COASTAL FLOODING

As mentioned, the main goal of Westport's TDR program is to move residents out of East Beach because that area is so vulnerable to coastal flooding and sea-level rise. However, the current design of the market will not produce enough credit value to incentivize all East Beach owners to leave. The TDR market is expected to generate up to $3,407,657, produced by 40 credits purchased at $85,191 each. If the credits are also sold at the same value, then the 40 credits might induce as few as 5 or as many as 15 owners to leave East Beach, assuming that each owner will only sell their credits if they expect to receive roughly the current assessed value of their property. Since 131 credits are available but only 40 are sellable, this means that the majority of East Beach owners will not be able to benefit from this program. For this important reason, TDR has only limited success at reducing overall exposure to flooding.

There are a few other reasons that undermine TDR's use as a hazard risk reduction tool. As a voluntary program, it may take time for any sending area owner to be willing to leave East Beach. If some owners decide to sell and gradually desert the area then the remaining residents will become more isolated over

time, which could add to their social vulnerability and do nothing to reduce their flood exposure risk. East Beach may be gradually abandoned anyways without TDR, especially if the town is unable to find other programs to finance managed retreat. However, the TDR program as currently designed does not identify any alternative solutions for residents who miss out on the opportunity to sell their credits using TDR. There is no contingency plan if there is more demand than supply or if there is more supply than demand. On the other hand, Westport may not have a better option for residents in East Beach given the expected high costs of many climate adaptation policies, as well as the heavy competition in the future for a limited pool of state and federal adaptation project funding.

In summary, the Westport TDR program mitigates disaster risk for some residents but is not a complete solution as it will not generate enough money to purchase credits from all the sending area owners.

Prioritize Needs of Most Vulnerable

Vulnerability is a relative term. When trying to identify the most vulnerable individuals to prioritize resources for them, the bounds of the population matter. While the Westport TDR program does mitigate some of the hazard exposure of East Beach residents, the town of Westport also have to consider whether this program is worth its cost, because other town residents may need more help avoiding and recovering from coastal flooding than the residents of East Beach.

If you use social or socio-economic determinants to define vulnerability, then the Westport TDR program does not prioritize the needs of the most vulnerable. The Westport TDR sending area was chosen based on physical vulnerability relative to other areas in the town, not because of the people who lived in the area. Many of the homes in East Beach are vacation properties, so most owners have another place to live if their properties are flooded. For those residents who do live in East Beach full-time, the program does not include a mechanism to ensure that they will be able to find new housing within Westport if they choose to leave the sending area. The median amount that these owners would receive in TDR credits is $340,766, which is less than the median value of owner-occupied housing units in Westport at $366,800 (US Census Bureau, n.d.).[16] Given the challenge of finding another affordable home in town, these residents might be forced to stay in place as long as possible, negating any potential reductions in hazard exposure. TDR is simply not designed to address identity-related aspects of vulnerability, such as age or poverty level. The program creates a market for land based on the land's characteristics, and there may not be a way to prioritize certain buyers or sellers without undermining the ability of the market to generate transactions.

The use of East Beach as the sending area should be critically examined. East Beach was historically a working-class beach community and was decimated by early 20th century hurricanes (Westport Historical Society, n.d.-c). The seasonal land use associated with many of the parcels in this area may be a result of past storms destroying any permanent construction on those lots. Today, East Beach is vulnerable to sea-level rise and storm surge but also is sparsely populated. Based on a conversation with a local planner, Westport is concerned about coastal flooding across the town and also has to deal with increased

[16] Data from 2014-2018.

precipitation related flooding. While the vulnerability of the access road and utility infrastructure is a concern for East Beach, it is difficult to say whether this area is truly the most vulnerable in the town and therefore most worthy of the public effort required to set-up a buy-out program.

In considering whether to provide any funding support for Westport's TDR program, state program administrators should also consider the fact that Westport census tracts have relatively low CDC Social Vulnerability Index scores, indicating that the town as a whole may have a low general level of vulnerability. This index is an imperfect representation of vulnerability and misses details that might make a community more or less vulnerable to specific hazards, but it provides a general indication that other municipalities may need more support in preparing for hazards than Westport.

IMPACT ON HOUSING

The Westport TDR program creates more density but also taxes this density increase by enabling it only with the purchase of TDR credits. Westport is a low-density community. Eighty-four percent of Westport's housing units are detached single-family homes, many of which are on large lots in compliance with the town's minimum lot size of one unit per 60,000 square feet (US Census Bureau, 2018).[17] In 2015, only six percent of the town's housing consisted of multi-family units, and the town had a 0% estimate rental vacancy rate (Town of Westport, MA, 2017, p. 37). If Westport undertook a robust TDR planning process that incorporated broader climate resilience planning, then it could lead Westport to pass zoning changes that might not otherwise be accepted like 30,000 square foot residential lots. It might also force Westport to grapple with fact that much of its waterfront housing will be endangered by rising water levels, and come up with a serious long-term plan for retaining its full-time population and seasonal visitors. However, as currently designed, the program is only expected to add a maximum of 40 units to the town's housing inventory in the more optimistic TDR demand scenario.

While homes in Westport are relatively inexpensive compared to the Boston Metropolitan Area, some people in Westport may struggle to find an affordable place to live due to their very low rate of rental vacancies. Existing renters are disadvantaged by this program. They may not be able to afford the new housing in the receiving area, do not benefit from the sale of credits in the sending area because they do not own property there and would be displaced from the sending area if they currently live there and the owner decided to sell. The density that TDR enables does not accommodate multi-family units but the creation of new single-family homes might still benefit the community's housing stock and could be used as rental properties. However, TDR also adds cost to the construction of the houses on these smaller lots, potentially leading to higher final sale prices. In summary, while the TDR program could add new housing density to Westport, it will not necessarily add the rental housing that the town badly needs.

