Incorporating Wild Forests into Vermont's UVA Program

Prepared for Wild Forests Vermont
November 2021

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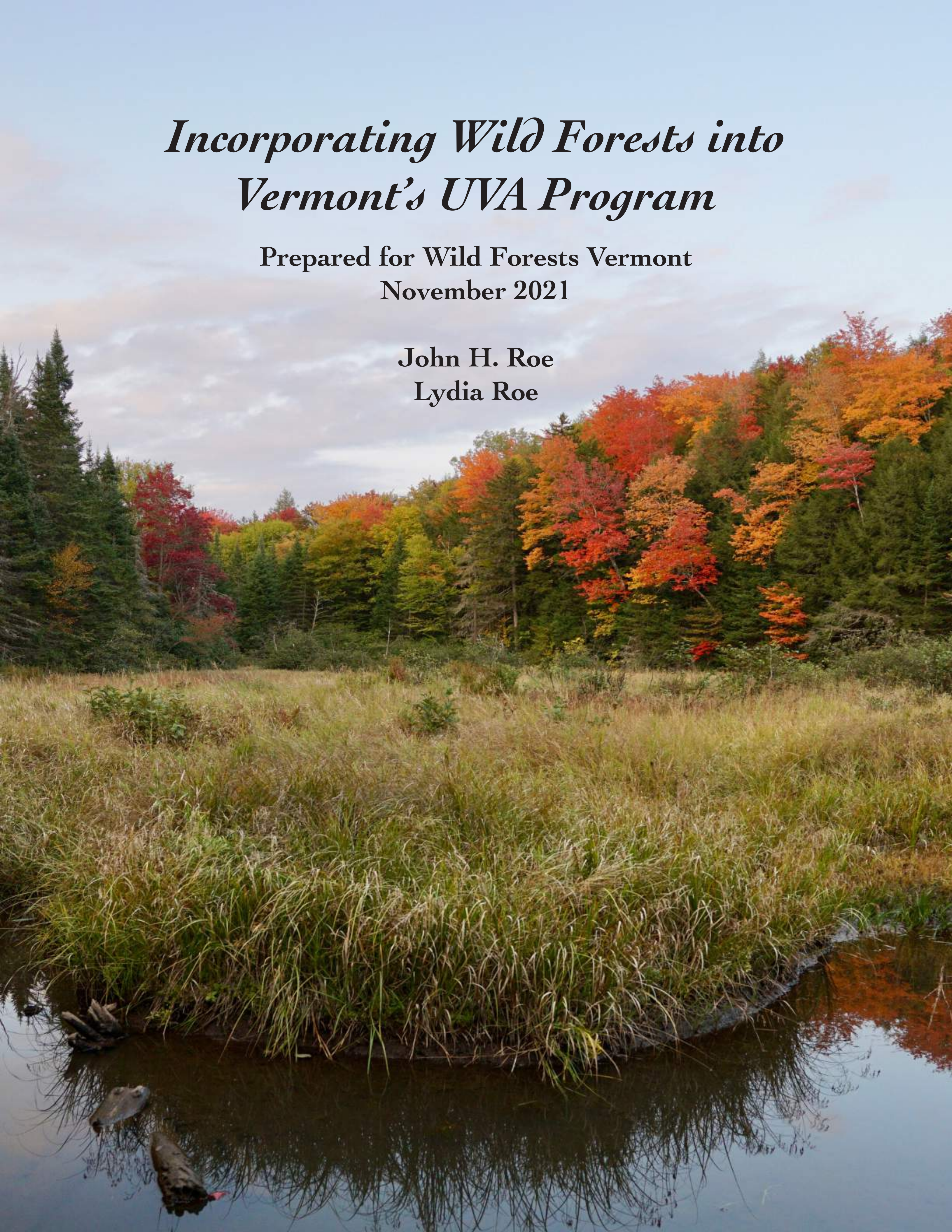

Title Page Photo: A view toward the proposed Woodbury Mountain Wilderness Preserve. © Zack Porter.

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Acknowledgements

The authors (John Roe, lead author, and Lydia Roe) would like to thank Deb Brighton for sharing her UVA expertise with us throughout this project, and specifically for adding cost information to our dataset. We are additionally grateful to Keith Thompson of Forest Parks & Recreation for sharing his team's data layers with us, and insights into the reasoning behind them. Thanks also to Sue Morse and Zack Porter for their spectacular and inspiring photographic contributions. Finally, our appreciation runs deep for all the members of Wild Forests Vermont, for commissioning this work and for their thoughtful edits and discussion of it.

Executive Summary

This report was written for Wild Forests Vermont in order to investigate adding a new category to Vermont's current use law that would allow wild forests to be enrolled as an acceptable forest management option. Currently, enrollment in the forestland program of Use Valuation Appraisal (UVA) is limited for private landowners to those who manage land to produce timber, but research shows that as originally passed in 1977, UVA's goal was broader than that. Improving forest management for timber was a component of the original law, but one could still enroll even if that was not the sole focus of one's management. Therefore, incorporating wild forest into UVA is really going back to its roots and is not a radical idea. Keeping Vermont's forested landscape healthy is as or more important now as it was then, since climate change is adding stress to our forests beyond encroaching development and other human activity.

Wild forests play important roles that complement managed forests at a landscape scale. In their old forest stage, they provide maximum habitat for a wide range of species. Very high percentages of Vermont's wildlife are in some way linked to high levels of large decaying woody material on the forest floor, which create healthy soil conditions that support the mycorrhizal fungi we now know trees depend upon for their health. Old forest also creates unique habitat to support species that would be rare in a highly managed forest, and create highest-quality habitat for some species, creating source populations that disperse into managed forest so that the species still fulfill their function in forests where reproduction may not be high. Most importantly during a time of rapid climate change, they store large amounts of moisture and enhance resistance to stand destroying fire, greatly enhance moderation of storm run-off and erosion, moderate some of the temperature extremes climate change will create, and absorb massive quantities of carbon.

Three different scenarios for adding wild forest to UVA were examined to compare their ecological benefits and costs. One, labeled ALL, allows any landowner who currently qualifies for forestry current use to enroll as wild forest, either as a new enrollment or by changing an existing enrollment. The second, labeled VCD, allows enrollment from landowners within the highest priority forest blocks identified in Vermont's Conservation Design plan of 2015 and 2018. The third scenario, labeled ESTA, is the approach proposed by Vermont Forest Parks & Recreation, where eligibility is determined by high concentrations of important natural communities and steep slopes.

The Vermont Conservation Design sets acreage-specific old forest goals within each of Vermont's nine biophysical regions. One of the key measures of ecological benefit examined in this report was how well each scenario could meet the Vermont Conservation Design old forest goals. ALL and VCD could meet those old forest goals fairly straightforwardly, where ESTA has more challenges. ESTA and VCD meet other measures of ecological benefit better than ALL, but ALL sequesters much more carbon. ALL potentially creates more old forest than VCD, and VCD much more than ESTA, since the latter is actually designed to minimize effect on the timber industry. Any of the three scenarios, though, have the potential to significantly increase the amount of wild forest in Vermont.

From a cost perspective, ALL is the most expensive scenario, but also the most equitable to landowners as it does not change any aspect of eligibility. VCD is very cost-efficient at implementing VCD, but would not cover important forests outside of the mapped highest priority forest blocks. The study determines various cost sidebars for each scenario, ranging from \$1.7M - \$18.9M with the old forest goals most likely met in the range of \$1.7M - \$3.8M. Even a cost of \$5M is just a 7.6% increase in UVA's current annual cost. An investment of between \$1.25M and \$2M will more than double the amount of wild forest in Vermont.

Project Overview

In November of 2019, Sue Morse, Donna Goldberg, and Jon Leibowitz convened a conference of invited foresters, Vermont Agency of Natural Resources (ANR) personnel, foresters, ecologists, economists, water quality advocates, private landowners, wildlife biologists, and environmental leaders to discuss the importance of wild forests and how to increase their representation in the Vermont landscape. Similar discussions were happening more broadly in New England at the time (Wildlands & Woodlands 2017), and ANR's Vermont Conservation Design (VCD) work had recently been completed and released in 2018. Among the recommendations that emerged from the conference was one to create a Steering Committee to explore further how to include permanently conserved wild forests in Vermont's Current Use Program – more formally known as Use Valuation Appraisal (UVA) – and how best to incorporate VCD into this work. The proposed Steering Committee became what is now called Wild Forests Vermont (WFV). WFV commissioned this report on how UVA can be a vehicle for Vermont landowners to more easily manage their land as wild forest. The report models possible changes to UVA to make it more wild forest-friendly, and quantifies how each scenario would fit with broad ecological goals, climate change mitigation and resilience goals, and VCD goals; importantly, it also examines how each would affect the cost of the UVA program. While the authors have incorporated feedback from members of WFV throughout the process of its creation, ultimately this report does not represent the opinions or position of the group. It is rather an effort by the authors to provide WFV and policy makers relevant history, context, data, and analysis of cost and environmental benefit associated with three different approaches to adding a wild forest category for private lands under the current UVA program.

Wild Forest Scientific and Policy Context

1. What is a Wild Forest?

Defining what a wild forest is may be easier than deciding what it should be called. The State of Vermont prefers the term "old forest," as that was the term used in ANR's three-part report called Vermont Conservation Design (released Dec. 2015, Feb. 2018 and March 2018) as well as in UVA materials about the Forest Program enrollment. On the other hand, Wildlands & Woodlands, an organization born out of work at the Harvard Forest in Massachusetts around 2005 that has since published several reports and convened conferences, uses "wildlands," "wilderness," and "wildland reserves" in their materials. The academic literature and many reports use the term "forest reserves," while last year's draft legislation from Vermont's House Committee on Natural Resources used the term "reserve forestland." In its report to that committee, ANR's department of Forests, Parks and Recreation (FP&R) adopted the same terminology but continues to use the term "old forest" elsewhere. Additional options include "forever-wild," which is often used in drafting conservation easements, and the original term used by many writers but now synonymous with federal lands – "wilderness." More recently, advocates are using "self-willed land."

In common use within the United States, all of the previously mentioned names for a forest that is left to grow old convey the same concept. However, in recent years the technical details of nuance captured by the related terms wild forest, forest reserve and old forest are strongly argued by some, so it is important to take a moment to more carefully define what is meant in this report by "wild forest," WFV's term of choice.

Wild forest and forest reserve are most similar as both are basically a land use category and directly mean

Picture 1: *Lobaria pulmonaria*, or lung lichen, a reliable indicator of healthy old forests. Photo: © Susan C. Morse.

a forest that is allowed to mature on its own. In general use in the US, the term forest reserve emphasizes not harvesting trees for wood products and setting forest aside for nature, usually to achieve biodiversity values not found in more heavily managed forests. The term forest reserve is most often connected with some governmental designation. Wild forest is a more generic term, but with the same connotation for some people that is found in the terms "self-willed" and "untrammeled" forest. Those labels indicate a higher form of removing human influence, which in practical terms can mean not even attempting to fight invasive species. The end point for both of these designations is that the forest develops into an "old forest."

The definition of old forest in the VCD March 2018 Natural Community Technical Report includes the following basic characteristics: mature forests with native trees typical for that particular forest natural community; complex stand structure with a wide range of diameters; multiple vegetative layers; abundant and complete distribution of coarse woody material of all the species in all the stages of decay; natural gaps; and standing dead trees of various ages and sizes. For the northern hardwoods that are the dominant landscape forest in Vermont these characteristics are generally not represented until many, if not most, of the trees are 150 years old. For balsam fir, the shift is around 100 years old and for hemlock it is beyond 200, as hemlocks can easily live for 600-800 years. The VCD goals are expressed as acres on their way toward being old forests, not necessarily areas that already have those characteristics.

Recent research by William Keeton at UVM and others has developed the concept of using silvicultural techniques to manage stands in a manner that accelerates old forest characteristics. Some of these are direct, like felling large diameter wood or girdling large trees to speed up the benefits and habitats formed over the decades that it takes for large diameter wood to rot. Some are complex, like using machines to artificially create tip-up mounds. This soil disturbance is an emblematic characteristic of old forests that usually only occurs when very old trees are blown down by wind rather than snapping the bole, which is more characteristic of younger forests. Some argue that this type of silviculture can include the sale of wood to pay for this ecologically enhanced forest management. Others argue such an approach would represent a bit of human hubris, since any management or disturbance has ecological consequences and human actions may have unintended effects that are vastly different from the randomness in timing and scale of natural wind disturbance (the agent of disturbance naturally most prevalent in northern hardwood forests). The sale of wood would also remove the ecologically most important characteristic and process of an old forest in New England – abundant, large, dead material lying on the ground slowly rotting.

Wild forest for this report will be defined as forest that:

- Can be any age, but is managed with the intent that it be able to develop the old forest characteristics mentioned above;
- Is not harvested for wood products;
- Is a natural community that is largely passively managed (trees just left to grow), except in rare circumstances;
- Is shaped by natural disturbances;
- Does not experience the use of herbicides or pesticides to control invasive species, unless the landowner can show these are the only feasible option with no alternative silvicultural or reasonable mechanical

approach possible. This assessment shall be by a qualified professional, with the burden of proof and monitoring of results and possible unintended effects the responsibility of the landowner. Herbicides and pesticides used must be the least disruptive to the wider ecosystem possible, shall not be widely broadcast in the forest, and shall use targeted application methods least likely to have detrimental effects beyond the species targeted for control.

2. Ecological Benefits of a Wild Forest

At the time of European settlement, old forest overwhelmingly dominated the New England landscape, and supported a level of wildlife diversity and abundance that is nearly incomprehensible now. There is a widespread perception that old forests support little wildlife, but this reflects the fact, more than anything else, that we collectively think any stand over 100 years of age represents a mature forest. A uniform stand of northern hardwood forest, recovering from the regional deforestation that was complete by the mid-1800s, at that age is actually going through its period of least biodiversity because it hasn't started breaking up into patches of different age groups through disturbance events. It may be economically mature by most forestry stocking tables' standards, but reaching ecological maturity doesn't even begin until about 150 years of age.

Ultimately, the level of biodiversity health in an old forest is largely tied to the abundance of large-diameter rotting logs and the resulting rich, complex, and deep soil ecosystem that is the defining characteristic of the northern hardwood forest natural community. The second driver of this biodiversity is the immense number of micro-habitats created by the complex structural diversity in old forests (Lindenmayer & Franklin's 2002 book *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach* and Kohm & Franklin's 1997 book *Creating a Forestry for the 21st Century: The Science of Ecosystem Management* both published by Island Press are good entries into the vast scientific literature of large decaying matter and complex structural diversity driving forest biodiversity). Our land use history has removed this once-dominant habitat from the landscape, and the second- and third-growth forests that have gradually replaced it have lost much of that soil ecosystem and have little large-diameter dead material. Based on research in the White Mountains it takes, on average, 65 years for the forest floor organic matter to recover from intensive cutting (W. W. Covington in Bormann & Likens 1994 *Pattern and Process in a Forested Ecosystem*, Springer-Verlag).

The functions and values of a well-managed timber-producing forest and a wild forest clearly overlap a great deal for many decades. They both help recharge groundwater and they both can provide recreation and a place of renewal for many people. Changing the status of a forest from management for timber to wild forest has relatively little effect in the first 10-20 years, but it is a necessary step to create a path that must be maintained for a very long time to see the most important ecological benefits of truly old forest. This would be true even if we were not also facing the tipping points of radical climate change during that same period. Below we discuss the role of wild forests in relationship to climate change, but first, a summary of the benefits accrued when wild forest reaches the point of being an old wild forest, arranged in rough order of increasing importance:

Picture 2: Decaying wood demonstrating its capacity to store water and create moist, fungi-friendly habitat. Photo: © Susan C. Morse.

- Enhanced resistance to stand destroying wild fire. Political actors often argue otherwise, but data in

nearly all hardwood forest types indicate it is true, and there is a reason the northern hardwood forest is known as the asbestos forest. For the most part, fires in northern hardwood forests come from the desiccation caused by clear-cuts.
- Nitrogen concentration and storage caused by the vast living ecosystem in decaying wood.
- More resistance to invasive species and edge species becoming established, as these usually follow roads and clearings into core forest areas.
- No nutrient loss, which always occurs after any mechanized harvest or one that opens canopy gaps of more than about a couple of thousand square feet.
- Greatly enhanced moderation of storm run-off or erosion from structural and vegetative complexity and large dead logs on the ground, and no erosion from logging roads into streams.
- Vastly enhanced water storage and quality, above and below ground, because of better soil and lots of decaying (i.e. wet) large logs;
- Long term reference points, formal and informal, of differences between forests managed for timber versus passive growth. Silviculture is a relatively new idea, forests are complex systems, and we still have a great deal to learn from forest driven by natural processes.
- So-called "life-boating" of rare species and source populations for our matrix forests (forests types which cover the majority of the landscape), particularly the northern hardwood forests. This role of wild forests is so important – particularly for birds, about which we have more data, but probably for many species – it deserves to be explained in more detail in the paragraphs below.

There are two givens when a forest is harvested for timber, no matter how carefully: it adds stress to the forest functions and, from a species perspective but not just about tree species, it picks winners and losers as the system adjusts to the stress. As users of natural resources, humans depend upon the natural ability of a system, particularly a forest system, to be resilient; in this case, that means regenerate and regrow the wood we extract and use, and ideally not force any species to extinction. Unfortunately, it is deeply embedded in our culture that management is *necessary* for a healthy forest. Despite increasing evidence that our current path has the capacity to overwhelm a forest's resilience, the policy debates about management still revolve around this more extractive perspective rather than a sustainable perspective, which would be focused on determining how to live within the system's ability to easily adjust to perturbation.

As a general ecological concept, in a natural landscape an unmanaged mature ecosystem (ignoring climate change and non-native invasive species, which add immense complexity because they introduce rates of change outside of normal evolutionary responses to natural community change) represents the maximum species diversity with the maximum possible populations of the different species present.[1] Humans can obviously manage conditions conducive to a particular species or suite of species, such as a game species or a species threatened with extinction, but maximum ecological health and production comes from an unmanaged system. (Here it is important to acknowledge that at some point in history humans were very much a part of that system of so called "checks and balances" we call nature, but it is just as important to acknowledge humans are now well outside of any evolutionary pressures or ecosystem checks and balances, except the

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1 This statement is really the synthesis of the ecological concepts of niche theory and island biogeography which were introduced by G. Evelyn Hutchinson, Robert H. MacArthur and E.O. Willson in the 1950s, 60s and 70s. The research those theories spawned has evolved into new areas of ecological research and theories called landscape ecology and conservation biology. The concepts from these disciplines were brought to forestry by Kohm and Franklin in their 1997 book *Creating a Forestry for the 21st Century: The Science of Ecosystem Management*(Island Press), with Malcolm Hunter's essay "The Biological Landscape" (Chap. 4 in the book) providing a very good summary of how populations, forests and landscapes interact. An excellent book, now dated but still highly relevant, *Wild Forests Conservation Biology and Public Policy* by Alverson, Kuhlmann and Waller (Island Press 1994) brings these concepts of conservation biology to the midwestern and eastern forests of the United States. This entire area of ecology is still highly active with academic testing of theoretical concepts (such as R.D. Holt's 2009 "Bringing the Hutchinsonian niche into the 21st century: Ecological and evolutionary perspectives," or J.M. Chase's 2014 "Spatial scale resolves the niche versus neutral theory debate"). However, in forests it is now accepted enough that some permutation of the opening to this study on forest beetles is not that unusual: "An increase in species diversity with forest age has been observed in many ecosystems and is an important motivation for the conservation of significant areas of long-undisturbed habitats" (H. Gibb et.al. "Functional Roles Affect Diversity-Succession Relationships for Boreal Beetles" PLOS ONE v.8, issue8, 2013, e72764).

point at which we cause the system to collapse as we know it and change into something entirely different). These unmanaged populations create "source populations" because generally they create excess individuals that disperse to seek new habitat.

The original northeastern US forest, with northern hardwood being the dominant natural community, was someplace between 70-90% old forest depending upon location, extent of fire usage by Indigenous populations, and how one is defining old forest. That habitat now makes up less than 1% of the Northeast. We are never going back to a situation where old forest will dominate the landscape or, most likely, anything close to the majority of the landscape. However, putting wild forest back into the landscape, at a significant scale throughout the most forested areas of the landscape, will create source populations for the matrix forests of the region. To use an interior forest bird example, these source populations of birds will disperse excess individuals into the managed landscape where they will fulfill their ecological role even without sustainable reproduction. This allows the forest system to be healthy despite the fact that within the managed portions where wood is harvested we may be simplifying the habitat enough to cause the interior bird species to decline (for example, changing the understory that is critical for nesting but not feeding). In short, the establishment of wild forests will increase resilience in the whole forest and thus allows the removal of wood to be more sustainable.

Picture 3: A fledgling hermit thrush, one of Vermont's interior forest bird species. Photo: © Susan C. Morse.

3. Wild Forest and Climate Change

Climate change in Vermont will cause, as compared to the present, a longer growing season with similar or increased amounts of water, but with less annual snowfall and more periods of "drought" and high heat between more energy-intense storms. Such storms will create rainfall more concentrated in time and area, with its associated threats of greater runoff and erosion. These threats (and all those associated with climate change) will, for the foreseeable future, become more extreme as time progresses. Thus, the time to establish passively managed wild forest is now. Wild forest needs time to differentiate from forest where timber is harvested and build up healthy habitat for increasingly stressed species, some of which will need to permanently "migrate" to escape changes in heat and moisture. The micro-climate within these wild forests will be more moderate than thinned or harvested forests – which result in more sun and less moisture-retaining structure – and thus they can serve as temporary refugia where habitat niches have not changed as much for species moving on the landscape.

Wild forests will have ameliorating influences on the hydrologic changes coming under climate change. Their structure, alive and dead, absorbs and slows the rate at which rainfall moves through them. This in turn reduces the amount of water moving into streams, increases aquifer recharge, decreases flooding and decreases erosion. These changes in well-managed forest take time to develop, which possibly could be moderately shortened through silviculture for old forest characteristics. The important point, though, is that in 100 years when storms are more intense and the capacity to absorb them more urgently needed, wild forests will only have an enhanced ability to process water *if* we start creating them now.

Picture 4: Lynx, dependent upon snowshoe hare as their primary foodsource, are thus threatened by a changing climate. Photo: © Susan C. Morse.

Forests, and wild forests in particular, have a connection to the hydrologic cycle that will add climate resilience to forested regions, like the Northeast, in ways that go beyond the above paragraph and are often overlooked. This is due to the tree respiration that occurs as forests grow. Sugars, the products of photosynthesis, are used by trees to create energy, and in this process CO_2 and water are released, largely through leaves (evapotranspiration). As that water evaporates into the air it has a cooling effect on the surrounding air. One can easily see this in the foggy mist that often surrounds a heavily forested area before the sun is fully out; fog is water vapor that has cooled. While the differences between silviculturally fully stocked forests and old forests is not large, old trees have larger leaf area (Anderson, M. G. 2019 and 2021, *Wild Carbon: A synthesis of recent findings* and *Wild Carbon Supplement: Analysis of sequestration in old forests*, Northeast Wilderness Trust) and thus will have a greater direct cooling effect on air temperature. This will moderate the high daily heat under climate change, particularly over that of any forests that have been harvested recently.

The single most important role wild forests with large trees play in climate resiliency is their ability to sequester and store immense amounts of carbon. For years, many people, including foresters and scientists, thought that old forests had little role in sequestering carbon because of the decay of their dead wood. In fact, some models of tree growth never account for the very mature old forest stage of tree growth because it so far exceeds what is considered financial maturity. And, particularly in the Northeast, the lack of old growth forests to study has impeded our understanding. However, the rise of carbon markets and interest in burning wood as a supposedly carbon-neutral energy source have helped spur an advance in our collective understanding of carbon sequestration in forests harvested for wood products versus passively management forests. Mark Anderson provides an excellent summary of what is a complex and evolving literature on the role wild forests play in carbon sequestration in his two works cited in the previous paragraph.

While there is still much to learn, the following is a simplified summary of current understanding about forest carbon sequestration by most people in the field, even if there is not political consensus. The first step is to understand that climate resilience has both a short-term and long-term component. According to the Intergovernmental Panel on Climate Change's 2018 report, the globe must reach net zero human CO_2 emissions within the next 30 years in order to stay below 1.5 degrees Celsius of warming. Time is of the essence, and in this critically important short-term climate perspective, any wood product harvested has only 30 years in its alternative life as, say, lumber or biofuel, to cause the release of less *net* CO_2 than a tree left alone to grow for that time. This is self-evidently impossible when wood is used for biofuel, given that the tree's stored carbon is released right away, and that burning wood actually releases more CO_2 per energy unit than the fossil fuels it would supplant. The result is not quite so obvious when wood products are durable and designed to replace more CO_2-intensive materials, such as mass timber versus steel or concrete, and the answers here are only beginning to be investigated with any seriousness (regionally, by New England Forest Foundation, as one example). The carbon reduction achieved by not using steel or concrete would have to have a larger absolute value than all the carbon expended in harvesting, transporting, and manufacturing a mass timber wood product, plus the sequestration sacrificed by not letting the trees used continue to grow for the next 30 years. Anything less than that is simply front-loading additional carbon emissions in the short time frame in which they need to be reduced as quickly as possible, even if the change might reduce comparative emissions in the long term.

Looking at forests *in situ*, the results are clear: over the short-term, wild forests are always better at sequestering carbon as compared to traditional management. In wild forests, nothing is lost through harvest, no fossil fuels are burned to harvest, and the amount of wood stored increases as the tree grows in size. A 2010 study by Nunery & Keeton published in the Journal of Forest Ecology & Management found that passive management in wild forests stored between 39% and 118% more carbon than common active management plans over both long and short timespans, and that this was true even though the lifespans of wood forest products were taken into account. They also found that forest management was the number one factor affecting forest carbon sequestration. As for passive vs. "ecological" management designed to increase old forest characteristics, the consensus is less clear. Ford & Keeton published a 2017 study showing that ecological management resulted in 15.9% less carbon sequestered during a 10 year period as compared to a modeled passive management baseline, but these results were not statistically significant. However, they write in the paper that "management scenarios involving no treatment have consistently shown the greatest total long-term carbon storage, accounting for both in situ [sic] forest carbon and the life cycle of wood products." It is also not clear if the carbon emitted in harvest and transportation of any sawlogs was accounted for.

Picture 5: The mighty trunk of an old sugar maple gets deserved thanks for sequestering so much carbon. Photo: © Susan C. Morse.

Old forests not only store the most total carbon over the long term, they also continually sequester more than young forests, a fact which has not been fully understood until recently due to confusion concerning a tree's rate of growth (higher when young) vs. rate of total wood volume added (higher when old). An old tree's ring of annual growth may get skinnier, but this growth is spread over a much larger surface area, as an old tree has a complex structure where some of its branches are basically trees in their own right. We now have hard data from around the world demonstrating that old forest trees continue to sequester, not just store, huge amounts of carbon as they continue to get larger (Stephenson et. al. "Rate of tree carbon accumulation increases continuously with tree size," 2014, Nature 507 and Anderson 2019 & 2021), and that their accumulation rate actually increases with age and size. This is again related to the fact that old trees have high leaf area, probably in the Northeast through increased branching in broad-leafed hardwoods and increased height in conifers, which overcomes the decrease in growth efficiency during maturity. Calculations show that this accumulation of carbon extends to the stand even when accounting for death and decay (Anderson 2019 & 2021). To understand why this makes sense, consider that logs with greater width and height take much longer to fully decay than a small branch. This helps them provide continued carbon storage after death since a mature tree won't fully decompose until up to 75-125 years later depending upon species and location, even though the trees replacing it have started the regeneration process. Contrast that to a small limb or bole that will decay in a short period of a decade or so, depending upon size. Therefore, from a long-term carbon perspective, wild forests created now will be actively sequestering and storing large volumes of carbon for hundreds of years. Which future species are dominant in terms of stand diversity may be different than the present given climate temperature changes, but the hickory and oak that may gradually replace current hardwood forest species will still be a carbon-dense hardwood forest that can provide sequestration in the years when it will be important to bring down atmospheric CO_2 concentration. The natural community transitions may even be less severe in a wild forest setting where harvest activity can't stress the soil mycorrhizal associations, which we now know are so critical for both individual tree and whole stand health and vigor.

