Research and Recommendations Pertaining to the Management of the Second College Grant

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1. Executive Summary of Recommendations

This report provides an extensive study and evaluation of the current management methods of the Second College Grant, with the objective of generating discussion among the members of the Dartmouth College community on ways to improve usage of the Grant and increase engagement of local actors in land management policymaking. The Grant's services were evaluated and contextualized in scholarly research utilizing the framework outlined in the Millennium Ecosystem Assessment from 2005. Based on results from this background research, this report outlines a number of proposed recommendations. First, awareness of the Grant could be achieved through an updated and extensive website under the Dartmouth College domain and would serve to easily disseminate information regarding opportunities at the Grant such as research or recreation. Both members of the Dartmouth community and Coos County would benefit from clarification of the Grant's management. Together, the website and physical material onsite would lead to increased awareness of procedures and dismissal of unwanted tension. Also, recreation opportunities could be marketed easily through this website, with the potential to help several of the existing programming events at the Grant. Improvement of the current facilities would benefit both students and faculty, by enticing interns and professors for research, as well as encouraging students to come into the Grant for recreational.

Timber management on the Grant currently demonstrates effective management policymaking. The management incorporates preservation of ecosystem services, focusing on conserving biodiversity, seed dispersal, and

elemental cycling. However, it is important to note that neighboring land management interacts with and affects the sustainable management of services provided by the Grant, so these interactions and their effects must be considered in designing land management policies that ensure sustainability in the future. Attention should be given to procurement of these lands, especially because current value of the deforested land is minimal. Potentially procuring more land would facilitate more control over the watershed regions by the College, and, thus, mitigates the adverse effects of surrounding areas upon the Grant's ecosystems. The acquisition of land could also assist Dartmouth in achieving carbon neutrality through carbon offsets. Obtaining a conservation easement for the Grant could greatly augment revenue and ensure sustainable future management of this land.

These recommendations demonstrate a range of options for improving the management plan of the Second College Grant. The recommendations represent a spectrum of options for Grant management improvement, varying from simple to complex. However, each recommendation outlined in this project demonstrates the potential for improvement of the overall management plan for the land, and should be considered strongly for implementation by the College.

2. Introduction

The compilation of this report occurred during the spring of 2013 for the purposes of evaluating the current use of Dartmouth College's property, the Second College Grant (hereafter referred to as "the Grant") through the Second College Grant Act. The State of New Hampshire gifted Dartmouth the 27,000 acres located by the towns of Errol and Wentworth in 1807. The Grant originally served as a

source of revenue for the College from timber that helped pay for Dartmouth students' financial aid. Timber harvesting began in 1828, and continued under the supervision of a professional forester from 1905. In 1919 the Act was amended to state that the profits from the Grant could be used for the general expenses of the College (Dartmouth College Woodlands 2011). Current administration of the Grant falls on four main branches, Director of Woodland Operations, Director of Outdoor Programs, the Green Tag Forestry Program, and the Vice President for Campus Planning and Facilities through the Second College Grant Management Committee. The Second College Grant Committee evaluates the progress towards objectives and meets quarterly to discuss not only long–term goals, but also budgets, contracts, and operational data. The Grant Advisory Committee meets once a year to review recreational activities and consists of the Director of Outdoor Programs, Director of Woodland Operations, alumni, and representatives from the Office of Planning and Facilities.

In the late 1960's and early 1970's, when the money represented a small portion of the College's operating costs, the Grant started to reduce harvests to manage the Grant more sustainably, which resulted in lower profits. In 1973, the Deeryard Management Plan was adopted, which was the first move to managing the wildlife and other natural resources of the Grant (Dartmouth College Woodlands 2011). Since then, the College has become more proactive about conserving the land and ecosystem of the Grant as a whole, exemplifying strong forest management in New England. In 1993, the Grant made an agreement with New Hampshire Fish and Game to protect and enhance wildlife habitat (Dartmouth College Woodlands 2011).

The Grant not only contains diverse species of wildlife and various kinds of plants, but also the watersheds of the Dead Diamond and Swift Diamond Rivers (Dartmouth College Woodlands 2011). Emphasis on the protection of these invaluable assets ensures their continued success.

By placing significance on ecosystem services and understanding the complex role the Grant plays in New Hampshire, the Grant has succeeded in protecting many of these values. As a result of these conservation and sustainable management practices, the Grant's profits have scaled back, and now the College generates approximately $140,000 per year in profits from timber harvesting (Dartmouth College Woodlands 2011). However, environmentally sound practices are viewed extremely favorably, as increased attention to long-term value of protecting ecosystems has grown in recent years, and now also increasingly generate income. Therefore, this report explores venues to increase profits without changing current harvesting practices. More opportunities for support exist in other aspects of the Grant's influence, especially in terms of augmenting awareness surrounding the benefits of the Grant and the accessibility, especially to Dartmouth affiliates and the local community. By reviewing available literature, this study reports findings on present practices, and envisions new possibilities for the Grant. Through initiating these recommendations, Dartmouth contains the potential to transform into a leading land management institution, repair relationships between affiliates, and generate profit. Simple education measures aimed at Dartmouth's members and the local community could serve to ease tensions. Conservation easements and carbon credits are both fairly viable options that could earn the Grant revenue and still

maintain current management procedures.

A. Comparison of Peer Organizations

Various other institutions like Middlebury College, Harvard University, Yale University and the University of Maine direct forests and retain conservation measures. In order to better evaluate and understand the Grant's current management procedures, these peers were studied and evaluated in this project. Hopefully, Dartmouth will match or exceed the precedent set by competitors, as well as utilize their innovations.

Middlebury does not own a large forested area, but uses timber from local sources for campus buildings and furniture. The value system at Middlebury centers on exceptional environmental standards for supervision of their facilities and properties. In terms of recreation, Middlebury offers various courses in addition to community-based outdoor programs (Middlebury 2013). The Harvard Forest focuses on research and education of ecological connections between humans and the landscape, boasting exceptional facilities on-site and an extensive website with a multitude of resources for currents (Harvard 2013). These opportunities vary from research positions to recreational activities to environmental outreach and several organizations provide ample funding. Yale University manages numerous sites in Connecticut, New Hampshire and Vermont, which serve as areas for field trips, training programs, and research development opportunities. This working forest aims to value the ecosystem dynamic while also continuing to provide teaching tools through research and sustainable, profitable harvest of forest products like timber. Yale also instructs students through a Forestry school and provides easy

access to prospects for studies through a remarkable website (Yale University 2013). The University of Maine owns the Penobscot Experimental Forest (PEF) with the goal of sustainable timber harvesting to fund forest research and internships (PEF 2010). The PEF is similar in timber management to the Grant but on a much smaller scale with about 3,900 acres of total managed land (PEF 2010).

Looking closely at these programs, several practices could be easily transferred and employed at the Grant. An important aspect of these research institutions is the availability of past findings and access to new funding opportunities. Dartmouth could explore grants for fellowships and internships from the National Science Foundation like Harvard. Availability of these chances should be clear if proper upkeep and redesign of the Grant's website occurred. Maintaining correct habitat and population inventories guide decision-making for the Grant, and reinvesting in the Wildlife Management Project and updating numbers serves to remedy this issue. Dissemination of this material easily could occur through an updated website and through departments such as Environmental Studies, Biology, Engineering, Chemistry, English, History and Studio Art. Comparatively, Dartmouth employs a restrictive access policy to the Grant, and adherence to traditions of public access to the surrounding areas should be prioritized. One of the main restrictions that limits Dartmouth student as opposed to members of other institutions is the proximity of similarly peaceful, educational areas like the Moosilauke Ravine Lodge. Increasing transportation opportunities to the Grant would be an important first step in recognizing the limiting factors of Dartmouth. Facilities at the Grant currently fall short of other organizations and consideration

should be given to the construction of showers and laboratories, or at the minimum areas for classes to convene. Creation of a ropes course or similar bonding structure would serve to attract even more student organizations.

B. Forestry Stewardship Council (FSC) Certification

Dartmouth College currently relies on the Green Tag Forest Certification program as a measurement and indication of necessary and rewarding forest management practices (Dartmouth Woodlands 2011). Since 1999, the Grant has adhered to the 10-step certification process outlined by the Green Tag system, which was created only a year prior by the National Forestry Association (Green Tag 2010). This national certification requires minimal costs, needing only $150 at initial registration and then $0.10-$1.25 per acre to renew the certification every 5 years (Green Tag 2010). In comparison, the FSC Certification, recognized internationally, was developed in 1993 by the Forestry Stewardship Council and garners a high level of respect (Rickenbach 2000). FSC certification, however, also incurs higher costs, approximately $3000 for the same length of certification (FSC 2013). Nevertheless, the actual requirements for both Green Tag and FSC programs are essentially the same (Rickenbach 2000, 7). According to a report published by Oregon State University, "those familiar with certification systems view FSC as supported by the major international environmental organizations while Tree Farm, Green Tag, and SFI (Sustainable Forestry Initiative) certifications are considered more aligned with landowners and the forestry industry" (Rickenbach 2000, 3). The attainment of FSC Certification would bring the Grant more in line with the goals and recommendations discussed in this report. Specifically pertaining to carbon

offsets and conservation easements, obtaining FSC certification would increase the ability to pursue such options (Rickenbach 2000).

It is recommended that Dartmouth pursue FSC certification for the Grant at this time. The FSC industry label is more widely acknowledged on a national and international scale and signals a serious commitment to the environment and sustainable resource management on the part of the holder. In line with other recommendations contained within the report, the College should recognize FSC certification is more aligned with the overall ecosystem services goals of the Grant, rather than strictly the forestry perspective. It is believed that FSC certification would greatly increase the visibility and renown of Dartmouth's environmental efforts.

http://www.fsc.org

3. Ecosystem Services

A. Millennium Ecosystem Assessment

In 2005, the Millennium Ecosystem Assessment undertook a comprehensive examination of the effects of environmental change on ecosystems as a result of increasing human impact on the environment (MA, 2005). This report framed the services provided by ecosystems in terms of complex human-environment interactions, incorporating how society has benefited from these services, as well as how the environment has responded to increasing use by humans as a result of a growing world population and economic development. Ecosystem services defined are "the benefits people obtain from ecosystems" (MA, 2005, 49). The Millennium Ecosystem Assessment examined how rapidly increasing resource use by humans has altered environments in substantial ways resulting in biodiversity loss and

environmental degradation. The Assessment importantly examines how increasing resource use by humans diminishes the benefits of other services provided by ecosystems irreversibly. Asserting the interconnectedness of ecosystems and recognizing the breadth of benefits provided by ecosystems is an important step in developing management policies that incorporate tradeoffs between utilizing ecosystems in the present and preserving these benefits for future generations.

Before the Millennium Ecosystem Assessment, researchers lacked a standardized framework for assessment, making the valuation of ecosystem functions especially difficult. In recent years, an increase in publications noting the importance of ecosystem functions for human benefits also asserted the need to develop a consistent framework for the valuation of a wide range of ecosystem services in the field of ecological economics (de Groot, Wilson, and Boumans, 2002). The Millennium Ecosystem Assessment provided a standardized framework for the valuation of ecosystem services and their impact on human well-being, and exceeded prior models by extending beyond a limited set of resources to broadly encompassing the full array of ecosystem contributions to society over a variety of scales (Daniel et al., 2012). The framework for the Millennium Ecosystem Assessment builds on the principle in ecological economics that says that human benefits derive from different forms of capital, of which ecosystem services represent natural capital (Daniel et al., 2012). Daniel et al. explain,

> "The [ecosystem services] framework extends prior models by expanding the focus from individual resources to the full array of contributions ecosystems make to human well-being and by better recognizing the interconnectedness of ecosystems across the broad temporal and spatial scales over which ecosystems and humans interact" (2012).