ENVIRONMENTAL CO-BENEFITS

In theory, a coastal managed retreat program could generate new open space like publicly accessible beaches or restored marshland that might absorb wave impacts. It is unclear whether the TDR program will contribute any environmental co-benefits like these. One challenge is that the TDR program not

[17] 2014-2018 American Community Survey Data.

remove all uses from East Beach, just some of the residential homes. The TDR program is unlikely to incentivize all homeowners to leave the area, so the area's future land use pattern may be a patchwork of homes and open spaces. The residential lots are interspersed with trailer homes, which would retain their title and would likely be used as long as possible, which also limits the amount of contiguous land that could be restored. Another challenge is that much of the land area is expected to eventually be underwater, leading to permanent overwash of East Beach, and may result in natural ecological changes that are beyond the focus of this paper to analyze in detail. One additional factor of environmental uncertainty is the on-going East Beach vulnerability study, which may recommend major changes to the environment or infrastructure of the area. A related factor is the town government's stance on the long-term viability of East Beach road. Based on the vulnerability study recommendations, the town may decide to reinforce existing infrastructure on East Beach to enable continued use of the access road and utilities in a future that involves sea level rise and increased flooding. This could complicate any future environmental restoration efforts.

ADVANTAGES AND DISADVANTAGES OF TDR IN WESTPORT

This research illustrates how a simple TDR program could be deployed to address risks from climate hazards in Westport, MA. Having discussed how the program would be structured, the market would work, and how effective the program would be at addressing its goals, the following section discusses whether this program makes sense for Westport.

The following table summarizes the advantages and disadvantages of CATDR that were brought to light by Westport's hypothetical TDR program. Each will be discussed in further detail below.

Advantages	From the use of managed retreat	East Beach has always been vulnerable, makes sense to abandon it
		Financial advantages for the town from retreat
	From the use of TDR	TDR fills funding gap for managed retreat buy-outs
Disadvantages	From the use of managed retreat	Residents may not want to leave (contributing to difficulty establishing TDR and generating exchanges)
		Environmental co-benefits difficult to produce
	From the use of TDR	A TDR market does not generate sufficient funding for retreat
		A TDR bank could help the retreat strategy succeed but is too difficult to fund
		TDR is difficult to establish
		TDR raises the cost of development
		Demand in the receiving area is uncertain
		TDR is difficult to adapt over time

Table 4: Advantages and disadvantages of using TDR as a climate adaptation strategy to facilitate managed retreat in Westport, Massachusetts.

Advantages of TDR Funding a Managed Retreat Program

The main advantage of using TDR for the town is that it provides a new funding source for the town's adaptation, assuming that it does want to pursue a managed retreat program for East Beach. Managed retreat funded through TDR makes sense for the town because of the vulnerability of East Beach, and the financial liabilities of the town associated with residential development in such a vulnerable location. TDR is a good solution to help achieve this adaptation approach because other adaptation funding sources may not be available.

East Beach has Always been Vulnerable

East Beach's noted vulnerability to coastal flooding, which has already led to a gradual abandonment of the area, makes it a sensible site for a potential future managed retreat program. Today East Beach is sparsely inhabited, and its population has declined significantly since its hey-day before the 1938 hurricane. In the words of the Westport Historical Society: "The community of East Beach is most notable for the fact that it no longer exists."(Westport Historical Society, n.d.-c) This contrasts with other historic coastal villages in Westport like Acoaxet and Westport Point, which will face similar risks from coastal flooding but could be more challenging for the town to abandon given the relatively high number of homes and businesses in those areas compared to East Beach. Unlike Acoaxet, an affluent summer resort, East Beach was a historically working-class community (Westport Historical Society, n.d.-a). Westport Point, by contrast, was the historic center of Westport's coastal economy and is now the site of a nationally recognized historic district (Westport Historical Society, n.d.-d). East Beach may have been the less affluent beach community in Westport because of environmental characteristics that made it more vulnerable to severe storms. It is unfortunate that an important part of the town's working-class history will be further depopulated while more historically affluent areas may be preserved. However, the Westport TDR program allows landowners to continue seasonal use of their property for as long as it remains unflooded, enabling the traditional summer beach use to continue.

Financial Advantages for Town

The town is concerned about the future of the area in the context of climate change, in part because the periodic over-wash of East Beach damages the roadway that the town maintains. A local official noted that the road was already elevated after Hurricane Irene, but providing on-going funding to maintain the road is difficult for the town. It is hard for them to imagine undertaking major future improvements to the road given the existing lack of maintenance funding. Any method that results in a vulnerability reduction for East Beach may cost money, but the advantage of TDR is that it also generates funding through the sale of credits in the receiving area. Retreating from an area like East Beach could alleviate pressure for the town to elevate the roadway in a future scenario when most of the land surrounding it will be flooded. Municipalities like Westport are already being challenged to find funding sources for climate adaptation projects. Financing projects may be increasingly difficult in the future when climate change impacts become more apparent, as budgets are stretched by disaster response and recovery, and more local governments compete for grant funding. Westport's property tax revenue will be impacted by sea-level rise, but it is not projected to be among the worst-hit municipalities in the state (Shi & Varuzzo, 2020). This is good news because Westport may be better off than nearby communities dealing with coastal flooding. It is bad news because the town may still have to deal with substantial impacts from coastal

flooding but could have a difficult time competing for funding with communities that face even greater challenges. The TDR policy proposed for Westport would give the town a badly needed funding source to reduce its vulnerability by retreating from East Beach, allowing it to plan for the impacts of sea-level rise, and buying it a small degree of autonomy in a resource-constrained future.