Use-Value Appraisal Program History and Operation

1. Importance, Early History, and Purpose

It is hard to overstate how important both the agricultural and forestry programs in Vermont's Current Use Program, formally known as Use Value Appraisal (UVA), have been to the trajectory of Vermont's land use. As the state's recent report to the House Committee on Natural Resources, Fish and Wildlife, "Consideration for a Reserve Forestland Subcategory in Vermont Use Value Appraisal Program" (hereinafter State's Reserve Report) states, "nearly 60% of all privately owned forestland and 70% of all eligible acres" are enrolled in UVA. Given that there are 4.523 million acres of forestland in Vermont according to 2019 FIA data (USDA Forest Service 2020, Forests of Vermont 2019, Resource Update FS-243) and that data showed 79% is privately owned, this means over 50% of all the state's forestland is part of the UVA forestland program. Comparing UVA-enrolled land to protected land in the state emphasizes what an outsized role it has played in protecting Vermont's ecosystems from development. While accurate numbers on the amount of protected land in Vermont are harder to come by than ideal, the most comprehensive are from the American Land Trust Alliance census of land trusts reported by LandScope America, according to which 10.4% of the state was protected in 2010. Now, probably between 11-13% is more accurate. However, to get acreage or percentage that is forestland is even more of an estimate; our best guess would be that protected forestland is about one-fourth of the total UVA acreage and about one-tenth the number of parcels.

The first columns of Table 1 provide a quantitative perspective on the universe of UVA-eligible parcels as defined in our methodology section. There are 26,761 eligible parcels, of which 15,645 are currently enrolled in forest UVA, leaving about 11,116 eligible for future enrollment. In this universe of selected parcels, the acreage totals approximately 3,149,000 acres, of which 2,248,000 (71%) are in the forest UVA program. The state's protected lands are critically important as they represent a view of future guaranteed resources, but in terms of current conservation on private parcels, protected lands pale in comparison to UVA; only 1,551 parcels are 75% or more protected, and the total overlap of protected land with all parcels is 442,000 acres. Essentially all protected parcels are also enrolled in UVA. The bottom line, though, is that UVA is not a permanent program. People can unenroll upon paying a penalty, and as a result, 86% of this land is totally unprotected in the long term.

One of the most important points made in the State's Reserve Report is in the section on the role of UVA, quoted here: "Because the majority of Vermont's private forestland is enrolled in UVA, Vermont will *only* (emphasis added) achieve the targets it has established for its forest conditions if the management strategies to attain them are eligible in UVA." Since the importance of wild forests ecologically and their role in sequestering carbon (as well as passive regrowth of forest generally – now called proforestation) is very different than was known in 1978, when the UVA program was created by the Vermont legislature, some historical overview is necessary.

UVA Universe, Enrolled & Eligible to Enroll			
	Parcels	Parcel Acres	Size
Total land acres enrolled or eligible to be enrolled in UVA	26,761	3,149,000	Avg: 118 Med: 70
UVA Enrolled	15,645	2,248,000	Avg: 144 Med: 84
Not UVA Enrolled	11,116	901,000	Avg: 81 Med: 55
Permanently Protected (>75%) via easement	1,551	403,000 Actually Protected: 383,000	Avg: 260 Med: 132
Partially Permanently Protected (>5-75%)	1,236	218,500 Actually Protected: 59,000	Avg: 177 Med: 89
Protected & UVA Enrolled	1,539	401,000	Avg: 260 Med: 133
Totally unprotected (0-5%)	23,974	2,527,000	Avg: 105 Med: 66

Table 1: Overview of parcels currently enrolled in or eligible to be enrolled in forest UVA in Vermont.

In the 1960s and 1970s, Vermont shifted from a rural state that was hard to access to one served by the Interstate. It became an easy drive from the eastern population centers. The first speculative, large subdivisions in very rural towns appeared, such as the three Hawk Mountain developments (1966 in Pittsfield, 1967 in Stockbridge and 1968 in Rochester). Act 250, created in 1970, was the first governmental response to the land development economic trend, which threatened Vermont's culture, tourism aesthetics, and working landscape of farms and forests. Real estate was suddenly much more valuable, and large subdivisions were not the only threat. Landowners throughout the state now had a way to make money beyond their labor by selling a few parcels of land for development. And more to the point in the context of this report, the increases in value meant that taxes increased and made it hard for traditional landowners to keep owning large tracts of land. Use value assessment laws had started appearing elsewhere in New England as a way to reduce the cost of holding land and encourage landowners not to break up the landscape – thus making it easier to keep the land in traditional economically productive use. One person led the research and political charge to bring that change to Vermont – Benjamin Huffman (much of the following history is pulled from reviewing a sample of Burlington Free Press articles from 1977-1980 through Newspapers.com). Huffman was the coordinator of the Fair Tax and Equal Education Coalition and showed that it was not possible to pay taxes based on the return from average forest land. For farms, he found the tax burden was almost double that in other states. A May 16th, 1977 article captured the range of perspectives on the politics surrounding the tax reform discussion. The Democrat said "[landowners] sign an agreement not to develop their land for a specified number of years in return for a lower tax assessment" and the Republican perspective was that the "purpose of this bill is to give a subsidy to someone who is going to produce… greater production in food and timber."

Huffman must have been a skilled political organizer, because in the end the major organizations active in Montpelier politics all supported it – Vermont Natural Resources Council, Vermont Farm Bureau, Vermont Association of Snow Travelers, League of Women Voters, and others. More telling is that the bill passed in 1977 with a vote of 144-1 in the House. The rule making of the first Current Use Advisory Board (CUAB) that followed the passage of the bill was contentious, with fights over whether farmers would be allowed to still sell small parcels with a minimum withdrawal fee, how much the statewide current use assessed values should be, how the money and assessment details would work, and whether enrollments should be delayed for another year. In the end, it met the original deadline and opened for enrollments in 1980. Some quotes from the time show the theme of this bill was about helping landowners meet their tax burden so that it would reduce development pressure:

- October 11, 1979: Tom Vickery, Chair of the CUAB, said current use was "designed to help landowners in towns with high tax burdens but low assessments." The same article reads "the law, which gives landowners the option of applying for the tax break is designed to cut development of farm and forest land."
- January 23, 1980: "the law was designed to give farmers a tax break so they would have more incentive to grow crops instead of selling out to developers."
- January 24, 1980: "under the program adopted by the 1978 legislature the farmer gets lower property value assessments in return for not selling his land to a developer."
- July 30th, 1978 (snippet of which is shown below): Huffman himself gave his perspective. The article states that "Huffman warned against 'overloading' the law with claims for it. The bill offers a 'reasonable tax' to the farmer and forestland owner who uses it." He went on to say the bill doesn't create markets and is a "'necessary but insufficient condition' for the preservation of land."

Vermont's Fair Tax Law Protects Farmland, Forests

From Page 5B

the plan has no specific time period.

"Once you are in, you stay in," Huffman said. He considered this a strong inducement to keep the land in the program. "The longer you stay in the program, the smaller the penalty for withdrawing."

But Huffman warned against "overloading" the law with claims for it. The bill offers a "reasonable tax" to the farmer and forestland owner who use it.

"But it won't suddenly create markets for timber and milk," he said. The bill is "sort of a necessary but insufficient condition" for the preservation of land. Dairying and lumbering obviously depend upon other factors such as markets and feed and equipment costs.

"Tax reform is not land reform," Huffman added. Huffman still thinks that in the future the state may have to follow several other states in purchasing development rights further to protect farmland. "But the perceived need here was tax relief," he said.

Huffman, who came to Vermont as a planner almost 10 years ago, admits some personal satisfaction with the passage of the bill.

"The land use issue used to be an upper-class phenomenon, but with the creation of the Open Space Tax Coalition several years ago, it seemed for the first time that real Vermonters were getting involved," Huffman said.

The coalition focused first on purchase of development rights, but its focus shifted as membership grew and broadened. Huffman assumed the role of an "honest broker" and oversaw the writing of a bill before the Legislature even met. By that time, he had groups aboard as various as the League of Women Voters, the Vermont Association of Snow Travelers, the Vermont Farm Bureau and the Vermont Natural Resources Council.

Even after four House committees had worked on the bill, it passed 144-1. The quiet-spoken Huffman was midwife to a "motherhood" issue.

Although much of the bill's attention was on the farmland elements, Huffman said he believes its forestland provisions may have an equal or greater effect on the state's economy, because of its encouragement of improved forestry practices in the coming age of alternative energy.

Huffman expressed regret that the Legislature had failed to alter the present "Miller formula" for distributing state aid to education, which is based upon fair market value, but he contended the "bill's reimbursement provision constitutes a significant remedy of a basic fault in the formula's method of evaluating local property 'wealth.'"

Huffman leaves in September to spend a year at Harvard University on a fellowship in the Graduate School of Design. He will devote a quarter of his time sharing his experiences in tax and planning work, and the remainder studying economics.

"Vermont has prided itself on its forward-looking environmental legislation. By this bill, the state has shown its willingness to put its money where its mouth is. I'm sure that is very heartening to the farmers and forestland owners."

Picture 6: A Burlington Free Press clipping from July 30, 1978. From Newspapers.com.

With this context, including knowing that almost no one opposed the bill, here is the Purpose section of the legislation:

> *The purpose of this subchapter is to encourage and assist the maintenance of Vermont's productive agricultural and forestland; to encourage and assist in their conservation and preservation for future productive use and for the protection of natural ecological systems; to prevent the accelerated conversion of these lands to more intensive use by the pressure of property taxation at values incompatible with the productive capacity of the land; to achieve more equitable taxation for undeveloped lands; to encourage and assist in the preservation and enhancement of Vermont's scenic natural resources; and to enable the citizens of Vermont to plan its orderly growth in the face of increasing development pressures in the interests of the public health, safety, and welfare.*

Over the 33 years this law has been on the books, every other part of the original has been amended, but not this section. Note that the words "primary purpose," which are used fairly widely in FP&R materials, do not occur anywhere. In fact, much more inclusive words are used: "encourage and assist." If conservation biology or landscape ecology had existed as sciences in 1977, if we had even started researching wild forests let alone understood them, if climate change and carbon sequestration were topics of discussion in 1977, they would have been in here. In the language of its time, supported by nearly everyone, this was the clearest expression of "keep forests as forests" that there could have been. The bill was about landowners and equitable taxation, natural ecological systems and preservation, as much as production and economy. A political success of finding common ground, it provided something for everyone.

The current collective emphasis on the production and economy of the working landscape has come from one amendment in particular, rulemaking and the language used in the UVA manual. A comparison of the original law as passed with the current law as amended reveals some trends. However, it is beyond the scope of this research to track the exact sequence of amendments. First, it is important to acknowledge that the current law does require "active long-term forest management for the purpose of growing and harvesting repeated forest crops" to qualify for UVA. With the exception of the addition of "long-term" this is the language in the original law. Second, the overwhelming majority of changes don't change original intent and are simply clarifying, updating or rearranging process or language to match modern legal language and statute construction. Some are appropriate cross-references to other parts of statute. Making sure the stream buffers required on farms don't make land ineligible for UVA is an example of the latter type of change.

There have been some positive incremental steps through amendments. A landowner must be in compliance with clean water standards. The addition allowing conservation entities to manage solely for conservation values is quite important. Acknowledging that up to 20% of a parcel – though excluding any operable matrix forest – could be managed for ecological values without timber harvest through the Ecologically Significant Treatment Areas (ESTAs) concept seemed like a huge step when it was established in 2008, and that cap has recently been eliminated. However, when viewed from a historical perspective, that change in fact does not match the scope of what the original law allowed – explained below.

Two changes reduced the flexibility of the original law. One of those changes was clearly to add specificity – it changed accepted forest management practices to minimum accepted forest management practices, which the state then defines in rules, articulated through the UVA manual. The other may have had larger ramifications over time. The original law allowed for management plans to be created by credible forest management entities other than the state, such as the Tree Farm program. It makes sense for ease of program operation to have only policies of the state in play, but removing that flexibility just increases the political motivation to shape the program because landowners have no other alternative. Current county foresters are quite flexible in the types of management they approve, as long as it is between the sidebars of minimum standards (essentially the Forest Service Silvicultural Guides) and it excludes passive management for wild forests. It is not clear, though, that this flexibility has always been the norm.

Which brings us to by far the most substantive amendment in the history of UVA that truly undid the political balancing act which had resulted in the 411-1 vote. At some unknown date, an amendment eliminated all of the language that allowed enrollment in UVA as long as at least 50% of a parcel was actively managed timberland. That amendment existed relatively early in UVA's history because in the 34 years I've (John) worked in Vermont conservation no one has ever mentioned that there was a time when UVA didn't have a singular focus on actively managed forest, which was the situation before ESTAs were allowed. Knowing the original intent of the drafters also puts the existing purposes section into clearer focus. One can imagine the trajectory of relationships between landowners, the timber industry, conservation entities and the state would have been much more collaborative if the original balance of the drafters had survived. Here is the original language defining managed forest land that passed in the 1977 legislature:

> *(9) "Managed forest land" means any land, exclusive of any housesite, which is at least 25 acres in size and which is under active forest management for the purpose of growing and harvesting repeated forest crops in accordance with accepted forest management practices. There shall be a presumption that land is under active forest management if at least 50 percent of the land*
> *(A) is certified to be a "tree farm" under the American Tree Farm System;*

(B) has qualified for a federal cost-sharing forest improvement program, and that program has actually been carried out within the past five years; or
(C) is certified by the county forester as conforming with accepted forest management practices; or
(D) conforms with such criteria for managed forest land as are accepted by the board

There is one other piece of history that is important only because it is now surfacing in reports like the State's Reserve Report as a purpose of the UVA program. It is a section of the law called "Statutory Purposes" which was added in 2013, Bill No. 200. Its one sentence reads "The statutory purpose of the Vermont Use Value Appraisal Program in chapter 124 of this title is to preserve the working landscape and the rural character of Vermont." It was added as part of a large bill that added one-sentence statutory purposes to probably hundreds of statute chapters to fulfill a bond requirement that statutory purpose had to be attached to any law through which the state spends money. Note that none of the words is in the original purposes, and none of the purposes cited in the original statute appears. Whether intentional or not, from the perspective of operating the UVA program, the language used is unfortunate because it does not reflect original intent at all. However, this addition was to serve one specific purpose for finance bonding. It was not a debated bill nor was it drafted to reflect policy consensus, so it should not be used to articulate any aspect of the purposes of the UVA program operation.

2. Operation of UVA

This section is not designed to be comprehensive or explanatory for using UVA. It is a brief summary of important aspects of the practical operation of UVA that increase understanding about incorporating a wild forest-eligible category in UVA.

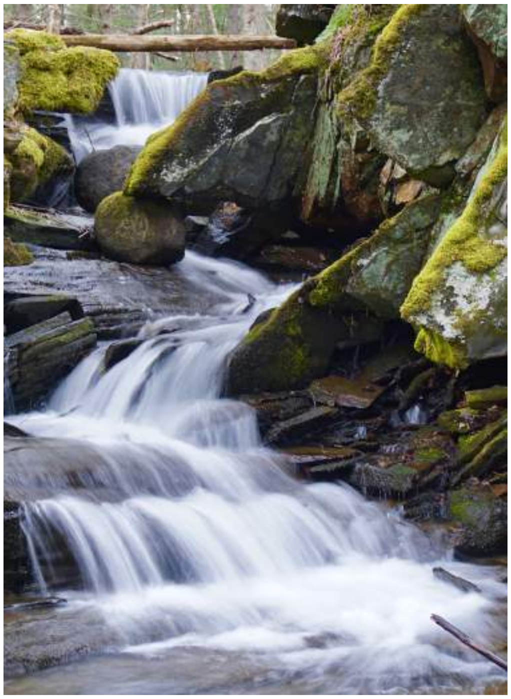
Stakeholder perspectives
Landowner – Parcels enrolled in UVA are taxed using a value set by the state instead of local governments, generally granting landowners a tax liability reduction of 80-90% below what they would have paid based on assessed values. (The only published figure found was 88.4% average tax reduction statewide including both the agricultural and forest programs in 2010. This is from the UVA history current to 2010 found in the 2010 UVA Manual on the FP&R website). However, there are significant costs in meeting the administrative requirements of UVA, particularly in the creation of a management plan by a professional. From a land use goals perspective there are sidebars to a landowner's freedom – particularly for landowners who own a given parcel for a long time – because at some reasonable point the management plan's harvest must be implemented. The relatively recent creation of ESTA categories adding management flexibility for a parcel's ecologically sensitive land, within UVA's focus on wood products, has eased many conflicts about land use goals. But any passive approach to restoring matrix forest conditions is hard-to-impossible to get approved.

Town – The state reimburses the town the difference in taxes they would have received from the landowner under 100% fair market value (FMV) assessment, thus making UVA a state program in terms of cost and administration, not a town program. This is a simplistic view because of how education is financed in Vermont, but the basic concept holds. This is in stark contrast to some of Vermont's neighboring states, where towns just lose tax base by current use assessment and the tax burden is shifted to others in the town.

State – UVA from its inception was designed as a state program with an annual cost, which for both the farm and forestland programs now totals 66 million dollars annually. However, it depends upon towns accurately and regularly assessing properties at FMV, which is part of the legal structure around property taxes. Unfortunately, people who work in real estate know there are examples where towns over-value remote, low value timberland. This increases the cost to the state. Normally, the check on assessment overvaluation is the property owner because it directly affects them – as explained above, however, landowners are no longer really part of the assessment system. Separately, approving and tracking required forest management plans is a significant time and money cost to FP&R. However, that connection has also probably created some of the shift to working forest issues at higher administrative levels and yet also creates a clearer connection to understanding landowner goals at the county forester level.

Foresters – Because management plans must be updated every 10 years and any time a property is sold to another owner, UVA provides a lot of work for foresters. In general, that heavy involvement of foresters has over time improved the quality of forest management in Vermont. Many landowners own land over long periods and even encourage a new owner to use the same forester so knowledge of what prescriptions worked or did not work accumulates in the program. However, a change in ownership or major life event can just as often result in a change in management philosophy and "undo" years of resource improvement if management becomes more aggressive. Continuity of purpose and direction is highly variable from parcel to parcel.

Timber industry – According to 2019 FIA data, harvest operations occur on about 50,000 acres a year in Vermont, and the amount of timber removed is overwhelmingly located on private land. Both the UVA and unenrolled lands are important for harvest operations, but since UVA forested parcels on average are larger (Table 1) and, as outlined above, between 60 and 71% of eligible forest land is enrolled in UVA, the industry carefully tracks any changes to UVA. In general, the industry views changes that remove trees from potential future harvest, or restricts the ease of harvest, as negative. The industry has been generally supportive of the ESTA categories because they focus on rare species or natural resources and are generally quite limited in size. The industry also understands the difficulties of working on steep (> 35%) slopes without having negative effects on the land, and thus categorizing those as essentially inoperable isn't really a loss. This is largely the reason that the State's Reserve Report focused on natural heritage resources and steep slopes. All proposals to increase the ease with which landowners can pursue wild forest management are unlikely to be welcomed by the timber industry.



Picture 7: ESTAs include riparian features, such as streams and their buffers. Photo: © Zack Porter.

Why is it difficult to modify UVA?

From 1991-1995 the State could not fully fund the program, and in fact had enrollment moratoriums during 1992 and 1993. In addition, in 1996 and 1997 there were changes in UVA that made it more restrictive. It isn't clear what the statutory situation was at that time, but during these years the state felt it had not met essentially a contractual obligation to landowners to lower taxes to use value. Thus, the state allowed so-called "easy outs" from both the agriculture and forest programs. The original law provided for no penalty payments for unenrollment if the state could not fully meet its payment obligation to a town for enrolled landowners. However, it is no longer in statute. It is doubtful that any statute covered the situation in 1996 or 1997; in any case, a total of 1,540 parcels were unenrolled without penalty from UVA. For the forest UVA program this represented 133,785 acres, with nearly 40,000 withdrawn because of the legislative changes to the program, probably because of the doubling of the penalty for withdrawal. Ever since, when people talk about making changes to UVA that increase restrictions, the response is that 'we can't because of the easy out problem.' The result is largely a one-way political street – changes can make the statute more oriented toward working landscape values rather than ecological values or enhanced management standards. There have been exceptions, notably the additions of ESTAs for sensitive ecological features, through management plan requirements that don't reach the need for legislative change and/or don't force landowners to manage in a particular manner. For example, ESTAs are not mandatory protection for ecologically sensitive areas, they just allow landowners who want to protect them room within the program to do so without losing eligibility under the UVA statute. Luckily, incorporating eligibility for wild forest would be an enlargement of the program that does not involuntarily affect those already in UVA; thus, no concerns about the "easy out" history of accommodating landowners are relevant here. The fact that the language doesn't exist anymore for withdrawal without penalty also may have removed this impediment toward improving management standards for UVA. In any case, it's clear that a wild forest enrollment category would not create a situation where landowners could leave UVA without penalty.

Penalties for Conversion to Development

Currently the penalty to withdraw a property from UVA to develop it is 10% of the full fair market value of the withdrawn parcel, valued as a parcel. If wild forests become an eligible category in UVA they will only be ecologically meaningful if they stay in the program for long periods of time. The statute could be amended to create a different penalty regime uniquely for enrollment as a wild forest so as to not create an "easy-out" opportunity for other enrollments. UVA penalties, either the existing or one enhanced to be a larger deterrent for wild forests conversions, may start the maturing trajectory for wild forests. However, to play an ecologically significant role in the landscape, all of them will have to eventually be permanently protected by conservation easements since only easements have the permanence that matches the fact that a wild forest only just begins to enter its "old forest" stage of life when it is 150 years old.

UVA Interaction with Conservation Planning and Easements

At the simplest definition of conservation – the prevention of development – there is no comparison between how much forestland UVA has kept from development compared to easements on private land. As we discussed earlier, easements only protect 14% of eligible or enrolled acreage. It is not clear as to whether the outcome would be substantively different if the same amount of money spent on forestland current use over the years had been spent instead on purchasing easements or more public land. This was the approach in many other states but generally it is probably correct to say those programs have not had the same proportional impact on the entire state forested land base.

From the beginning of UVA a forest management plan has been required. One of the unexplained incongruities between the farm and forest sides of the UVA program has been the lack of management plans required for farms, even though their management affects ecological values just as much as forest harvest does. One would have thought that the long-standing familiarity with forest management plans would have made it easy to incorporate new evolving ecological knowledge into how Vermont forests are managed, particularly since one of the threads of discussion when UVA was created was to improve typical forest management. The first step in improvement did happen as the state set the USDA silvicultural guides as the minimum standard. But in many ways, it got stuck there. The reverse sequence of evolution has happened in conservation easements held by various nonprofit conservation organizations such as The Nature Conservancy, the Vermont Land Trust and others. Early easements just had language about sustainable forest management where more modern ones get into the details of leaving coarse woody material, preventing clear-cuts and other details of forest management. The last decades of experience between state-required management plans and types of management required by an easement has been a bit of an imperfect partnership. County foresters can suggest direction to a landowner but usually don't go past the standards in the silvicultural guides. Even when a property is protected by a conservation easement the state county forester review of what is acceptable in a landowner's management plan for UVA doesn't include connection to the easement. The state depends upon the nonprofit to require the more ecologically-oriented management, and this can create a situation where a forester for a landowner can work the state and conservation group against each other in matters of interpretation. Wild forest, as discussed earlier, is a less well-established concept so this triangle of discussion of acceptable management plans is not going to get easier. The state is not going to exempt wild forests from management plans, but it might be possible to have state and nonprofit partners work together to define what needs to be addressed in a wild forest management plan.

UVA Interaction with Exemplary Forestry

It may surprise people that UVA struggles in any way with forestry planning issues given its focus on the working forest landscape. It is not an issue of how the purposes of the program are written. The right words are there – even if not as explicit or using the language of landscape ecology that might be used in 2021 – and it is written at the scale of systems and Vermont's forest landscape. However, as currently implemented it is almost completely constrained by scale. It works solely at the scale of the individual landowner and the parcel they own for the period they own it. That is true even though, because the program enrolls such a high percentage of the forested landscape, the county forester approving a plan often knows what the plan of the abutting landowner is. But there is no directive in UVA to coordinate between adjacent properties.

The issue of invasive species is a good example of the failing of scale for UVA forest management. Some aspect of invasive species control can be beneficial at a property scale, but ultimately it is usually a landscape issue, dependent upon what types of forest management and invasive species management neighboring properties are doing at a particular point in time and how heavy the invasive species load is within a landscape. To have long-term productive forestry in Vermont given this reality will require the UVA program to operate at a regional scale and possibly ignore the typical approach in regulations that treats each landowner by exactly the same standards. Some variation on performance standards may be needed to take into account the conditions surrounding a particular parcel. UVA is a public expenditure that should expect a public good more broadly defined than by economic activity. ESTAs were a good step toward broadening forest values that can be reasonably defined at a small scale. However, in 2021 we know that forest systems also work over watershed and regional scales in ways that are just as important. Connectivity, which is one of the ecological aspects that Vermont Conservation Design set out to define for Vermont, is another example of how UVA has to incorporate forest values at a larger scale into a parcel-by-parcel enrollment if Vermont's forest are to be resilient. A useful analogy of this problem of scale in the farming community is phosphorus pollution into Lake Champlain. One farmer's management can't solve it, but one can make it impossible to get the benefits of better management on other farms.

Unfortunately, UVA also doesn't incorporate long time scales well even though exemplary forest management is almost the definition of having to think in long time scales. There is no trajectory for a forest created when a management plan is approved for a parcel in UVA. The objectives of one landowner, say to create large diameter sawtimber and excellent habitat for interior forest birds, may only last a few decades before the next owner of that parcel decides that they need more cash flow over a few years to pay for a college tuition. The net result of truncated time trajectories is a forested landscape that hovers around the economic needs of shorter-than-a-human-generation timescales, rather than a progression toward a landscape of great structural diversity and resilience producing large amounts of timber and wildlife. Public lands can be examples of thinking at scale, but remember 80% of our forests are privately owned. They will determine how our forested landscapes function.

Climate change will force us to adjust our scale of thinking, but wild forest enrollment will also. Wild forests in Vermont are never going to become the dominant forest in Vermont's relatively fragmented the landscape. Therefore, to bring their ecological and climate resilience values into the landscape in a functional, and hopefully cost-effective way, will require thinking outside of the scale currently considered normal for UVA forest management planning.

3. How does VT UVA compare with other New England States?

This simple overview will compare features of Massachusetts, New Hampshire and Maine.

All of these current use programs started out in the 1970s solely aimed at reducing taxes on timberland that was producing timber. In that respect they were all single tier. All except New Hampshire required state-approved timber management plans, but New Hampshire allowed for a lower assessment if there is a timber management plan meeting recognized standards (like the Tree Farm program). The Massachusetts and Maine programs evolved to have additional Open Space categories of allowed use where timber management was not required, but could be practiced. In Massachusetts that management plan still needs state approval, in Maine it does not. All three states include a lower tax assessment if the landowner allows public recreation of some limited kind, except New Hampshire where it simply must not be posted. Maine's program is the most flexible and comprehensive – the Open Space category only must have some type of public good as determined by the town assessor. It can be as simple as a scenic vista from a public road or the protection of endangered species habitat. The list is quite comprehensive.

All except Vermont's program require the towns to use a current use valuation to calculate the current use tax rate. Maine's is the only program that is truly tiered. The basic open space assessment reduction is 20%, but through a combination of whether it is permanently protected, allows recreation, manages for timber, or is permanently forever-wild with public recreation, it can get as high as a 95% reduction in tax assessment. However, the permanently forever-wild requires a permanent easement keeping it that way so very few people enroll.

Penalties vary. The penalty for removal in Maine is as high as 30% and is never less than 20% in the commercial timber program. For the Maine open space program it can be the greater of the 30%/20% arrangement or 5 years of back taxes less what had been paid. New Hampshire never allows removal but a landowner can develop the smallest legal parcel and that is taxed at 10% of the parcel developed. Remaining land must remain in the program until it is no longer possible to have a remainder parcel left greater than 10 acres. Towns get the penalty payment. Massachusetts just has a 10% penalty of the fair market value which declines 1% for each year of ownership. After 10 years there is no penalty. However, there is a lien on the land that gives the town the right of first refusal if the land is ever sold for development.