The Millennium Ecosystem Assessment broadened the discussion of ecosystem services, and emphasized their interconnectedness, which is an important consideration for the valuation and management of natural capital. The implication of this framework impacts land management policymaking by reshaping the way in which ecosystems are valued by individuals and communities.

For the scope of this project, the Millennium Ecosystem Assessment's classification of ecosystem services provides a framework for identifying and discussing the benefits or potential for benefits to the community existing in the Grant. Using the Millennium Ecosystem Assessment framework allows for better, consistent valuation of the Grant, and facilitates comparison to published studies, offering access to broader and deeper understanding of the material covered in this project. The Millennium Ecosystem framework divides services into four groups. These four types of ecosystem services, regulating, supporting, provisioning, and cultural, offer a variety of important services to people that can be measured in a number of ways to reflect the value of these services to communities surrounding particular ecosystems. Since the Millennium Ecosystem Assessment in 2005, the principle that these types of services can be enumerated and evaluated to assess human interactions with the environment has played an important role in determining land management policies.

B. Supporting Services

In 1997, Costanza, *et al.,* published a paper placing a value of US$16-54 trillion on ecosystem services for the entire biosphere. This value, however, is only the "use" value of these services and does not include existence or option value,

suggesting that the value of ecosystem services may actually be somewhat higher than this estimate. Use value includes, for example, the money that would have to be spent if New York City were to install a water filtration system if the Catskill Mountains, where the city gets a significant portion of its water from, did not exist. In the 2012 World Factbook, the US CIA estimates 2012 world gross product to be about $72 trillion (Central Intelligence Agency, 2012). This helps understand the importance of the world's ecosystem services.

Supporting services is the subcategory of ecosystem services that relates to the primary production and soil formation within an ecosystem. The indirect and direct drivers - such as land use, irrigation and species habitation - of change that influence ecosystems make supporting services crucial components of resource management and land use. Because these services are vital for the correct functioning of any ecosystem, their maintenance is of utmost importance. All ecosystem services depend on supporting services for functionality (Corvalan et. al, 23). Other ecosystem services change due to the management of an ecosystem to achieve certain goals (Corvalan et. al, 23). These alterations are crucial in planning as they impact the health of wildlife and other resources within the ecosystem. Nutrient cycling, soil formation, primary productivity and watersheds underpin supporting services; these are all relevant for the Grant in the fulfillment of its objectives and the implementation of policies that pertain to the surrounding areas.

a. Seed Dispersal:

The longevity of the timber resources within the Grant relies on the seed dispersal patterns and sustainable harvesting of the trees. Each tree species

disperses seeds in different mechanisms and patterns. For this reason, forest management practices should accommodate each species. Conservation biology deserves a rightful forefront in this matter as it seeks to minimize the permanent losses of tree species due to negligence (Young, 2000: 74). The existing management plan should continue in order to emphasize the growth of long-rotation, high quality, solid wood forest products.

Moreover, selective clear-cutting and partial harvesting are important management tools that should be continued. These inexpensive and expeditious methods free the Grant of low quality trees, while simultaneously attaining the College's goals of wildlife habitat and the transition to sustainable flows of high-quality saw-logs in hardwood stands. In addition to its ability to provide a variety of wildlife habitats, clear-cutting allows some tree species within the Grant to re-grow better in full sun rather than shade. Selective clear-cutting also ameliorates soil deficiencies that are necessary for tree regeneration. The natural regeneration of tree species from selective clearcutting occurs because trees produce more cones as a result. The Grant management's decision to limit the selective clear-cutting sections to ten acres ensures that this method is not overused. Overuse would result in the removal of too many trees, which would render selective clear-cutting nearly unselective. This is important for successional species, as fewer disturbances to the ecosystem make it more likely for a speedy recovery. Plants and animals have characteristics that allow them to survive, exploit and depend on disturbances (Smith, 2007: 8). The remaining forestry permits recovery and regeneration. Some tree species also require removal to produce and disperse seeds (Smith, 2007: 5).

The retention of spruce is another effort to increase diversity. Spruce encourages insect and disease resistant softwood stands (Second College Grant Master Plan, 2006: 69). Furthermore, heavy harvests, as witnessed by Hubbard Brook, lead to nutrient loss. Without selective clear-cutting and partial harvests, there would be a dramatic decline in tree cover; ultimately many nutrients within the Grant would be lost due to leaching by acid rain (Campbell, et. al, 37). White Pines can grow in many soil conditions and they also provide habitats for many different species within the forest. Soil conditions heavily influence the growth patterns and types of available species, and their importance must be recognized. Poor soil conditions dramatically affect the primary production of the grant - a major aspect of supporting services - and also impede the regeneration of tree species for other types of fauna (SERI & IUCNCEM, 2004: 5). Addressing concerns about soil conditions directly correlates with methods to foster proper regeneration from seed dispersal, and it fulfills the objective of ecological restoration and sustainable development within the Grant.

Additionally, silvicultural treatments are equally important aspects of the current management plan, and thus, they should be continued. This practice pertains to the growth, health and quality of forests; silvicultural treatments would allow the Grant to meet diverse needs and values. The treatments aim to "reduce stand densities to optimal growing levels and to remove diseased trees" (Second College Grant Master Plan, 2006: 68). These treatments work in tandem with the carefully planned timber harvests that focus on improving the health and productivity of these forest resources and wildlife habitats. According to the U.S. Department of Agriculture, silvicultural systems underlie the maintenance of a

healthy forest community over an extended period of time (Hoffman et. al, 5).

b. Nutrient Cycling:

The effect of nutrient cycling in forests on soil fertility, decomposition, and productivity has been greatly analyzed and studied in recent decades. Nutrient cycling is the movement of nutrients from one reservoir to another in a cyclical fashion and is essential for the correct functioning of any ecosystem. Some of the most important nutrient cycles include water, nitrogen, carbon, oxygen, and sulfur. Nitrogen and sulfur are in many cases the limiting nutrients in ecosystem productivity. At the same time, excess amounts of these nutrients can hinder productivity. The water and carbon cycle are essential for the simple reason that all forms of life on Earth are based in carbon and require water for survival. Maintaining the correct functioning of these cycles will be a key step in maintaining the productivity and natural characteristics of the Grant. There are several factors affecting each cycle, ranging from factors contained within the Grant that Grant managers have some control over to factors largely beyond the control of managers due to their regional character. All of these factors, whether controllable or not, must be considered in any Master Plan. An overview and recommendations pertaining to the water cycle and the nitrogen cycle follow.

c. *Water Cycling:*

The water cycle is arguably the most important cycle within the Grant, as it is responsible for the movement of most nutrients and as a source of livelihood for many organisms and animals. Shown in Fig. 1 is a simplified diagram of the water cycle.

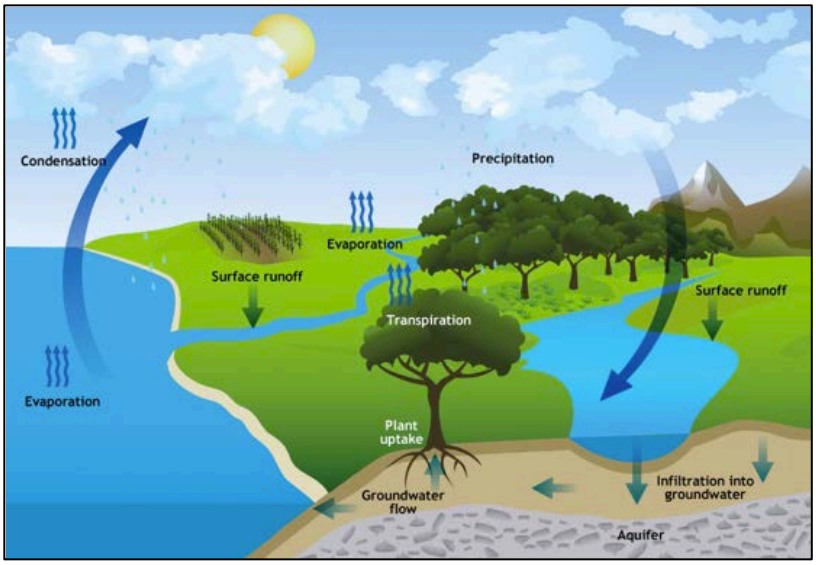


Figure 1. Simplified diagram of the water cycle.

Source: http://guernseysoil.blogspot.com/2012/07/your-backyard-woods-water-cycle.html

As can be seen in the diagram, there are a number of factors that have high potential to affect the water cycle. These principally include percent imperiousness, amount of tree cover, and damming and diversions.

Percent imperviousness refers to percentage of land in which runoff of water, as opposed to absorption of water, occurs. Surfaces such as roofs and paved roads have high imperviousness, whereas soils tend to have much lower imperviousness. Areas in Fig. 1 labeled as "Surface Runoff" are areas with high imperviousness. Much of this runoff ends up in lakes, streams, rivers, or the ocean. Areas surrounding the Grant, some of which have been heavily forested, will therefore have much higher runoff rates than do most areas in the Grant. Areas within the Grant, on the other hand, with high tree coverage have much lower percent imperviousness.

Tree cover also greatly affects the cycling of water. Fig. 1 shows trees as sources of water uptake. Areas with high tree cover can absorb enormous amounts of water from the ground; an area with low density of trees will have significantly more runoff, as the water has no place to be absorbed. Low densities of trees can therefore lead to flooding and erosion.

A third factor significantly affecting the water cycle is damming and diversions (not show in Fig. 1). Dams and diversions can change the natural course of water flow and have a large impact on the water cycle if water is allowed to gather in one area while it is deficient in another. As of the year 2000, there were about 800,000 dams in the world, acting as one of the largest anthropogenic impacts on the global water cycle (Rosenberg *et al.* 2000). A well-known example of the effect of diversions on the natural flow of water is the Colorado River. Once flowing from its source in the central Rocky Mountains of Colorado (La Poudre Lake Pass) before emptying in the Gulf of California, the river no longer reaches the gulf due to increased diversions along its course. Water flow within the Grant is a much lower quantity, making even small dams and diversions have a much larger relative impact.

Within the Grant, current management plans are working to maintain the natural cycling of water. There are few roads in the Grant, and of those roads few are paved. Additionally, tree cover within the Grant is high, and certainly much higher than surrounding areas. Dams and diversions are also minimal within the Grant. Since management within the Grant is currently working well, the College

must look to sources of cycling outside of the Grant to create a more comprehensive management plan.

It is important to note that factors affecting water both inside and outside the Grant will strongly influence the cycling of water within the Grant. Therefore, focus on regulation of the water cycle must be regional in scale rather than locally-focused on the Grant.

The Grant is located partially in the Swift Diamond Watershed and partially in the Dead Diamond Watershed. As a result, waters flow into the Grant from surrounding areas that may not be of the quality desired due to contamination from runoff. Surrounding areas are more developed and have profound effects on regional water cycling.

The Grant is a part of a much larger cycle that includes more than the Grant itself. The Grant is a relatively small are of the regional cycling and thus has essentially no control over the regional cycling; however, regional cycling can have a profound impact on the water cycling within the Grant. Huntington (2006) claims that intensification of the global water cycle due to global warming is likely to increase incidents of flooding, precipitation, and runoff. Therefore, management must be aimed at mitigation of outside forces. This will focus on limiting runoff from surrounding areas. Part of the reason it is so important to limit runoff into the Grant is because runoff usually contains contaminants and may increase nitrogen and/or sulfur levels, which are not desirable (see *Nitrogen Cycling)*.

d. Nitrogen Cycling:

The nitrogen cycle is essential for productivity on the Grant. Nitrogen exists in many forms in nature, such as atmospheric nitrogen (N_2), NO_3, and NH_3. Shown in Fig. 2 is a simplified version of the nitrogen cycle. It has been known for a long time that limited amounts of nitrogen and/or phosphorous can inhibit both growth and decomposition of plants and trees. For example, Ryle and Hesketh (1969) show that nitrogen deficiency causes decreased carbon assimilation, thus limiting plant growth. On the other hand, the presence of excessive nitrogen or phosphorous leads to eutrophication and decreased productivity of forest ecosystems. Gilliam (2006), for example, says that chronically high (i.e. excess) levels of nitrogen in forest ecosystems lead to decreased biodiversity. Finding the correct balance, of course, is the goal.