TDR Fills a Funding Gap for Strategic Managed Retreat

A TDR program to address climate hazard risks is a good idea for Westport because it addresses risks of coastal flooding that are ignored by existing federal and state regulations. FEMA FIRMs are based on historical data and therefore ignore future risk. Also, FEMA's Hazard Mitigation Grant program does not allow buy-outs before disasters happen, as a form of strategic managed retreat, but instead supports buyouts after disasters occur and homes are already destroyed (A. Siders, 2013). FEMA also subsidizes flood insurance and provides discounts based on the age of the policy, which disconnects the prices of the policy from the realistic risk of flooding. The "grandfathered" rate program discounts policy costs for homes built before 1974 and this discount may apply to 22 of the homes in East Beach. The grandfathered NFIP rate could reduce any sense of urgency for homeowners to leave the area because it masks the true cost of insuring their property against flood risk. TDR could address this issue by providing an incentive for existing owners to leave, while preventing new owners from taking over the property, thereby eliminating the confounding impact that FEMA policies have on coastal property purchases in East Beach.

Disadvantages of Using TDR as a Finance Strategy for Managed Retreat

There are many problems with the performance of Westport's hypothetical TDR program as a funding solution. The TDR market is not expected to generate enough funding to incentivize all sending area residents to leave the area. While TDR may require less direct public funding than a tax-payer funded buy-out program, it is complicated to set-up and is not cost-free. This implementation of TDR also provides minimal housing or environmental benefits to the town as co-benefits to the main vulnerability reduction goal of the program. Finally, TDR may be an ineffective tool in part due to the long-timeline and highly uncertain context of climate change.

TDR Funding is not Enough

The most glaring disadvantage of using TDR as a way to address hazard risk in Westport is that the program is expected to generate enough funding to incentivize only a minority of sending area owners to leave East Beach. As currently designed, the program does not provide a pathway to relocation funding for the remaining homeowners unless they are willing to leave for less money than anticipated, or receiving area landowners are willing to pay more for TDR credits. The program is also limited to only impacting homeowners threatened by coastal flooding at East Beach, but many other places in Westport are also expected to see severe flooding. The sending area only includes a small portion of properties at risk, and it was still too large for the TDR program to generate enough funding to compensate everyone for the full value of their property.

Adding a TDR Bank Could Contribute to Program Success but Needs Long-Term Funding

Westport's hypothetical TDR program does not include a TDR bank. Fully capitalizing the TDR bank may be too difficult for a small town like Westport and the program could tie up funding for extended periods before TDR credit sales take place. However, a TDR bank could be an important way to ensure that sending area owners have a buyer for their credits when they are ready to leave East Beach. TDR credit sellers and purchasers may be ready to make purchases at different times, which might limit the TDR sales that take place. A TDR bank could act as a guaranteed buyer of credits or could allow credit purchases in the receiving area in advance of any sending area residents selling their credits. Unfortunately, according to the TDR market analysis, there may never be enough TDR credit purchases to account for the sales needed to incentivize sending area residents. If the program had been designed with a TDR bank, it would need to find another funding source to keep paying for East Beach buy-outs or end the buy-outs program once a specific cap on funding is reached.

TDR Programs are Challenging to Set-Up

Another disadvantage is the significant planning and upfront investment needed to support a well-run TDR program. If Westport were to proceed with TDR, then they would need to conduct a thorough real estate market analysis, at a level of detail well beyond what was completed for this research, to be confident in the program's assumptions about likely demand for TDR credits in the receiving area. Equally important would be the public engagement in both the sending and receiving areas to ensure that the community supports the program goals and understands the expected impact on the sending and receiving areas. This engagement may be essential in building support for denser development in Central Village, which was suggested in the town's recent Masterplan but may face public opposition when implemented. While the town might benefit from an intense planning and community engagement

campaign that focuses on the town's future in light of climate change, undertaking this process specifically to stand-up a TDR program may be a waste of town resources that might be better spent exploring other adaptation options.

Also, there is the fact that TDR programs may draw resources indirectly from other community priorities. For example, in order to generate the most demand for TDR credits, Westport might decide to eliminate any other programs that provide ways to achieve density above existing zoning, such as inclusionary zoning, for example. This approach is recommended by TDR best practices. However, incentivizing TDR credit transfers in this way means potentially sacrificing additional affordable housing. It may be possible to create a way to incorporate multiple priorities into the TDR program but this necessarily complicates the program, which violates the TDR success factor that emphasizes program simplicity.

TDR Raises the Cost of Development

Another negative aspect of TDR is that it increases the price of development. While the program increases the density allowed by the existing zoning in Westport, it nevertheless makes this new development dependent on a willingness to finance adaptation projects that only benefit existing construction. Westport could choose to allow denser development in Central Village by-right because greater density in the area was included in the town's 2016 Master Plan, or because it wants to increase the number of housing units in the town to alleviate some of alleviate some of its affordability and rental unit availability deficiencies. Alternatively, additional density could only be enabled through the purchase of TDR credits. This scenario might be framed as a win-win situation because it achieves greater density in the town, and achieves some positive adaptation outcomes. However, this produces an inequitable outcome. By requiring the purchase of TDR credits to increase density, the cost of development rises. Either denser development does not occur because it cannot support the cost of the TDR credit, or the development occurs and homes are sold at a higher price that accommodates the additional cost. In either case, the people who need more affordable housing in Westport are unable to benefit. Meanwhile, existing homeowners, who are commonly second-home owners in East Beach, receiving funding for the sake of climate adaptation. While this could result in risk reduction in East Beach, it undermines the ability of economically vulnerable residents of Westport to find affordable housing.

Environmental Co-Benefits will be Difficult to Produce

It may be difficult to incorporate environmental remediation into the TDR program. Deconstruction and environmental remediation are costly, and since the credit seller is responsible for these activities, it may take more money than expected to incentivize them to sell. However, this might be preferable to the town that if the municipality covered this cost, thereby requiring all of Westport's citizens to indirectly subsidize this cost. Also, since the TDR program is not expected to incentivize all East Beach homeowners to leave, the program is may result in a patchwork of developed and more natural land uses that collectively do not produce meaningful ecosystem services.