Payment for Ecosystem Services

In recent years there has been increased focus in harnessing the economic market to help pay for reducing some detrimental environmental change. Among those arrangements is payment for ecosystem services (PES). This has been widely used for watershed protection, but with the focus on climate resilience and carbon markets its profile has increased.

It is widely accepted that Paul and Anne Ehrlich coined the phrase PES in their 1981 book about extinction. Slightly earlier in 1997, Robert Costanza et al. in a Nature article economically quantified how ecosystems support humans, which essentially founded the field of ecological economics. Here in Vermont, the Gund Institute at UVM has been a leader in the ecosystem services field and is associated with Costanza.

In its most basic form PES is a legal structure where an entity, public or private, incentivizes landowners to undertake land management that provides an ecosystem service through a regular payment. It may or may not be a directly calculated value, it just has to be a payment that is enough to change or maintain landowner behavior to maintain something of value to the entity making the payment. The key is that it is a voluntary economic transaction with definable environmental benefit that is delivered. There is a whole literature on what qualifies for an ecosystem service, but simple is better in this case – the parties just need to have a standard they agree on, it is clearly provided by an ecosystem, and there is payment for the management wanted.

This is in distinct contrast to a regulatory approach to reduce environmental harm or other programs that don't involve more than a single payment to require a certain behavior. Pollution regulation fits the first type and is not voluntary. The purchase of a conservation easement is voluntary, but it is not an on-going payment, it is a purchase of a property right.

UVA is a PES in every sense of the word. It didn't evolve into that but started there, and the founders knew their approach was different from all the rest of the New England states' approach to use value. Other use value programs created voluntary programs landowners could choose to enroll in, but the ongoing payment for that was shifted to all of the other landowners in the town of the person enrolling. The difference in value between Fair Market Value and Use Value simply disappeared by state law, and the town, to collect the same taxes, had to increase the rate on everyone else. Of course, in many towns the period from the 1970s to the present day has been one of constantly increasing real estate value, so some of that tax shift is simply not seen by landowners. The programs have been around so long at this point that they are just viewed as normal tax policy.

Picture 8: The benefits of healthy forests are increasingly framed in economic terms as ecosystem services. These include those shown off in this picture: clean water, fresh air, and stunning views. Photo: © Zack Porter.

The drafters of the original Vermont UVA understood how that would affect landowners and towns, and so created a program financed by state payments on an ongoing yearly basis as a way to prevent development on farms and forestland. The newspaper articles of the time make it clear legislators understood the consequences of the new approach, and there was concern about how much it would cost the state as time went on. Benjamin Huffman in particular knew how unusual this approach would be. It is widely accepted that the USDA Conservation Reserve Program from 1985 is the oldest PES in the United States. That is clearly wrong; the Vermont UVA in 1977 was at the cutting edge of protecting the value of ecosystems and the founders knew it – the modern accepted term just didn't exist until 1981. From the July 30th, 1978 issue of the Burlington Free Press:

> *"Until this bill, most proposed solutions depended on shifts of burden within towns, and in effect, were exercises in 'robbing Peter to pay Paul.'*
>
> *Thus this determination of the state to 'put its money where its mouth is,' in the*

words of Rep Robert Kinsey, R-Craftsbury, makes the law 'one of the most advanced land use assessment approaches in the country,' Huffman said....

The landowners who qualify are then taxed at the current use, and the state pays the local community the difference between the current use tax and the fair market value tax."

One of the oddities of Vermont's UVA being a PES is that it reduces the tax so much there is limited room to "add" services to it, such as providing recreational access, or enhance the level of the existing service being paid for, like setting standards for retained coarse woody material, snags, or other approaches discussed in the FP&R report "Voluntary Harvest Guidelines for Landowners in Vermont." UVA has been amended to incorporate ESTAs and create congruence with modern water quality standards, but the modern forest management world has moved well beyond the minimum standards currently required by UVA.

Other than an historic curiosity, why is it important in a report about wild forests and their interaction with UVA to discuss UVA in the context of PES? In a word: carbon. Recent research has shown how important native forest ecosystems are in sequestering carbon, in particular carbon-dense forest like a northern hardwood forest. Vermont sits in the heart of a globally important forest which is more intact at a regional scale than many temperate broadleaf forests. The forest sequestration carbon markets and their PES structure are becoming quite robust and recognized as increasingly part of the puzzle for climate resilience. While it is technically possible to manage and harvest timber in ways that enhance carbon storage, and thus qualify for a carbon credit payment, the amount of stored carbon is much less than just paying landowners to allow trees to grow for the period of time required by the carbon markets. Wild forests that are not protected by a forever-wild easement before enrolling in a carbon market also qualify for carbon credit payments as they store carbon for much longer periods of time, as discussed earlier in the report.

Carbon storage is a forest product just as much as timber is, and it is increasingly an attractive PES for landowners. However, current UVA legislative language removes that passive management option, and the potential for increased carbon PES income, from landowners. The program itself is compatible with recognizing carbon storage, whether through carbon projects or wild forests, and the law could be relatively easily amended from a drafting perspective to accommodate it.

Project Goals

The overarching purpose of this research project was to investigate the financial impact of adding a wild forest category to the forest UVA program. The steering committee of Wild Forests Vermont started discussing the design in the fall of 2020 and work started at the end of February by hiring John Roe to lead and undertake the research.

The design was to run different eligibility scenarios to test how it might affect the program financially and how it might support ecological goals of the state. Uniquely, the mechanism for doing this would be sampling specific parcels and then modeling their impact in an attempt to quantify likely landowner behavior. The hope was to determine landowner interest in a forest reserve, or at least set likely sidebars so the result would be a range of likely costs. Test runs were completed to see if one could reasonably figure out how behavior by different types of landowners, by ownership size, measures of wealth or geographic location might drive results. In the end, the decision was made that anything other than random selection of eligible parcels would just add unverifiable assumptions to the work.

The original timeline was completion by the end of August. However, unexpected draft legislation to add such a program to UVA was before the House Committee on Natural Resources, Fish and Wildlife for hearings. The state (FP&R) was asked to undertake some analysis of its effect on the UVA program and how such a category could be added. After listening to the preliminary data analysis of the state we decided this project would be stronger if it were built off of the same data set of parcels that the state used, and if one of the approaches analyzed was to use the same eligibility criteria the state had modeled.

The final design was to compare three potential eligibility criteria, all based on the basic 25 acres needed for UVA. The three were statewide enrollment eligibility, parcel eligibility only within the boundaries of the highest priority VCD forest blocks, and then the state's approach of concentrated ecological values, all based on random selection of parcels at varying levels of hypothetical enrollment between 5 and 20%. These parcels were then run through various publicly available quantified measures of ecological values to determine both cost and ecological efficiency of the different scenarios. This change in direction, in which much work was started over using the new data set from the state, delayed the final report by a few months.

Methodology

1. Data Sources

A mix of data sources was assembled. First, publicly available GIS layers from Vermont's Open Geodata website (geodata.vermont.gov) were downloaded. Four layers were initially used:

1. A map of all parcels in Vermont organized by SPAN with their 2019 tax data attached
2. A map of all protected land in Vermont, last updated in June 2021. This map, although recently updated, is still not perfect, particularly with regards to Upper Valley Land Trust parcels in the Upper Valley because it did not participate in the initial upload of data years ago, and that backlog has not yet been incorporated into the layers. This data base did not include SPAN numbers so it had to be connected to parcels via spatial overlay, described below.
3. A map of parcels enrolled in UVA, with forest management plans, from 2020.
4. Layers showing highest priority VCD elements (we used highest priority Interior Forest, Physical Landscape, and Connectivity blocks, dissolving them into one layer used to define "VCD" for this project)

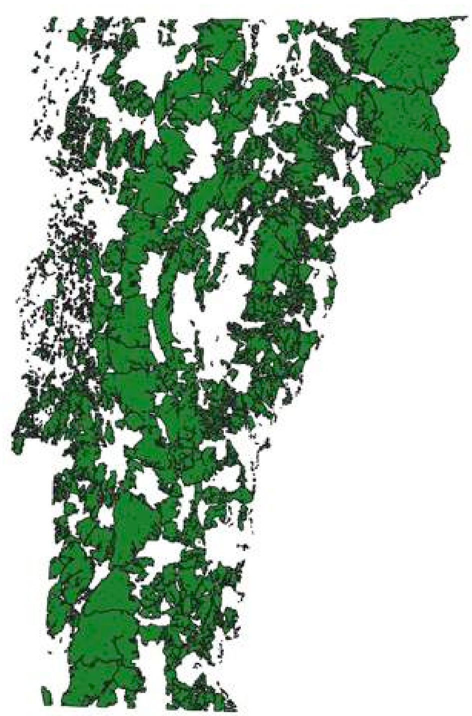
These data sources were combined to make a master dataset with any given parcel attached to its tax data and UVA data via SPAN number. Because UVA is a program only for private lands, all public lands were removed. Rough assumptions about what parcels may or may not be potentially eligible for UVA enrollment based on size and tax category were made, and parcels that were less than 27 acres according to the Grand List or those that were considered commercial, industrial, unlanded mobile home parks, utilities, or uncategorized parcels were removed. Most farms were also easy to remove, but we knew that parcels that were a mix of open land as well as forest were probably being included in higher-than-ideal numbers. This dataset was used to experiment with different eligibility criteria and sampling scenarios to mimic landowner enrollment behavior. There has been a history of concern in UVA policy that some potential landowners only enroll to avoid taxes; and thus, creating a category of land that did not require harvest might disproportionately attract those landowners. Various filters, including town and value per acre were tested, but in the end the decision was made that the only truly defensible approach was a random selection of parcels to reflect landowner behavior if they were offered a chance to enroll under a wild forest UVA category.

2. Defining Dataset Decision Rules

Some rules of eligibility were developed during this phase of the project that need a more complete explanation. For example, one might typically assume a parcel size cut-off for basic eligibility to be 25 acres, which is the criteria for eligibility in UVA. While 25 acres are needed for UVA, in practice and for the purposes of this report the minimum is 27 acres to account for a house site, since house sites are ineligible for inclusion in UVA. In practical terms most landowners are not going to encumber a 25 acre parcel with UVA and make it impossible to build on, thus the decision to use 27 acres for the cut-off.

A rule for defining protected land status was also necessary because there was no direct link between the standardized parcel data and the map of protected parcels. Without a lot of data cleaning there is rarely a one-to-one match between different shapes outlining the same geography in GIS; therefore, a rule was developed after a bit of experimentation that seemed to reflect reality well. If a parcel was overlaid by a protected land shape by 75% or more the parcel was considered "protected." Since most easements have some excluded acres, 75% seemed like a good measure that all of the parcel that could be protected was protected. If the overlap was between 5-75% it was characterized as partially protected – in other words, it seemed likely that more could be protected or developed in the future depending upon a landowner's goals. If the overlap was less than 5% it was deemed just error caused by a shift in shape location and the parcel was categorized as unprotected.

Vermont Conservation Design was a comprehensive effort led by the state to map the most critical parts of Vermont's landscape required to protect the state's biodiversity, now and in the future, and to provide resilience to climate change by creating connection across the landscape as multiple scales. Given its link to the statewide landscape and incorporation of many layers of ecological function, it immediately came to mind as a possible way to shape the potential enrollment of wild forest in UVA. At the beginning of the project the thought was to simply compare a scenario of UVA enrollment eligibility for just within VCD versus anywhere in the state. The steering committee debated what aspects of VCD highest priority layers should define "within VCD." In the end, wild forest is about forest ecological values and the group decided that the three highest priority forest blocks (Interior, Connectivity and Physical Landscape, see Map 1) would be used to define a wild forest as within VCD or not. The other highest priorities could be protected by several other means, and the forest blocks often contained smaller units of biodiversity like vernal pools. But defining "within VCD" was not simple since the forest block boundaries were not related to parcel boundaries. In addition, it seemed arbitrary to define a line for deciding what was in or out. The forest boundary is more of a buffer. Thus, "within VCD" became defined also by spatial overlay. If a parcel was overlaid by a VCD highest priority forest block layer by 75% or more, or at least 50 acres were within that layer, it was considered "within VCD." This buffering expanded the VCD boundary outward by about 300,000 acres and about 70,000 acres within the state's defined VCD boundary were lost, resulting in a net addition of 230,000 acres defined as "within VCD."



Map 1: Total Vermont landscape coverage of VCD's highest priority landscape blocks.

3. Readjusting Potential Enrollment Universe

Unexpectedly, legislation was drafted last legislative session to incorporate wild forest into UVA, an initiative led particularly by the

House Committee on Natural Resources, Fish and Wildlife. Keith Thompson, Private Lands Manager with FP&R, generously offered to give us access to the data layers he used to analyze possible changes to UVA that might be acceptable to FP&R. Keith had taken a more precise definition of potential UVA enrollment by quantifying whether or not a parcel had at least 20 forested acres on it. FP&R also had forest acreage data for every parcel. The ability to directly compare our study's results with the FP&R work, along with the precise determination of forested acres, resulted in the decision to change our working dataset to be the universe of parcels FP&R had defined. From this universe we would do our modeling and analysis, including the cost to UVA of all potential new enrollments.

However, work with that dataset revealed enough inconsistency around potentially eligible parcels that some data cleaning was undertaken to ensure that the final analysis was as accurate as reasonably possible. First, 337 parcels of public land were eliminated so that there was no public land in the analysis. Then, parcels between 25 & 27 acres (either by Grand List data or GIS measurement, to err on the side of caution since either method introduces error) that included a house site were also eliminated, as their automatic two-acre exemption would place them under the threshold of 25 enrolled acres. Additionally, as explained above, the first universe of potential wild forest parcels did not include any industrial, commercial and utility property. The state left these in, but in the end after visually analyzing about a third of those (110 parcels of 350), it was decided that some were not actually viable candidates for UVA enrollment. Based on that visual work, parcels with less than about 60% canopy coverage and less than 40 total parcel acres were not reasonable UVA candidates for any UVA enrollment, let alone a wild forest. The lien and subsequent penalty for removing the property from UVA would have intruded on operations or made no sense in terms of the actual use. These were often campgrounds, golf courses, small ski areas, small quarries, mobile home parks or industrial areas surrounded by development.

As for the enrolled dataset, few edits were made. Although there were parcels included in it that would have been cut from the potential dataset given that they either had less than 20 acres of forest coverage or were smaller than 25 acres, the state is a trustworthy source of information on what is actually enrolled, and it was assumed that ground-truthing on these parcels revealed UVA-eligible conditions. Also, sometimes those smaller parcels can be parts of a larger whole, but must be treated as individual parcels because of town boundaries or other features. The only edits made to the enrolled data were to remove all parcels owned by the timber company Weyerhaeuser, which are located in the Northeastern Highlands and total 84,000 acres in 16 parcels. These parcels were once part of the so-called "Champion Lands" conservation effort; they are subject to easements requiring them to be timberlands that produce harvested forest products and thus would not be eligible for future enrollment as wild forest.

This data cleaning left us with a set of enrolled parcels which is the same as the state's except for the Weyerhaeuser lands, and a set of potential parcels which is perhaps a bit conservative on the whole[1], but from which samples could be taken with confidence.

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1 We estimate that this set is possibly conservative for two reasons. One, because FP&R's potential dataset did not have 3,790 parcels in it that our initial one (14,542 parcels) did, of which 515 could be explained by discrepancies resulting from the fact that FP&R weeded out parcels by GIS-calculated acreage while we had initially just used Grand List acreage. The remaining 3,275 likely were eliminated because they weren't as forested as our methodology had assumed; however, spot-checking with the Vermont Natural Resources Atlas revealed that, while this was true of some parcels, others appeared to have 20 forested acres and it wasn't apparent to us why they weren't in the FP&R dataset. The second reason to think our final universe is a bit conservative is precisely due to the presence of parcels in the enrolled state data that would have been eliminated as part of the potential data clean. Presumably, some eliminated potential parcels should also technically be eligible for UVA given these parcels' presence in UVA – 1,500 of them, usually small with less than 20 wooded acres. Some of these may be parts of farms that qualify for ESTAs or parcels "stranded" from other enrolled property by some boundary, and, as mentioned, were left in the analysis. These issues, however, raise data questions we did not have the capacity to answer. While there likely are explanations, at this time the presence of those parcels leads us to think our final working dataset for potentially enrollable parcels generally errs on the side of more limited than actuality rather than less.

4. UVA Cost Calculations

This refined universe of potential parcels was then given to Deb Brighton (former director of the UVA program and recent chair of the Vermont Tax Structure Commission), who ran them through her assembled databases in order to determine the cost to the state on a parcel-specific basis if any were to enroll in UVA. For these parcels, a two-acre exemption was assumed for a current or future house site, and the total acres of each parcel that was greater than one mile from a Class 1, 2, or 3 road was estimated by intersecting the parcels with a buffered map of Class 1, 2, and 3 roads (publicly available). The ratio of GIS-calculated acres of each parcel that were greater than one mile from these roads to the total GIS-calculated acreage of each parcel was applied to the Grand List acreage for each parcel. Deb calculated the cost of each parcel to the General and Education Funds if it were to enroll in UVA using 2020 Grand List valuations.

Potential costs of enrolling wild forests are calculated four ways under each of the scenarios using different assumptions to create reasonable sidebars to inform policy decisions. Calculations 1-3 are endpoint calculations – in other words, they represent the maximum costs when all the assumptions are met (or as close to met as the data will allow). The fourth is based on the actual costs of the parcels chosen through sample modeling, and then averaged across the five runs for each scenario at each enrollment percentage.

1. Calculation 1: This first calculation is the total cost if every potential parcel in a particular scenario universe were to enter forest UVA, whether as timber producing or new wild forest category. This is the maximum cost possible, as existing forest UVA enrollments could also switch to the new wild forest category but there would be no increased expense as they are already in the program.
2. Calculation 2: The second approach determines what it would cost to implement the VCD old forest goals. This assumes that in each scenario enrollment would be capped once the VCD target is reached in each biophysical region. It is unrealistic to think the capping process will be that precise, but this approach gives a reasonable approximation. The most important assumption in this calculation is that people are equally likely to enroll as wild forest whether the land ownership is already enrolled in UVA or not. Given that such a large proportion of Vermont forestland is already enrolled in UVA, and thus enrolling as wild forest would not affect its cost, this calculation represents the likely least-cost estimate for VCD implementation.
3. Calculation 3: The third calculation assumes that VCD old forest goals are largely completed through new enrollments. We know how many forested acres are needed in each biophysical region to reach the VCD goal and the calculation uses parcels from each scenario's universe of potential parcels to reach that goal. In those regions where there is an excess of acreage available the calculation is an average cost of all the parcels applied to the acreage needed to reach the goal. If potential parcels are not enough then the remaining needed are from enrolled parcels and do not add costs. This third approach is essentially the first approach but capped at the VCD old forest goal for each biophysical region. It represents the maximum cost for each scenario under a wild forest UVA category designed to implement VCD.
4. Calculation 4: This cost is derived from sample-based modeling runs (explained at the end of the methodology section). The cost for the parcels sampled in each run is calculated, and then the average for the five runs are used to represent the cost of that sampling intensity. This is both a confirmation of Calculation 2 and allows the results to be presented over a range of hypothetical enrollment percentage so that one can see how cost might increase over time.

5. Testing Ecological Benefit

Most public policy aims to get a desired change for the public good at the least cost or least disruption while still achieving the goal. The public policy goal of adding wild forest as a UVA category is essentially about adding habitat diversity, enhancing the ecological health of our landscape scale forests – known as matrix forests – and increasing the resilience of Vermont's ecology to climate change. Traditionally quantifying the small elements of biodiversity, particularly rare species habitats and natural communities with high ranking from the Vermont Nongame and Natural Heritage Program would be a measure of the ecological importance of a given forested parcel. This is basically the approach of the FP&R report on forest reserves referenced throughout this document. Advances in understanding from the sciences of conservation biology and landscape ecology make it clear that it is also critically important to look beyond a parcel and to the wider local and regional landscape to determine the ecological benefit of changing the management trajectory of a given forest parcel.

There are two comprehensive tools that incorporate all aspects of both local and regional ecological importance, including long term landscape connectivity. The tool created by the state is Vermont Conservation Design (VCD). The other was made by The Nature Conservancy (TNC) to define resilient landscapes at local, ecoregional and national scales: the publicly available "Resilient Landscape Mapping Tool."

TNC Resilient Landscape Summarized Methodology

The basic methodology used for this tool was to bring dozens of databases together to quantify the entire landscape at 30-meter pixel granularity. Their mapping tool then allows the analysis of any polygon on many different values that are derived by assembling the data bases. The unique aspect of the work was to comprehensively look at how each pixel was connected to its adjacent pixel and the surrounding landscape of pixels to determine permeability and flow of species through the landscape. This concept of linking each pixel to its landscape of pixels was also brought into measures of natural community condition and microhabitat diversity to determine whether a given pixel was above or below average for the ecoregion in which it sat. The latest iteration of the mapping even allows one to quantify the current carbon stocking for that given pixel as well as its future potential to store carbon if left undisturbed.

To work through one particular example, this is the description of how local connectiveness is determined for each pixel. First, every type of land use was given a resistance value. Another way to think about it is how similar are two adjacent pixels and how supportive are each to natural systems and species. A natural forest may be fully connected, while an industrial forest plantation may be fairly resistant because all the roads and frequent cutting impede "ecological flows" outward from a given point. The average of three adjacent pixels is calculated to create a connectivity value from least (0) to most (100). Then this connectivity value is "compared" outward to a three-kilometer diameter landscape around the 90-meter pixel. This average value is then compared to the overall regional average connectivity to determine how much above or below the average it is to determine the overall local connectivity score. This is so computationally intensive that it takes weeks of computation to finish scoring a region.

Similar thinking and analysis was done by TNC to determine how resilient a pixel is to climate driven changes. These take into account landform diversity, elevational range, wetland score and soil diversity, usually in a 100-acre circle around each 30-meter pixel. To determine the relative ecological value of any selection of parcels to be enrolled in UVA as wild forests this study relied most on the TNC measurement of the overlap of three critical values – resilience, diverse flow (a measure of a landscape without huge barriers in it over a fairly wide area) and recognized biodiversity. The last is probably the most important as it is directly mapping landscapes with known highly ranked natural communities or rare species, so it is the most easily used way to differentiate two parcels. It is also directly applicable to the more traditional ways of measuring forest biodiversity. This overlap measurement is entitled "RFRB acres" in the various tables of results. Other measures from the TNC mapping calculations are also provided for the acres selected for wild forest enrollment by our modeling, including the TNC projections of existing carbon and carbon sequestered over 40 years if the parcel is simply left to grow.

Vermont Conservation Design Summarized Methodology

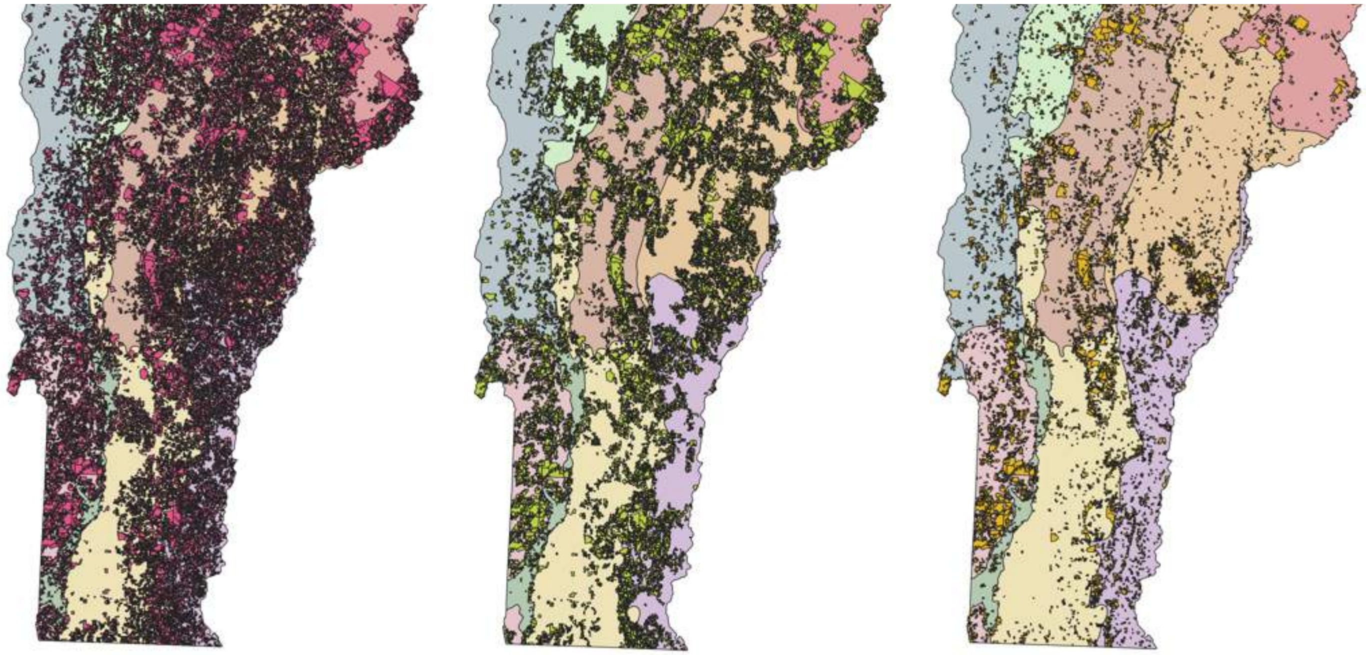
VCD incorporates many of the same databases that are used by the TNC work. They both use Heritage data, they both use measures of landscape diversity, and they both are spatially specific and do some ranking of the ecological importance of a particular location. However, they are different in several ways. First, and probably foremost, is that the basic scale of the TNC mapping is a 30-meter pixel, while the primary unit for the forest components of VCD are natural community boundaries and unfragmented forest blocks that incorporate many smaller ecological features. In general, VCD is simpler in concept and coarser in how it uses many data layers, and makes no attempt to quantify connectivity and flow. In the end, VCD does recommend a specific connected landscape that incorporates all the representative biodiversity and needed species migration produced by climate change. In comparison, TNC's work makes no recommendations of specific conservation design, but goes to great lengths to quantify regional flow of species and connectivity, both regionally and locally, and makes careful distinctions between diffuse resilient flow and much more constrained concentrated flow. VCD addresses some of those issues via a feature called Connectivity Blocks.

For the analyses in this report there is a fundamental assumption that at both a landscape level and a long-term, small-habitat level any parcel within the VCD boundary inherently carries higher ecological value. Such a parcel is more likely to be well connected into a larger landscape, fragmenting features are likely to be less serious, and the overall condition of the majority of the various natural communities found within it are in better ecological health. This is not to say that habitat outside of VCD can be ignored, and there are many small-scale features that are critical for long-term forest health. Vernal pools are a perfect example – every single one of these natural forested pools must be protected in a nearly unmanaged condition for overall forest health and the resilience of many species. But based on discussions, including with Eric Sorenson, coauthor of VCD, only the three large-scale landscape filters of Interior Forest Blocks, Physical Landscape Blocks and Connectivity Blocks are used to both define what is within VCD for the purposes of enrollment analysis and as a measure of ecological benefit. All of the small-scale VCD filters of biodiversity importance are largely located within these blocks, are aquatic features, or – most importantly – can be protected by less than whole-parcel means. Within a UVA management plan context that means they qualify for ESTA treatment as small reserves within the management of the surrounding forests.

The specific measurement used to quantify ecological benefit of wild forest enrollment in UVA was how many acres were added by each enrollment scenario, expressed as a percentage of the acres that would need to be added to meet VCD's old forest goals. These goals were defined for each of Vermont's nine identified bioregions: Champlain Hills, Champlain Valley, Northeastern Highlands, Northern Vermont Piedmont, Northern Green Mountains, Southern Vermont Piedmont, Southern Green Mountains, Taconic Mountains, and Vermont Valley. The goals took in the specific landscape history of each biophysical region; in other words, some areas no longer have large forest blocks left so the acreage goals were set to be more modest than for the regions which are still largely forested. They were also specifically related to matrix forest goals, not overall wildlands. It might be critical that a large wetland like Cornwall Swamp remain wild, but that acreage would not be considered to help meet the old forest goal for that biophysical region. Unfortunately, our study had no way of differentiating between matrix forests and other forested natural communities on parcels potentially enrolling as wild forest, so the figures used to indicate progress toward the goal is just total forested acres. This study also did not measure progress toward VCD's minimum block sizes for old forest stands; we tested a way of encouraging aggregation of adjacent wild forest parcels, but in the end did not pursue it.