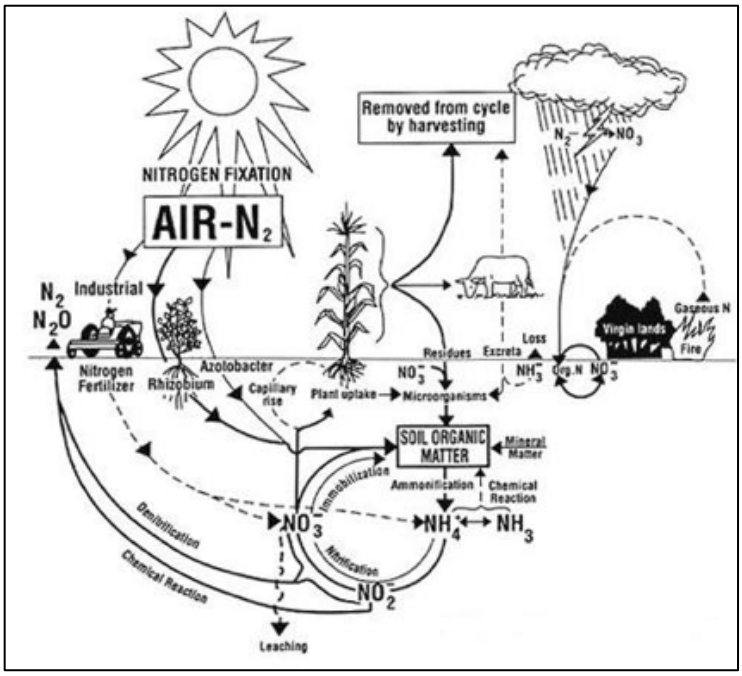


Figure 2. Simplified diagram of the nitrogen cycle.

Source: http://ohioline.osu.edu/aex-fact/0463.html

As shown in the diagram, the nitrogen cycle, like the water cycle, is incredibly complex, and can be affected by a number of factors. Of the many forms of nitrogen in nature, not all are available for uptake by plants; while elemental nitrogen (N_2) may be abundant in the atmosphere, making up 78% by volume, it must be fixed before being taken up by plants for use as a nutrient. This conversion of atmospheric nitrogen to ammonia (NH_3) is called nitrogen fixation, and can be carried out mainly by bacteria in plants and by lightning. Nearly all fixed nitrogen that is taken up by plants is either NO_3 or NH_3. Fertilizers applied to crops contain nitrogen in these forms for easy uptake by plants. To create these fertilizers, the Haber-Bosch process has been used, and is responsible for the increase in food production over the past century. Human fixation of nitrogen has greatly affected the global nitrogen cycle, as human activity has doubled nitrogen input into the global nitrogen cycle (van Breeman, 2002).

In regions of the world, such as the forests in the Northern Hemisphere, where serious human activity has resulted in reduced amounts of organic nitrogen, nitrogen runoff is a serious problem. Due to a lack of plants and trees in industrialized regions, nitrogen runoff can affect neighboring areas. Too much nitrogen can cause biodiversity loss, acidified soils, lakes, and streams, and eutrophication of coastal areas (van Breeman, 2002).

Trees and plants are responsible for the uptake of fixed nitrogen. In areas of low tree density, nitrogen will simply runoff and may pool in one area, causing an over-supply of nitrogen in that area. Nitrogen runoff, it is well-known, can lead to

eutrophication of surrounding areas, which in turn limits productivity of ecosystems.

Soils hold onto nitrogen and nutrients and thus play a major role in the cycling of nitrogen. There are a variety of soil types within the Grant, with varying ability to cycle and absorb nutrients. Different soils have different nitrogen-retention rates, depending on their chemical composition. Sandy soils, which have low water retention rates, tend to lead to more leaching than clay soils which have higher water retention rates due to their charged surface that attracts water molecules (Simmelsgaard, 1998).

Fertilizer use has an enormous impact on nitrogen cycle. Humans currently produce as much nitrogen in fertilizers as is natural fixed each year (Vitousek *et al.*, 1997). Anthropogenic effects on the nitrogen cycle have the potential to have serious repercussions. However, on the Grant, there is little use of fertilizers to affect the natural cycling of nitrogen.

Current management of the Grant limits the use of fertilizers. Due to limited effects on the tree and soil cover and fertilizer use, current management works to maintain the natural cycling of nitrogen. However, as was seen with the water cycle, looking at factors outside the Grant in order to create a more comprehensive management plan for the future. Many of the surrounding areas have been clear-cut or have been heavily affected by human activity, leaving little plant and tree cover. This increases the probability of nitrogen runoff into the Grant.

In regards to nitrogen cycling effects occurring outside the Grant, the best and most feasible approach is mitigation of excessive nitrogen buildup. This would

require limiting the amount of nitrogen that can enter the Grant. As with water, a filtration system may be the best approach.

At the present time, the management of the land on the Grant works well to maintain the natural cycling of nutrients. However, factors outside the Grant must be considered, for those influence and change the health of the internal ecosystem. For nitrogen and water cycling, the use of a filtration system to limit polluted waters and an excess of nitrogen to enter the Grant remains the first important recommendation. In addition, prioritizing supporting services over other ecosystem services within the grant is vital to proper management. This conclusion is based on the fact that all other services depend on supporting services for functionality and even the most minute alteration to supporting services can affect the entire Grant. It is imperative that the Grant continues its management practices that deal with seed dispersal and tree regeneration like selective clear-cutting, silvicultural treatments, which would address the need for trees, soil formation needs and the overall health of this ecosystem.

C. Regulating Services

The Grant's vision is to steward the land in a way to maintain a working forest and balanced ecosystem that sustains fish and wildlife populations (Master Plan 2011). "Building on ecological features" and "protecting natural features" of the forest when harvesting timber requires the College to take care of the regulating services that sustain the Grant (Master Plan 2011). The Millennium Ecosystem Assessment defines regulating services as the benefits obtained from the regulation of ecosystem processes (MA 2005). Regulating services extend beyond the

boundaries of the Grant and sustaining these services depends on activities occurring on the surrounding lands. Unhealthy forests directly affect "forest landowners, rural communities, and the economy" (Ecosystem Services 2011). Under Section III, Guidelines of the current Grant Master Plan, it is recommended that the College be alert of the activity occurring on neighboring lands and accentuate the cooperation agreements to sustain lands outside the Grant.

To maintain a plan that addresses habitat needs requires the Dartmouth community to broaden its perspective on enhancement projects and monitoring programs that influence the ecosystem, rather than exclusively lands within the Grant's boundaries. As a private landowner the College has the opportunity to set an example by capitalizing on the realized benefits of regulating services. The Northern Forest Center (NFC) is beginning to create a network that supports sustainable forest projects such as the 13 Mile Wood Project near the town of Errol. The project is financed by New Market Tax Credits that supports the local community (NFC Annual Report 2012). With the creation of the network, a mission of the NFC is to create a sustainable economic initiative that incorporates the collaboration to create regional regulating services markets (Northern Forest Center 2013). Regulating services, such as biodiversity, create additional services that are necessary for life. Services, including creating soil and purifying water, multiplies into the aesthetic beauty of the environment and decreases the cost for water treatments systems (NFC Wealth Index 2000). Regulating services filter out and decompose wastes that are in the watershed and vegetative land cover as a regulating service maintains soil

retention that prevents erosion and land degradation (EPA Science Advisory Board 2003).

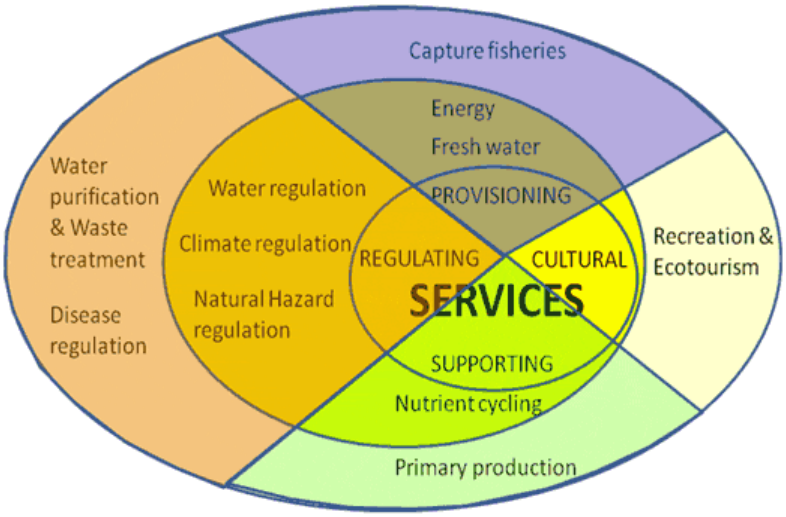


Figure 1: Regulating Services are "interlinked" with all ecosystem services and allow the ecosystem to function and contribute to human wellbeing. Graph adapted from MA 2005. (UNEP 2005).

The quality of the land cover in and around the Grant affects regulating services including the climate, water regulation, erosion control, regulation of disease, pollination, and storm protection (EPA Science Advisory Board 2003). Change in land use in New England may reshape the landscape with “major implications” for the quality of natural resources and ecosystem services (Rideout et al. 2006). The quality of the stewardship of regulating services is not determined by what it produces but how the services are being “enhanced or diminished” (EPA Science Advisory Board 2003). For example, if forest land coverage is stripped this will lead to degradation of numerous regulating services. It will erode the land, pollute the water, alter temperature and precipitation at the local scale, and harm to human health and biology due to the diminishment of resilient provisioning services.

For the Grant to be sustainable requires the effective management process and activity occurring on and around it to enhance the regulating services because sustainability depends on the maintenance of the ecosystem that has "natural ecological boundaries" (Rideout et al. 2005).

The benefit and value of stewarding ecosystems sustainably is often greater than other uses of land (MA 2005). The multiple uses in the Grant depend on regulating services. The 1992 Management Plan proposed conservation easements to be established in the Grant and it is highly recommended that the College do so today (1992 Management Plan 1992). Most regulating services change as a result of increasing provisioning services (MA 2005). With an increase in activity on the Grant there is increased impact on regulating services including an increase threat of non-native species and change in water purification services. Didymo, variable milfoil, and smallmouth bass are currently the main threatening species (NH Dept. of Environmental Services 2008). It is important to document the sources of degradation and ensure prevention measures are taken. Having an effective management process in place to oversee forest cover that "encompasses ecological conditions" will help protect native species and healthy wildlife populations (Wildland and Woodlands 2010; Rideout 2005). The New Hampshire Department of Environmental Services focuses on education and outreach, early detection monitoring, control of infestations, and regional cooperation to effectively regulate invasive species and emphasizes the importance of private owners like Dartmouth College to be involved in a regional approach (Smagula et al. 2008). To enhance this regulating service the College may want to work with the New Hampshire Department of Environmental Services.