Demand in Receiving Area is Uncertain

The final two problems with TDR in Westport are related. First, demand in the receiving area is uncertain, which makes the entire TDR market uncertain. Sending area homeowners will not necessarily drive demand for new density in the receiving area because many are seasonal residents and have second

homes elsewhere. While the TDR program is designed to neutralize the loss of property tax revenue in the sending area by increasing density in the receiving area, it's unclear who will be drawn to Westport in the future. The entire TDR program has to be designed in the context of uncertainty, with the knowledge that future environmental contexts may be very different but not being able to predict exactly how that will manifest in the real estate market. Designing a program like this is similar to basing building restrictions on historic flooding. Basing TDR on historic and near-term expectations for development is limiting when we know that the future will be radically impacted by climate change. TDR is a long-term program and so a certain degree of uncertainty is inherent in it. If Westport proceeds with setting up a TDR program, then it could limit the other adaptation options available to the town in the future and lock them into a future where the town's climate resiliency is dependent on higher density development that may or may not happen.

TDR is not a Flexible Solution

TDR programs require significant planning to set-up as well as changes to municipal zoning. Zoning changes can be politically controversial and are especially difficult to achieve in Massachusetts where a supermajority of a municipality's governing body is required to pass any changes. If Westport invests resources into a TDR program for climate hazard mitigation, are they also able to set-up a contingency plan if the market does not work? Many TDR programs fail to live up to expectations, and it may be unwise to expect Westport's program to work perfectly. However, putting checks in place to periodically assess the program's impact may require additional labor, as would the process of finding an entirely new solution if CATDR does not work at all. While any adaptation solution should require some monitoring and evaluation, given the costs associated with CATDR program set-up and the limited capacity of the town to plan for climate resilience on its own, it may be difficult for Westport to pivot from CATDR to another solution in the future if the program does not work as well as expected. It is also unclear whether having additional funding potentially available would make the community more or less eligible for outside assistance from FEMA or other buy-out assistance programs like Community Block Grants. For example, if a storm decimates the homes on East Beach soon, and the town decides to apply for a federal buyout, how would the Westport's TDR program factor into the outside aid that they might receive? Before implementing CATDR, Westport needs to understand whether CATDR would eliminate its ability to use other adaptation approaches or funding sources in the future.

WHAT COULD MAKE TDR IN WESTPORT MORE SUCCESSFUL?

CREATING MORE RECEIVING AREA CREDITS

A larger receiving area and more thoughtful receiving area zoning might result in more TDR credit purchases and therefore more homes purchased in the sending area. A more detailed plan for Central Village that incorporates design guidelines and the potential for smaller lots and multi-family units might incorporate a lot more density in the area. The town might even consider building new utility infrastructure like a wastewater treatment facility to support this level of density. In this scenario, Central Village might also allow more diversity in construction allowed by right so the town could make TDR credits more flexible. Instead of doubling the density specifically for 60,000 square foot lots, they could be based on FAR, for example. If the town does not want to alter Central Village, then it should instead expand the boundary of the receiving district to allow more parcels to be eligible to purchase TDR credits.

ENSURING PROGRAM FLEXIBILITY

Climate change may cause widespread and unexpected transformations for Westport. TDR is generally a long-term program so the town needs to make sure they monitor its effectiveness and can adapt it if the town's needs change over time. If Westport adopts a TDR program to support their climate adaptation objectives, they should plan to periodically review the program to evaluate its effectiveness on an on-going basis. The program could be evaluated by the Planning Board every five to ten years and the results presented to the Town's Board of Selectmen. The purpose of the evaluation would be to review the credits available, check whether adjustments should be made to the program, and make sure that it still aligns with the town's adaptation goals.

EXTERNAL FUNDING

Westport will likely need state funding to support its TDR program. It may need an initial grant to conduct detailed planning to create the TDR program. However, it will need a much larger amount if its goal is to remove all construction from East Beach as the basic market analysis predicts that there will not be enough credit sales to incentivize all sending area owners to abandon their property.

Westport could get more value from the TDR credit process by using TDR as a funding match for a federal buy-out. Federal funding typically covers 75% of the buy-out cost (A. Siders, 2013), so Westport could try to leverage the expected revenue from TDR credit purchases in the receiving area as their local matching contribution. The TDR revenue is not guaranteed because receiving area developers may elect not to purchase credits, so the state of Massachusetts may need to guarantee funding on behalf of Westport.

NEW SENDING AREA: PRIORITIZING FULL-TIME RESIDENTS IN FLOODPLAINS ACROSS TOWN

Rather than targeting East Beach, TDR could be used across Westport to incentivize people to leave year-round occupied housing in flood plains. Westport may want to prioritize funding for full-time rather than seasonal residents, and may also consider vacation homes to be less vulnerable because they are occupied for only part of the year. The town could also expand eligibility to year-round occupied homes in low-lying inland areas, and long-term rental homes. Reprioritizing who is eligible to sell credits might extend the impact of funding.

SHOULD WESTPORT USE TDR AS A CLIMATE ADAPTATION TOOL?

Westport could use TDR as a climate adaptation tool in certain scenarios. It could be a useful way to generate matching funding that could be used in a federally sponsored buy-out program. It could also be used as a locally managed retreat program if Westport modifies the TDR sending area to prioritize full-time residents who are more vulnerable to climate hazards than vacation-home owners.

However, before considering TDR as a climate adaptation tool, Westport first needs to undertake a more thorough climate scenario and planning process at the municipal level. While the town has already joined the Municipal Vulnerability Preparedness program, the MVP workshop only scratched the surface in terms of identifying local vulnerabilities and priority actions. The vulnerability assessment of East Beach is a good starting place, but Westport should consider applying for another MVP action grant to undertake a town-wide vulnerability assessment that generates specific hazard data projections for the town and evaluates the impact of those projections on the town's land use. The Town of Sandwich's 2019 Vulnerability Assessment is an example of this type of detailed study. The findings of the vulnerability assessment should be incorporated into the town's master planning process, and at that point, the town can evaluate whether it wants to develop a managed retreat policy.