6. Modeling Three Scenarios

This study models three different levels of landowner eligibility to potentially enroll in a new UVA category that would not require the harvest of timber. This is called a wild forest enrollment in this analysis; the draft legislation in the House Committee on Natural Resources, Fish & Wildlife in the spring of 2021 and the FP&R report to the Committee called it reserve forestland. It is impossible to predict how many landowners would find such a new enrollment attractive without more intensive data collection. Therefore, the methods of analysis used in this study for potential enrollment are designed to create a realistic range of outcomes and thus costs to guide decision making.



Maps 2-4: From left to right, the ALL, VCD, and ESTA scenario universes.

ALL Scenario
This universe of parcels eligible for potential wild forest enrollment is essentially all parcels that are currently eligible for productive forestland enrollment in UVA. Eligibility is not determined ecologically; it is solely based on the landowner's interest in wild forest. ALL is the most expansive scenario in terms of eligible acreage, making wild forest possible in every part of Vermont's landscape.

VCD Scenario
We chose to use VCD (defined above in the "Defining Dataset Decision Rules" section) as a lens for one of our scenarios because our analysis is designed to look at potential wild forest in ecologically meaningful ways which also reflect what is not currently possible under the existing UVA program in Vermont. Forest UVA already uses the concept of ESTAs to allow portions of an eligible parcel to set aside rare species habitat, wetlands, or highly ranked rare natural communities (S1-S3 Natural Heritage rankings). The VCD scenario focuses on the larger landscape-scale incorporation of potential wild forests, which would bring true ecological forest values found in the common forests of the state meaningfully into the picture of Vermont's nature and biodiversity. VCD also provides a reasonable definition for an eligibility scope between FP&R's more restrictive proposed ESTA approach and the entirely open ALL scenario.

ESTA Scenario
This universe of eligible parcels was defined by the state's work and details are laid out in their Reserve Forestland Report. Parcels that have greater than 30% of their total area covered by previously existing "Ecological Special Treatment Areas" (ESTAs) or steep slopes (>35% grade) are eligible to enroll all of the parcel's forested area as wild forest (or "reserve forestland," to use FP&R's terminology). In this scenario, eligibility is driven by small scale biodiversity filters, and was designed by FP&R to minimize the amount of productive timberland that would be lost to wild forest management (represented as the correct "balance" of

values). This is the most restrictive of the scenarios.

Modeling Enrollment

The basic statistics of each of the three eligible universes of parcels says much about what the endpoint of each scenario looks like in terms of costs and meeting VCD old forest goals. It creates the side bars to the range of possible costs under various assumptions of whether or not enrollment is capped at the point of meeting VCD old forest goals. However, a key component of our analysis aims to understand what might actually happen if each eligibility scenario were implemented and thus we attempt to quantify a range of actual landowner behavior. These are somewhat rough estimates given data isn't available on several factors: one, what proportion of people eligible in any given scenario will actually enroll; two, how quickly they would do so, i.e., how enrollment would look over time; and three, what proportion of enrollments would come from parcels already in UVA vs. those eligible but not currently enrolled.

Given this, the approach was kept simple. Time was spent trying to figure out if any variable could predict which landowners were likely to enroll in a new wild forest category. In the end, having the decision to enroll be random seemed to introduce the fewest assumptions about behavior. However, we also made no differentiation in enrollment rates between potential and currently UVA-enrolled parcels because we could find no basis to inform such a judgement (even though we suspect there is not equal potential). Similarly, various assumptions about the growth of new enrollment were entertained, but in the end, we decided it was best to just present what the current annual UVA enrollment activity is and let others extrapolate from there.

The expectation had been that longstanding programs in Massachusetts and Maine would inform the study on what proportion of eligible parcels might decide to enroll in a new wild forest category. However, the Massachusetts current use program requires the landowner to give the town a right of first refusal to acquire the parcel if it is ever sold as a condition of enrollment in an open space category. For many people that could be a deterrent to enrollment so it didn't seem reasonable to use Massachusetts data. Unfortunately, Maine's program is not a statewide program, but rather administered town by town with no requirement to aggregate information. Based on aerial photos and website information three towns were identified that attempted to mimic Vermont's mix of economics and land use. Criteria included: a strong agricultural presence in a town whose landscape was dominantly managed forest, a commercial center far enough from a larger city such that the town was not a bedroom community to the city, and finally a reasonably strong second home and tourist economy. Three towns were identified but only one responded to a request for information about their current use program.

The universe of eligible parcels for the ALL, VCD and ESTA scenarios were randomly sampled at four levels spanning the range of what were considered reasonable possible enrollments. The random samples represented endpoint enrollments (i.e. no component of over what time period was incorporated) of 5, 10, 15, and 20%. The parcels chosen to represent an enrollment were identified by QGIS's random sampling research tool. The sampling was repeated 5 times for each level of enrollment to get a sense of the variability possible, particularly in costs to the UVA program created by who might enroll. The averages of the five runs were used to calculate costs and measure ecological benefit using the methodologies detailed in prior sections.

Results

1. Summary

The results of this work are presented as answers to five questions, through the perspective of each of the three scenarios. This section starts with the basic facts of distribution and scale of the three approaches, then addresses how each support ecological/environmental goals, and ends with an analysis of cost to the UVA program. Each scenario has strengths and weaknesses. ESTA focuses on smaller-scale elements of biodiversity and minimizes any impact on timber production, but because of its distribution of eligible parcels and scale largely fails as a way to implement Vermont Conservation Design (VCD) goals. The ALL and VCD scenarios both implement the VCD plan, with VCD closer to ESTA in terms of many measures of ecological benefit and ALL being significantly more expensive. The cost analysis determines several key sidebars to the potential costs of adding wild forests to the UVA program, but adding just $5 million to the program's current cost of $66 million a year has the potential to meet old forest goals outlined in the VCD plan.

2. What do we know about the three possible scenarios modifying UVA to include wild forest?

Table 2 provides the acreage and parcel summary for the three scenarios.

Scenario	All			VCD (>75% or 50 acres)			ESTA		
	Parcels	Parcel Acres	Parcel Size	Parcels	Parcel Acres	Parcel Size	Parcels	Parcel Acres	Parcel Size
Total land acres enrolled or eligible to be enrolled in UVA	26,761	3,149,000	Avg: 118 Med: 70	15,497	2,188,000	Avg: 141 Med: 80	7,184	928,000	Avg: 129 Med: 70
UVA Enrolled	15,645	2,248,000	Avg: 144 Med: 84	9,155	1,615,500	Avg: 176 Med: 99	4,212	675,000	Avg: 160 Med: 84
Not UVA Enrolled	11,116	901,000	Avg: 81 Med: 55	6,342	573,000	Avg: 90 Med: 59	2,972	252,500	Avg: 85 Med: 56
Permanently Protected (>75%) via easement	1,551	403,000 Actually Protected: 383,000	Avg: 260 Med: 132	897	304,000 Actually Protected: 290,000	Avg: 339 Med: 159	509	141,000 Actually Protected: 133,000	Avg: 276 Med: 126
Partially Permanently Protected (>5-75%)	1,236	218,500 Actually Protected: 59,000	Avg: 177 Med: 89	933	177,000 Actually Protected: 44,000	Avg: 189 Med: 94	473	96,000 Actually Protected: 24,000	Avg: 203 Med: 87
Protected & UVA Enrolled	1,539	401,000	Avg: 260 Med: 133	889	302,000	Avg: 340 Med: 160	505	140,000	Avg: 277 Med: 126
Totally unprotected (0-5%)	23,974	2,527,000	Avg: 105 Med: 66	13,667	1,707,000	Avg: 125 Med: 77	6,202	691,000	Avg: 111 Med: 66

Table 2: Summary table for total universes of ALL, VCD, and ESTA scenarios.

Key Summary Points from Table 2:

- ALL encompasses the most parcels and acreage, ESTA the least, and VCD in between. The ESTA scenario reduces the UVA-eligible universe as measured by parcels and acres by more than 70% as compared to ALL scenario.
- UVA-enrolled parcels in each scenario are always larger than their equivalent unenrolled parcels, and the reduction in average size in each scenario is roughly the same (44% to 49%) with largest percent reduction in VCD.
- By average (mean) and median measures VCD parcels are consistently larger than ALL or ESTA in all categories except partially protected where ESTA is larger.
- The proportion of protected land in each universe is similar. The number of parcels that are >75% protected is about 6-7% of the total in all three universes, while actually protected acres make up 14% of the ALL universe, 15% of the VCD universe, and 16% of the ESTA universe. Parcels that are totally unprotected (essentially parcels without any easement on them) provide 80% of total parcel acreage in ALL, 78% in VCD, and 74% in ESTA.
- Essentially all protected lands are enrolled in UVA.
- Land protected by UVA enrollment by acres is five times greater than land protected by conservation easement; when looked at from a parcel perspective, 10 times the number of forest landowners have protected land through UVA versus permanent easements.

All three scenarios are designed as ways to select for forested acres that could potentially become wild forests. Table 3 provides the aggregate figures.

	Total Acres	Forested Acres	VCD Forest Acres
ALL Enrolled	2,307,000	1,727,000	1,325,000
ALL Potential	901,000	678,000	451,000
Total ALL	3,208,000	2,405,000	1,776,000
VCD Enrolled	1,590,000	1,256,000	1,256,000
VCD Potential	573,000	451,000	451,000
Total VCD	2,163,000	1,707,000	1,707,000
ESTA Enrolled	654,000	518,000	433,000
ESTA Potential	252,000	196,000	145,000

Table 3: Overview of acres, forested acres, and forested acres in VCD of three scenarios, by enrolled, potential and total (rounded).

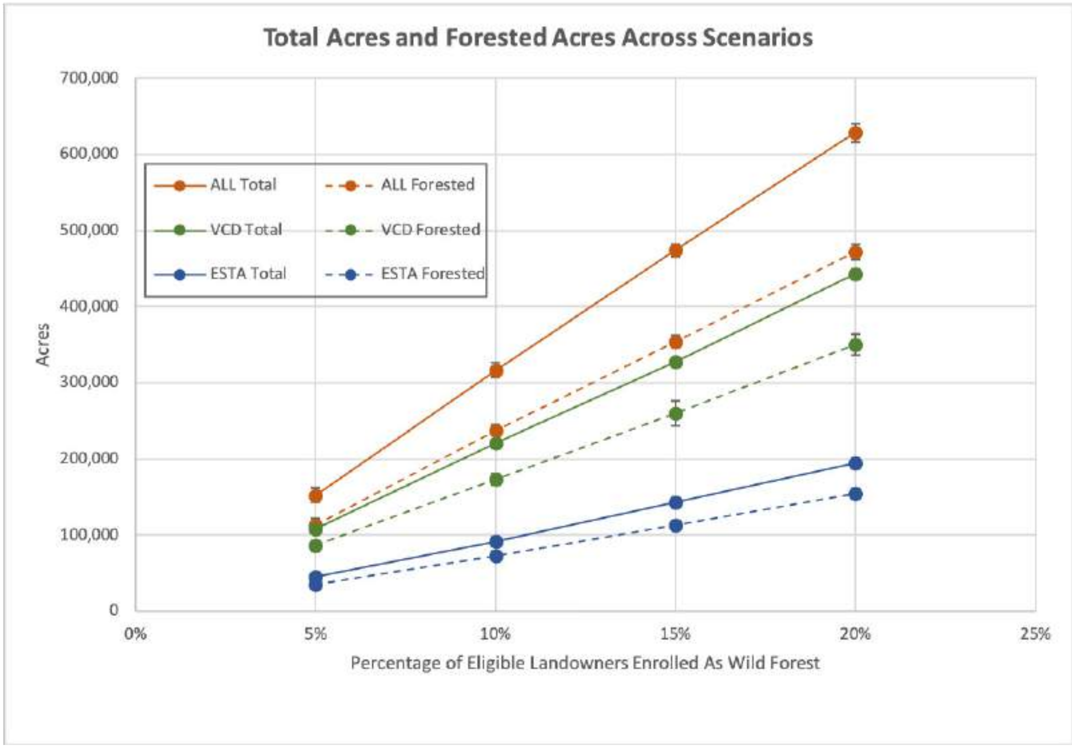
Key Summary Points from Table 3:

- All categories include non-forested land, which here is the difference between total acres and forested acres.
- The percent non-forested acreage is 25% for ALL and 21% for VCD and ESTA, for both the currently enrolled and the potentially enrollable.
- ALL consistently has the highest number of total acres and forested acres.

The sampling runs (Graph 1), which mimic landowner enrollment in wild forest at various percentages, confirm the conclusions above that were based on the whole universe of parcels. The total acres in each scenario of course is much smaller than the table presenting the entire universe (compare Table 3 and 4). The standard deviation is very tight for these sampling runs which provides evidence that the methodology is accurately sampling the potential universe of each scenario.

Key Summary Points from Tables 3 and 4, Graph 1 (bringing in some information from the full data found in Appendix 1):

- Number of parcels at 5% sample: ALL 1,338; VCD 775; ESTA 359. 10% sample would double those and so forth.
- On average, sampled ALL parcels are 75% forested.
- VCD and ESTA parcels are 79% forested.
- ALL accumulates more total acres and forested acres.



Graph 1: Sampling scenario results for total acreage and total forested acreage. All data points have standard deviation error bars, but some are too small to see.

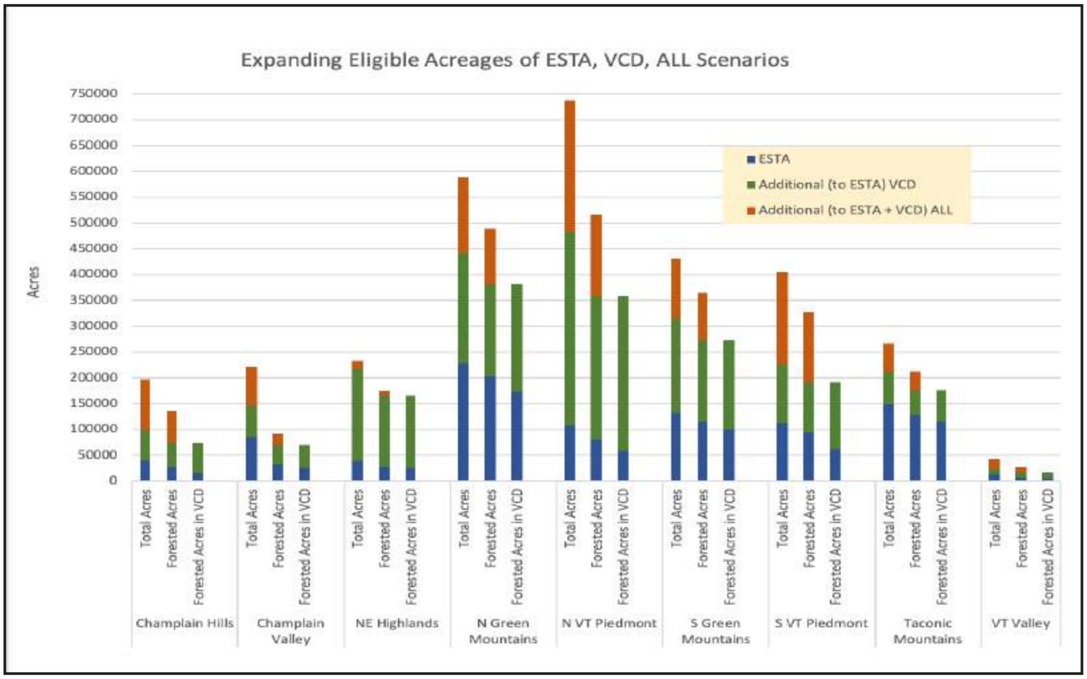
The trends around acres within each scenario's universe of parcels are the same when broken out by biophysical region – ESTA captures the fewest, ALL the most. In Graph 2, below, each column represents a combination of already enrolled and potentially enrollable acres in each scenario, with total acreage for each scenario being its section of the column plus whatever acreage it encompasses that is also in a smaller scenario (aka the sections of columns below it). This graph shows that the relative contribution of each scenario to eligible acreage is quite different depending upon the biophysical region.

Sample Size	Scenario	Total Acres	Forested Acres	VCD Acres
5%	ALL	152,000	113,000	83,000
	VCD	108,000	86,000	86,000
	ESTA	45,000	35,000	28,000
10%	ALL	316,000	238,000	175,000
	VCD	220,000	173,000	173,000
	ESTA	92,000	73,000	60,000
15%	ALL	474,000	355,000	260,000
	VCD	328,000	260,000	260,000
	ESTA	143,000	113,000	93,000
20%	ALL	629,000	472,000	347,000
	VCD	444,000	351,000	351,000
	ESTA	195,000	154,000	127,000

Table 4: Scenario acres as sampled from universe (rounded).

Graph 2 presents this visually, but the tables in Appendix 1 provide the actual numbers behind this graph and Table 2. One key thing to note from this graph is that for all three scenarios, total acres always exceeds forested acres so every scenario is capturing some open land or house site land – sometimes quite a lot of it, as in Northern Vermont Piedmont and the Champlain Valley.

Graph 2 introduces the idea that the scenarios capture proportionally differing amounts of forests across



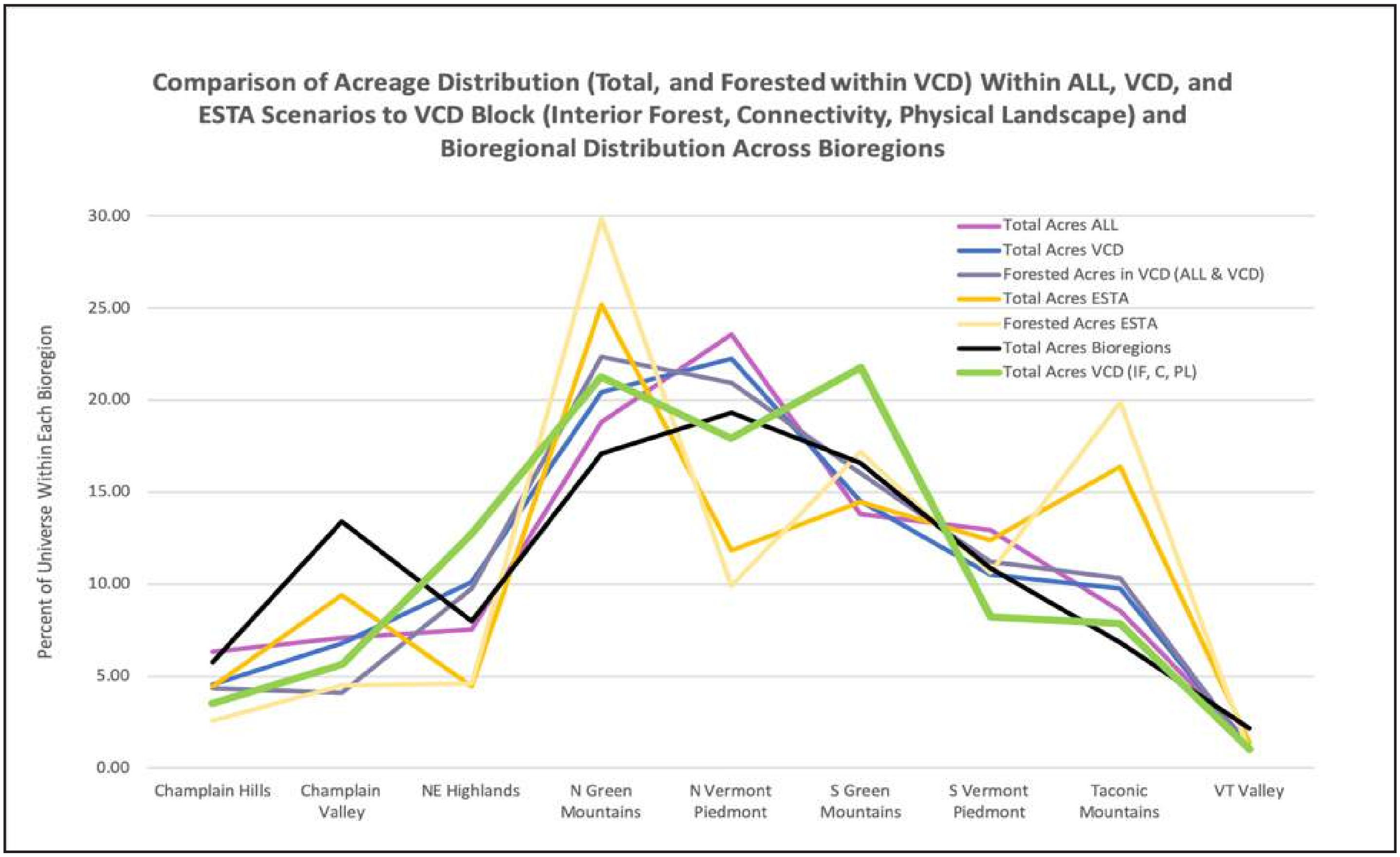
Graph 2: Distribution of scenario acres across biophysical regions. Note that the ALL scenario does not add any additional VCD acres, as the VCD scenario was created specifically to capture them all.

bioregions, which makes sense given that they are driven by different factors. The key question is, how much do these differing factors skew bioregional representation within each scenario? To answer this, the percent of each scenario's total acreage captured by each biophysical region was calculated and compared to the percent of the state's total acres each bioregion represents. The same comparison was done with VCD acreage; so, the percent of each scenario's total forested acres within VCD captured by each bioregion was compared to the percent of VCD (highest priority Interior Forest, Connectivity, and Physical Landscape blocks) within each bioregion. These forested blocks of the VCD plan are basically defining what is most critical to sustain the remaining forested landscape for each biophysical region, so the distribution of the scenario's sampling of the landscape is an important

	Total Acres Bioregional Distribution (percent of total of each category that is within each bioregion)				Acres in VCD Bioregional Distribution		
Bioregion Name	Bioregion	ALL	VCD	ESTA	VCD (HP IF, C, PL blocks)	ALL & VCD (forested)	ESTA (forested)
Champlain Hills	5.8	6.3	4.5	4.4	3.5	4.4	2.6
Champlain Valley	13.4	7.1	6.8	9.4	5.6	4.1	4.5
Northeastern Highlands	8.0	7.5	10.1	4.5	12.8	9.8	4.6
Northern Green Mountains	17.1	18.8	20.5	25.2	21.3	22.3	29.8
Northern Vermont Piedmont	19.3	23.6	22.3	11.8	17.9	20.9	9.9
Southern Green Mountains	16.6	13.8	14.5	14.5	21.8	16.0	17.2
Southern Vermont Piedmont	10.9	12.9	10.5	12.4	8.2	11.2	10.6
Taconic Mountains	6.8	8.5	9.8	16.4	7.8	10.3	19.9
Vermont Valley	2.2	1.4	1.1	1.4	1.0	1.0	0.9

Table 5: Bioregional distributions across scenarios and as compared to VCD and the biophysical region areas themselves.

comparison (which will come into play in the next section as well). This information is presented in tabular and graphical form in Table 5 and Graph 3.



Graph 3: Bioregional distribution comparisons, where the acres of interest in each bioregion are displayed as a percentage of the total acres of interest across the state.

Key Summary Points from Table 5 and Graph 3:

- To a great extent, the difference between the black and green lines represents the fact that in some biophysical regions – with the Champlain Valley being the most extreme – agriculture and development has removed disproportionate amounts of forest.
- ALL and VCD (in terms of total acres and forested acres in VCD) track the VCD highest priority block distribution more closely than the ESTA scenario, which has more noticeable peaks and valleys in the Northern Green Mountains, Northern Vermont Piedmont, and Taconic Mountains particularly.
- Within VCD forest proportion is slightly better for ESTA (4.4%) than ALL and VCD (4.1%) in Champlain Valley, but neither reflect the 5.6% of the VCD plan.
- All three scenarios under sample the Southern Green Mountains and, to a lesser extent, the Northeastern Highlands.
- The largest discrepancy between ALL & VCD scenarios and the ESTA scenario when measured by percent of forest within VCD is in the Northern Vermont Piedmont, a spread of 11 percentage points.

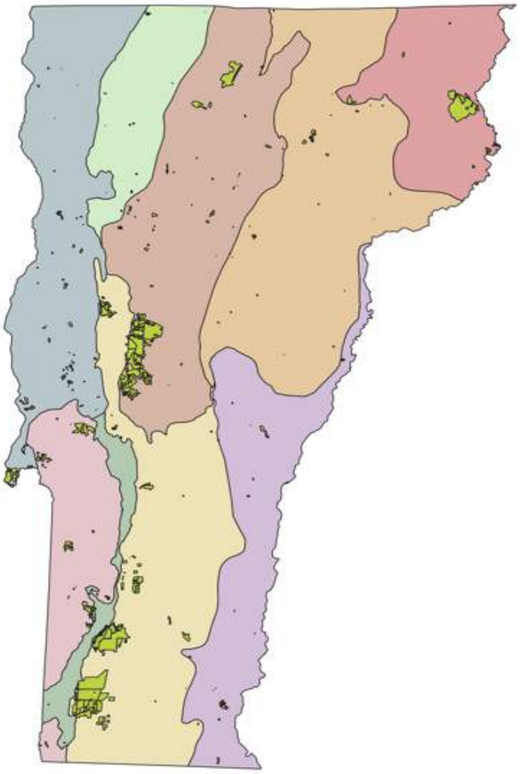
3. What do we know about how these scenarios would help the state meet its old forest goals?

In order to figure out what is needed to meet the VCD planning document's (Vermont Conservation Design Part 2 Natural Communities and Habitats Technical Report 2018) old forest goals, Vermont's existing wild forest land first needs to be quantified by ecoregion. Using a parcel's GAP status[1] the state's GAP 1 acres are broken out by biophysical region in Table 6 and overlaid on a map of Vermont's biophysical regions in Map 5.

GAP 1 acres are found on public and private land. The largest blocks and greatest acreages are the wilderness areas within the Green Mountain National Forest. The largest state ownership of wild forest is the West Mountain Wildlife Management Area's core reserve area of 12,628 acres. The total for publicly owned GAP 1 is approximately 118,000 acres. Almost all of the privately owned GAP 1 land is in The Nature Conservancy (TNC) ownership. A few small areas are owned by other conservation entities, such as Green Mountain Audubon and Northeast Wilderness Trust (NEWT). NEWT also holds forever-wild easements on nine parcels totaling 7,798 acres, some of which are TNC land. The total for all private GAP 1 parcels is approximately 27,000 acres based on the Protected Lands dataset used for this analysis.

Bioregion	VCD Old Forest Goal (Acres)	Existing GAP 1 Acres in VCD	Percent of Statewide-Existing GAP 1 VCD Acres	Acres Needed	Percent of Goal Met
Champlain Hills	13,000	118	0.08%	12,882	0.9%
Champlain Valley	15,000	6,117	4.4%	8,883	40.8%
Northeastern Highlands	59,000	15,638	11.3%	43,362	26.5%
Northern Green Mountains	95,000	46,738	33.8%	48,262	49.2%
Northern Vermont Piedmont	78,000	1,392	1.0%	76,608	1.8%
Southern Green Mountains	91,000	57,507	41.6%	33,493	63.2%
Southern Vermont Piedmont	31,000	2,073	1.5%	28,927	6.7%
Taconic Mountains	33,000	8,499	6.1%	24,501	25.8%
Vermont Valley	4,000	264	0.2%	3,736	6.6%
Total	419,000	138,346	100%	280,654	33%

Table 6: An overview of GAP 1 status land in Vermont, by biophysical region.



Map 5: GAP 1 acres in Vermont.

1 In 1989 the US Geologic Survey developed a nationwide system for categorizing the level of protection on land parcels irrespective of their ownership status as a way of analyzing the conservation of species, including common as well as rare species. This has greatly facilitated conservation planning at the landscape level. GAP 1 land is managed for biodiversity by keeping it in its natural state where natural disturbances are allowed to proceed, which is also what is commonly meant by wild land. Normally land is not given a GAP 1 status without some legally enforceable management structure; however, there are exceptions. For example, in Vermont the lands TNC owns are GAP 1 even though in some cases the legal structure ensuring that is relatively weak – usually a Board designation as a preserve and the management plan submitted to UVA.