The Brook Trout projects are an example of solid research that needs to be implemented into policies based on the ecosystem and watershed management. The health of the Brook Trout is an indicator of the stability of ecosystem services (Androscoggin River Watershed Council 2013). The Androscoggin River Watershed Council stresses the significance of maintaining brook trout habitat in their projects. The increase in biodiversity of Brook Trout over history is an enhancement to regulating services (Kelson 2012). Nislow and Lowe determine that logging in New Hampshire strongly affects brook trout and other macro-invertebrates in New Hampshire (Nislow and Lowe 2006). Regulating Services should be monitored at the watershed level in order to effectively use resources in specific areas and for optimal health of the system (Kelson 2012). The current measures to prevent invasive species pertain to rules entering the grant and specific activity instructions and with increased activity within the grant there will be increase impact on regulating services. The current wildlife management plan has widened its vision to "ecosystem-based management" but successful management needs to be done at "the watershed level" in a way that "focuses the limited resources and efforts" in a way where specific areas are given attention to sustain wildlife such as the Brook Trout (Kelson 2012).

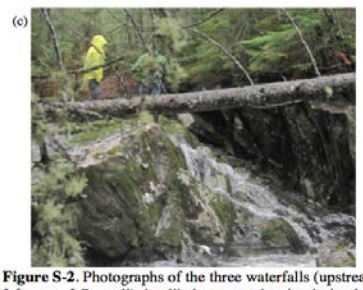


Figure S-2. Photographs of the three waterfalls (upstream to downstream a - 4.3 m; b - 3.0 m; c - 2.7 m tall) that likely act as a barrier during low flow for brook trout movement at the mouth of South Branch tributary to the Dead Diamond River (May 2012).
Source: Kelson (2012)

The Current Master Plan currently requires inventories and annual assessments of wildlife but new policies need to be implemented with collaboration of the New Hampshire Department of Environmental Services because waters are public and invasive species come from outside the Grant. The New Hampshire Department of Environmental Services goal is to achieve sustainability and "to institute anti-degradation measures" of watersheds in order to maintain balance given the multiple uses of the environment (NH Environmental Services 2008). Changes in land cover, especially timber harvest areas, are a "direct driver" of change in ecosystem services and greatly influence the watershed including change in siltation and temperature of the water (MA 2005). Forests mitigate soil erosion, flooding, and runoff while improving infiltration, the filtration of pollutants, and wildlife diversity (FWS Watershed Services 2007).

The Grant has defined parameters, but the regulating services cannot be adequately regulated within the socially constructed borders. The largest threat to sustainable management is the land outside the Grant, specifically the headwaters of the Androscoggin Watershed. The Northern Forest is central to the headwaters of New Hampshire and the Northeast's major rivers that society receives its water from. The land at the headwaters faces heavy harvests of timber that threaten the health of the ecosystem. Timber harvest at the headwaters in northern New England impairs the habitat quality downstream and has a "local effect" on brook trout (Nislow and Lowe 2006). The Connecticut Lakes Headwaters Forest case study demonstrates cooperation of stakeholders at the local, state, and federal level who have created a plan to sustainably steward the headwaters (Rideout et al. 2005).

The US Geological Survey created a science framework that watershed managers may learn from and incorporate useful tools to other watersheds. The Grant Master Plan states that there are no "Special Regulations" because water is public (Master Plan 2011). Article (f.), Water Resources instructs the protection of ecosystems near streams to have minimal impact from timber and road construction. Article (f.), a priority, is being respected within the Grant and this is why logging activity restricted to the winter season. However, as a public service running through private property it is crucial to have agreements and a communal and public management. A key recommendation for the forestry sector made by the Millennium Assessment encourages the strengthening of partnerships and forums of stakeholders at all organizational levels (Key MEA Findings 2005.) The Connecticut Watershed case study further supports this recommendation for watersheds in New England like the Androscoggin by encouraging a "share public vision" within a region dominated by private landowners like Dartmouth College (Rideout et al. 2006).

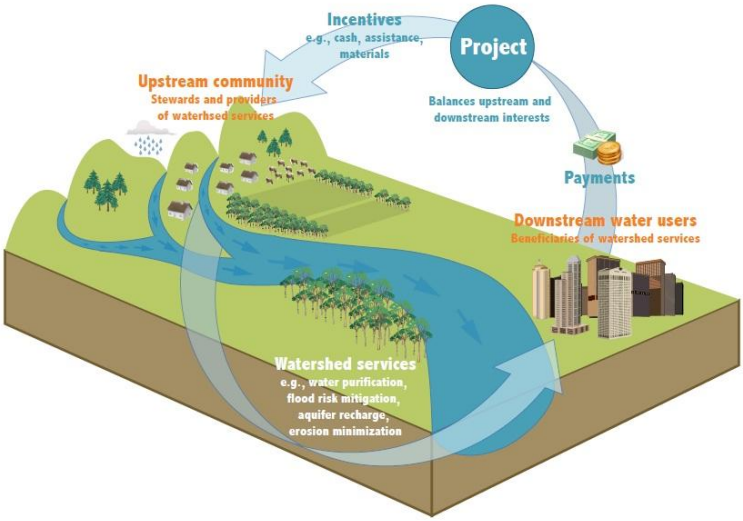


Figure 1: Regulating Services are Embedded in Watershed Services that heavily depend on Upstream Communities for their health. "Investment in Watershed Services Model" (WatershedConnect 2013).

Current approaches to improving the health of forests include the creation of partnerships, implementation of regulations, conservation easements, acquiring land, and tax incentives (Ecosystem Services 2011). Watershed payment for ecosystem services (PES) is a growing market but not yet established to "increase transparency" by clarifying responsibilities in the management of complex watersheds (MA 2005). At the local level the alternation of land cover may change temperature, precipitation, and flow of water (MA 2005). The Center for the Environment at Plymouth State University and the Wildlands and Woodlands organizations both have a vision of collaboration in New Hampshire (Center for the Environment 2013; Wildlands and Woodlands 2010). At the 2013 New Hampshire Water and Watershed Conference, the plenary speaker Linwood Pendleton discussed how New Hampshire natural capital depends on the watershed and ecosystem (Center for the Environment 2013). Regulating Services in the Northern Forest support the production of timber. Rather than focus on forest management based on timber harvest, it is important to manage based on these services (Northern States Research Cooperative 2013). Aligning with the New Hampshire Forest Resource Strategies private landowners should retain their regard to managing the forest in a way that "contributes to the well being" of the communities (New Hampshire Forest Resource Strategies 2010).

Dartmouth College, as a leading educational institution, should use the Grant to be a leader and break down barriers to steward the forest because it is vital to enhance the health of watershed services and maintain the water quality within the Androscoggin Watershed and greater ecosystem. The authors of this report urge

the College to create partnerships, collaborate with stakeholders, and develop plans that improve the management of the land around the Grant. To take initiative and be a role player in sustainable timber management demands the creation of conservation easements in and around the grant because easements are a current way to ensure the protection of regulating services. It is crucial to maintain land use policies that effectively protect regulating services. Water pollution, the risk of invasive species, and impact on wildlife, such as Brook Trout, should be accounted for when developing policies for plans of recreation, land use, and subsistence harvest.

D. Provisioning Services

Generally defined, provisioning services are the products obtained from ecosystems, such as fiber, fuel, and freshwater. These three specific provisioning services on the Grant currently require a broader spectrum to be effectively and sustainably managed and utilized. Each of these services has a past and present role on the Grant and current also particular sets of policies in place to manage them. However, these services also present several future opportunities for the Grant to be taken advantage of in years to come.

Fiber and fuel are two areas of consideration for expanding the Grant's provisioning services. Both of these services could weave closely into the Grant's current effective and lucrative management of timber and logging (Daily & Matson 2008). To start, the Grant has a long-

Photo: Contour Construction Corp

standing reputation as one of the finest timber management plans in all of the New England area such as our current sustainability and efficiency of logging (Grant Master Plan 2011). The Grant's current focus is on the sustainable growth of long rotation solid wood products in combination with sustainable cutting and harvesting patterns. In addition, a yearly inventory analysis is taken of the Grant that was created in 1998-99 in order to better monitor logging practices and allows the timber managers to streamline criteria and data to better maintain sustainable forestry practices.

While there are currently effective forestry practices and management policies for harvesting timber in place on the Grant, there is an overemphasis on logging production for producing high quality saw logs that neglects the important role timber can also play in further developing other fiber and fuel services. As of present, fibers that could come from the Grant's timbers include pulpwood, which can be used for paper, paper products, packing, and packing materials and timber fuels such as fuel, wood and charcoal. Although timber might not seem like a realistic fuel source given the current size of the Grant today, a possibility for further development, on a small scale, of this resource in the future exists (Sampson 2005). The past and present history of timber and logging on the Grant connects into our main recommendation of broaden the focus past the timber industry to begin sustainably improving other services such as fiber and fuel (Grant Master Plan 2011). However, in doing so it will be critical to monitor and analyze how expanding upon fiber and fuel services will affect other aspects of the Grant and subsequent recommendations.

Once this recommendation is in action, future opportunities can be explored. The Grant can then begin utilizing fiber and fuel services to help make the land prosper both environmentally and economically similar to how timber has. Future opportunities for fiber and fuel could include, but are not limited to, the following examples. Wood pulp processing improvements could be made, utilizing wood fiber on the Grant to supply a small portion of craft material for the Studio Art department, increase the buying and selling of fuelwood and charcoal for cooking and heating in due to its easy transport and marketing to blacksmiths and ceramic and brick makers. In addition, wood residues such as bark, sawdust, and wood trimmings can be used for fuel or to produce other fiber products and lastly wood-fueled power plants could be tapped into, which use wood and wood wastes to produce steam passed through a turbine to produce electricity (Sampson 2005).

Many of these opportunities and examples are viable and could be done in the near future, however, they will depend on budgets, sustainable feasibility, and continued growth and capacity of the Grant itself, though with the current conditions, this move remains feasible. Northwest Missouri State University, a leader in forestry and alternate fuel usage, has a wood chip fuel source program that makes use of scraps and wood waste in coordination with their 448-acre forest laboratory and campus wide goals of reducing their petroleum fuel dependence (Northwest Missouri State University 2012). In doing so, Northwest Missouri State has been meeting 80-85 percent of its campus energy needs and saving 12.5 million dollars without relying on petroleum-based fuels. This post-secondary institute, while on a larger scale than the Grant, is an example that can provide Grant

managers with some incentive to begin expanding their visions for tapping into all of the provisioning services in order to help both the environment and the college sustainability in the long run (Northwest Missouri State University 2012). However, due to the Grant's current smaller logging capacity and scale of the college it is not necessarily a definite option to pursue. What the Northwest Missouri State University provides this report with instead is a successful working example of sustainable management of a college's nearby land and natural resources.

Similarly, the provisioning service of freshwater on the Grant is directly affected by the timber industry and also the creation and development of roads. The past and present development of the timber industry and of surrounding roads has led to erosion and stream runoff, which is exacerbated during rainstorms. Although freshwater is currently considered clean and undisturbed by human impact, the College should focus on ensuring the current efforts.

Freshwater rivers on the Grant include the Dead Diamond, the Swift Diamond, and the Magalloway. Other freshwater sources include cold-water rivers, cool-water rivers, warm-water rivers, rock pools, iron seeps, wetlands, springs (Brungot and Dart Wentworth) and oxbows that support many invertebrate and vertebrate species, and are also important for many wildlife species (Grant Master Plan 2011). The Grant is part of a larger interconnected regional system therefore making freshwater protection of paramount importance as a provisioning service and it will require continuous management, monitoring,

Photo by: Eli Burakian '00

and sustainable policies in place to protect it.

Top recommendations for the improvement of freshwater on the Grant are as follows. First, in order to keep the freshwater quality high, closer attention to how the timber industry and its byproducts are managed needs to occur. Second, current policies and cutting practices are affecting the watershed quality and supply and the College needs to ensure that the timber and freshwater on the Grant are both aligned to achieve long-term sustainable development. Lastly, it is critical to maintain a high level of freshwater quality on the Grant to guarantee a healthy and functioning environment (Reid 2002).