While East Beach is vulnerable to coastal flooding, and much of it is projected to be permanently underwater due to sea-level rise, the residents of the area may be unwilling to participate in the program at all. The majority of homeowners in the area appear to be seasonal residents who may be willing to risk their property flooding to continue enjoying their vacation home because they have a second-home elsewhere that they can rely on. Based on a conversation with a planning official familiar with Westport, the homes on East Beach are not expensive and are typically inherited property owned by middle-class families who have lucked into owning oceanfront property. Family history tied to the location may lead sending area residents to oppose the TDR program during its implementation process, or ignore the buy-out incentive offered for the property. Rather than accepting a buy-out and leaving the area, owners might choose instead to elevate their properties and plan for their long-term future in East Beach, deepening their ties to their property and making them less likely to leave voluntarily in the future. This dynamic could undermine the managed retreat approach and therefore make use of the TDR program less rational.

During any future conversation about climate adaptation options, community engagement will be fundamental to achieving positive adaptation outcomes. If TDR is pursued, both the sending and receiving areas owners will need to fully engage with the program and its goal for the market to generate transfers. Engagement will also be critical in the town's broader climate planning process, as it grapples with what its future will look like in the context of climate change. Decisions will need to be made about what aspects of the town residents want to invest resources in. During this process, it is critical that the town work with the group of people that it identifies as especially vulnerable to climate hazards and starts building their adaptive capacity. One expert on managed retreat noted that "even when conducted with beneficial intent, however, [retreat] programs purposefully targeted at vulnerable populations are most likely to avoid inequity if they consider social justice as an integral part of program design and if they are chosen through a transparent and participatory pre-disaster planning process" (A. R. Siders, 2019a, p. 251). Westport must meaningfully include vulnerable populations in their climate vulnerability assessment process to better understand and prioritize the support that this group needs. Managed retreat through

TDR may or may not be the tool best equipped to help this group, but it is impossible to say for certain without the construction of a deeper knowledge base about the town's overall vulnerability to climate change.

The many uncertainties about the impacts of climate change on Westport mean that there might be other policy options that should be considered. There are also likely other priorities for the town than incentivizing coastal retreat. There is no reason to set up a voluntary buy-out program if residents are not interested in it, and TDR is only one option for facilitating retreat it the town moves down that path.

The very simple TDR policy explored in this report only generates $3.5 million, which is not guaranteed revenue and falls far short of the $11 million needed to provide close to a fair market value buy-out for all sending area residents. However, any funding captured by TDR is money that would not otherwise be captured and put to climate adaptation purposes. This money could be stretched further by limiting the sending area residents eligible for buy-outs or could be increased by expanding the receiving area. The TDR process also benefits Westport by encouraging an increase in Westport's tax base to offset the loss of flooded coastal properties.

RECOMMENDATIONS FOR USING TDR AS A CLIMATE ADAPTATION TOOL IN MASSACHUSETTS

Over the last few years, the state of Massachusetts begun devoting resources to guiding municipalities in the initial stages of climate adaptation planning. To supplement efforts like the state's MVP program, Massachusetts might vet new climate adaptation strategies and start educating municipalities on how to use them effectively. However, having reviewed the mixed results that implementing CATDR could have on a Massachusetts town like Westport, the following sections discuss some key issues that state leaders should consider before promoting TDR as an adaption tool.

STRUCTURAL CHALLENGES OF USING TDR AS AN ADAPTATION TOOL

Unfortunately, transfer of development rights undermines equitable outcomes when used as an adaptation tool that facilitates managed retreat.

CHALLENGE #1: TDR MAKES ADDING NEW DENSITY MORE DIFFICULT AND EXPENSIVE THAN IT NEEDS TO BE

Traditional TDR requires developers to purchase credits if they want to exceed zoning density but the municipality could have enabled that density by right. In the Massachusetts context, though perhaps especially in the Greater Boston area, housing can be unaffordable for many. Denser development and multi-family construction can cost less because more units are constructed on a fixed area of land, and lower development costs can result in more affordable housing. TDR's requirement for receiving area credit purchases makes it more expensive to build at the density level that the state arguably needs.

CHALLENGE #2: MANAGED RETREAT IN COASTAL AREAS DIRECT FUNDING ONLY TO EXISTING PROPERTY OWNERS

On the sending side of the transaction, TDR inhibits equitable outcomes because it only channels funding to existing property owners. While owning a house is not necessarily an indicator of wealth, coastal property is often expensive so the owner of a waterfront home may be relatively better off than another citizen of the municipality that can only afford to rent. This disparity may not be the case when considering sending areas for other environmental hazards like inland flooding. Nevertheless, TDR is not a cost-free adaptation solution, and any use of public funding should prioritize equity. Directing funding exclusively to property owners excludes a portion of the population that may be considered socially vulnerable and could use funding for climate adaptation projects that benefit them.

CHALLENGE #3: TDR IGNORES NEED WHEN ALLOCATING BENEFITS

Another challenge with redistributing funding through TDR is that credits are a commodity that can be bought and sold based on price. Amongst property owners, the program does not base the receipt of benefits on the owner's existing wealth or full-time residency within the municipality. Geography is the only eligibility criteria, so even amongst property owners, there are equity concerns as vacation home-owners may be less sensitive to a flooding event than someone who lives in their home full-time, but both types of owners are allowed to participate in the TDR program. Vacation home-owners may be less likely to participate because they are less sensitive to the financial risk of losing property, but this is still a concern and may prove to be politically challenging. While the TDR program could introduce constraints on eligibility for sending area homeowners, TDR markets sometimes have difficulty generating any

transactions so tight restrictions on participation may undermine the ability of the market to function at all.