Key Summary Points about GAP 1 status land in Vermont:

- There are approximately 138,000 acres of GAP 1 land on 611 parcels in Vermont.
- VCD old forest goals are explicitly matrix forest goals (VCD Part 2 2018 Technical Report) and thus we included only GAP 1 acres within VCD's highest priority Interior Forest, Connectivity, and Physical Landscape blocks as those that contributed to the region's goal. Note that this definition of within VCD is different than the one used for parcels throughout the rest of this report – instead of a 75% buffer, a simple spatial overlay was used to find GAP 1 acres within the hard boundaries of VCD.
- Existing wild forest meets 33% of VCD's summed old forest goal acreage statewide. However, the progress is wildly variant from region to region – completion by that measure ranges from .9% to 63%.
- The Northern Vermont Piedmont is largest biophysical region in VT (Table 3) but only 1% of GAP 1 is located there, representing only 1.8% of the VCD goal.
- See discussion for potential data refinements.

The interplay between each region's VCD goal, how close it is to that goal, and total VCD forest eligible in each scenario will determine how well each scenario can contribute to those goals. Combining the available forested VCD acres from the enrolled and potential parcels for each biophysical region for each scenario and comparing it with the acres needed to reach the VCD old forest goals allows one to calculate the percent that will need to enroll as wild forest to meet the goals. These are given in Table *7*.

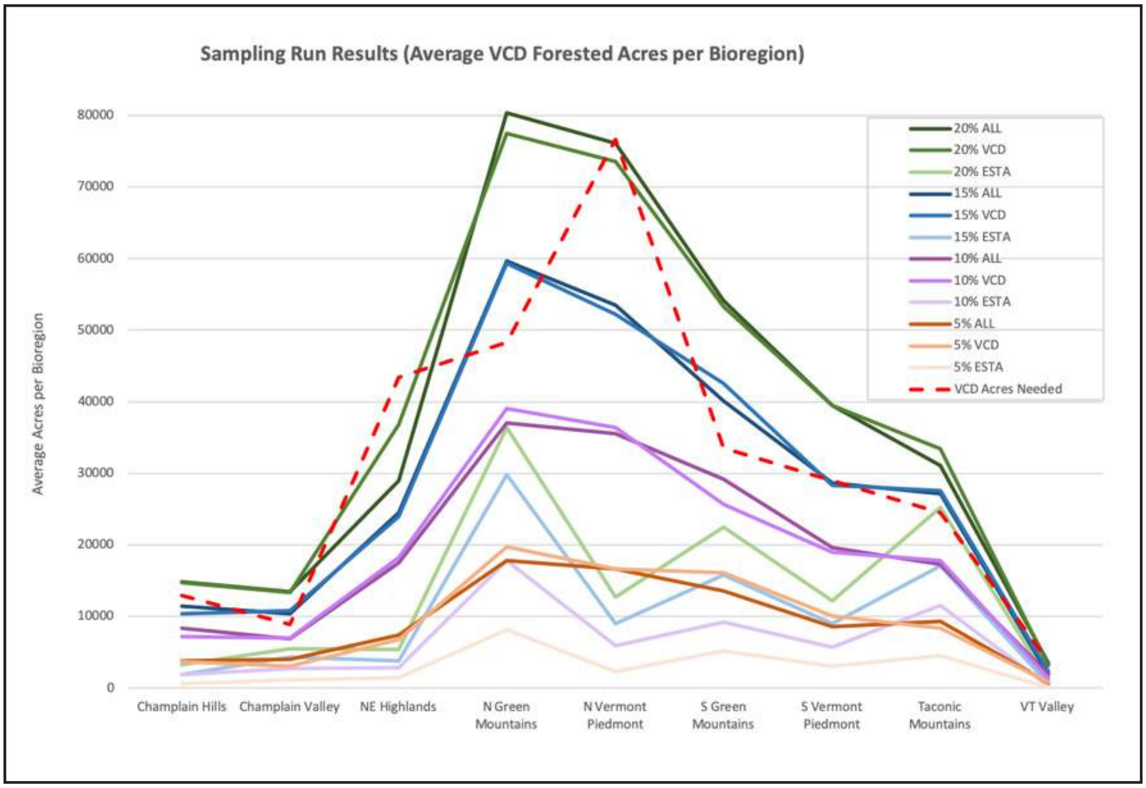
The Key Summary Points from Table *7*:

- The ESTA scenario cannot meet VCD old forest goals for the Northeastern Highlands and Northern Vermont Piedmont as the need is greater than available acres.
- The overall level of enrollment needed to meet VCD old forest goals through the ESTA scenario exceed realistic levels, except for the Taconic Mountains and maybe the Northern Green Mountains.
- Enrollment needed in the ALL and VCD scenarios ranges from 12.6% to 26.3% with an average of 17.2%.
- The special conditions in the Northeastern Highlands are detailed in the Discussion section.
- These percentages are also indirectly a measure of the level of effort that would be needed to reach the goals; it takes much more work to get buy-in from 46% or more of a universe of people than 17%, even if it's a similar number of people overall.

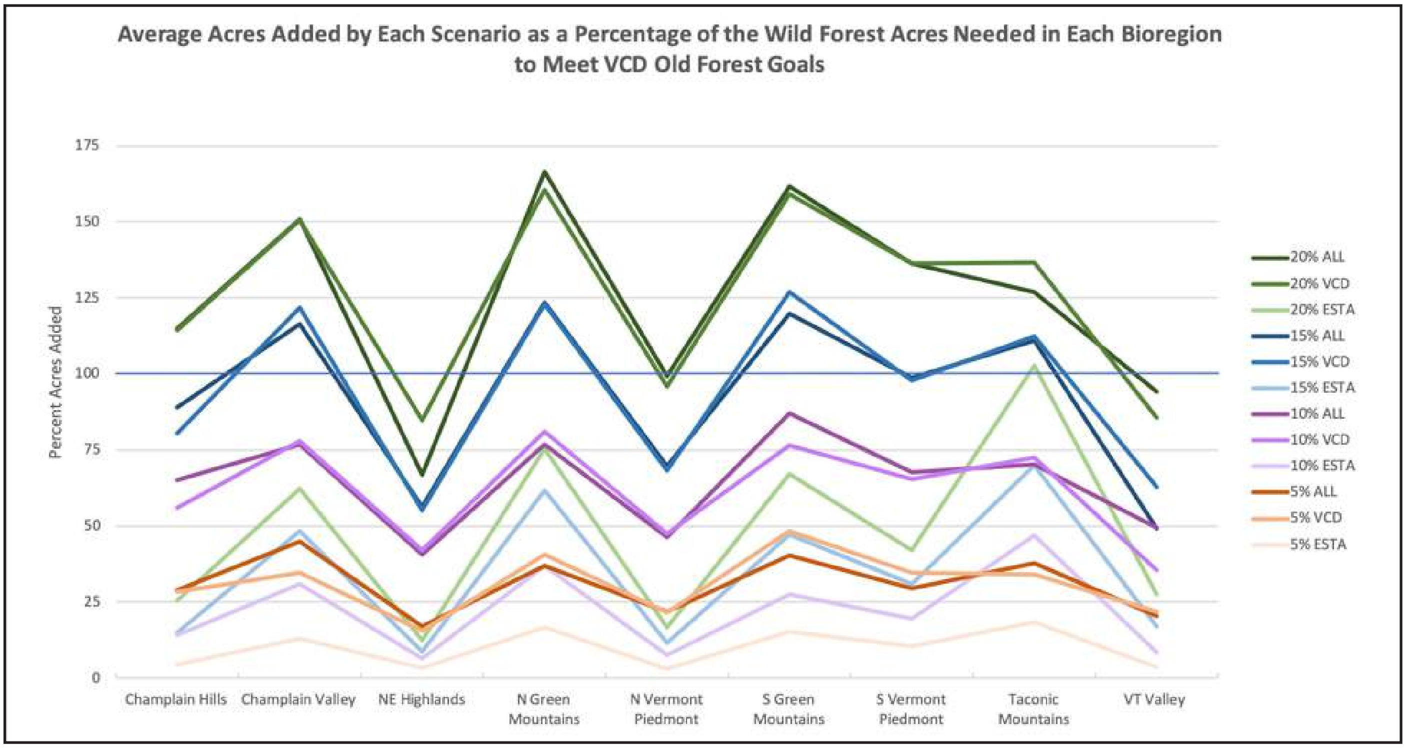
Bioregion	ALL & VCD Scenarios % of Forested VCD Acres Needing to Enroll to Meet VCD Targets	ESTA Scenario % of Forested VCD Acres Needing to Enroll to Meet VCD Targets
Champlain Hills	17.3%	85.8%
Champlain Valley	12.7%	34.3%
Northeastern Highlands	26.3%	166.8%
Northern Green Mountains	12.6%	28.0%
Northen Vermont Piedmont	21.4%	133.7%
Southern Green Mountains	12.2%	33.6%
Southern Vermont Piedmont	15.1%	47.1%
Taconic Mountains	13.9%	21.3%
Vermont Valley	23.0%	72.9%
Average	17.2%	69.3% (or 46.1 if impossible removed from average)

Table *7*: Percent of all forested acres in VCD in each scenario universe that need to enroll in order to meet VCD old forest goals.

The sampling runs graphically displayed in Graphs 4 and 5 basically confirm these calculations in acres enrolled at various intensities, and in percent completion toward the old forest goals.



Graph 4: Average forested acres in VCD per bioregion enrolled as wild forest if 5,10,15, & 20 percent of all eligible landowners in each scenario were to enroll (specific variations between VCD and ALL scenarios likely reflects variability due to limited numbers of runs since they wouldn't be expected to behave differently, and empirically appear to be converging on the same VCD acre totals).



Graph 5: Percent of currently unmet old forest goal completed by different levels of wild forest enrollment (see Graph 4's caption for explanation of the variations between ALL and VCD scenarios).

Key Summary Points from Graphs 4 and 5:

- The Northeastern Highlands, Northern Vermont Piedmont and Vermont Valley will take high enrollment rates (20% or more) within the ALL and VCD scenarios to have old forest goals completed by private enrollment as wild forest.
- A 10% enrollment rate for ALL and VCD will get all biophysical regions except the Northeastern Highlands to 47% of their unmet old forest goal. These runs show that VCD doesn't get that high for the Vermont Valley, but ALL does; but, again, that variation is likely due to the limited number of runs rather than any real differences. Since VCD and ALL scenarios have the same number of total VCD acres eligible, they can be expected to add the same number of VCD acres, with additional total acres in the ALL scenario coming from its additional non-VCD acres.
- Table 3 shows that 10% enrollment in ALL or VCD would add between 173,000 and 175,000 acres of wild forest, 126% more than the existing 138,000 acres of GAP 1 land.

4. What do we know about how well these scenarios capture ecological value and position the landscape to be more resilient to climate change?

The TNC Resilient Landscape Mapping Tool was used to quantify ecological value because it is a third-party tool that provides a relative measurement of how resilient the landscape would be under each sampled scenario. Because there was almost no change as the sampled enrollment increased, each scenario in Table 8 represents the average of 20 different samples.

Scenario	Resilience Score	Local Connectedness Score	Landscape Diversity Score
ALL	.34	.34	.32
VCD	.54	.63	.46
ESTA	.76	.70	.79

Table 8: Landscape scores from TNC's Resilient Landscape mapping tool.

The ESTA scenario had the highest landscape scores and ALL was always the lowest, usually half the value that ESTA had. VCD was midway between the two except for local connectedness when it was almost the same as ESTA.

Sampling Level	Scenario	Total Acres	RFRB Acres	% RFRB
5%	ALL	152,000	53,000	35%
	VCD	108,000	56,000	52%
	ESTA	45,000	20,000	46%
10%	ALL	316,000	115,000	37%
	VCD	220,000	108,000	49%
	ESTA	92,000	46,000	51%
15%	ALL	474,000	169,000	36%
	VCD	328,000	159,000	49%
	ESTA	143,000	71,000	50%
20%	ALL	629,000	222,000	35%
	VCD	444,000	216,000	49%
	ESTA	195,000	97,000	50%

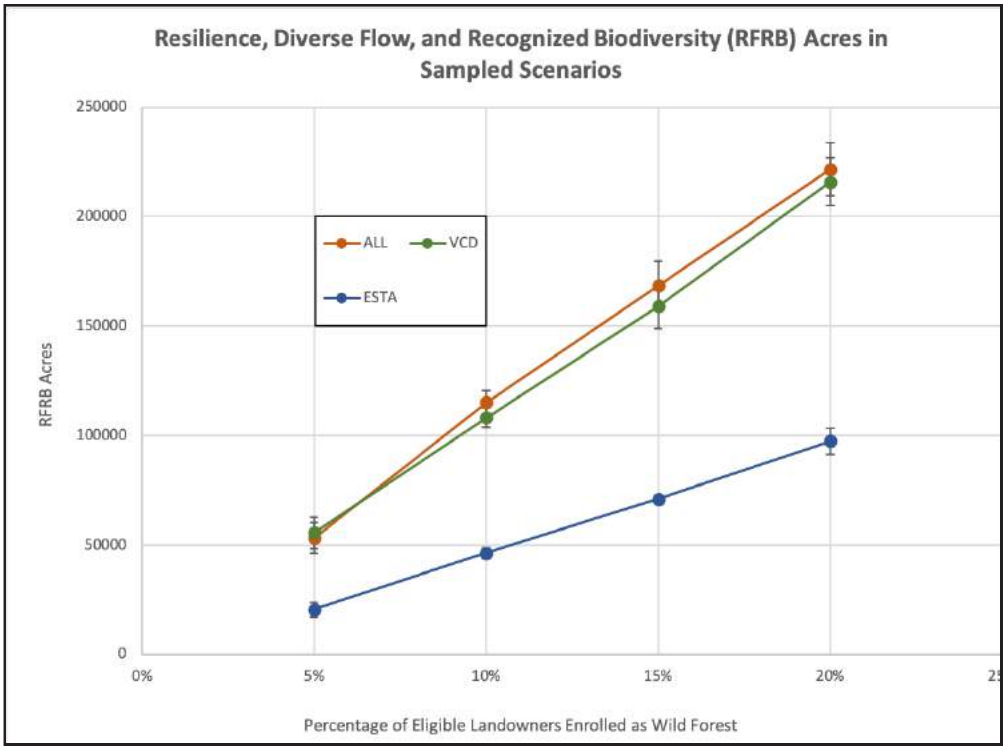
Table 9: RFRB Results for each scenario sampled across the ranges.

The TNC mapping tool also analyzed each acre by resilience, diverse flow across the landscape for species movement, and recognized biodiversity, which is largely Heritage rankings of rare species and high-quality natural communities. The output (Graph 6) was the number of resilience, diverse flow, and recognized biodiversity (RFRB) acres captured by each sampled scenario.

Key Summary Points from Graph 6 and Table 9:

- As with other metrics the total acres of ALL is much more than other scenarios.
- The percent RFRB for ALL is 35%.

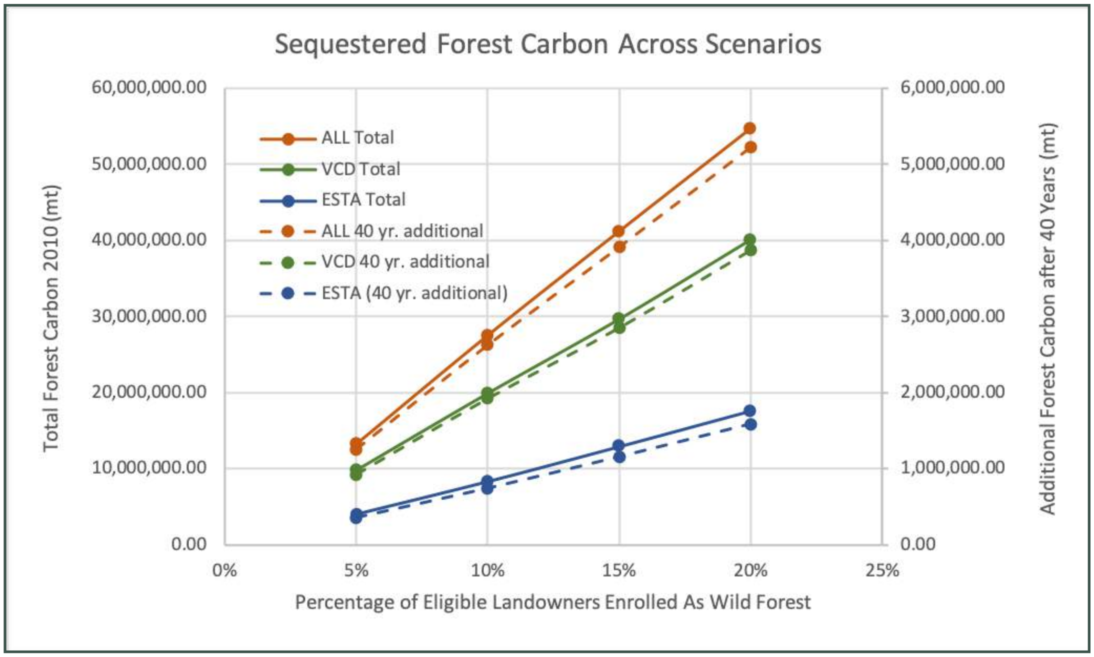
- Other than in the 5% sample, ESTA and VCD have similar percentages of RFRB acres, hovering around 50% RFRB.
- Total RFRB acres captured are quite similar for ALL and VCD.



Graph 6: RFRB acres captured by each scenario at varying levels of enrollment.

5. What do we know about how well these scenarios help Vermont mitigate climate change?

The amount of carbon stored and sequestered over 40 years was used to quantify climate mitigation capacity by each of the scenarios. Both are directly correlated with total forested acres. On average, the total carbon pools sequestered .2 metric tons of carbon annually per acre. If just the living tree biomass above ground was considered, the amount drops by 50% to about .1 metric tons of carbon annually per acre.

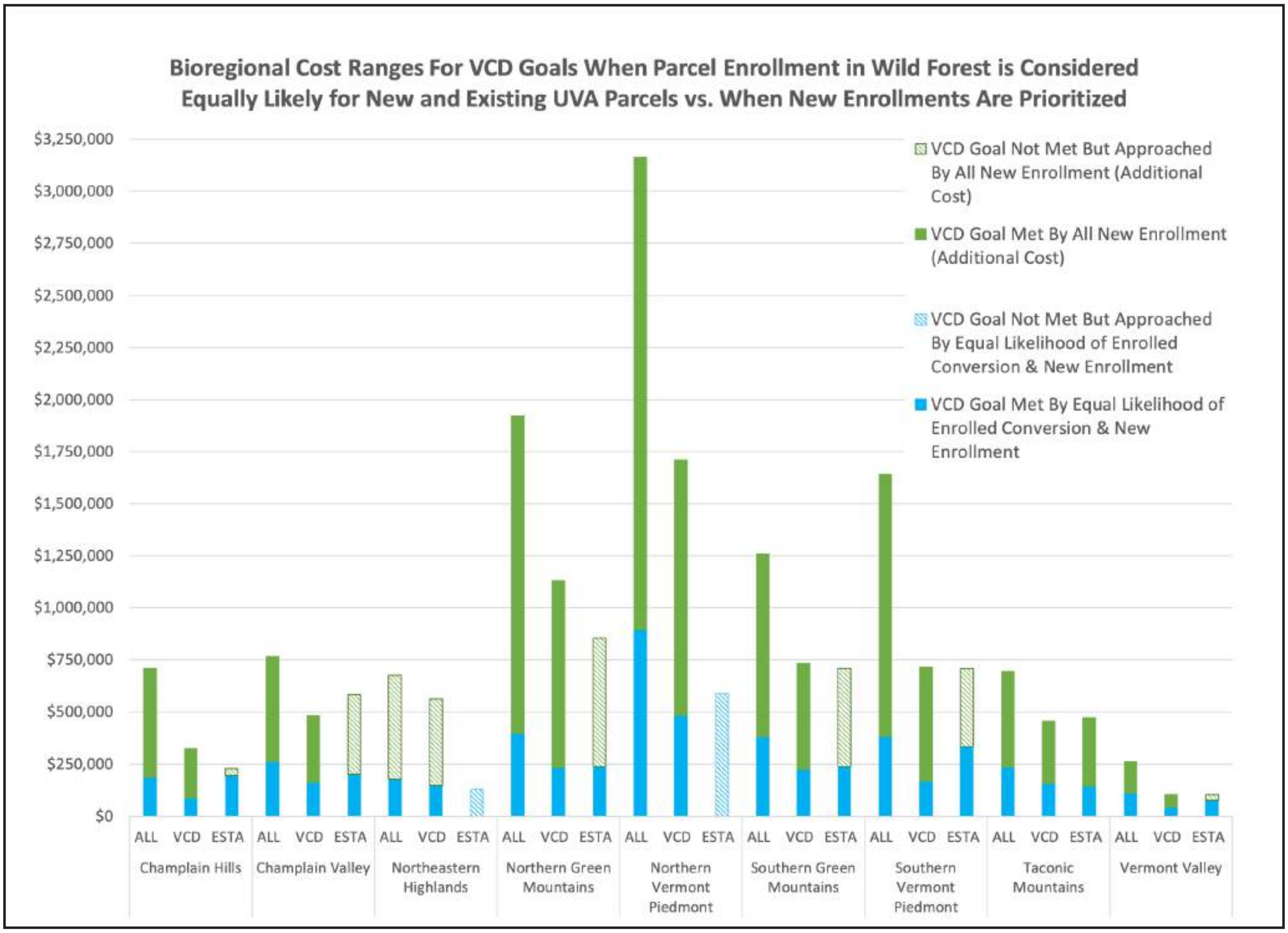


Graph 7: Carbon sequestered in current sampled parcels (carbon levels reflect 2010 data), and additional sequestered if left alone for 40 years (since 2010, so by 2050).

In all the runs, the ESTA scenario consistently sequestered carbon at the lowest rate and the VCD scenario was highest in all the different percent enrollments at an average annual rate of .217 metric tons of carbon per acre. This is a 6.9% increase over ESTA and 4.8% over ALL.

6. What do we know about how much these scenarios will cost the state?

As described in the methodology section, three endpoint calculations are used to set ranges of potential costs for enrolling wild forests. These are broken out by biophysical region in Table 10. The key comparison here is between Calculation 2 and 3, which is laid out visually in Graph 8. The overarching information in the table is that any cell in red reflects the cost of enrolling every single remaining parcel eligible for UVA enrollment and yet it is still not possible to reach the VCD goal – and so the cost number is the same as the total enrollment reflected under Calculation 1.



Graph 8: This graph compares Calculation Methods 2 and 3. The blue columns show the cost of meeting VCD old forest goals for each region if already-enrolled and potential parcels were equally likely to become wild forest, while the green columns show the additional expense if as much of the goal as possible was met with potential parcels, creating a theoretical most expensive possible scenario for meeting VCD goals in each bioregion. Additionally, the data displays how much capacity there is to meet VCD old forest goals if all parcels are eligible to enroll vs. just potential ones. The dotted pattern of some columns indicates that the potential (and enrolled, for the blue columns) parcels available in each scenario are not enough to meet VCD old forest goals even at 100% enrollment as wild forest.

UVA Cost Sidebars	ALL Scenario			VCD Scenario			ESTA Scenario		
Bioregion	Calc 1: Every Potential Parcel	Calc 2: VCD Goal Enrolled & Potential Parcels	Calc 3: VCD Goal Met Potential First	Calc 1: Every Potential Parcel	Calc 2: VCD Goal Enrolled & Potential Parcels	Calc 3: VCD Goal Met Potential First	Calc 1: Every Potential Parcel	Calc 2: VCD Goal Enrolled & Potential Parcels	Calc 3: VCD Goal Met Potential First
Champlain Hills	$1,073,000	$186,000	$710,000	$489,000	$85,000	$323,000	$228,000	$195,000	$228,000
Champlain Valley	$2,049,000	$260,000	$768,000	$1,288,000	$163,000	$483,000	$584,000	$200,000	$584,000
NE Highlands	$677,000	$178,000	$677,000	$563,000	$148,000	$563,000	$127,000	$127,000	$127,000
N. Green Mountains	$3,129,000	$396,000	$1,924,000	$1,840,000	$233,000	$1,131,000	$854,000	$239,000	$854,000
N. VT Piedmont	$4,184,000	$896,000	$3,165,000	$2,263,000	$485,000	$1,712,000	$587,000	$587,000	$587,000
S. Green Mountains	$3,116,000	$381,000	$1,258,000	$1,819,000	$223,000	$735,000	$707,000	$238,000	$707,000
S. VT Piedmont	$2,548,000	$384,000	$1,642,000	$1,113,000	$168,000	$717,000	$708,000	$333,000	$708,000
Taconic Mountains	$1,689,000	$235,000	$698,000	$1,106,000	$154,000	$457,000	$679,000	$145,000	$473,000
VT Valley	$475,000	$109,000	$262,000	$187,000	$43,000	$103,000	$103,000	$75,000	$103,000
Total (millions)	$18.940	$3.024	$11.105	$10.667	$1.700	$6.224	$4.576	$2.139	$4.371

Table 10: Maximum costs using three different parameters. For Calculations 2 and 3 (VCD goal-based calculations), red entries indicate the VCD old forest goal for that bioregion is not possible to meet under the assumption of the calculation.

Key Summary Points from Graph 8 and Table 10:

- It is not possible to meet VCD goals using just new enrollments under the ESTA scenario, except in the Taconic Mountain biophysical region.
- Cost of completing VCD goals under VCD scenario in the two bioregions that currently have the least

GAP 1 land (Champlain Hills and Vermont Valley, Table 5) would be extremely modest – between $43,000 and $103,000 in the Vermont Valley.

- The spread between most expensive (ALL using potential parcels) and least expensive (VCD using a mix of currently enrolled and potential parcels), combined with the scale of cost involved and how little is currently GAP 1 (Table 5) means implementation to reach VCD goals in the Northern Vermont Piedmont will have to be thoughtful.
- These costs do not represent any of the costs to legally protect parcels as permanent wild forests so that they can't be converted to another use.
- For ALL and VCD scenarios only in the Northeastern Highlands is achieving old forest goals using new enrollments to UVA *not possible*. In comparison, for ESTA only in the Taconic Mountains is this goal *possible*. (Red entries in Table 10 mean the goal is not possible to meet). See the discussion section for more detail.
- Biophysical region costs vary significantly between scenarios. Calculation 2 costs for ALL can be over two times the cost for VCD in some regions to reach old forest goals.
- ALL is more expensive in all calculations compared to VCD and ESTA.

Many people make assumptions about huge future costs to any changes in UVA. Table 11, a summary table without the biophysical region detail, provides a useful sense of scale.

	Total Cost of all Potential Parcels in each Bioregion (Calc 1, millions)	Cost of Meeting VCD Targets With Proportional Enrolled & Potential Wild Forest Enrollment (Calc 2, millions)	Upper Cost Limit of Meeting VCD Targets (using potential parcels if available) (Calc 3, millions)
ALL	$18.9	$3.1	$11.1
VCD	$10.7	$1.7	$6.2
ESTA	$4.6	$2.1	$4.4

Table 11: Cost summary of scenarios rounded to the nearest hundred thousand dollars.