Maintaining a healthy environment on the Grant is a top priority underlying provisioning service recommendations (Searle & Serita 2009). Freshwater, like fiber and fuel on the Grant, is a fundamental service for both effective ecological processes and land management. Failure to meet and protect this service could translate into serious long-term ecological damage. Therefore, maintaining freshwater quality will require constant policy, managerial, and community support from the directors, workers, and people who visit and use the Grant.

a. Hunting and Fishing:

Food exists as a provisioning service in the Grant with several different functions – food for human consumption, food for wildlife, and through these food chains, a means for nutrient cycling, storage and dispersal (de Groot et al 2002). The MEA defines food as a provisioning service to include the range of products "derived from plants, animals, and microbes" (MEA 2003: 57). The Grant has provided human food services primarily in the form of hunting and fishing

(Dartmouth College Woodlands 2011; F&W Subcommittee 2011). Visitors also have access to the Blueberry Management Area on Swift Diamond Road (Members of the Grant Management Committee 2006), but this area is not formally harvested or harvested for profit.

The Grant's Master Plan outlines a general goal and objective, "To have a comprehensive fish and wildlife management program that addresses the issues of habitat needs, health of populations, and effective hunting and fishing programs," and reveals a systems that directly affects the food products obtained from plant and animal populations (Members of the Grant Management Committee 2006: 12). Thus far the management team has done well to fulfill the aforementioned goal of wildlife management through their careful consideration of wildlife habitats and populations in conjunction with timber harvesting and other Grant activities. Since the 1940s, Grant management has completed grouse and deer surveys in conjunction with New Hampshire Fish and Game whose biologists also currently assist the College in riparian and deer yard management (Dartmouth College Woodlands 2011). Hunting and fishing remain open to members of the Dartmouth community as well as the general public with a NH hunting and fishing license and in accordance with the laws of NH Fish and Game, with whom the College has always had a working relationship (F&W Subcommittee 2011: 2; Dartmouth College Woodlands 2011). Given the popularity of hunting with alumni and locals, the Grant sees roughly 400-500 hunters per season, as estimated by College Forester Kevin Evans (Evans E 2013). In a longstanding tradition, the entire Grant is kept open to hunting and fishing with the exception of areas temporarily closed for wood

harvesting operations, special management or research projects, or for safety reasons (F&W Subcommittee 2011: 1). Small game include grouse, woodcock, snowshoe hare, and turkey, while big game include deer, bear, and moose (F&W Subcommittee 2011).

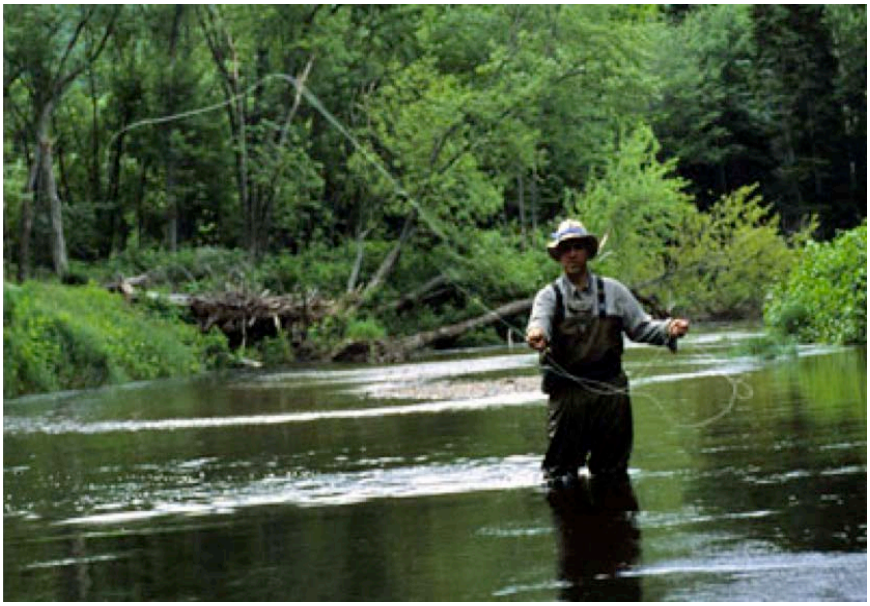


Photo by Joseph Mehling '69

Fishing is available on the Swift Diamond and Dead Diamond Rivers as well as other small streams and ponds located in the Grant. Fish species include landlocked salmon sometimes found in the Dead Diamond, River Rainbow trout occasionally found in the Swift Diamond, as well as yellow perch, bass, pickerel, pike, crappie, sunfish, carp or goldfish (F&W Subcommittee 2011). In order to ensure the vigor of fish stock in the Grant, fishermen are encouraged to follow catch and release practices for all trout and salmon and a voluntary two fish per person per day, among other recommendations (F&W Subcommittee 2011: 5). However, as discussed in the *Master Plan of the Second College Grant*, "Special Regulations for fishing in the Grant should not be imposed because the waters are 'public,'" and regulations passing through a public hearing process would draw more attention to the fishery's unique status and could further endanger fish populations (Members of the Grant

Management Committee 2006: 38; Evans E 2013). Officially sectioning off portions of the rivers as "catch and release only" leads to the marking of these locations on maps of the landscape, which in turn often indicates an area of special interest to fishermen (Evans E 2013). To avoid drawing excess attention while still encouraging healthy practices, bulletins posting recommendations for sustainable fishing and hunting should be maintained and installed in appropriate places to better educate visitors on management practices (Members of the Grant Management Committee 2006: 38).

While open to the general public on foot, the Grant's hunting and fishing grounds see predominant use by Dartmouth alumni who have easier access to the grounds by vehicle (F&W Subcommittee 2011: 2). In this sense the Grant is less a resource for subsistence hunting and fishing of locals, and more available as grounds for sport. While game populations may be able to handle increased hunting and fishing, greatly increasing access to these populations would require more intense management and tracking of game exiting the Grant. The current management and regulations do an excellent job at maintaining population levels but do rely on the good will of visitors to abide by recommendations for catch and release of certain species and limits on species removal, among others (F&W Subcommittee 2011). Increasing access to these resources, say by allowing non-Dartmouth vehicle access, would potentially open up the Grant to mismanagement if the College's ability enforce its hunting and wildlife recommendations does not increase as well. However, some locals take issue with the limited vehicle access and its impacts on hunting accessibility. The *Local Community Connections* section below

further discusses this point of contention, which must be considered carefully for its impacts on wildlife populations but the College should explore room for expanding hunting and fishing accessibility to the local community to a certain extent.

Willingness to pay and the economic value of hunting and fishing activities serve as an interesting element in the debate over hunting, fishing and harvesting access. In New Hampshire in 2011, hunting and fishing activities by residents and non-residents averages at 19 days per angler with an average trip expenditure of $35 per day, and 24 days per hunter with an average of $25 trip expenditure per day (U.S. Fish & Wildlife Service 2011: 4). Given a rough estimate of 450 hunters and fisher in the grant per season (most game seasons run in some range from September-December) (Evans E 2013; New Hampshire Fish and Game 2013) this equates to roughly a $299,250 value for fishing and $270,000 value for hunting per season in the Grant.

Further a 2011 study on the social capital and value of hunting club memberships in the Champion Lands in New York State's Adirondack Park sheds light on the value of hunting club memberships (Green 2004). Beyond hunting related expenses, the authors estimate members' willingness to pay for a hunting club membership at over $1,290 (Green 2004). Given the nature of the Grant's structure as a resource primarily for Dartmouth College alumni with cabins and other amenities, in some respects the Grant takes on elements of a hunting club. Given the Grant's current hunting use of roughly 400-500 hunters per season, this value of private hunting grounds for Dartmouth alumni equates to about a $580,500 value per season.

b. Plant Crops:

Aside from providing game and plant products for wildlife sustenance, the Grant provides plant products for human consumption with its approximately 18-acre Blueberry Management Area on Swift Diamond Road (Members of the Grant Management Committee 2006; Evans E 2013). Visitors currently harvest blueberries in season, however Kevin Evans notes that the majority of the berries serve as a food source for wildlife (Evans E 2013). While serving as a food source for both humans and animals, blueberries and other berries, nuts, fiddlehead ferns, wild leeks, and fungi among other wild crops of the region could be expanded and harvested more frequently by humans. Several species growing in the Grant have special value, such as anti-inflamatory chaga mushrooms (Yoon et al 2013) and the spring delicacy of fiddlehead ferns (McGrory-Klyza 2012), and could provide an extra revenue source for the Grant or local harvesters (Evans E 2013). If the Grant were to gain an intern, another student work crew, or increase access to locals for food provisioning the wild, edible crops available in the Grant could be more thoroughly utilized by more constant harvesting and monitoring.

Source: www.thekitchn.com/seasonal-spotlight-fiddlehead-47357

Better signage and communication would further allow visitors and locals to access, harvest, and benefit from the blueberries and other wild crops on the Grant. Locals in NH and VT often harvest seasonal species such as blueberries, fiddleheads

(young ferns), ramps (wild leeks), and mushrooms for extra profit and consumption (McGrory-Klyza 2012). Dartmouth should consider allowing greater access to local, non-Dartmouth people in this context either through better information pamphlets and bulletins at the entrance to the Grant or a more formalized campaign. However, as currently in place for hunting and fishing, regulations and recommendations must be developed in order to avoid perils of overharvesting these plant species (McGrory-Klyza 2012).

More involved harvesting expansion could include the use of Grant crops as specialty items in Dartmouth dining facilities, however, careful consideration of the balance of wildlife food sources with human consumption must be considered. Implementing a sustainability plan on campus, Dartmouth Dining Services (DDS) currently sources roughly 4% of its food locally and aims to expand sustainable purchasing (Dartmouth Dining 2012). DDS cites buying seasonal and local produce and fruits as one method for implementation (Dartmouth Dining 2012). Given the popularity of blueberries and fruit smoothies with students, berries from the Grant could serve as a specialty item in Dartmouth dining facilities. Collis already serves small amounts of produce raised on the Dartmouth Organic Farm when available and could incorporate Grant produce into their offerings for specialty items and supplementation. Berries could be sent down to campus during summer months for fresh fruit and surplus berries could be frozen and used in smoothies at

Photo: http://www.ablueberryinn.com

Collis off-season. If the Grant procured a summer intern, picking and packaging berries could be a weekly chore and built into their stipend. The main cost of this operation would be incurred in shipping the berries to Hanover, as Dartmouth Dining Services already owns and operates freezers, refrigerators, and other required food service equipment.

Recommendations for the Grant's food provisioning services include the maintenance of current wildlife management practices, population monitoring, and the enforcement of hunting and fishing regulations. Specifically, maintain the reporting structure of game kills exiting the Grant in order to understand population levels and encourage catch and release, tagging, and the removal of invasive fish species. Further, food products from plant species are underutilized. Increase access and harvesting of the blueberry patch and plant more berry patches, fungi, and nut species that can survive in the region's climate. Better signage, bulletins, and a more welcoming entrance with information packets would better encourage and educate visitors on the Grant's food resources, management of invasive species spread by human activities, and hunting and fishing guidelines and protocol. Management committees should also incorporate the value of hunting and fishing to Dartmouth's alumni base and NH residents and visitors into future management practices and decisions.

c. Genetic Resources:

According to the MEA, genetic resources include the "genes and genetic information used for animal and plant breeding and biotechnology" (MEA 2003: 57). Genetic resources serve as a very important provisioning service for the Grant and

the larger population in that they maintain diversity and increase the potential value of the Grant. A rare species may one day provide functions and services needed for a new technology and holds a lot of inherent value in its existence. A loss in genetic diversity "reduces overall fitness and adaptive potential, and it limits the prospects for recovery of species whose populations are reduced to low levels" (MEA 2005: 4-5). As biodiversity and genetic diversity decline globally "the marginal value of biodiversity increases" meaning the maintenance of the Grant's biodiversity and in particular their genetic diversity will accrue a greater value if global development remains largely unsustainable (MEA 2005: 4-6). Currently de Groot et al values genetic resources in the range of $2.5-47 per acre per year (de Groot et al 2002: 406) . Given the Grants 27,000 acres, this valuation amounts to $67,5000-1,269,000 per year for the Grant's genetic resources.