Recommendation: Explore other adaptation solutions before addressing coastal vulnerability using buy-outs funded by TDR

The state should also use caution in promoting or investing resources in TDR because while it may provide a local funding mechanism for property buy-outs, buy-outs and property revenue replacement may have limited adaptation benefits. Focusing too many resources on an adaptation mechanism that relies on private property and new development may be evidence of a path dependency, which is a form of maladaptation. It refers to institutional decision-making that repeatedly generates the same set of choices and outcomes, which produces a pattern that self-reinforces and remains locked in over time (Parsons et al., 2019). Essentially, if decision-makers always think about a problem in the same way then they always come back to the same conclusion, and the conclusions they come back to often make the problem worse. As explained by Shi and Varuzzo (2020), local governments in Massachusetts are trapped in a cycle of generating and maintaining property values so that they can fund necessary services including climate adaptation projects. While TDR might have a neutral effect on property values by replacing the housing it helps buy-out, the benefits of the buy-out itself may be insignificant compared to the scale of the problem. Using TDR as a way for the property market to address future flood risk for existing property owners is a tidy solution but only benefits a limited group of people. Rather than investing resources in TDR, the state should explore new municipal fiscal policy models (Shi & Varuzzo, 2020), new forms of regional governance and more radical thinking about what adaptation to climate change and coastal flooding will mean for the state.

OPPORTUNITIES FOR FUTURE RESEARCH ON WAYS TO IMPROVE TDR

TDR's potential as an adaptation tool might be improved if it was used more intentionally to promote equitable outcomes. One idea worth further exploration is how TDR might fit into a zoning scheme that permits relatively compact development by-right, and allows large single-family lots only with the purchase of a TDR credit. The status quo zoning in this scheme would be cost-efficient, walkable, transit-oriented development. It would also allow individuals who want the traditional single-family home with a big backyard to achieve that goal in certain areas of a municipality if they are willing to pay a premium for that extra space. This would shift the burden of paying for adaptation to wealthier individuals who can afford new single-family home construction, rather than on denser forms of construction that may be cheaper per unit and more aligned with the state's growth objectives. Another idea that is worth further investigation is using a fixed sale price or price floor for TDR credits, based on criteria like owner income, residency within the municipality, the median cost to purchase a home in the same area. This price floor would be intended to ensure that some owners receive a guaranteed price for their TDR credits. However, the success of this approach might be entirely dependent on whether the TDR market has significant demand for credits so that sales could rise above the price floor. This would complicate the program and potentially limit the number of credit sales, therefore dampening the effectiveness of TDR at reducing hazard exposure. However, it would be worth exploring this approach or other ideas that prioritize buy-out funding generated by a TDR market to those with fewer alternatives to living in a hazard-prone area.

OVERCOMING POLITICAL BARRIERS

IMPLEMENTING CATDR WILL BE DIFFICULT WITHOUT CHANGES TO ENABLING ACT

Assuming that the flaws identified for CATDR can be solved with innovative TDR program design, any widespread use of TDR as an adaptation tool in Massachusetts will be challenged by the provision in the state's Zoning Enabling Act that requires a supermajority of the municipal governing body to approve any zoning changes. Buy-out programs are politically divisive, and TDR programs alone can stir strong community opposition from opponents and supporters of new density. A TDR policy that facilitates a community buy-out might struggle to get the support of 2/3 of elected officials in a community. Supporting this change in the Zoning Enabling Act is one action the state government could take to remove local hurdles to TDR implementation.

PILOT APPROACH

Another strategy to promote the use of TDR is to pilot it in a community that has strong local support for a managed retreat program. The regional planner interviewed as part of this research suggested that towns might be more willing to adopt new climate adaptation strategies like TDR once they see it work well in another town. The state could support this process by investing funding in the initial municipality's planning process, providing expertise, and offering on-going financial support to fund a TDR bank. The pilot town should have a high degree of local planning capacity, a good relationship with state planning policy officials, prior experience with climate adaptation planning, and a community-driven desire for a managed retreat program. However, it may take a long time before any transfers are generated, which could undermine the ability of the pilot program to prove CATDR's usefulness.

RECOMMENDED NEXT STEPS

TDR should be considered a tool for adaptation planning, but it has some major limitations. Instead, the state should direct its resources to:

1. ENSURING THAT ALL MUNICIPALITIES STRATEGICALLY PLAN FOR THEIR FUTURE IN THE CONTEXT OF CLIMATE CHANGE

CATDR should not be a primary focus of the state's capacity-building efforts, which should instead focus on integrating climate vulnerability assessments with land use planning and on supporting equitable adaptation processes. The MVP program has been very successful at getting municipalities to consider how they might be impacted by climate change and has funded some necessary adaptation projects. However, it does not require municipalities to complete detailed vulnerability assessments backed by locally specific data, or push local governments to consider how climate change will impact their land use planning and zoning.

2. GENERATING GRANULAR CLIMATE HAZARD PROJECTIONS

In addition to financial support to undertake this detailed planning, municipalities also need granular projections for climate hazards like coastal and inland flooding, as well as guidance from the state on how to determine the best allocation of limited resources when reviewing adaptation options. Decision-making guidelines or a comprehensive state climate planning strategy might help local officials determine where funding should be spent to reduce vulnerability, and where it might instead result in maladaptive outcomes.

3. SUPPORTING COMMUNITY-LED ADAPTATION PROJECTS THAT ARE NOT LED BY MUNICIPAL ACTORS

The state also needs to focus on building capacity for equitable adaptation planning processes. The MVP program channels adaptation funding exclusively through municipal governments, which means that the only funded projects are those that the local government thinks are a priority. These projects are not necessarily those that are prioritized by the most vulnerable members of the community to climate hazard impacts. While municipal project funding is necessary, the state should also directly support diverse grassroots initiatives that promote community goals and address needs that might be overlooked in government-led adaptation planning processes.

CONCLUSION

TDR is a convenient way for local governments to generate funding without directly taxing their citizens. However, when used to facilitate managed retreat programs, the TDR concept has some major weaknesses. As shown with Westport's hypothetical program, they can increase the price of denser development, can channel adaptation benefits only to existing property owners, and can divert funding away from more equitable adaptation strategies. Some of these challenges can be solved by clever program design, but CATDR is still a flawed solution. Setting up a TDR market that successfully generates transactions is very difficult, and allowing the future of a managed retreat program to hinge on an unreliable financing mechanism like TDR is a risky proposition. There may be a place for TDR programs that facilitate managed retreat in communities with thoughtful, community-driven, and data-informed climate adaptation plans, where other policy tools can compensate for a TDR program's weaknesses. However, many communities in Massachusetts have yet to undertake this type of climate planning process and are therefore not yet ready to consider CATDR as a potential adaptation tool.