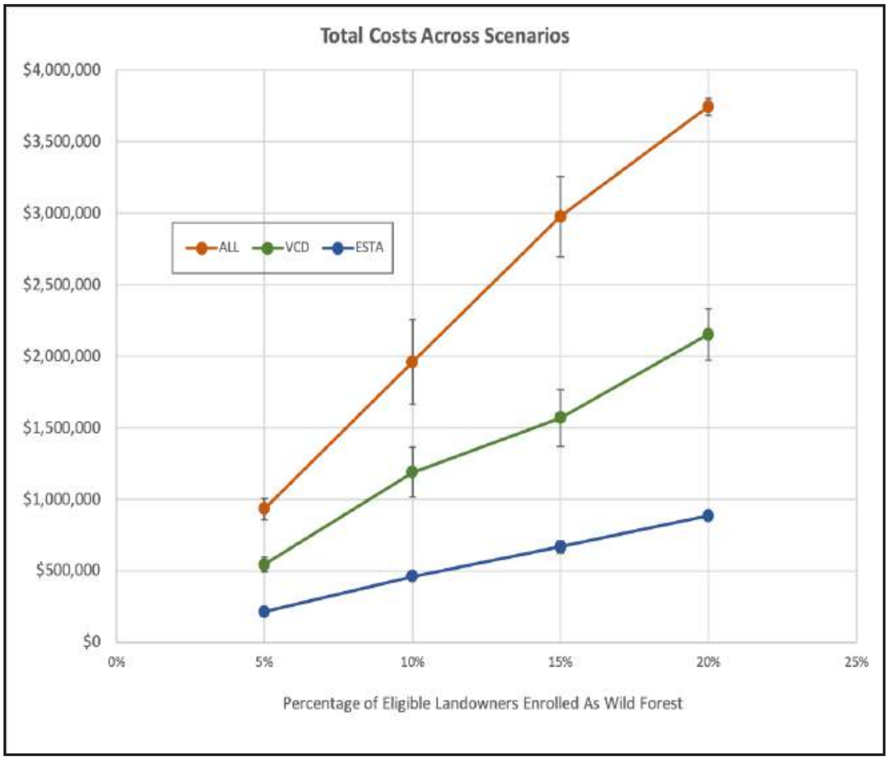
Key Summary Points from Table 11:

- As stated in the UVA overview section of this report, the current cost of UVA to the state is $66 million.
- The $18.9 million maximum expenditure possible under the ALL scenario is the price tag associated with fully enrolling every parcel possible statewide in UVA. This could be true under existing rules, but it also represents the maximum expense in adding a wild forest category to UVA.
- Thus, the absolute worst-case cost scenario is roughly a 29% increase over the current cost.
- The $10.7 million cost in the VCD scenario Calculation 1 represents the cost to enroll every remaining unenrolled acre in the VCD highest priority forest blocks – 572,731 acres. Whether or not these are enrolled as land for timber production or wild forests, this is the cost of completing the VCD goal of having all of the state's highest priority blocks remain as forests.
- Under this type of analysis, the most probable cost to meet VCD goals probably lies between the Calculation 2 and 3 sidebars of cost.
- This shows that an expenditure of $5 million could go a long way toward successfully completing VCD goals. $5 million represents just a 7.6% increase in current UVA costs.
- Calculation 2 for VCD and ESTA, combined with the information in Table 7, shows that the ESTA scenario could cost more than VCD and with a much higher risk it would not meet VCD old forest goals due to the high percentage of enrollments needed.

All of the above cost estimates are using endpoint analysis, with no sense of progression or whether sampling based on random enrollment gives the same results. These are presented below, starting with total cost in Graph 9.

Key Summary Points from Graph 9:

- Sampling methodology confirms trends of endpoint analysis – ALL costs more than VCD, and of course the number of acres follows the same trend.
- The standard deviations are well separated in data points, so despite the higher range in variability than other metrics discussed thus far, the core trend is statistically legitimate.
- From Graph 8 we know a 10% enrollment wild forest enrollment under VCD or ALL adds approximately 174,000 acres of GAP 1 – 126% more than we have currently – for a cost under the sampling assumptions of between $1.25 and $2 million dollars.
- The modest $5 million expenditure discussed above could be even more than needed, as 15-20% enrollment levels of VCD – enough to meet most VCD goals – range from $1.6 million to $3.8 million in Graph 9.



Graph 9: Total costs of each eligibility scenario given a range of enrollment rates. The standard deviation for cost is higher than any of the other sampling results.

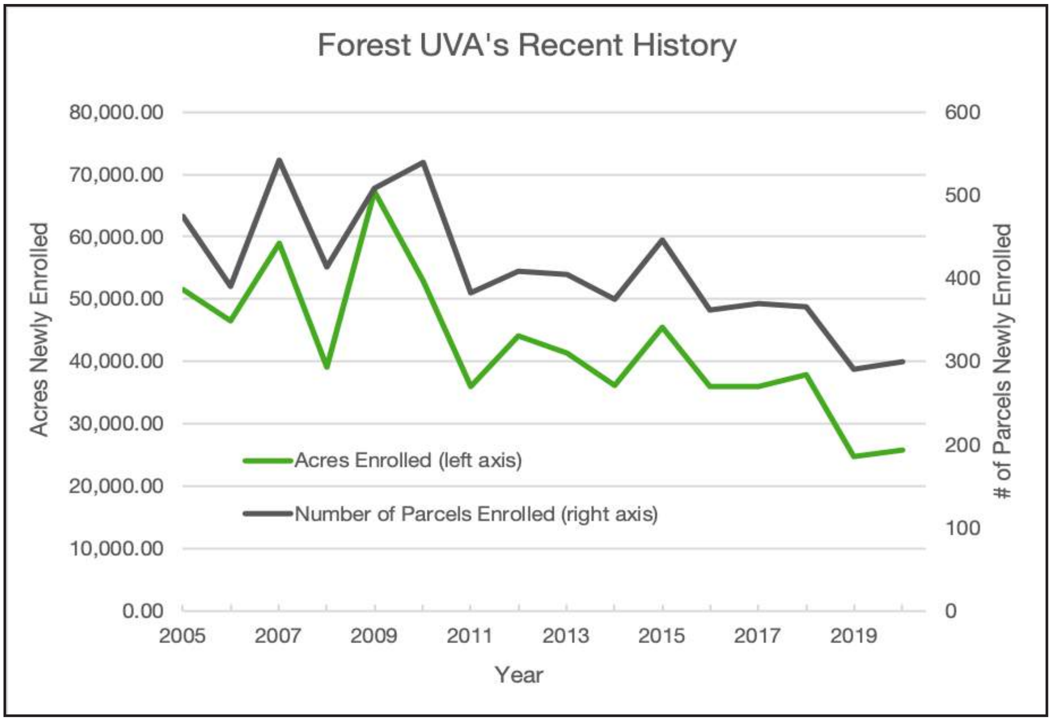
Administrative Costs

Administrative costs for any program are real, but there is no way to predict what those might be if UVA changed to include wild forests. We simply have no way to predict how many changes will occur in existing enrollments or new enrollments. This is a fairly mature program so procedures are familiar, and there are many people with a role in UVA so increased workload is – to an extent – spread. That said, this would be a significant enough change that some increase in personnel time would be expected.

We can look at the history of the UVA program and the data in Table 2 to make educated guesses about the likely relative costs.

The average parcel size of unenrolled parcels is less than 100 acres, which is the same as the annual average parcel size of current UVA administrative activity. The unenrolled parcels in each of the three scenarios are approximately 40% of total parcels. If one assumed a similar ratio to be added to the UVA process that would equal 40% of the current activity level of approximately 250 new enrollments annually, or about 100 parcels. In 2005 the annual number of UVA enrollments was between 400-500. Given that a wild forest category would be a new program, it doesn't seem unreasonable to think there might be an initial burst of activity. A doubling of a proportional representation of parcels would be about 200 parcels. This is well within the historical levels of activity within UVA, but some additional administrative capacity would likely be needed as the State's Reserve Report indicates that there is currently no excess capacity.

A second way to analyze this is to look at the number of parcels involved in the 5% enrollment scenario. There is no way to know how rapidly it would take to get to that level of enrollment, but 1% a year potential-



Graph 10: New enrollments in forest UVA for the past 15 years. Although not shown on the graph for clarity, a linear trendline for average parcel size showed a decrease from about 117 to 91 acres during this time.

ly seems on the high side. For the ALL scenario, that would represent 134 parcels and for VCD, about 78 parcels. Even if that rate doubles, the additional load on UVA would still be within historical norms.

A third estimation looks at how many total new enrollments are needed to reach VCD goals. The ALL scenario represents approximately 2,380 new wild forest enrollments, and VCD 1,990 new enrollments, based on average parcel size and the overall old forest acreage goal. These numbers include new UVA enrollments as well as changes from managed forest to wild forest within existing UVA enrollments. Best estimates are that meeting VCD goals will involve approximately 2,175 parcels, someplace between the ALL and VCD projected wild forest enrollment numbers. It is not unreasonable to think it would take at least 10 years, or about 200 projects annually.

It seems prudent to plan on between 100 and 200 new enrollments if a wild forest category were added to UVA.

Costs Related to Public Environmental Benefits

The remaining analysis of costs is all drawn from the sampling model as it is from that data where most environment benefits other than VCD were quantified. As plots were made of the average costs per acre against the four enrollment percentages it became clear that there were no trends, just the scatter of variability around a particular cost (which was to be expected given that the sampling was random and costs per acre wouldn't have any reason to change as smaller or larger samples were taken). Standard deviations were calculated for all of these and, with the exception that the cost of the ALL scenario was always higher, there were no obvious differences in costs between VCD and ESTA on a per acre basis.

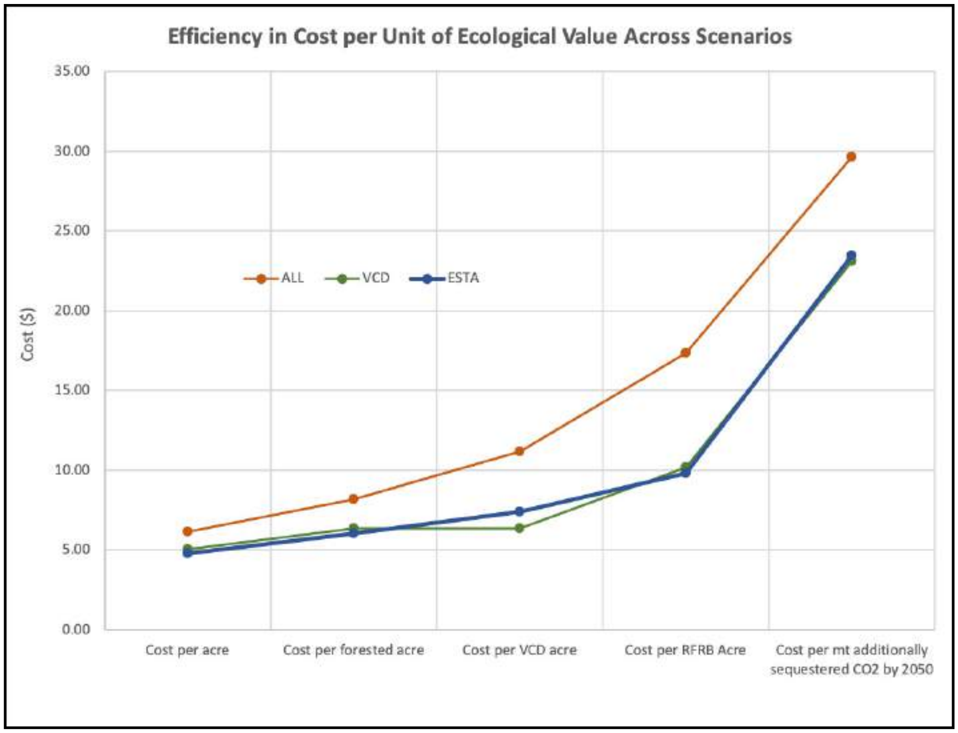
Given there was no discernable changes in costs as the sampling level increased to reflect different potential enrollments, the 20 runs for each individual scenario were combined. Graph 11 shows those results. Cost per total parcel acres was relatively the same for the three scenarios, but the efficiency of incorporating the various environmental benefits was less for ALL as its curve diverged from the VCD and ESTA curves.

Key Summary Points for Graph 11:

- ALL is the most expensive of the scenarios on a per acre basis
- VCD and ESTA are similar in expense
- ALL includes more acres so both its relative and total cost is higher than the other scenarios, but, given

the unknowns around how climate change will play out over a forested landscape, its larger overall acreage may in itself be worthwhile.

- The cost of carbon per metric ton sequestered per acre annually ranged, over all the runs, from \$20.68 to \$33.23, with the average for the ALL scenario closer to the top of the range at just under \$30 per metric ton/acre/year. The overall average cost per metric ton of carbon sequestered over the 40 years modeled was \$25.40 cents/per metric ton/acre.



Graph 11: Cost per acre for various measures of environmental benefit under each scenario. Runs were combined so each line represents the average of 20 sampling runs.

Discussion

1. Possible Uncertainties & Further Considerations

Adjustments to GAP 1

Much of the analysis on a potential modification to UVA revolves around how each scenario works to fulfill the old forest goals laid out in the VCD plan. To do that with any accuracy requires two things – an accurate database of GAP 1 land in Vermont, and natural community information, particularly acreage, for each of the GAP 1 parcels. Given that some GAP status is linked to specific management designations in easements or public land management plans, ideally this natural community determination would be even more specific than the parcel level. The protected lands database from the Vermont state open data portal has limitations in both respects.

It is quite important to stress that the VCD old forest goals explicitly focus on the matrix forest natural communities (Vermont Conservation Design – Natural Community and Habitat – Technical Report March 2018). To quote from page 15 of that report: "Within the matrix forest in the highest priority forest blocks in each biophysical region, 15% should be managed as, or for, an old forest condition." Matrix forests cover millions of acres of the landscape and thus are the most widespread of Vermont's forests: northern hardwood forest, red spruce-northern hardwood forest, and lowland spruce-fir are examples. The report also set minimum patch size for these old forests (see Appendix 3 for a discussion of this aspect of the report's old forest goals) but this is not incorporated into the current analysis. Most likely those will develop from potential implementation strategies that encourage grouping of wild forest enrollments.

How the lack of natural community information might affect specific results can be illustrated in some of the Champlain Valley GAP 1 parcels. By manually looking through the protected lands data base, 32 parcels totaling 1,871 acres were found associated with TNC ownership at LaPlatte River Marsh, East Creek and Cornwall/Otter Creek Swamps. Much of the acreage is marsh and swamp wetland natural communities. The associated uplands in some cases include clay plain forests. These wetland areas are all critically important protected lands, appropriately classed as GAP 1 since they are wild land shaped by natural disturbance. However, technically only the clay plain forest acreage should count toward the old matrix forest goals of VCD. The other acreages are S1 and S2 natural communities and very large wetlands tracked by VT Fish & Wildlife Nongame and Natural Heritage Program as separate protection goals in VCD. These areas are large enough that if the adjustments were made to just reflect matrix forest, the 41% progress toward VCD's Champlain Valley old forest goal figure used throughout this report would probably drop closer to 30-35% progress. At some point this type of adjustment to increase accuracy may be useful to keep track of all of the various VCD goals throughout the state. Right now, it's just important to understand that GAP 1 land includes all types of forest, wetlands and other aspects of the landscape. The 280,654 acres from Table 6 is a wild forest goal for matrix forests, not a GAP 1 goal. We simply used GAP 1 status as a convenient shorthand because there was no other resource to more accurately assess what is or is not matrix forest acreage.

Two significant areas of GAP 1 lands that are largely matrix forest are missing from the list of GAP 1 lands in the state database. There is a long segment of the Appalachian Trail between the Green Mountain Forest and NH, owned by the National Park Service, that is not listed. In addition, a couple of small parcels are shown in the Camel's Hump state lands, but not on the list are approximately 2,142 acres of Phen Basin and possibly as much as 4,922 acres of Camel's Hump State Park. These adjustments would result in the Northern Green Mountains biophysical region being 57% complete rather than 49%.

Overall, we believe our estimates are conservative. In other words, we have likely undercounted the amount of GAP 1 and thus our projections of acreage and costs required to meet the VCD goals are on the high side.

Northeastern Highlands are a Special Case

The Northeastern Highlands are a special situation when it comes to old forest potential. All three scenarios modeled for this analysis underrepresent the region. The largest state lands designated as future old forest are within the West Mountain WMA, and are an important reason the Northeastern Highlands is almost 27% of the way to the VCD goal. This is the fourth highest percentage for the nine biophysical regions. Lastly, the largest privately owned parcels are in this biophysical region.

However, reaching the VCD goal for this biophysical region will be difficult. This seemingly anomalous situation results because most of the private land is held by industrial forest management companies, which are unlikely to ever set forests aside to grow old. More significantly, Weyerhaeuser, the largest ownership by far, has VLT conservation easements on 84,000 acres that require the land to permanently be used to produce timber. This was a result of the 1998 partnership work to protect the 132,000-acre Champion Lands (now called the Kingdom Heritage Lands), with the remainder becoming public land owned by Vermont Fish &Wildlife and the federal US Fish & Wildlife Service (USF&WS).

To meet the goal of 15,000 acres of matrix forest another 43,362 acres of wild forest will be needed. There are only 34,574 acres of unenrolled potential wild forest from private forested acres within the VCD boundaries. Even after taking out the Weyerhaeuser lands from the enrolled lands, there are still well over 100,000 acres within VCD that could change enrollment to wild forest. However, the enrollment rate for those acres would have to be 26.3%, higher than any other biophysical region under ALL or VCD, and a particularly daunting goal given that the overwhelming majority of the enrolled land is owned by industrial forest owners unlikely to consider wild forest management. Even if a huge percentage of the unenrolled land became wild forest, it seems likely additional wild forest would have to be designated on public land if the VCD plan's old forest goal of 59,000 acres is to be met. The Nulhegan Basin is 26,000 acres owned by USF&WS as part of the Silvio O. Conte Refuge. There is potential there for more GAP 1 land, but to date the management plan does not specifically set aside large areas of forest, and much of it is wetlands, not matrix forest. Several large areas of state lands, in addition to the West Mountain WMA, are in the Northeastern Highlands, but to date there have been no matrix forests of size set aside as permanent wild forest that we know of. Given these impediments, one has to conclude that reaching the VCD plan's old forest goal in this biophysical region is going to be challenging.

Reclassification or New Enrollments?

The greatest unknown for this study is how many and how quickly wild forests parcels will enroll if a new category is created in UVA. Some argue few landowners will be interested. On the other hand, if one could still change classifications later, or even unenroll just as you can now, it seems plausible that interest could be high. During this project's design the thought was that most of the new wild forest enrollment would come from newly enrolled landowners rather than existing enrollments. It seems less clear now why current UVA landowners would be motivated any differently from landowners who are not enrolled. At this point in a very mature 30-year-old program, the people who remain unenrolled may be people with low tolerance for state oversight, bureaucratic paperwork, and hiring foresters to create plans. This might not change just because there is a new category allowing wild forests, and it may actually be easier for landowners who have already gone through the process to decide to just switch to wild forest because it fits them or the times better, rather than trying to do light-touch forestry in a system oriented around regular creation of forest products. Finally, we don't know what the near future brings in terms of carbon markets. If the price of forest carbon sequestration credits goes up significantly there may be much more interest in wild forest and/or passive management carbon credit projects as the income could be significant for the landowner. The bottom line is we simply don't know, and that is why we used a random selection of potential wild forest enrollments.

We do know, however, that having a category for wild forests has not overwhelmed the current use programs of other nearby states. The data from Maine (see appendix 2) seems to indicate maybe 8% of the landowners will be interested in a less timber-oriented management. Maine's program requires permanent easements for its forever-wild category and John's discussions with land conservation professionals indicate that category is almost never used. The fact that conservation easements to permanently protect forest land cover only about 10% of Vermont's forest parcels (Table 1) also seems to indicate that there are not huge numbers of landowners oriented around permanently shaping the future. Enrollment numbers are likely to be influenced by how any changes to UVA deal with the longevity of enrollment as wild forests. We estimate that enrollment will ultimately be about 10-15%, implemented over at least 15 years, unless the PES payments from registered carbon markets suddenly increase greatly in price.

PES and Carbon Projects

As detailed earlier in this report, Vermont's UVA program is a true Payment for Ecosystem Services program or PES. Carbon projects are also a PES, just in the private rather than public sector. In all other respects they are the same – a regular payment is made to compensate landowners to manage toward a particular goal that improves ecosystem functioning. Given where society is in the work to lower carbon emissions, it seems logical that forest carbon sequestration will play a larger role than it already has for entities of all kinds to reach carbon neutral operation. If that is the case, the PES payments are likely to become much more common and much larger per metric ton of carbon sequestered than they are currently.

At the moment, a landowner in Vermont can take advantage of these carbon project PES payments only if their management for enhanced amounts of sequestered carbon includes harvesting of wood products. What types of management and harvest constitute additional carbon sequestration over typical management is an active literature full of debate. Determining how close to that line forest management can get before a legitimate project turns into greenwashing is also a place of public concern and debate. The problem of "leakage" (when reduced harvest in one place just increases harvest in another place) has been raised by some as a reason not to encourage carbon projects in Vermont. This report is not the place to discuss any of those issues.

What there is no debate about is that wild forests sequester large quantities more carbon than traditional forest management, and it is likely this not only continues, but increases, as the trees become old forest (Anderson 2019 & 2021). There is also little debate about the role that carbon markets can play in reducing emissions, just as similar markets have done for other types of air pollution. The markets are not perfect, and do function to a certain extent based on good-faith intent by institutions to also reduce emissions, not just offset all emissions. While greenwashing cannot be dismissed out of hand, rules will mature as the market enlarges and prices increase, and it seems clear carbon markets will help drive investments to sequester carbon by technological means and by the green infrastructure represented by natural ecosystems.

Picture 9: An old-growth red spruce with exposed roots demonstrating the level of carbon stored by old trees both above and (usually) belowground. Photo: © Susan C. Morse.

While the future details are not completely clear yet, it is clear that without a change in UVA that allows both wild forests and passive forest management for at least 40 years of time, as a way to maximize PES payments, few landowners in Vermont will get the benefit of carbon PES payments to help them keep their land as a forest. In addition, development pressure is only going to increase in Vermont under climate change because its climate will be quite favorable compared to some other parts of the country. Given the expected rise in real estate prices, higher PES payments, ideally through the carbon markets rather than the Vermont taxpayer, will be needed to keep land forested. The UVA law was originally set up as a PES to resist the conversion to development, and it should be adjusted to react to the new reality under climate change conditions. The UVA law needs to be changed so landowners can take advantage of this new source of carbon income, above and beyond the real estate tax benefits of UVA. The changes detailed in this report will create the balance between a forest producing timber and a forest sequestering carbon to enhance climate resilience, and it will provide landowners a way to keep their forests intact.

One of the reasons for encouraging wild forests to be incorporated into Vermont's UVA program is their important role in sequestering carbon as they become old forests, thus providing some mitigation against climate change. The calculations show that the cost of carbon using wild forests as a mitigation technique through UVA is economically reasonable, but not a bargain if viewed in isolation as only paying for carbon. The overall average price was $25.40 with a range from $20.68 to $33.23 per metric ton of sequester carbon. It is extremely hard to quantify the current price of carbon, with some arguing it is very low but set to rise (https://www.greenbiz.com/article/carbon-offset-prices-set-increase-tenfold-2030). Sale prices on California's voluntary market vary widely depending upon time, seller and buyer as the price of nature-based carbon offsets are often based on the story behind them that the buyer can use in marketing. A sale of carbon credits at $25 per ton is above or at the very high end of sales on California's market. Currently the price is $14.54 (https://carboncredits.com/carbon-prices-today/) but for much of the year it has been about half that. Globally most credits are between $10-$30 per ton (https://carboncreditcapital.com/value-of-carbon-market-update-2021-2/). At the end of 2020 it was about $20 per metric ton and as of June 2021 it is $34.99. Global prices generally are higher than US prices.

Penalties and Permanency

Wild forest will only be a reality if it is hard to withdraw from UVA and ultimately it will have to be permanently protected by a conservation easement if it is not going to be harvested by future generations. This report does not make suggestions on how to make enrollment for wild forest more stable, but we can provide some data to give a sense of the challenges. UVA is a 40 year-old program, but the average time a current parcel has been enrolled is only 16 years. Only 154 parcels have remained unchanged within UVA 36 years or more, and there is a six-fold drop between 26-30 years and 31-35 years. This is an imperfect measure as it only tracks land via parcel units, which frequently change (when someone withdraws a building lot, for example) and don't reflect the continuity of specific acres in the program. Clearly, most of the forestland in the state when UVA began is still forestland. However, it also does show wild forest will be difficult to achieve under the current penalty arrangements. Easements will have their own challenges. We know from prior parts of this report that protected land only makes up about 14% of the total UVA-enrolled and potential eligible acres. To provide permanency for old forest goals that make up 15% of the highest priority forest blocks would require a doubling of the easement work that has been done to date in Vermont. These challenges should not hinder the development of wild forest in Vermont; the most important step is to start the trajectory toward old forest. There will be years to solve the permanency part of maintaining privately held wild forests for hundreds of years, but we should not underestimate that challenge. In the meantime, maturing forests will enhance the ecology and resiliency of our landscapes as we face climate change.

2. Conclusions

ESTA Scenario

While people will fall on different sides of whether this is a strength or not, the ESTA scenario was designed by Forest, Parks & Recreation (FP&R) to limit the conversion of productive timberland to wild forest. Their filter for eligible parcels is based on concentrations of ecological measures that combine the most sensitive ecological features of the landscape with the least productive forests. Currently, UVA management plans can generally exclude most rare species habitat and high-quality natural communities that are tracked by VT Fish & Wildlife from timber management under ESTA provisions. Plans can also exclude land steep enough to be inoperable land, which often are the least productive forest lands. While the state has no formal definition of inoperable land for timber production, FP&R did, at the request of the legislature (Act 24 of 10. VSA Section 2750), publish "Voluntary Harvest Guidelines for Landowners in Vermont" in January of 2015. In that, to protect water quality and prevent erosion, the recommendation was to limit skidding on slopes of greater than 20%. The report (p.39) also included this statement about operability: "According (sic) the Natural Resources Conservation Service (NRCS), operators may begin to experience equipment limitations on slopes between 25% and 35% grade. They may be unable to operate equipment safely on slopes greater than 35%."

The ESTA universe was those parcels where 30% of the parcel or more is covered by one or both of these filters. This has two effects: 1) it reduces the number of parcels selected for potential wild forest because that concentration of ESTA natural communities and steep land is not that common; and, 2) fewer additional acres are removed from timbering because the acres chosen could be exempt anyway, and a concentration of such steep land means the abutting lands are probably also relatively steep and of lower forest productivity.

If one believes there is a relatively low probability that landowners will enroll as wild forest, the smaller ESTA universe of potential enrollment creates less chance that meaningful numbers will actually enroll. For those that do enroll as wild forest, the ESTA elements of biodiversity and steep land make up, on average, about 46% of their eligible land, so actual acreage taken out of likely production is the remaining 54% of the parcel that is forested (likely itself less productive than average). This matrix forest land is still about a half million acres, and so would be a significant change toward wild forest if a high proportion were to enroll. However, it also represents a continuation of a trend in conservation history where the least valuable, least productive lands are protected as wild, and we set aside relatively few examples of the best, most productive examples of forests and the wildlife for which they provide habitat.

What ESTA does well is efficiently capture the small elements of biodiversity on the landscape, including landscape diversity as long as it is in a mountainous area, in areas where those biodiversity elements are well integrated into the surrounding landscape. This is good because both the VCD plan and the Nongame & Natural Heritage Program want these areas to increase in quality and sustainability. ESTA consistently ranked highest in all measures of ecological benefit, except in meeting the goals of the state VCD plan's old forest goals for representative matrix forest, and in sequestering carbon. The ESTA scenario even captures VCD acres efficiently, just not enough of them or well distributed among the various biophysical regions of the state. ESTA had the lowest rate of carbon sequestration, which is logical since as discussed above it on average captures the least productive forests in Vermont.

While this scenario represents a positive change in public policy perspective toward passive management and wild forests, it has to be summarized as doing a poor job of advancing the protection of critical ecological resources at a landscape scale. In terms of VCD old forest goals, ESTA parcel representation on the landscape misses some very important parts of the state, while emphasizing other regions that are generally already well represented in GAP 1 land. Most importantly, the scale is so limited in parcel numbers that it isn't possible to meet most VCD old forest goals without very unrealistic levels of ESTA enrollment – up to 86% of eligible land in the Champlain Hills. Finally, to reach those old forest goals with challenging enrollment percentages is not even the cheapest solution – the VCD scenario provides a route that has a much higher probability of success with a 19% savings (Table 11). However, if it were to be embraced well by landowners, the ESTA scenario still does represent many acres of potential wild forest.

Two final points arise when evaluating the ESTA scenario. One, implementation of ESTA probably carries the highest administrative burden of the three scenarios. It would definitely be the most costly to implement for landowners (another way it may reduce actual enrollment), primarily because basic eligibility is only determined by expensive field work, not maps produced by the state and easily transposed to forest management maps. Two, it is important to stress that not pursuing an ESTA scenario does not mean the many very important small-scale biodiversity elements, particularly the highest ranked Heritage elements, will be lost or subject to extractive management. Most of them are eligible elements for ESTA consideration without harvest in currently existing UVA management plans. They could and should become wild land in their own right without a change in UVA legislation.