Notable genetic resources in the Grant include: the native brook trout, the endangered pine marten and Peregrine falcons (Members of the Grant Management Committee 2006: 57; Dartmouth College Woodlands 2011), the bald and golden eagle (ENVS 50 1992); the rare spring salamander, Gyrinophilus porphyriticus (Ayres 2013), lance-leaved draba, Robinson's hawkweed and cranesbills (ENVS 50 1992), and twayblade – and endangered orchid found in Hell Gate (ENVS 50 1992; Dartmouth College Woodlands 2011). The Grant's brook trout remain a unique genetic resource, as they are some of the last remaining

Salvelinus Fontinalis (brook trout). Source: http://fish.dnr.cornell.edu

populations in New Hampshire and the northeast (F&W Subcommittee 2011; Kelson 2012). Rare plants include the Broad-lipped twayblade, millet-grass, and marsh horsetail relict which are "examples of relict calcicoles that remain today in the Second College Grant" (Dartmouth College Woodlands 2011). Further, according to *Some natural history highlights from Second College Grant*, the Grant contains "uncommon or absent species from the southern 2/3 of the state" and hosts a recorded 150 bird species and several dozen mammal species, and an estimated several hundred species of aquatic insects including of mayflies, stoneflies, caddisflies, beetles and true flies (Ayres 2013).

While the Grant does a good job maintaining its resources from within, unsustainable management practices in lands surrounding the Grant threaten the continued existence of species within the Grant. The lower the perimeter area, the higher the exposure of resources to unsustainably managed lands and increased pressure (MEA 2005). As habitat around the Grant degrades, more and more animals may seek refuge in the Grant, throwing off the natural population balance, and pollution may trickle down into the Grant and degrade the Grant's own wildlife, their habitat, and crop species. The creation of protected areas with increased corridors and perimeters will provide an added value for the College, especially as climate change and future development intensify species stress (MEA 2005, 10). The purchase of surrounding land would ensure greater longevity and sustainable management of these species.

The Grant forester, Kevin Evans, alongside standing regulations and policies, provides management of wildlife habitat and monitoring of non-native invasive

species to the extent feasible by any management system (Evans E 2013). Visitors to the Grant are asked to monitor for non-native invasive species such as Didymo and Eurasian Milfoil that can take over habitat and resources for local populations, yet this monitoring and compliance is difficult to achieve and even the best methods do not ensure safety from species entering the landscape (F&W Subcommittee 2011; Evans E 2013). Fishing regulations also require the killing and removal of eight non-native invasive species when found in the river: yellow perch, bass, pickerel, pike, crappie, sunfish, carp or goldfish (F&W Subcommittee 2011). Policies such as these help ensure the survival of the Grants precious endangered and rare species such as the native brook trout, which has significant genetic resources that must be maintained. The expansion of human activity in the Grant must also be carefully considered as many of the non-native and invasive species spread through human activity such as hunting, fishing, canoeing, kayaking, other water contact (F&W Subcommittee 2011: 4)

Figure Didymo "rock snot" Source: http://www.des.state.nh.us/

Current and past research projects have also proved beneficial for gaining a deeper understanding of the Grant's genetic resources. Suzanne Kelson's thesis on brook trout (Salvelinus fontinalis) has most recently centered on research in the Grant and has provided important data on the native brook trout population (Kelson 2012). Maintaining research projects and policies that protect endangered, rare, and

native species is highly recommended. Further, increased research opportunities on species in the Grant, in particular endangered, rare, and native species would give the College a better sense of the Grant's potential value through these unique species and would guide further management practices for their protection. As mentioned above, better signage discussing the implications of invasive species and how to eliminate and deal with them would also benefit visitors and wildlife alike.

E. Cultural Services

Cultural services are ecosystem services defined as "the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (MA, 2005). Cultural services focus on the intersection of nature and culture, drawing attention to certain benefits increasing human well-being. These services are further broken down into subcategories grouping the different types of nonmaterial benefits that can be obtained by people from the ecosystem. The Millennium Ecosystem Assessment (2005) groups these services into the following types: cultural diversity, spiritual and religious values, knowledge systems, educational values, aesthetic values, social relations, sense of place, cultural heritage values, and recreation and ecotourism. These subcategories represent a variety of different ways humans interact with the environment, categorizing these interactions into specific benefits provided by ecosystems influencing the cultural and societal development of a given region. The classification of cultural services as ecosystem services within the Millennium Ecosystem Assessment framework importantly highlights the different ways in which human interactions with ecosystems benefit society.

Recent studies have examined the value of cultural benefits that ecosystems provide to increase human well-being, and have grappled with the issue of quantifying these values in a way that allows for land management plans to incorporate cultural services and negotiate important tradeoffs (Hernández-Morcillo, Plieninger, and Bieling 2013; Daniel et al., 2012). Results from studies indicate that human uses of cultural services are increasing with population growth and increased consumption (MA, 2005; Carpenter et al., 2009). Thus, anthropogenic activities increasingly are relying on goods and products obtained from ecosystems (Guo, Zhang, and Li, 2010). In addition, ecosystem services are an important factor in economic development, as demand for inputs such as water, food, and fiber increase with development, and pressure to assimilate waste increases (Guo, Zhangm and Li, 2010). These activities place more pressure on ecosystems, resulting in the degradation of services in the environment. Dijks, Oteros-Rozas, and Bieling (2013) importantly note that while other classifications of ecosystem services, such as regulating and provisioning services, may be substituted as development progresses, cultural values of an ecosystem are irreplaceable. Furthermore, the research conducted by Guo, Zhang, and Li (2010) stresses that societies become more dependent on cultural services as development progresses. Therefore, proper valuation of cultural services is important in order to incorporate them effectively into land management policies.

The classification of cultural services in the past has made them difficult to assess using traditional valuation methods applied to other types of ecosystem services (Plieninger, 2012). As a result, the difficulty in quantifying benefits often

categorized as "intangible" or "subjective" often has pushed cultural services out of management plans aiming to conserve ecosystem services within a specific area. However, the Millennium Ecosystem Assessment's framework emphasizes the importance of social values, necessitating further research into innovative valuation methods that will encompass social constructs in environmental management implementation (Daniel et al. 2012; Bryan et al., 2010). Daniel et al. (2012) applies existing social science models to demonstrate how cultural services provide vital benefits to society in a tangible, quantifiable method. Results from cultural service valuation studies reflect the significance of human interaction with ecosystems, and can reveal certain environments of cultural importance where ecosystem service tradeoffs must be made in designing conservation policies.

Incorporating the social values provided by cultural services into environmental management and planning is a key component to land management policies. Since cultural services are ecosystem services focusing specifically on the importance of community-nature interactions in a given environmental scale, they highlight the different ways and varying degrees in which humans interact with spaces. Designing land policies incorporating social values can "enhance social learning (Blackstock et al., 2007), increase the likelihood that environmental investment decisions are perceived as holistic and fair (Reed et al. 2008), and increase the quality and durability of decisions (e.g. Fischer, 2000; Plummer and Armitage, 2007)" (studies cited in Bryan et al., 2010). Thus, effective management of ecosystems must incorporate local community values in order to achieve lasting policy changes.

Currently, the Grant provides a number of cultural services to members of the Dartmouth community. First, it is an important resource for education for a variety of departments including, but not limited to, Environmental Studies, Biology, and Earth Sciences. Several courses include educational field trips to the Grant as a component of the curriculum. Additionally, students may utilize the Grant for research for independent studies and thesis projects. In addition to undergraduate use, professors and graduate students at Dartmouth College access the Grant for valuable data gathering for research projects.

The Grant also serves as an important source of recreation for the Dartmouth community. The College has a number of cabins made available to students and alumni that can be reserved ahead of time online. Besides camping and overnight stays, different types of activities in the Grant include hiking, biking, hunting, fishing, and cross country skiing, among other forms of outdoor recreation. The popularity of the Grant for recreation is reflected in the limited availability for cabin reservations, which fluctuates according to the season and academic term calendar of the College. As a result, some weekends the Grant cabins are completely booked, while many periods of time the cabins remain unused and unoccupied.

Finally, a number of the cultural services provided by the Grant reflect some of the more abstract subcategories discussed in the Millennium Ecosystem Assessment. The landscape and natural beauty of the Grant may serve as inspiration for art, photography, and nature writing. There is the potential to incorporate this service into educational opportunities by expanding the Grant to be utilized by more departments and academic fields like Studio Art and English.

Similarly, the landscape has an intrinsic aesthetic value that attracts visitors who seek out the beauty of the area as a place to spend leisure time. Also, student groups or alumni groups on campus can utilize the cabins located in the Grant, which has the potential to foster social relations as an ecosystem service if community structures are implemented to make the environment more user-friendly.

4. Community Interactions

A. Dartmouth Community

The Grant is an integral part of Dartmouth College. However, there have been low levels of student involvement in the past. Grant Management believes there is a large discrepancy between current levels of student use and the immense opportunity the Grant has to offer, specifically with respect to research. A detailed description of current undergraduate uses and a campus-wide survey analyzing student's perceptions were used in order to determine what barriers stand between Dartmouth Students and the Grant.

a. Current Use- Academics and Research:

The Grant provides a vast array of research and educational opportunities with its pristine streams and wildlife and rich history of forest management. The Grant has been used for many different research opportunities up until this point, including studies on local plant and animal species, soil, and the effects of climate change. A major ongoing project involved tagging brook trout populations and tracking their migratory patterns. This experiment involved electrofishing and surgically implanting a tracking device. Results showed that the brook trout traveled all throughout the Dead Diamond and Swift Diamond Rivers and the

surrounding watershed within short amounts of time. Suzanne Kelson, D '12, conducted her senior honors thesis on the Grant, "*Conservation Management for Brook Trout (Salvelinus fontinalis) in the Second College Grant: Analysis of the Genetic Structure of a Metapopulation*." Kelson collected scale samples from various populations of brook trout and concluded that there was much genetic diversity among brook trout populations (Kelson, 2012). Beginning in 1998, with the help of the U.S. Fish and Wildlife Service, Dartmouth researchers captured woodcock and fitted them with transmitters to identify which habitat areas woodcock were using within the Grant (http://www.timberdoodle.org/demo/second-college-grant-dartmouth-college-coos-county-new-hampshire). Additional research projects conducted on the Second College Grant can be found in the appendix.

The Grant has also been used as an important classroom tool for classes such as Bio 31: Physiological Ecology, in which students explore the diverse plant and animal life at the Grant and become acquainted with the tools and methodologies of field ecology. ENVS 50 and engineering classes have also utilized the Grant in projects, including the construction of a suspension bridge over the Dead Diamond River (Nelson, 2013).

The current infrastructure on the Grant includes three cabins available for rent by DOC (Dartmouth Outing Club) members, seven cabins available for rent to college staff and alumni, maintained by the OPO (Outdoor Programs Office), and the newly constructed town office. The town office was constructed to support research and educational goals and currently serves as the host facility for students participating in long-term research at the Grant. The town office has access to a

generator for electricity but does not currently have any phone or internet access. There are currently no formal laboratory facilities at the Grant.