APPENDIX A: TOP 10 TDR SUCCESS FACTORS

The following list of success factors is based on a 2008 article titled "What Makes Transfer of Development Rights Work?: Success Factors From Research and Practice" by Rick Pruetz and Noah Standridge. Any reference to TDR for climate change is original analysis.

Attribute:	Relevance to a successful TDR program?	Relevance to a TDR for climate change program?
Demand for bonus development – Developers need a reason to purchase TDR credits. If there is little local real estate demand, or if developers can get the density they want without purchasing credits, then the TDR program will not generate credit exchanges.	Essential	Essential. Any TDR program, regardless of its specific objective, must sell credits in order to finance preservation in the "sending area".
Customized receiving areas – Thoughtful analysis went into the designation of the receiving area and its development suitability. For example: the receiving area is compatible with the comprehensive plan, it has infrastructure to support greater density, and the existing property owners accept the need for growth in the area.	Essential	Essential. If the receiving area is not well-planned, it may not achieve adequate demand for development.
Strict sending area zoning – Sending areas with permissive zoning leads to more credits per acre, and may result in fewer transfers because developers do not need to purchase as many credits to achieve their target density.	Very important	Largely irrelevant for coastal areas where sending areas are already built at the maximum density permitted by zoning.
Few or no alternatives to TDR for achieving additional development – Developers should not be able to get bonus density through other programs because this makes them less likely to purchase TDR credits. Purchasing TDR credits should be the most	Very important	Important. Communities should consider total community costs and benefits of a TDR program compared to existing density incentive programs like inclusionary zoning prior to launching a TDR program.

profitable way for them to achieve a density bonus.		
Market incentives – The majority of top programs used an enhanced transfer ratio, meaning they award more than one TDR credit per existing unit permitted by sending area zoning. If done right, marketability incentives make the program more attractive to buyers and sellers by matching demand price more closely to the supply price.	Very important	Very important. Communities should consider what types of transfers their local real estate market will support, rather than solely implementing one to one transfers. Programs should aim for the price of TDRs to meet or exceed the value reduction in the sending area to incentivize sellers to abandon hazardous areas.
Ensuring that developers will be able to use TDR – Developers may be less motivated to purchase TDR credits if they think their project will be subject to a discretionary approval process. Receiving area zoning should allow maximum density for all projects that "comply with all zoning regulations including TDR requirements".(Pruetz & Standridge, 2009, p. 84)	Helpful	Helpful. This success factor is based on developer preferences, and would not be influenced by the program goal. However, a TDR program for climate goals should make sure that receiving area zoning includes appropriate restrictions on development that reflects risk from future climate-induced hazards
Strong public support for preservation – The municipality demonstrates support for the goal of the TDR program through tax-payer funding for complementary programs that work towards the same goal. Strong public support for the program goal, with or without taxpayer funding, is key to avoiding political compromises and administrative decisions that might undermine the program's effectiveness.	Helpful	Very important. TDR programs with climate change objectives need public support for municipal climate adaptation. Without recognition and acceptance that the community must adapt and will change, it will be difficult to pass zoning changes to establish a TDR program.
Simplicity – This success factor varies from program to program, but is related to minimizing the requirements and procedures inherent to selling, purchasing, and using TDR credits. Inter-jurisdictional credit transfers are an example of a complicated program, though some programs with this characteristic are highly successful.	Helpful	Helpful, though it is difficult to characterize what a simple program might look like. In general, keeping the program easy to understand may encourage more participation, and reduce transaction costs.

TDR promotion and facilitation – The TDR program should be regularly promoted to the sending and receiving areas, as well as to the general public. A well-maintained website can assist with this.	Helpful	Helpful. For a TDR program associated with climate change, program promotion should include clear communication about local risks from climate-related hazards. This will help sending area landowners, and all residents, make informed decisions about how to prepare their property. This might also be accompanied by a municipal climate adaptation plan for the municipality, to help residents understand how TDR fits into the municipality's adaptation vision.
A TDR bank – "A TDR bank is an entity officially authorized by the community to buy, hold, and resell TDRs."(Pruetz & Standridge, 2009, p. 85) TDR banks can purchase TDRs from sending area owners who don't have a receiving area credit buyer, can set TDR prices, and can track and facilitate transactions.	Helpful	Important. The primary objective of a TDR for climate change program is to move residents out of high-risk areas. TDR banks could help resolve timing disparities between sending and receiving area transactions. As soon as a sending area owner is willing to sell, someone should be ready to purchase their credits immediately in order to prevent the owner from reselling their residence to another individual. A TDR bank can ensure that funding is available to purchase credits when sellers are ready, regardless of whether a buyer is lined up for the credits in the receiving area. However, capitalizing a TDR bank may be difficult for some communities, especially since funding could be tied up for extended periods of time.

APPENDIX B: WESTPORT TDR CALCULATIONS

The following pages document the steps used to calculate metrics about Westport's hypothetical TDR sending and receiving areas. Calculation steps are loosely based on guidelines in Beyond Takings and Givings by Rick Pruetz (2003, pp. 119–166).

Datasets used in this analysis include:

- Standardized Assessors Parcels (Massachusetts Office of Information Technology, Office of Geographic Information, 2020)
- Building Structures (2-D) (MassGIS (Bureau of Geographic Information), 2019)
- NOAA Office for Coastal Management Sea Level Rise Data: 1-10 ft Sea Level Rise Inundation Extent (National Oceanic and Atmospheric Administration, 2017a)
- Protected and Recreational OpenSpace (MassGIS, Executive Office of Energy and Environmental Affairs (EOEEA), 2020)

STEP 1: COLLECTED SENDING AREA PARCEL DATA USING GIS.