VCD Scenario

The VCD scenario is a significant increase in landscape scale from ESTA, potentially influencing more than double the number of acres, but represents the middle ground between ESTA and ALL in terms of potentially eligible wild forest acres. However, it is biologically and monetarily the most efficient scenario. This scenario is specifically focused on implementing the VCD planning document's vision of using the plan's three forest blocks (Interior Forest, Connectivity, and Physical Landscape Blocks) to be a coarse filter for many smaller-scale elements of biodiversity, while simultaneously defining a connected landscape of matrix forests that will be highly resilient in the face of climate change. The plan's goal is to keep all of those blocks permanently forested with at least 15% of their area set aside to develop into old forests representative of Vermont's matrix forests. The VCD scenario is an explicit implementation strategy for the forest components of the VCD plan.

Our analysis shows the VCD scenario's strength is the efficiency at which potential wild forests meet most aspects of good conservation planning. First and foremost, the eligible acres are well distributed across the biophysical regions and 100% of new enrollments will support the VCD plan goals. Because of this, the scenario's eligible acres sit within the least fragmented private forestland regions of the state, the parcels have larger average parcel size, and generally sit within very productive forestland. All of this results in the carbon calculator showing the VCD parcels sequester carbon at the highest rate of the three scenarios. VCD also does well in meeting all the measurements of ecological benefit; the capture of RFRB acres (strong measure of climate resiliency and biodiversity protection) is typical. For example, 50% of the total VCD acres are RFRB acres (as is true for the ESTA scenario), but the scale of acres is vastly different, more than double ESTA and increasing as enrollment increases. Total RFRB acres between ALL and VCD are very similar, but ALL accumulates many other acres so the percent of RFRB acres in the ALL scenario falls to 35%. If one considers the rate at which a wild forest UVA category meets the old forest goals set in the VCD plan as a measure of success then the ALL and VCD scenarios are quite similar, but VCD is the more efficient at doing so.

To put it simply – VCD is better than ESTA in terms of numbers of acres, while it is better than ALL in terms of cost. A 10% enrollment in VCD would cost slightly more than $1 million, get all biophysical goals except Vermont Valley nearly to 50% and at the same time increase the amount of GAP 1 within the VCD forest blocks by 126%. That would be 174,000 acres of new wild forest at approximately an annual cost of $7 an acre. Generally, ALL is about 78% more expensive than VCD in the various ways cost sidebars are calculated in the analysis. This report has looked at VCD largely as a way of meeting the VCD plan's old forest goals and thus in a sense capped at that level of enrollment. But even uncapped its maximum cost would be under $11 million. Good public policy normally attempts to get targeted public benefit at the least cost; this defines a VCD scenario aimed at reaching VCD old forest goals.

The major drawback of the VCD scenario is that an important change in the UVA law, and its resulting change in taxation, would only be available to a subset of landowners. Given that UVA generally is not available to all landowners anyway this does not seem like a large problem, but through several discussions it is clear some people feel very strongly that there is a major equity problem with the VCD scenario. The other drawback is that not all of the landscape's ecologically important parcels are within the VCD boundaries. This could readily be fixed by an exception process. Landowners could petition to qualify for wild forest enrollment under the VCD scenario provided that they showed their parcel contained high ecological values similar to those defined in the VCD plan, or other exceptional ecological value. This approach might also satisfy some people concerned about equity since there would be a wider recognition that wild forest could be important in many locations on the landscape.

ALL Scenario

The ALL scenario represents the most expansive, largest scale change to UVA. Any landowner currently qualifying to be in the forest UVA program would also qualify for wild forest management instead of forest products management. This is one of the scenario's strengths – it is equitable to all landowners because no judgement is made as to how important the parcel is ecologically. It creates tax equity in a manner one could argue is actually closer to the original purposes of the UVA law – the state will basically pay the landowner to keep the property forested and not developed. This goal is at least as important as it was in 1977, and probably more so now. Wild forest does not harm anything; in the long run it vastly improves local forest and landscape health and aids in climate mitigation and resilience. All of these are positive values just as important as improving the management of timberland.

ALL is less efficient on a per acre basis or a cost basis than VCD, but it tracks all the implementation of VCD old forest goals very similarly to the VCD scenario, in distribution and percent enrollment. In addition, it potentially could enroll many more forested acres as wild forest because many parcels include forests that are outside of the VCD mapped boundaries. Assuming that any cap on acres enrolled is in some way linked to VCD implementation means the excess forested acres in a sense are additional above the cap. This speaks to the other major strength of the ALL scenario as compared to the other two – it sequesters far more carbon.

Picture 10: Wild, healthy, unfragmented forests are a boon to society for all the practical reasons outlined in this report. They're also incredibly beautiful. Photo: © Zack Porter.

There are two potential drawbacks to the ALL scenario. The first is inherent in its strength as equitable for landowners; wild forest will be placed on the ground potentially in a random manner, with little connection to any conservation planning work identifying the most important places for wild forests from a long-term climate resilience and basic landscape health perspective. Small parcels in a fragmented landscape setting of rural development, more common in the ALL scenario, would be subject to edge effects that are not normal in larger blocks of forest. For example, the enhanced old forest structure could attract interior ground nesting forest bird species that would then be unsuccessful in reproducing because of the increased edge effect from predators not common in deeper forests, like blue jays, skunks, fox and house cats. That would change a potential source population role of wild forest into being a sink for vulnerable bird species. Similarly, invasives can more easily invade a forest where rural roads and edge effects of small parcels near fields might be more numerous. Even the browse effects of deer are more intense because edge is a preferred habit; therefore, understory cover for birds is reduced and herbaceous species like trillium can disappear.

The positive side of the more random placement on the landscape is that VCD does not define all the ecologically important land in the state. The ALL scenario would make those other parcels eligible as potential wild forest without the additional administrative burden of determining eligibility as in ESTA or for potential exceptions under VCD. It is also important to be humble when it comes to conservation planning such as the VCD plan. It is the best we have, but the history of conservation work has many examples where at the time of protection a parcel did not meet any planning criteria, but in hindsight it turned out to be a fortuitous project. We can never know all the factors that make land ecologically robust. In the end, though, the VCD old forest goal is to create large intact old forest blocks, and the ALL scenario, particularly at the lower enrollment rates, creates old forest with maximum scatter.

Cost is the ALL scenario's greatest downside. In general, public policy does not want to pay more for results than it has to, and we know from this study that VCD provides the same or better ecological results at less cost. However, sometimes cost is in the eyes of the beholder. As the analysis has shown, the worst-case cost situation for UVA would be $19 million. For many people, an increase that is less than a third of the current cost of UVA to enroll nearly all remaining eligible parcels in UVA is acceptable. The more important point is that this $19 million increase is possible with no changes in UVA, as it is the build-out cost of the current program. For those that want more cost constraint, or wild forest constraint, it would be relatively easy to cap the program at the VCD goals by biophysical region.

Cost Summary and Conclusions

It is fair to say that in the past the unknown cost effects of making changes to UVA have limited serious discussion on how to improve the program. There are those who don't want any change in the focus of UVA on land managed to produce timber, but in general most realize that the balance between active management and passive management probably is not "correct" by the many measures one could use. It is the fear of increased cost, because UVA is a direct PES arrangement, that has been the stumbling block.

It is never possible to precisely define the cost of a program, but it is usually possible to set the sidebars if one is both careful about assumptions and "tests" those assumptions against other reasonable assumptions. It is also fair to say that any large data analysis always contains imprecision – the goal is to make sure one works from a baseline of information that has the least likelihood of containing data that would fundamentally change the big picture conclusions. Because we started from the State's data that actively measured forested acres for inclusion we think the many smallest forested parcels are not clouding data. From a cost perspective, Deb Brighton has lent her expertise and database as Vermont's expert on UVA cost impacts so error there should be minimized. The goal has been to be conservative – to overestimate cost rather then underestimate. The one place that could potentially have a large effect on conclusions are the parcels that cluster around the 25-acre cut-off for UVA eligibility and have houses on them. We expect that there are parcels that qualify to enroll in the 25-27 acre range that have not been sorted perfectly, particularly given differences between GIS-calculated acreages and Grand List acreages we know exist, and the possibility that remote sensing of forested acres probably gets more sensitive to its errors when dealing with small acreages. However, we feel our methodology is a conservative approach to this problem and that any error here does not affect the big picture conclusions.

The sidebars of potential costs to change UVA to incorporate wild forest enrollments are a combination of Table 11 and Graph 9. We know from the sampling models that completion of the VCD old forest goals is met someplace between the 15% and 20% enrollment universes (Graph 5). If the assumption that all landowners, whether enrolled or not, are equally likely to decide to enroll as wild forest, then the likely cost to the program is between $1.7 and $3.3 million as a rough average between Scenario VCD and ALL. While that assumption is not empirically verified, its resulting average could be considered an approximation of the cost of VCD with exceptions made where it cannot quite meet old forest goals at a 15% enrollment rate. This range largely agrees with the end point analysis of Table 11 where the two sidebars are $1.7 and $3.1. If our assumption about the equal likelihood of wild forest enrollment is not met then Table 11 shows that the highest possible sidebars of cost would be $6.2 and $11.1, depending upon which scenario – or a hybrid of the two that allows exceptions to VCD – were implemented. These costs would be spread out over some unknown period of time, but probably no less than 10 years. These are all modest increases in cost to our current UVA program cost of $66 million as a PES program, and yet would likely have huge public benefits in forest health, biodiversity and climate resilience.

If capping the wild forest program to the old forest goals of each biophysical region adds a complexity of administration, landowner understanding, and landowner equity (people might be excluded simply based on the time at which they enroll) then the total costs to the program could not exceed either $10.7 or $18.9 million. In actuality we would expect it to be much less than that as there is no evidence from any direction that exceeding 20% enrollment is likely. Even if carbon markets created huge incentives much higher than current rates, it seems unlikely one would ever have a program that was fully enrolled, which is what the $10.7 and $18.9 million dollar costs represent.

Overall, our conclusion when thinking about the three scenarios is that ESTA is weaker than either ALL or VCD from an added ecological benefit perspective and a cost perspective. One might have hoped it would be a useful pilot program, but other than minimizing effects on the timber industry, its complexity and lack of scale and landscape representation in terms of the goals laid out by Vermont Conservation Design don't seem to match the need during times of rapid climate change. Thus, we conclude that either the ALL or VCD scenario, if capped to the VCD plan's old forest goals to minimize costs, are both valid approaches to adding wild forest to Vermont's landscape.

Appendices

1. Appendix 1

Appendix 1 provides a more detailed summary of data for both the endpoint analysis (Tables 1-3) and the sampling analysis statewide (Tables 4-7) and broken out by biophysical region (Tables 8-11). This is provided so that people can make other comparisons or calculations if they want to answer different questions than those we focused on.

Total acreages in each sample run (in Tables 4-7) will thus disagree slightly with the summed acreages in the samples broken out by biophysical region (Tables 8-11). This is because land that already had Gap 1 status was included in the overall sampling but removed for the analysis of how each scenario would meet VCD's old forest goals.

ALL Scenario	Enrolled ALL Parcels						Potential ALL Parcels					
Biophysical Region	Total Enrolled Acres	Enrolled Forested Acres	% of Total Forested	Forested Acres in VCD	% of Total Acres Forested Within VCD	% of Forested Acres Within VCD	Total Potential Acres	Potential Forested Acres	% of Total Forested	Forested Acres in VCD	% of Total Acres Forested Within VCD	% of Forested Acres Within VCD
Champlain Hills:	141,243	96,452	68.3%	55,017	39.0%	57.0%	55,425	38,716	69.9%	19,479	35.1%	50.3%
Champlain Valley:	159,886	59,166	37.0%	46,304	29.0%	78.3%	61,696	32,734	53.1%	23,698	38.4%	72.4%
Northeastern Highlands:	265,074	204,224	77.0%	199,384	75.2%	97.6%	53,835	39,217	72.8%	34,574	64.2%	88.2%
Northern Green Mountains:	448,218	376,447	84.0%	303,232	67.7%	80.6%	140,263	112,325	80.1%	78,488	56.0%	69.9%
Northern Vermont Piedmont:	509,394	355,214	69.7%	256,523	50.4%	72.2%	227,068	160,988	70.9%	101,253	44.6%	62.9%
Southern Green Mountains:	284,370	241,999	85.1%	190,836	67.1%	78.9%	146,175	122,493	83.8%	82,943	56.7%	67.7%
Southern Vermont Piedmont:	303,855	244,038	80.3%	147,183	48.4%	60.3%	100,540	82,917	82.5%	44,880	44.6%	54.1%
Taconic Mountains:	170,255	135,539	79.6%	116,598	68.5%	86.0%	96,449	75,915	78.7%	59,328	61.5%	78.2%
Vermont Valley:	24,261	14,325	59.0%	9,479	39.1%	66.2%	19,490	12,587	64.6%	6,768	34.7%	53.8%

Table 1: Endpoint (i.e., whole-universe) analysis for ALL scenario.

VCD Scenario	Enrolled VCD Parcels					Potential VCD Parcels					
Biophysical Region	Total Enrolled Acres	Enrolled Forested Acres	% of Total Forested	Forested Acres in VCD	% of Total Acres Forested Within VCD	Total Potential Acres	Potential Forested Acres	% of Total Forested	Forested Acres in VCD	% of Total Acres Forested Within VCD	% of Forested Acres Within VCD
Champlain Hills:	72,376	55,017	76.0%	55,017	76.0%	25,709	19,479	75.8%	19,479	75.8%	100%
Champlain Valley:	104,009	46,304	44.5%	46,304	44.5%	42,529	23,698	55.7%	23,698	55.7%	100%
Northeastern Highlands:	170,309	130,595	76.7%	130,595	76.7%	46,322	34,574	74.6%	34,574	74.6%	100%
Northern Green Mountains:	349,001	303,232	86.9%	303,232	86.9%	93,800	78,488	83.7%	78,488	83.7%	100%
Northern Vermont Piedmont:	346,351	256,523	74.1%	256,523	74.1%	135,712	101,253	74.6%	101,253	74.6%	100%
Southern Green Mountains:	218,009	190,836	87.5%	190,836	87.5%	95,712	82,943	86.7%	82,943	86.7%	100%
Southern Vermont Piedmont:	175,017	147,183	84.1%	147,183	84.1%	52,236	44,880	85.9%	44,880	85.9%	100%
Taconic Mountains:	140,111	116,598	83.2%	116,598	83.2%	71,100	59,328	83.4%	59,328	83.4%	100%
Vermont Valley:	14,380	9,479	65.9%	9,479	65.9%	9,611	6,768	70.4%	6,768	70.4%	100%

Table 2: Endpoint (i.e., whole-universe) analysis for VCD scenario.

ESTA Scenario	Enrolled ESTA Parcels						Potential ESTA Parcels					
Biophysical Region	Total Enrolled Acres	Enrolled Forested Acres	% of Total Forested	Forested Acres in VCD	% of Total Acres Forested Within VCD	% of Forested Acres Within VCD	Total Potential Acres	Potential Forested Acres	% of Total Forested	Forested Acres in VCD	% of Total Acres Forested Within VCD	% of Forested Acres Within VCD
Champlain Hills:	27,561	19,294	70.0%	11,669	42.3%	60.5%	12,735	7,528	59.1%	3,352	26.3%	44.5%
Champlain Valley:	63,607	21,458	33.7%	17,648	27.7%	82.2%	21,718	11,237	51.7%	8,288	38.2%	73.8%
Northeastern Highlands:	29,068	20,797	71.5%	19,889	68.4%	95.6%	10,299	6,558	63.7%	6,112	59.3%	93.2%
Northern Green Mountains:	184,647	165,996	89.9%	145,006	78.5%	87.4%	44,005	36,983	84.0%	27,664	62.9%	74.8%
Northern Vermont Piedmont:	73,435	55,349	75.4%	41,931	57.1%	75.8%	33,938	25,294	74.5%	15,372	45.3%	60.8%
Southern Green Mountains:,	85,525	75,731	88.5%	68,001	79.5%	89.8%	45,809	39,691	86.6%	31,566	68.9%	79.5%
Southern Vermont Piedmont:,	82,421	68,695	83.3%	46,594	56.5%	67.8%	30,207	24,964	82.6%	14,813	49.0%	59.3%
Taconic Mountains:	101,443	87,132	85.9%	79,792	78.7%	91.6%	47,385	40,407	85.3%	35,146	74.2%	87.0%
Vermont Valley:	6,302	3,620	57.4%	2,761	43.8%	76.3%	6,383	3,520	55.1%	2,364	37.0%	67.2%

Table 3: Endpoint (i.e., whole-universe) analysis for ESTA scenario.

5% ALL (1,338 parcels)	total acres	total forested acres	Percent Forested	total forested acres in VCD	total TNC acres	RFRB acres	Percent RFRB acres	Resilience Score	Local Connected-ness Score	Landscape Diversity Score	Total Cost	cost per VCD acre	Cost per RFRB Acre	Total Forest Carbon 2010 (mt)	Additional C after 40 years	Annual Rate (mt/yr)	Annual Rate/Acre	Cost per mt additionally sequestered
Run 1	159,421	118,516	74.3	88,340	158,508	55,607	35.1	0.4	0.4	0.4	1,021,940	11.57	18.38	13,884,886	1,315,186	32,880	0.206	31.08
Run 2	162,378	123,459	76.0	92,375	161,671	60,292	37.3	0.4	0.4	0.3	917,594	9.93	15.22	14,231,519	1,350,994	33,775	0.208	27.17
Run 3	137,428	102,407	74.5	71,631	139,189	42,386	30.5	0.3	0.2	0.3	956,270	13.35	22.56	12,094,524	1,151,082	28,777	0.209	33.23
Run 4	154,234	114,290	74.1	83,688	153,782	56,476	36.7	0.4	0.3	0.4	944,085	11.28	16.72	13,259,104	1,258,074	31,452	0.204	30.02
Run 5	148,500	108,367	73.0	78,276	147,097	51,128	34.8	0.3	0.3	0.3	822,080	10.50	16.08	12,626,400	1,215,054	30,376	0.205	27.06
Average	**152,392**	**113,408**	**74.4**	**82,862**	**152,049**	**53,178**	**34.9**	**0.36**	**0.32**	**0.34**	**932,394**	**11.25**	**17.79**	**13,219,287**	**1,258,078**	**31,452**	**0.206**	**29.64**
5% VCD (775 parcels)																		
Run 1	118,584	95476.483	80.5	95476	118,354.20	61,518.40	52.0	0.6	0.7	0.5	522,965	5.48	8.50	10,878,576	1,021,015	25,525	0.215	20.49
Run 2	102,542	81,319	79.3	81,319	101,890	49,940.00	49.0	0.5	0.6	0.4	615,457	7.57	12.32	9,298,531	910,724	22,768	0.222	27.03
Run 3	103,380	82,894	80.2	82,894	102,968	56,071	54.5	0.6	0.7	0.6	573,002	6.91	10.22	9,560,104	865,346	21,634	0.209	26.49
Run 4	100,397	78,463	78.2	78,463	99,747	46,846	47.0	0.5	0.6	0.5	484,810	6.18	10.35	9,097,670	849,616	21,240	0.212	22.83
Run 5	113,703	91,765	80.7	91,765	112,281	63,627	56.7	0.6	0.7	0.5	517,282	5.64	8.13	10,394,274	977,876	24,447	0.215	21.16
Average	**107,721**	**85983**	**79.8**	**85983**	**107048**	**55600**	**51.8**	**0.56**	**0.66**	**0.5**	**542703**	**6.31**	**9.90**	**9845831**	**924915**	**23,123**	**0.215**	**23.47**
5% ESTA (359 parcels)																		
Run 1	41,809	33,123	79.2	26,845	41,701	19,574	46.9	0.7	0.6	0.8	215,703	8.04	11.02	3,842,405	338,796	8,470	0.203	25.47
Run 2	48,855	38,322	78.4	31,795	48,357	25,409	52.5	0.8	0.7	0.8	202,317	6.36	7.96	4,296,585	384,295	9,607	0.197	21.06
Run 3	45,946	35,547	77.4	28,547	45,730	20,462	44.7	0.7	0.7	0.8	219,131	7.68	10.71	4,093,378	386,663	9,667	0.210	22.67
Run 4	42,942	33,220	77.4	23,750	42,811	20,191	47.2	0.7	0.6	0.8	242,097	10.19	11.99	3,910,649	331,881	8,297	0.193	29.18
Run 5	44,555	35,408	79.5	27,269	44,368	16,196	36.5	0.7	0.7	0.7	188,345	6.91	11.63	4,013,091	364,286	9,107	0.204	20.68
Average	**44,821**	**35,124**	**78.4**	**27,641**	**44,593**	**20,366**	**45.6**	**0.72**	**0.66**	**0.78**	**213,519**	**7.72**	**10.66**	**4,031,222**	**361,184**	**9,030**	**0.201**	**23.65**

Table 4: Summary metrics for all three scenarios sampled at 5%.

10% ALL (2,677 parcels)	total acres	total forested acres	Percent Forested	total forested acres in VCD	total TNC acres	RFRB acres	Percent RFRB acres	Resilience Score	Local Connectedness Score	Landscape Diversity Score	Total Cost	cost per VCD acre	Cost per RFRB Acre	Total Forest Carbon 2010 (mt)	Additional C after 40 years	Annual Rate (mt/yr)	Annual Rate/Acre	Cost per mt additionally sequestered
Run 1	323,563	239,938	74.2	178,546	321,871	111,851	34.8	0.3	0.3	0.3	1,860,717	10.42	16.64	27,732,700	2,765,166	69,129	0.214	26.92
Run 2	301,033	226,054	75.1	164,236	299,688	106,606	35.6	0.3	0.3	0.3	1,876,304	11.42	17.60	26,392,549	2,450,719	61,268	0.204	30.62
Run 3	320,443	238,652	74.5	175,281	318,286	119,075	37.4	0.3	0.3	0.4	1,816,368	10.36	15.25	27,660,985	2,626,568	65,664	0.205	27.66
Run 4	314,147	237,572	75.6	175,968	313,080	119,746	38.2	0.4	0.4	0.3	2,480,813	14.10	20.72	27,310,028	2,627,459	65,687	0.209	37.77
Run 5	322,803	245,681	76.1	179,899	320,769	117,838	36.7	0.4	0.4	0.3	1,764,444	9.81	14.97	28,269,362	2,665,842	66,646	0.206	26.47
Average	**316,398**	**237,579**	**75.1**	**174,786**	**314,739**	**115,023**	**36.5**	**0.34**	**0.34**	**0.32**	**1,959,729**	**11.21**	**17.04**	**27,473,125**	**2,627,151**	**65,679**	**0.208**	**29.84**
10% VCD (1,551 parcels)																		
Run 1	213,914	167,476	78.3	167,476	211,746	105,034	49.6	0.5	0.6	0.4	1,086,212	6.49	10.34	19,329,523	1,864,518	46,613	0.218	23.30
Run 2	231,059	184,882	80.0	184,882	230,140	115,675	50.3	0.5	0.6	0.4	1,158,972	6.27	10.02	20,995,128	2,040,895	51,022	0.221	22.72
Run 3	224,312	175,645	78.3	175,645	223,065	106,804	47.9	0.6	0.6	0.5	1,250,593	7.12	11.71	20,225,783	1,938,279	48,457	0.216	25.81
Run 4	212,838	167,458	78.7	167,458	212,032	108,630	51.2	0.5	0.6	0.4	1,448,073	8.65	13.33	19,175,398	1,866,890	46,672	0.219	31.03
Run 5	219,597	171,747	78.2	171,747	217,932	104,388	47.9	0.5	0.6	0.5	992,835	5.78	9.51	19,819,760	1,895,620	47,391	0.216	20.95
Average	**220,344**	**173,442**	**78.7**	**173,442**	**218,983**	**108,106**	**49.4**	**0.52**	**0.60**	**0.44**	**1,187,337**	**6.85**	**10.98**	**19,909,118**	**1,921,240**	**48,031**	**0.218**	**24.72**
10% ESTA (718 parcels)																		
Run 1	88,881	70,081	78.8	56,430	88,260	44,864	50.8	0.8	0.7	0.9	457,042	8.10	10.19	8,000,969	715,616	17,890	0.201	25.55
Run 2	100,636	82,127	81.6	67,937	99,905	47,489	47.5	0.8	0.8	0.7	505,982	7.45	10.65	9,274,222	836,945	20,924	0.208	24.18
Run 3	94,067	76,277	81.1	62,745	93,180	49,803	53.4	0.8	0.7	0.8	467,883	7.46	9.39	8,622,331	772,536	19,313	0.205	24.23
Run 4	85,695	67,333	78.6	53,887	85,355	44,767	52.4	0.7	0.6	0.8	442,112	8.20	9.88	7,771,357	682,862	17,072	0.199	25.90
Run 5	88,396	68,439	77.4	56,687	88,020	44,357	50.4	0.8	0.6	0.9	434,233	7.66	9.79	8,011,653	712,419	17,811	0.201	24.38
Average	**91,535**	**72,851**	**79.5**	**59,537**	**90,944**	**46,256**	**50.9**	**0.78**	**0.68**	**0.82**	**461,450**	**7.75**	**9.98**	**8,336,106**	**744,076**	**18,602**	**0.203**	**24.81**

Table 5: Summary metrics for all three scenarios sampled at 10%.

15% All (4,016 parcels)	total acres	total forested acres	Percent Forested	total forested acres in VCD	total TNC acres	RFRB acres	Percent RFRB acres	Resilience Score	Local Connectedness Score	Landscape Diversity Score	Total Cost	cost per VCD acre	Cost per RFRB Acre	Total Forest Carbon 2010 (mt)	Additional C after 40 years	Annual Rate (mt/yr)	Annual Rate/Acre	Cost per mt additionally sequestered
Run 1	479,095	358,918	74.9	262,583	475,023	168,889	35.6	0.3	0.3	0.3	3,008,207	11.46	17.81	41,664,272	4,013,514	100,338	0.209	29.98
Run 2	480,023	359,482	74.9	268,359	477,383	180,458	37.8	0.4	0.4	0.3	3,202,313	11.93	17.75	41,835,295	4,017,960	100,449	0.209	31.88
Run 3	461,786	341,271	73.9	245,311	458,797	151,920	33.1	0.3	0.3	0.3	2,584,144	10.53	17.01	39,860,808	3,763,923	94,098	0.204	27.46
Run 4	468,764	350,658	74.8	259,726	465,557	165,409	35.5	0.3	0.3	0.3	3,262,984	12.56	19.73	40,595,482	3,811,526	95,288	0.203	34.24
Run 5	479,729	361,445	75.3	265,063	476,546	176,169	37.0	0.4	0.4	0.3	2,816,628	10.63	15.99	41,718,680	3,963,037	99,076	0.207	28.43
Average	**473,879**	**354,355**	**74.8**	**260,208**	**470,661**	**168,569**	**35.8**	**0.34**	**0.34**	**0.30**	**2,974,855**	**11.43**	**17.66**	**41,134,907**	**3,913,992**	**97,850**	**0.206**	**30.40**
15% VCD (2,326 parcels)																		
Run 1	310,698	247,389	79.6	247,389	309,311	149,085	48.2	0.5	0.6	0.5	1,483,176	6.00	9.95	28,175,520	2,730,440	68,261	0.220	21.73
Run 2	310,631	246,054	79.2	246,054	307,703	150,838	49.0	0.6	0.6	0.5	1,532,147	6.23	10.16	28,109,899	2,676,044	66,901	0.215	22.90
Run 3	312,709	250,797	80.2	250,797	310,954	156,762	50.4	0.6	0.7	0.5	1,371,218	5.47	8.75	28,545,304	2,693,838	67,346	0.215	20.36
Run 4	351,148	276,632	78.8	276,632	349,645	173,484	49.6	0.6	0.7	0.5	1,553,437	5.62	8.95	31,723,969	3,078,354	76,959	0.219	20.19
Run 5	353,493	279,468	79.1	279,468	352,162	164,969	46.8	0.5	0.6	0.4	1,899,183	6.80	11.51	31,632,913	3,073,308	76,833	0.217	24.72
Average	**327,736**	**260,068**	**79.4**	**260,068**	**325,955**	**159,028**	**48.8**	**0.56**	**0.64**	**0.48**	**1,567,832**	**6.03**	**9.86**	**29,637,521**	**2,850,397**	**71,260**	**0.217**	**22.00**
15% ESTA (1,078 parcels)																		
Run 1	140,906	110,255	78.2	89,296	139,001	69,142	49.7	0.7	0.7	0.8	666,675	7.47	9.64	12,575,585	1,111,513	27,788	0.197	23.99
Run 2	152,207	120,893	79.4	99,684	151,474	72,459	47.8	0.7	0.8	0.7	662,237	6.64	9.14	13,824,705	1,251,595	31,290	0.206	21.16
Run 3	136,135	108,669	79.8	87,958	135,313	68,822	50.9	0.8	0.7	0.8	740,656	8.42	10.76	12,385,998	1,107,245	27,681	0.203	26.76
Run 4	138,413	111,455	80.5	90,832	137,718	72,034	52.3	0.8	0.8	0.8	642,030	7.07	8.91	12,663,736	1,139,084	28,477	0.206	22.55
Run 5	147,164	116,035	78.8	97,270	145,336	72,530	49.9	0.7	0.7	0.7	632,225	6.50	8.72	13,207,228	1,173,973	29,349	0.199	21.54
Average	**142,965**	**113,461**	**79.4**	**93,008**	**141,768**	**70,997**	**50.1**	**0.74**	**0.74**	**0.76**	**668,765**	**7.19**	**9.43**	**12,931,450**	**1,156,682**	**28,917**	**0.202**	**23.13**

Table 6: Summary metrics for all three scenarios sampled at 15%.