There is an opportunity to increase research opportunities as well as other academic involvement with the Grant. Current research on the Grant is primarily restricted to fieldwork but the addition of laboratory facilities would allow other scientific fields to conduct research on location. Internet access would make the Grant appear more accessible to students who are unsure about spending three months in northern New Hampshire, as cited by Athena Aicher, D '11, whom acknowledged the issue of isolation while staying at the Grant (Aicher, 2013). Internet access would also increase the breadth of research opportunities available at Dartmouth. Data could be collected and processed in real time and the maintenance of long-term sites would be much more manageable. A review of peer institutions in the Northeast found that other Colleges and Universities with managed forest properties offered established research opportunities, internships, and fellowships related to the forest property (Harvard Forest, U. Maine PEF). Similarly, the Northeast Forestry Certification Standards suggest that Forests managed by a non-profit or academic entity include a component for "research and associated scientific study" at the Forest site (Northeast Forestry Standards 2007, 25).

b. Current Use- Recreation:

Most student group recreational activity at the Grant takes place through trips organized by the DOC or the OPO. Some of the most publicized trips to the Grant include First Year Trips, Ledyard paddling trips, Bait and Bullet fishing and

hunting trips and clinics, Cabin & Trail hiking and cabin-camping trips, PE classes, Grant Winter Weekend, Mountain Biking Club trips, Summer Crew, and an annual cross-country team fall training trip. Summer crew work involves trail work, firewood production, and cabin maintenance among other activities. In the past, students have helped in other facets of the Grant involving wildlife work, fish tagging, stream surveys, and woodcock tagging. Individual students and groups of friends, whether involved in a DOC group or not, regularly use DOC cabins in the Grant. While the research focused almost exclusively on undergraduate students, it should be noted that graduate student use has increased during the last few years, as well. The Grant Committee has communicated to us that students' input can help gauge their interests and tailor future use.

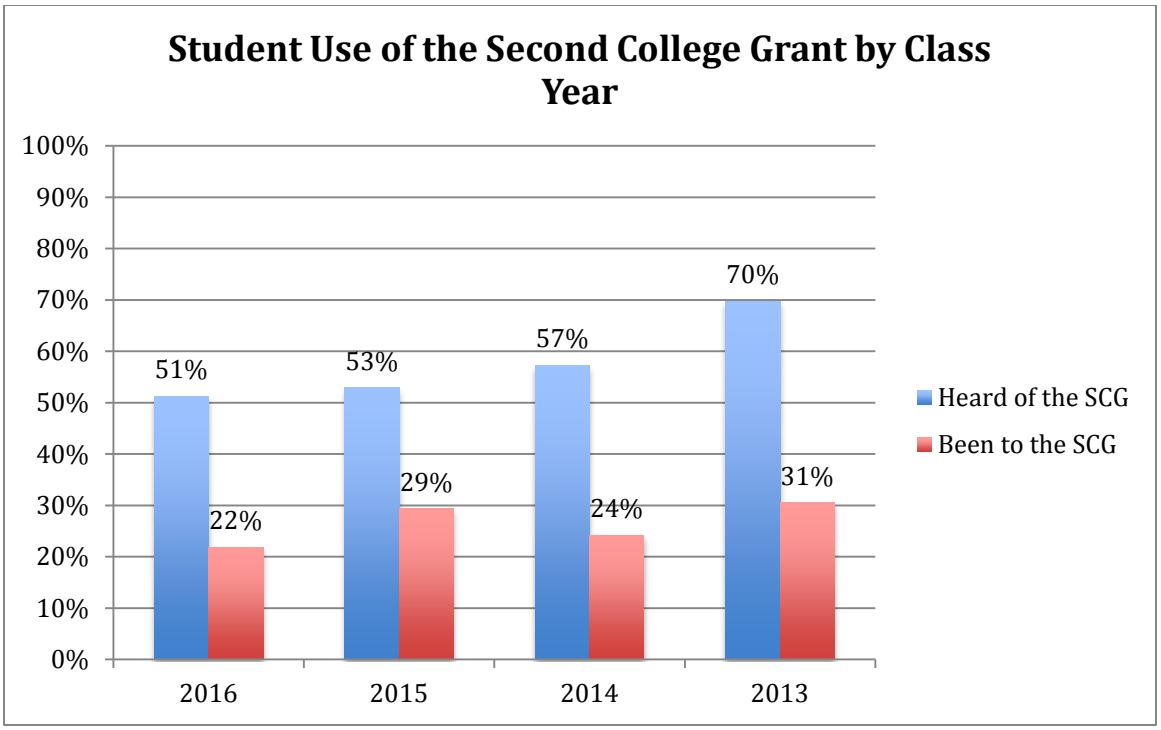
The three main areas for student involvement are First Year Trips, Winter Weekend, and Club Trips. First Year Trips are often Dartmouth students' first exposure to the Grant. In recent years, students on these trips have participated in a variety of outdoor activities, including kayaking, canoeing, mountain biking, trail work, photography, and nature writing, which receives curriculum guidance from Dartmouth Professor Terry Osborne. A first-year fishing trip also includes an educational component through a presentation regarding fisheries research.

Separate from First Year Trips, the Cabin and Trail, Bait and Bullet, and Ledyard trips are popular among students. For any student trips, the DOC can orchestrate transportation through the "Get Out!" program, which helps other student organizations organize and plan outdoor trips.

Both alumni and current students take advantage of volunteer opportunities at the Grant during work weekends, which happen twice each term. During these weekends, volunteers stay for free in cabins and work through a list of chores (often including a small wine and cheese reception). The resurgence of alumni interest has been notable for the Grant Management and Advisory Committees. Alumni work under the Director of Outdoor Programs to teach workshops to current students, including fly-fishing and hunting. A strong alumni presence is also felt throughout First Year Trips, during which 50th reunion classes rent cabins at the Grant and welcome incoming freshmen.

c. Perception:

A survey was sent campus-wide to analyze the relationship between Dartmouth Student's and the Grant. The survey recorded 806 responses, which were split nearly evenly between current enrolled class years (2013-2016). A list of the questions asked in the survey can be seen in the Appendix. Preliminary questions asked students what class year they are, if they have ever heard of the Grant and lastly if they had ever been to the Grant. The results from these questions can be seen in Figure 1 shown below.

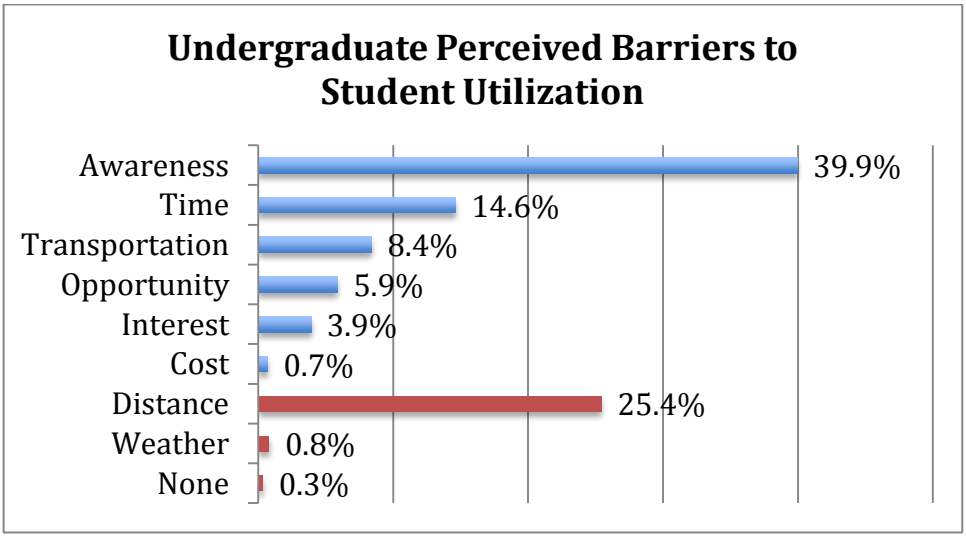


It is important to note that this survey was done at the beginning of the Spring 2013 term, and therefore 2016s have spent two full terms at Dartmouth. Only 51% of 2016s said they had heard of the Grant, while 70% of 2013s had. Interestingly, this number did not steadily climb, but jumped between the junior and senior classes. Although there was a climb from first years to seniors, the Grant's fundamental importance to Dartmouth should predict a percent reaching 100% by senior spring. Instead 3 out of 10 seniors said they had never heard of the Grant.

The more striking finding from this graph is shown with the results for the question "have you ever been to the Grant" which are seen in red. While awareness of the Grant rose 20% from first year to senior year, travel to the Grant does not increase at all. This response means that either use of the Grant has been increasing

in the freshmen classes over the last four years or every Dartmouth undergraduate who has been to the Grant went for their first time during their freshman fall or winter. Most likely it is a mix of both, but students who use the Grant often enter Dartmouth with an interest in the outdoors and therefore use the Grant early in their Dartmouth careers. This finding is extremely important with respect to the goal of increasing student involvement.

A final question asked students what barrier keeps them from utilizing the Grant. This question will be further referred to as Question 10. The answers to Question 10 were recorded in an empty text box and example answers were not provided. The purpose of this was to allow the responders to have an unbiased response as well as avoid confining students into predetermined categories. The responses were then individually tallied and all 806 fit within nine categories as seen in Figure 2. The blue bars in the graph represent the barriers that can be fixed within the scope of this class. From this list, the four most pressing barriers stood out as Awareness, Time, Opportunity, and Interest.



The barrier awareness is defined as students who do not know what the Grant is, where it is, or why they should get involved. In the survey over 40% of responders said one or more of these things in Question 10.

Dartmouth student's feel as though they do not have any time. Academics monopolize most of their time and the little free time they have is spent on other opportunities on campus. In the survey ~15% of responders said they did not have time to engage in opportunities at the Grant.

Although similar to awareness, the barrier of opportunity is differentiated as those students that do know the what/where/why of the Grant but don't know of any opportunity to get involved. In the survey ~6% of the responders noted they would be involved if they knew how.

The barrier interest is defined as students who feel as though there are no opportunities that they would like to get involved in at the Grant. In the survey ~4% of students said that the current uses of the Grant do not interest them.

Identifying and analyzing the previously mentioned barriers led to the construction of three goals. For increasing quantity and quality of Dartmouth use of the Grant three recommendations were developed. The first recommendation is to revamp the Grant's website and relocate it to Dartmouth.edu, the second is to improve research infrastructure, and the third is to tailor Grant experiences to student needs.

Recall that the dominant finding from Figure 1 is that those who experience the Grant do so early in their Dartmouth career. The dominant finding from Figure 2

is that over 40% of the 806 student responses said they are unaware of the Grant. Linking these two finding together lead to the decision of revamping the website.

The current website is on the DOC website and it is out of date. While there is no intention of breaking the link between the DOC and the Grant, the website must be moved to the main college homepage, Dartmouth.edu. The opportunities the Grant have to offer are vast and extend the reach of the DOC. The Dartmouth homepage reaches a much broader student population as student's daily access it.

The Grant website should be relocated to the "About" tab on Dartmouth.edu. The current Grant website on the DOC has subsections for general information, points of interest, activities, history, management, and directions. A revamped website would also have all of these tabs with similar information as currently provided, but would also include tabs for internship opportunities, research opportunities, news, and contact information. By increasing the breadth and ease of information on the site, awareness will increase dramatically. The use of the Grant will not increase in quantity, but quality, which aligns with the goals of the Management committee.