- Imported Standardized Assessors Parcels, Building Structures (2-D), and NOAA Office for Coastal Management Sea Level Rise Data: 1-10 ft Sea Level Rise Inundation Extent shapefiles.
- Used Building Structures file to explore flood damage in Westport under the NOAA 5 Feet of Sea Level Rise scenario.
- Identified East Beach as a sending area based on the proportion of buildings flooded in this scenario and other qualitative criteria like the MVP report, the area's isolation and vulnerable infrastructure, and accounts of historic flooding in East Beach.
- Joined "Tax Par Feature Class" shapefiles with the "Assess Database Table", both sourced from the MassGIS Standard Assessors Parcels data download.
- Exported data from all parcels in the sending area to Excel.

STEP 2: CALCULATED EXPECTED TDR SUPPLY USING EXCEL.

- Filtered residential parcels using state land use code value (1010).
    - Left with 32 residential parcels. This represents the **total number of residential parcels in the sending area**.
- Filtered seasonal camp parcels using state land use code value (1061).
    - Left with 103 parcels.
    - Took the average of all land values for parcels to calculate the Average Land Value of Seasonal Camps in the sending area
    - **Average Land Value of Seasonal Camps** = $110,298
- Subtracted Average Land Value of Seasonal Camps from each residential parcel's Assessed Total Value, then summed the remainders.
    - This sum represents the Sending Area Total Asking Value, which is the expected amount of money needed to incentivize residents to leave.
    - **Sending Area Total Asking Value** = $11,107,162
- Divided the Sending Area Total Asking Value by TDR Credit Price (calculated in step 3) to calculate the TDR Credits Needed.
    - **TDR Credits Needed** = 131.

STEP 3: COLLECTED RECEIVING AREA PARCEL DATA USING GIS.

- Imported Standardized Assessors Parcels and Protected and Recreational OpenSpace shapefiles.

- Used the erase tool in GIS to remove parcels that overlapped with any type of open space.
- Joined "Tax Par Feature Class" shapefiles with the "Assess Database Table", both sourced from the MassGIS Standard Assessors Parcels data download.
- Used attribute selection tool to:
    - Select parcels surrounding Westport's Central Village.
    - Exclude assessor parcels identified as rights of way.
    - Exclude all parcels smaller than 60,000 square feet.
- Remaining parcels comprised the TDR receiving area.
- Exported data from all parcels in the receiving area to Excel.

STEP 4: CALCULATED EXPECTED TDR DEMAND USING EXCEL.

- Scenario 1: Developable vacant parcels.
    - Filtered developable vacant parcels using state land use code value (1300).
        - While parcels over 60,000 square feet with existing residential units may also be able to purchase TDR credits in the receiving area, they may be less likely to do so.
        - This includes 14 parcels.
    - Selected all remaining parcels greater than 60,000 square feet and less than 120,000 square feet (7 parcels).
        - Averaged the land values of these parcels to calculate the Average Land Value (per Unit) in Receiving Area. This represents the value associated with a single residential unit's development right.
        - **Average Development Right Value (per Unit) in Receiving Area** = $ 141986
    - Selected all 14 vacant parcels and divided the total assessed value of each parcel by the Average Land Value (per Unit) in Receiving Area.
        - Summed up the individual values to estimate the number of residential units that could be built in the receiving area based on existing zoning (1 unit per 60,000 square feet).
        - This value is relevant because the price per parcel varies significantly and independently from the parcel size. This variation may be due to factors like the existence of wetlands or other development constraints, which are factors imbedded in the assessed land value.
        - **Likely Units without TDR** = 17
    - Multiplied the Likely Units without TDR value by 60,000 for each parcel to get an estimate of the **Likely Buildable Land** value for each parcel.
    - Divided Likely Buildable Land values for each parcel by 30,000 to get the expected number of units buildable on each parcel with TDR.
        - Summed up the individual values to get the receiving area's Likely Units with TDR. Rounded total expected units down to integer values.
        - **Likely Units with TDR** = 28
    - Subtracted the Likely Units without TDR value (17) from the Likely Units with TDR value (28).
        - The remaining value is the Expected Demand for TDR credits in the receiving area.
        - **Expected Demand** = 11 credits.
- Scenario 2: Developable vacant parcels and residential parcels.
    - Filtered parcels using state land use code value (1300) and (0101).
        - This includes 103 parcels.

- Used the Average Land Value (per Unit) in Receiving Area from Scenario 1.
  - **Average Development Right Value (per Unit) in Receiving Area** = $ 141986
- Followed the same steps as scenario #1 but with 103 total parcels to calculate remaining values.
  - **Likely Units without TDR** = 93
  - **Likely Units with TDR** = 143
  - **Expected Demand** = 80 credits

STEP 5: CALCULATED EXPECTED TDR PRICE USING EXCEL.

- Multiplied the Average Development Right Value (per Unit) in Receiving Area value ($ 141986) by .6 to calculate the TDR Credit Price. This value enables developers who want to use a TDR credit to achieve an estimated return on their investment of 40%. This assumes that doubling the residential density to 1 unit/30,000 sq ft also doubles the land value of the parcel.
  - **TDR Credit Price** = $85,191
- Multiplied TDR Credit Price by Expected Demand for Scenario 1 and 2 to calculate the Estimated TDR Sales for each scenario.
  - **Scenario #1: Estimated TDR Sales** = $937,106
  - **Scenario #2: Estimated TDR Sales** = $3,407,657

STEP 6: CALCULATED TDR MARKET RESULTS USING EXCEL.

- Subtracted expected TDR sales for each scenario from the Total Asking Value of the sending area. Both scenarios generated less TDR revenue than is required to ensure complete retreat within the sending area.
  - **Scenario #1: TDR Credit Shortfall** = -$10,170,056
  - **Scenario #2: TDR Credit Shortfall =** - $7,699,505

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