20% All (5,355 parcels)	total acres	total forested acres	Percent Forested	total forested acres in VCD	total TNC acres	RFRB acres	Percent RFRB acres	Resilience Score	Local Connectedness Score	Landscape Diversity Score	Total Cost	cost per VCD acre	Cost per RFRB Acre	Total Forest Carbon 2010 (mt)	Additional C after 40 years	Annual Rate (mt/yr)	Annual Rate/Acre	Cost per mt additionally sequestered
Run 1	618,587	463,188	74.9	335,302	614,651	207,798	33.81	0.3	0.3	0.3	3,804,184	11.35	18.31	53,883,196	5,138,852	128,471	0.208	29.61
Run 2	646,608	487,336	75.4	361,175	643,272	240,548	37.39	0.3	0.3	0.3	3,680,969	10.19	15.30	56,393,263	5,319,565	132,989	0.206	27.68
Run 3	632,621	476,100	75.3	353,197	627,746	223,221	35.56	0.3	0.4	0.3	3,709,266	10.50	16.62	55,061,307	5,262,084	131,552	0.208	28.20
Run 4	618,904	466,938	75.4	345,477	615,626	216,306	35.14	0.3	0.4	0.3	3,707,032	10.73	17.14	53,832,242	5,206,771	130,169	0.210	28.48
Run 5	625,973	467,045	74.6	341,156	622,293	220,600	35.45	0.3	0.3	0.3	3,809,061	11.17	17.27	53,945,896	5,189,697	129,742	0.207	29.36
Average	**628,539**	**472,121**	**75.1**	**347,261**	**624,718**	**221,695**	**35.47**	**0.30**	**0.34**	**0.30**	**3,742,102**	**10.78**	**16.93**	**54,623,181**	**5,223,394**	**130,585**	**0.208**	**28.66**
20% VCD (3,102 parcels)																		
Run 1	415,910	329,775	79.3	329,775	413,934	198,931	48.06	0.5	0.6	0.4	2,439,842	7.40	12.26	37,652,462	3,598,497	89,962	0.216	27.12
Run 2	464,382	365,236	78.6	365,236	459,911	224,263	48.76	0.5	0.6	0.4	2,118,291	5.80	9.45	41,601,287	4,096,816	102,420	0.221	20.68
Run 3	440,541	350,345	79.5	350,345	438,173	214,700	49.00	0.5	0.6	0.4	2,033,412	5.80	9.47	39,901,480	3,899,106	97,478	0.221	20.86
Run 4	439,754	347,544	79.0	347,544	437,033	214,751	49.14	0.5	0.6	0.4	1,978,705	5.69	9.21	39,847,983	3,786,011	94,650	0.215	20.91
Run 5	457,957	360,064	78.6	360,064	455,709	226,503	49.70	0.5	0.6	0.5	2,186,335	6.07	9.65	41,136,817	3,964,479	99,112	0.216	22.06
Average	**443,709**	**350,593**	**79.0**	**350,593**	**440,952**	**215,830**	**48.93**	**0.50**	**0.60**	**0.42**	**2,151,317**	**6.14**	**10.01**	**40,028,006**	**3,868,982**	**96,724**	**0.218**	**22.24**
20% ESTA (1,437 parcels)																		
Run 1	186,962	148,350	79.3	122,168	186,091	89,105	47.88	0.7	0.7	0.8	893,292	7.31	10.03	17,009,185	1,525,037	38,126	0.204	23.43
Run 2	194,903	152,398	78.2	124,557	193,006	94,166	48.79	0.8	0.7	0.8	887,986	7.13	9.43	17,387,472	1,549,031	38,726	0.199	22.93
Run 3	191,115	150,961	79.0	124,930	188,834	98,502	52.16	0.8	0.7	0.8	873,401	6.99	8.87	17,351,271	1,575,925	39,398	0.206	22.17
Run 4	203,037	161,986	79.8	135,065	201,341	104,904	52.10	0.8	0.8	0.8	888,443	6.58	8.47	18,405,168	1,660,722	41,518	0.204	21.40
Run 5	196,571	157,100	79.9	129,582	195,685	100,148	51.18	0.8	0.7	0.8	870,863	6.72	8.70	17,960,676	1,619,973	40,499	0.206	21.50
Average	**194,518**	**154,159**	**79.2**	**127,260**	**192,991**	**97,365**	**50.42**	**0.78**	**0.72**	**0.80**	**882,797**	**6.94**	**9.10**	**17,622,754**	**1,586,138**	**39,653**	**0.204**	**22.26**

Table 7: Summary metrics for all three scenarios sampled at 20%.

5% ALL (1,338 parcels)	Acres Needed	Run 1 VCD forested acres	Run 2 VCD forested acres	Run 3 VCD forested acres	Run 4 VCD forested acres	Run 5 VCD forested acres	5% ALL Averages	Acres Needed	VCD Forested Acres	Percent Progress Towards Goal
Champlain Hills	12,882	3,714	2,933	2,997	4,779	4,315	Champlain Hills	12,882	3,748	29.1
Champlain Valley	8,883	4,639	4,126	3,831	3,275	4,064	Champlain Valley	8,883	3,987	44.9
Northeastern Highlands	43,362	11,578	5,530	4,979	5,942	9,038	Northeastern Highlands	43,362	7,413	17.1
Northern Green Mountains	48,262	17,461	23,782	15,483	16,321	16,193	Northern Green Mountains	48,262	17,848	37.0
Northern Vermont Piedmont	76,608	13,679	17,573	18,543	18,631	15,007	Northern Vermont Piedmont	76,608	16,687	21.8
Southern Green Mountains	33,493	12,622	17,678	11,971	14,402	11,159	Southern Green Mountains	33,493	13,566	40.5
Southern Vermont Piedmont	28,927	9,990	8,869	6,025	8,909	9,024	Southern Vermont Piedmont	28,927	8,563	29.6
Taconic Mountains	24,501	13,336	10,170	7,015	8,435	7,452	Taconic Mountains	24,501	9,282	37.9
Vermont Valley	3,736	984	1,391	676	221	538	Vermont Valley	3,736	762	20.4
5% VCD (775 parcels)							5% VCD Averages			
Champlain Hills	12,882	4,063	4,011	3,107	3,337	3,791	Champlain Hills	12,882	3,662	28.4
Champlain Valley	8,883	1,936	3,107	3,109	4,454	2,844	Champlain Valley	8,883	3,090	34.8
Northeastern Highlands	43,362	10,105	9,119	3,508	1,809	9,223	Northeastern Highlands	43,362	6,753	15.6
Northern Green Mountains	48,262	27,641	16,205	21,001	14,905	18,676	Northern Green Mountains	48,262	19,686	40.8
Northern Vermont Piedmont	76,608	18,350	14,948	14,984	17,108	17,621	Northern Vermont Piedmont	76,608	16,602	21.7
Southern Green Mountains	33,493	14,513	15,117	17,362	17,840	15,944	Southern Green Mountains	33,493	16,155	48.2
Southern Vermont Piedmont	28,927	10,253	9,009	10,539	8,832	11,601	Southern Vermont Piedmont	28,927	10,047	34.7
Taconic Mountains	24,501	7,943	7,801	8,925	7,907	9,299	Taconic Mountains	24,501	8,375	34.2
Vermont Valley	3,736	538	1,448	349	728	1,030	Vermont Valley	3,736	819	21.9
5% ESTA (359 parcels)							5% ESTA Averages			
Champlain Hills	12,882	480	456	708	699	600	Champlain Hills	12,882	589	4.6
Champlain Valley	8,883	578	1,125	1,984	1,382	694	Champlain Valley	8,883	1,153	13.0
Northeastern Highlands	43,362	955	1,119	3,482	458	1,156	Northeastern Highlands	43,362	1,434	3.3
Northern Green Mountains	48,262	6337	9,053	8,869	4,959	11,386	Northern Green Mountains	48,262	8,121	16.8
Northern Vermont Piedmont	76,608	3089	1,776	2,276	2,608	1,910	Northern Vermont Piedmont	76,608	2,332	3.0
Southern Green Mountains	33,493	4279	5,877	4,084	6,858	4,721	Southern Green Mountains	33,493	5,164	15.4
Southern Vermont Piedmont	28,927	2406	3,181	2,653	3,650	3,119	Southern Vermont Piedmont	28,927	3,002	10.4
Taconic Mountains	24,501	4001	8,932	3,712	2,667	3,220	Taconic Mountains	24,501	4,506	18.4
Vermont Valley	3,736	35	45	0	433	145	Vermont Valley	3,736	132	3.5

Table 8: Biophysical region metrics for all three scenarios sampled at 5%.

10% ALL (2,677 parcels)	Acres Needed	Run 1 VCD forested acres	Run 2 VCD forested acres	Run 3 VCD forested acres	Run 4 VCD forested acres	Run 5 VCD forested acres	10% ALL Averages	Acres Needed	VCD forested acres	Percent Progress towards goal
Champlain Hills	12,882	9,518	8,618	8,579	7,141	8,181	Champlain Hills	12,882	8,407	65.3
Champlain Valley	8,883	7,251	6,469	7,706	7,212	5,498	Champlain Valley	8,883	6,827	76.9
Northeastern Highlands	43,362	20,642	15,186	15,147	19,547	16,828	Northeastern Highlands	43,362	17,470	40.3
Northern Green Mountains	48,262	39,699	31,173	39,780	34,869	39,743	Northern Green Mountains	48,262	37,053	76.8
Northern Vermont Piedmont	76,608	42,872	31,544	32,864	31,856	38,480	Northern Vermont Piedmont	76,608	35,523	46.4
Southern Green Mountains	33,493	25,514	31,845	31,548	29,944	26,758	Southern Green Mountains	33,493	29,122	86.9
Southern Vermont Piedmont	28,927	15,720	22,689	19,946	18,804	20,834	Southern Vermont Piedmont	28,927	19,599	67.8
Taconic Mountains	24,501	15,553	14,497	16,766	18,765	20,642	Taconic Mountains	24,501	17,245	70.4
Vermont Valley	3,736	1,500	1,462	2,116	2,453	1,711	Vermont Valley	3,736	1,848	49.5
10% VCD (1,551 parcels)							10% VCD Averages			
Champlain Hills	12,882	6,912	5604	8,162	8,835	6,649	Champlain Hills	12,882	7,232	56.1
Champlain Valley	8,883	5611	5878	7,825	6,866	8,502	Champlain Valley	8,883	6,936	78.1
Northeastern Highlands	43,362	21371	24,680	11,696	16,410	16,963	Northeastern Highlands	43,362	18,224	42.0
Northern Green Mountains	48,262	36,669	46,838	41,428	34,724	35,791	Northern Green Mountains	48,262	39,090	81.0
Northern Vermont Piedmont	76,608	31,858	39,141	36,146	36,391	38,302	Northern Vermont Piedmont	76,608	36,368	47.5
Southern Green Mountains	33,493	25,635	25,731	28,806	27,138	21,078	Southern Green Mountains	33,493	25,678	76.7
Southern Vermont Piedmont	28,927	20,811	16,210	20,231	20,195	17,332	Southern Vermont Piedmont	28,927	18,956	65.5
Taconic Mountains	24,501	16,008	18,860	15,974	14,655	23,493	Taconic Mountains	24,501	17,798	72.6
Vermont Valley	3,736	655	1,256	814	1,777	2,138	Vermont Valley	3,736	1,328	35.5
10% ESTA (718 parcels)							10% ESTA Averages			
Champlain Hills	12,882	2,132	1,470	2,713	1,592	1,303	Champlain Hills	12,882	1,842	14.3
Champlain Valley	8,883	3,130	2,917	1,871	2,556	3,262	Champlain Valley	8,883	2,747	30.9
Northeastern Highlands	43,362	1,598	2,394	4,388	3,203	2,715	Northeastern Highlands	43,362	2,860	6.6
Northern Green Mountains	48,262	19,361	27,818	18,022	12,005	12,106	Northern Green Mountains	48,262	17,862	37.0
Northern Vermont Piedmont	76,608	6,788	6,266	4,757	6,718	4,882	Northern Vermont Piedmont	76,608	5,882	7.7
Southern Green Mountains	33,493	7,423	8,586	9,380	9,516	11,274	Southern Green Mountains	33,493	9,236	27.6
Southern Vermont Piedmont	28,927	5,212	6,139	6,439	5,481	5,231	Southern Vermont Piedmont	28,927	5,700	19.7
Taconic Mountains	24,501	10,294	11,649	12,896	11,837	10,874	Taconic Mountains	24,501	11,510	47.0
Vermont Valley	3,736	409	277	89	533	287	Vermont Valley	3,736	319	8.5

Table 9: Biophysical region metrics for all three scenarios sampled at 10%.

15% All (4,016 parcels)	Acres Needed	Run 1 VCD forested acres	Run 2 VCD forested acres	Run 3 VCD forested acres	Run 4 VCD forested acres	Run 5 VCD forested acres	15% ALL Averages	Acres Needed	VCD forested acres	Percent Progress towards goal
Champlain Hills	12,882	11,371	9,954	10,766	12,174	13,139	Champlain Hills	12,882	11,481	89.1
Champlain Valley	8,883	9,935	12,701	9,403	10,969	8,737	Champlain Valley	8,883	10,349	116.5
Northeastern Highlands	43,362	24,731	34,535	13,593	25,161	24,371	Northeastern Highlands	43,362	24,478	56.5
Northern Green Mountains	48,262	55,858	57,516	58,712	60,588	65,353	Northern Green Mountains	48,262	59,605	123.5
Northern Vermont Piedmont	76,608	60,151	49,665	55,543	46,315	55,520	Northern Vermont Piedmont	76,608	53,439	69.8
Southern Green Mountains	33,493	40,344	41,632	39,460	42,102	36,842	Southern Green Mountains	33,493	40,076	119.7
Southern Vermont Piedmont	28,927	30,353	30,323	30,597	29,066	22,634	Southern Vermont Piedmont	28,927	28,595	98.9
Taconic Mountains	24,501	26,580	25,831	23,755	29,191	30,561	Taconic Mountains	24,501	27,184	110.9
Vermont Valley	3,736	2,264	2,023	2,100	1,320	1,484	Vermont Valley	3,736	1,838	49.2
15% VCD (2,326 parcels)							**15% VCD Averages**			
Champlain Hills	12,882	9,312	11,654	8,824	11,024	11,074	Champlain Hills	12,882	10,378	80.6
Champlain Valley	8,883	9,777	9,971	9,388	12,582	12,390	Champlain Valley	8,883	10,822	121.8
Northeastern Highlands	43,362	18,624	19,249	19,668	32,754	29,616	Northeastern Highlands	43,362	23,982	55.3
Northern Green Mountains	48,262	48,437	61,415	57,174	62,022	67,753	Northern Green Mountains	48,262	59,360	123.0
Northern Vermont Piedmont	76,608	57,556	50,819	49,875	52,783	50,183	Northern Vermont Piedmont	76,608	52,243	68.2
Southern Green Mountains	33,493	44,156	38,865	43,928	40,562	45,071	Southern Green Mountains	33,493	42,516	126.9
Southern Vermont Piedmont	28,927	31,373	27,327	24,488	29,619	28,699	Southern Vermont Piedmont	28,927	28,301	97.8
Taconic Mountains	24,501	26,101	21,269	33,681	27,372	29,351	Taconic Mountains	24,501	27,555	112.5
Vermont Valley	3,736	928	2,638	1,358	3,830	2,993	Vermont Valley	3,736	2,349	62.9
15% ESTA (1,078 parcels)							**15% ESTA Averages**			
Champlain Hills	12,882	1,502	2,316	1,799	2,304	1,746	Champlain Hills	12,882	1,933	15.0
Champlain Valley	8,883	4,230	4,871	4,973	4,029	3,363	Champlain Valley	8,883	4,293	48.3
Northeastern Highlands	43,362	3,582	6,121	3,138	4,575	1,777	Northeastern Highlands	43,362	3,839	8.9
Northern Green Mountains	48,262	21,251	39,336	24,648	32,166	31,849	Northern Green Mountains	48,262	29,850	61.8
Northern Vermont Piedmont	76,608	10,955	9,156	6,300	8,506	10,069	Northern Vermont Piedmont	76,608	8,997	11.7
Southern Green Mountains	33,493	20,513	12,280	15,775	14,305	16,290	Southern Green Mountains	33,493	15,833	47.3
Southern Vermont Piedmont	28,927	8,697	9,579	8,143	10,833	7,493	Southern Vermont Piedmont	28,927	8,949	30.9
Taconic Mountains	24,501	15,350	14,242	20,793	12,246	22,953	Taconic Mountains	24,501	17,117	69.9
Vermont Valley	3,736	639	684	743	620	503	Vermont Valley	3,736	638	17.1

Table 10: Biophysical region metrics for all three scenarios sampled at 15%.

20% All (5,355 parcels)	Acres Needed	Run 1 VCD forested acres	Run 2 VCD forested acres	Run 3 VCD forested acres	Run 4 VCD forested acres	Run 5 VCD forested acres	20% ALL Averages	Acres Needed	VCD forested acres	Percent Progress towards goal
Champlain Hills	12,882	15,637	17,051	13,711	12,947	14,772	Champlain Hills	12,882	14,824	115.1
Champlain Valley	8,883	14,395	13,291	12,365	12,884	14,117	Champlain Valley	8,883	13,410	151.0
Northeastern Highlands	43,362	27,417	32,399	35,120	29,231	20,569	Northeastern Highlands	43,362	28,947	66.8
Northern Green Mountains	48,262	82,228	79,473	79,739	86,803	73,781	Northern Green Mountains	48,262	80,405	166.6
Northern Vermont Piedmont	76,608	71,833	70,650	77,569	77,078	83,433	Northern Vermont Piedmont	76,608	76,113	99.4
Southern Green Mountains	33,493	53,416	60,738	53,169	49,176	54,311	Southern Green Mountains	33,493	54,162	161.7
Southern Vermont Piedmont	28,927	38,889	38,453	42,894	40,806	36,299	Southern Vermont Piedmont	28,927	39,468	136.4
Taconic Mountains	24,501	26,681	34,726	30,875	31,383	31,887	Taconic Mountains	24,501	31,110	127.0
Vermont Valley	3,736	3,316	4,075	3,415	3,204	3,563	Vermont Valley	3,736	3,515	94.1
20% VCD (3,102 parcels)							**20% VCD Averages**			
Champlain Hills	12,882	13,463	17,429	11,049	15,664	16,007	Champlain Hills	12,882	14,722	114.3
Champlain Valley	8,883	11,881	14,420	13,403	12,038	15,127	Champlain Valley	8,883	13,374	150.6
Northeastern Highlands	43,362	27,899	43,312	37,694	34,603	40,374	Northeastern Highlands	43,362	36,776	84.8
Northern Green Mountains	48,262	73,229	74,251	73,557	85,174	81,383	Northern Green Mountains	48,262	77,519	160.6
Northern Vermont Piedmont	76,608	67,875	81,050	81,510	68,948	68,308	Northern Vermont Piedmont	76,608	73,538	96.0
Southern Green Mountains	33,493	54,763	49,348	56,514	51,573	54,144	Southern Green Mountains	33,493	53,268	159.0
Southern Vermont Piedmont	28,927	40,997	39,353	38,588	39,766	38,448	Southern Vermont Piedmont	28,927	39,430	136.3
Taconic Mountains	24,501	34,352	38,733	29,985	28,439	35,786	Taconic Mountains	24,501	33,459	136.6
Vermont Valley	3,736	3,373	2,990	3,451	2,828	3,363	Vermont Valley	3,736	3,201	85.7
20% ESTA (1,437 parcels)							**20% ESTA Averages**			
Champlain Hills	12,882	4,251	4,571	2,554	2,113	2,898	Champlain Hills	12,882	3,277	25.4
Champlain Valley	8,883	5,919	5,095	5,058	6,189	5,381	Champlain Valley	8,883	5,528	62.2
Northeastern Highlands	43,362	3,502	4,177	9,177	5,316	4,696	Northeastern Highlands	43,362	5,374	12.4
Northern Green Mountains	48,262	37,558	32,971	31,738	39,013	40,654	Northern Green Mountains	48,262	36,387	75.4
Northern Vermont Piedmont	76,608	12,481	14,265	10,122	12,451	14,280	Northern Vermont Piedmont	76,608	12,720	16.6
Southern Green Mountains	33,493	24,314	22,041	26,925	16,922	22,066	Southern Green Mountains	33,493	22,454	67.0
Southern Vermont Piedmont	28,927	11,123	14,217	11,954	11,972	11,649	Southern Vermont Piedmont	28,927	12,183	42.1
Taconic Mountains	24,501	19,927	22,465	22,854	39,019	21,711	Taconic Mountains	24,501	25,195	102.8
Vermont Valley	3,736	993	1,785	540	1,161	692	Vermont Valley	3,736	1,034	27.7

Table 11: Biophysical region metrics for all three scenarios sampled at 20%.

2. Appendix 2

Opinions range as to how many landowners would be interested in managing for wild forest if taxes were equivalent to those placed on forest under active timber production. It's easy to make up reasons why it will be many or few, and it would have been very helpful to have a reliable estimate. We had planned to get a large enough sample from existing programs to say with confidence how popular wild forest categories are in other states' current use programs. We obtained a bit of insight from a single town in Maine, but not enough on which to base an analysis. To increase the sample would have been a town by town process based on manually analyzing potential candidates from aerial photographs, which would have put us well above budget.

The data we were given is from Fryburg Maine, a town with about the same mix of farm/forest/tourism/development and waterfront that Vermont has as a state. The Town of Fryburg encompasses 42,170 acres with 42% of that taxed at current use. This is similar to Vermont which had about a 40% overall UVA enrollment in 2018 (VPR 9/10/18 Jane Lindholm's interview of Elizabeth Hunt and Michael Snyder). The original current use program in Maine was called the Timber Growth program, which has Maine's largest current use enrollment. As in Vermont there is an agricultural current use, but in addition, there is an Open Space current use, with several tiers of tax reduction depending upon the public benefit provided.

Wild forest enrollment, called forever-wild forests in Maine's program, provides the highest tax reduction if the landowner also gives some type of public access. However, few landowners enroll in the forever-wild category of the Open Space current use because it requires a permanent forever-wild easement. Several people told me that most landowners not interested in state approved commercial timber production management plans use the Open Space category more broadly than just for the forever-wild category. A landowner is not required to manage a forest under the Open Space category, but does get an additional tax reduction if they do. The tiered approach allows landowners to choose what level of public benefit from their property they are comfortable in providing, and these are then added together to get the total reduction.

In Fryburg, 65% of the current use enrollment by acreage is under Timber Growth. Only 7.3% is enrolled under Open Space. This represents 9 landowners with parcels ranging in size from .54 to 625 acres. The assumption is the .54 acres is enrolled under a category to keep waterfront undeveloped. Median parcel size is 54 acres and the mean is 142 acres.

An enrollment of 7.3% is lower than the 10% we projected. Maine's Open Space program is fairly mature and there is plenty of forestland in Fryburg, so this may be an indication that not many people currently enrolled in UVA in Vermont would switch to a wild forest category.

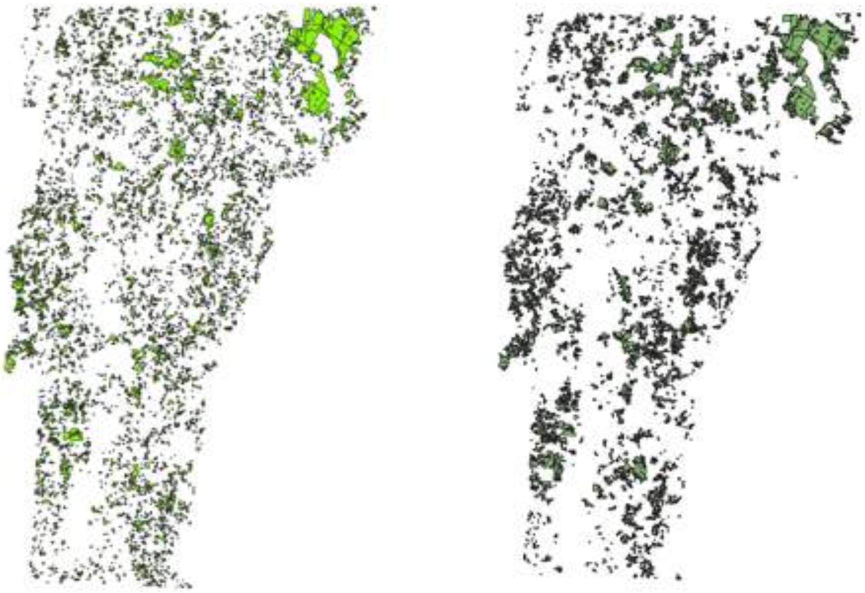
3. Appendix 3

The VCD plan's matrix forest goals provide minimum preferred patch sizes within each biophysical region. This is important to reach full functional and ecological value of the old forests. The plan even went further and set goals for each matrix forest community within each biophysical region; readers should consult Appendix B of the VCD Natural Community and Habitat 2018 for that level of detail. This report has made no attempt to quantify either the existing or future potential geography of wild forests, but the minimum patch size for each biophysical region is provided in the table below.

Biophysical Region	Champlain Hills	Champlain Valley	Northeastern Highlands	Northern Green Mountains	Northern Vermont Piedmont	Southern Green Mountains	Southern Vermont Piedmont	Taconic Mountains	Vermont Valley
Total Matrix Old Forest (Acres)	13,000	15,000	59,000	95,000	78,000	91,000	31,000	33,000	4,000
Minimum Patch Size (Acres)	1,000	500	4,000	4,000	1,000	4,000	1,000	1,000	500

Table 1: An overview of VCD old forest goals in each bioregion.

In our preliminary test runs we did look at a methodology of eligibility that tended to cluster wild forest, but decided not to pursue that approach further as it was too complex for easy implementation. Eligibility was defined based on adjacency to a permanently protected parcel or, after a wild forest UVA category was created, an enrollment in that category. It allowed for a very slow start-up to the program, but as clusters formed they grew outward at an increasing rate. The two maps below provide a visual comparison between a straight random selection of parcels within VCD and one where the random selections were from a universe that grew larger each year based on the prior year's selected parcels. These runs were not capped, so they represent acreage much larger than the old forest goals of the VCD plan.



Map 1: An example run from the clustered eligibility work. The left map shows random selection within VCD. The right shows random selection within VCD based on adjacency.

Assembling wild forest into minimum patch size goals will have to be done through active outreach to groups of landowners by conservation organizations or state agencies rather than just random enrollment. If wild forest UVA enrollment is capped by each biophysical region's goal, it will be necessary to have an exception to the cap based on whether a new enrollment is adjacent to a block of wild forest that is below its minimum block size. Creating blocks of protected land, or in this case wild forest blocks, takes a great deal of time, and in many biophysical regions one can expect the total acreage goal will be met by random enrollments before blocks are fully assembled. This is particularly likely under the ALL scenario just because more parcels will be eligible but the VCD old forest goals are the same.

View from Eagle Ledge in the proposed Woodbury Mountain Wilderness Preserve. Photo: © Zack Porter