According to student survey data, approximately 15% of subjects responded to the question "What prevents you from utilizing the Second College Grant?" with lack of time and approximately 4% responded with lack of interest. One way to address the barriers of time and interest is to increase the educational and research opportunities available at the grant, which would be achievable through the improvement of current research infrastructure. Dartmouth students are often overwhelmed with their schedules and incorporating the Grant into academics will

be both beneficial to the students and the college. Dartmouth College is one of the leading research institutions in the nation and yet the Grant, with vast educational and research opportunities, has been limited to primarily a source of income. The research capacity of the Grant can be enhanced. Improvements to the current infrastructure would encourage sustained research as well as create opportunities for different fields of study such as environmental chemistry and biology. In addition to highlighting current research opportunities on the grant, highlighting advanced research facilities would allow students to create their own research projects that they might not otherwise have been able to pursue with the current infrastructure. As an academic institution, Dartmouth College should maximize its research potential. The Master Plan for the Second College Grant (2006) states that the Grant should supply a "setting conducive to education and research." (11) The following are two recommendations to improve the academic capacity of the Grant.

A common barrier to sustained research at the Grant is attracting students to spend an entire term on the Grant, which can be isolated with tedious communication at best with the outside world. By increasing the profile of the Grant, the issue of isolation can be solved if one to two more students pursue long-term research each term (Ayres, 2013). It was commonly noted in discussions with both students and professors that the lack of phone and internet access is not only a safety concern, but also an impeding factor to long-term research at the Grant. Both professors and students need to keep in touch with their advisors, assistants, and families while residing at the Grant for extended lengths of time. Phone and Internet access would attract students who might otherwise balk at the idea of spending

three months in isolation (Aicher, 2013). In conversations with both Professor Matt Ayres, who brings his class Bio 31 to the Grant each year, and Professor Nicholas Reo, lack of phone and internet service was cited as the biggest impediment to long-term research (Ayres, Reo, 2013). In the case of an emergency, phone access could be crucial.

Internet service would also be beneficial to data collection and research. The Harvard Forest utilizes field wireless Internet access that enables equipment control and monitoring at long-term sites as well as real-time data collection and processing (Harvard Forest). These capabilities would make the Grant a prime destination for ecological research. For educational purposes, a class would be able to visit the Grant at the beginning of a term a put up data loggers that they could then monitor for the remainder of the term (Ellin, 2013). Funding was available to the Harvard Forest from the National Science Foundation and Harvard University for the implementation of technological infrastructure at their forest research cites (Harvard Forest).

Along with improvements made to the Grant website that would highlight past and ongoing research, improvements to the current infrastructure could expand research opportunities that would draw both Dartmouth and non-Dartmouth affiliated professors and students to the Grant. Although the current infrastructure has not compromised the existing research, the addition of laboratory facilities would enable expanded uses of the Grant in the fields of environment chemistry, biology, ecology, and environmental science.

The Harvest Forest is a LTER (Long-Term Environmental Research) site and has various research facilities and can be used as inspiration for potential improvements made to the Grant. The Harvard forest currently boasts greenhouses and experimental gardens, which support controlled research in biology and ecology. Their facilities also include six laboratories, ranging from soil labs to paleoecology labs. Although there are economic and environmental burdens of constructing a new facility on the Grant, the renovation of current infrastructure to include laboratories would sufficiently improve the current research and educational capabilities of the Grant. According to Dean Wilcox, Professor of CHEM 63: Environmental Chemistry, the lab portion of the course is dependent on student-initiated projects. If an environmental chemistry lab that supported research and teaching existed at the Grant it would encourage student projects using samples from the Grant and mitigate logistical concerns (Wilcox, 2013).

The implementation of improved infrastructure at the Grant would not be an easy process. According to Edythe Ellin, Director of Administration at the Harvard Forest, once electricity is implemented acquiring wireless access is attainable. However, the cost of connecting an area of the Grant with electricity would be pricey. In the Harvard Forest, 1.5 miles of electricity with a transformer or pad every 600 ft. for secondary electricity cost approximately $500,000 (Ellin, 2013). The addition of chemical substances to any laboratory facilities would require hazardous waste pickup (Ellin, 2013). A practical first step would be to construct a field station or wetlab with running water, bench space, and a fridge and freezer for samples. With basic electricity, researchers could bring microscopes or other equipment with them

to conduct their lab work (Ellin, 2013). The National Science Foundation has a funding program called "*Improvements in Facilities, Communications, and Equipment at Biological Field Stations and Marine Laboratories (FSML)"* with the following synopsis:

> Biological Field Stations and Marine Laboratories (FSMLs) are off-campus facilities for research and education conducted in the natural habitats of terrestrial, freshwater, and marine ecosystems. FSMLs support environmental and basic biological research and education by preserving access to study areas and organisms, by providing facilities and equipment in close proximity to those study areas, and by fostering an atmosphere of mutual scientific interest and collaboration in research and education. To fulfill these roles, FSMLs must offer modern research and educational facilities, equipment, communications and data management systems for a broad array of users. In recognition of the importance of FSMLs in modern biology, NSF invites proposals that address these general goals of FSML improvement.(http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5449)

Proposals for this program are due by the second Friday of December annually and would be a beneficial resource to the college. According to estimates based on the U.S. National Average costs from 2013 RSMeans cost data, the construction of a college laboratory assuming decorative concrete block/ bearing walls costs approximately $200 per square foot (Reed Construction). A lab facility similar to the one proposed at the Harvard Forest is approximately 200 m^2 or about 2,150 ft^2. Depending on construction policies and decisions, this project may accrue a cost of approximately $450,000.

A practical first step in implementing better communication and data systems would be to construct a rohn tower. The construction of a rohn tower, which is a small cell tower with a base of 1x1 ft., can be run on a battery and would enable radio communication. Additionally, a satellite dish positioned on the tower would provide delayed data to in the immediate surrounding area (Ellin, 2013). The

satellite would also enable a phenology camera that could track climate change. The construction of a rohn tower costs approximately $10,000-$12,000 (Ellin, 2013). This would be a good start until field wireless could be implemented.

Improvements to the research infrastructure at the Grant would attract further exploration of the rich scientific knowledge the Grant has to offer. The addition of phone or internet service as well as laboratory facilities would support the vision and statement of purpose as outlined in the *Master Plan for the Second College Grant*, which declares the Grant to be "important to Dartmouth for educational, research, recreational, wood production and financial purposes." (11).

The Grant is a unique setting for many student opportunities, and its management should strongly consider students' experiences and needs. Along with the Dartmouth Outing Club (DOC) and Outdoor Programming Office (OPO), striking a balance between spreading knowledge of the Grant's accessibility among students without increasing the overall influx of visitors is necessary to preserve the tranquility and allure. Another option is expansion of existing trips, especially Winter Weekend, and student work opportunities by working with the student members of the Grant Advisory and Management Committees and the "Get Out!" program.

A subgroup within the DOC, the "Get Out!" program is currently accessible to students only through an outdated website. As it is the goal of the organization to expose Dartmouth students to the outdoors by raising awareness of trip opportunities, the "Get Out!" program should be more formally reinstated. A more

up-to-date website connected to the Dartmouth.edu domain would likely be more effective marketing channel.

Two of the major impediments to student use are lack of time and transportation. The addition of trips during Dartmouth's academic breaks may help students overcome some of the time and travel constraints they experience during academic terms. Dartmouth's six-break stretching from Thanksgiving to early January provides ample time for students to travel to the Grant without the in-term commitments and activities that students claim limit their abilities to access the Grant.

Empowering students to decide their best use of the Grant allows them to more closely align their interests with those of the Grant's committees. Appointed by the President of the DOC, two students currently sit on the Grant Advisory and Management Committees. These students offer unique perspectives by serving as representatives of the student body's interests. Student DOC representative and faculty on the Grant committees should be responsible for outreach to their respective peers. For example, it should be the duty of these two students to carry out the implementation of strategies marketing the Grant to students.

Certain traditions are already experiencing substantial student support. The Grant's management is very effective at continuing to attract students to its annual Winter Weekend in February. Approximately 35 Dartmouth students attend the event each year and participate in snowshoeing, cross-country skiing, dogsledding, and bush crafting. It has been suggested by members of the Board that the event

could be expanded and improved to include a cross-country ski tour of the Grant led by members of Dartmouth's Nordic Ski Team.

While Winter Weekend is deemed successful, Outdoor Programming does not have much interest in replicating the event for other terms. This is partly because perceptions of the Grant render it most unreachable during the winter. Celebrating Winter Weekend therefore provides an opportunity to show students the wonders of the Grant in its harshest season, thus breaking the stereotypes of the property being too inaccessible to students. In addition, the Grant relies on fall, spring, and summer students to carry out their own trips, so there is not much demand for an additional large event during other terms.

Continuing a recent surge of alumni involvement will help connect students and alumni to opportunities at the Grant. Outdoor Programs can continue reaching out to alums through periodic articles in the DOC newsletter and website to advertise future meetings. Alums' continued use of Grant cabins is important in keeping costs low and extends the experience of the Grant beyond those currently active in the Dartmouth community.

A predominant challenge in raising awareness about the Grant is determining how to convey its value when there are many outdoor opportunities closer to campus that students tend to favor. To counter this point, Outdoor Programming believes the remote, quiet location of the Grant offers a unique experience precisely because it is farther away from Hanover. The existence of only eleven cabins on the property helps maintain this aura of visitors being in a true wilderness environment. The Grant presents opportunities for students' academic

interests and research outside of science, such as writing a novel, by offering a quiet, isolated space to allow for work, study, and inspiration.

One important opportunity for student research is the Northern Exposure funding, which can fund one or two students each year. While students have taken advantage of this research money in the past, the fund may draw more attention if it is advertised to a wider student body. Therefore, this internship should be included on DartBoard and listed alongside other competitive student internships. More could be done to encourage research, and listing opportunities where students are looking for other sources of funding may be helpful. Suggestions for internship projects along with the position description may make the idea of working at the Grant for a term more tangible. Such a suggestion may involve researching community education and outreach culminating in large community event, or any number of other topics presented in this report. Members of the Grant Advisory Committee remain open to the potential for an annual or biannual event on the property that is open to the entire community, which may draw additional student interest, and provide an unexplored opportunity for a student internship.

While student use of the Grant is encouraged, it is not advised that overall numbers of individuals using the Grant dramatically increase. This is because, first, Dartmouth is concerned with safety within the Grant. Second, the costs of increasing use may be internalized by the Grant management's infrastructure; the need to pay for wear and tear on roads, bridges, etc. within the Grant costs approximately $825 per mile for each year of maintenance. As there are 72 miles of

roads on the property, this amounts to approximate road upkeep of $59,400 each year.

In summary, collaboration between the DOC, OPO, student Grant Advisory Board members, "Get Out!," and student advertisement organizations is imperative to spreading awareness about opportunities at the Grant to current students. Expanding the reach of firsthand experiences and more effectively publishing opportunities to travel to the Grant could allow students to build a culture around and within the Grant that more prominently features it as a valuable asset to the Dartmouth community. Undergraduate-focused operations such as the Moosilauke Ravine Lodge and the Dartmouth Organic Farm are examples of outdoor-oriented initiatives that have been successful in creating unique cultures that impact students' experiences at the College. Dartmouth community stakeholders should work together to ensure student use is maximized while the high quality of the Grant is upheld. The committees should capitalize on existing student and alumni use experiences and expand its advertisement of Grant opportunities to maximize student awareness.

B. Local Community

Although the Grant may seem quite remote in relation to the Dartmouth College campus in Hanover, NH, it is in fact part of a delicate and unique Northern Forest socio-ecological community. And while this community may be very different from the Dartmouth College community, it too values and appreciates the ecological and cultural services provided by healthy, vibrant forests.

Historically, the Grant has been presented to both the local community and the Dartmouth community as primarily an area of resource extraction and secondarily an area of recreation and research for Dartmouth community members. As a result, efforts to connect with Northern Forest community members have been limited and tensions have developed between these two groups and the College. There is a need to reframe the way the Grant is perceived from both within and outside the Dartmouth community to more fully highlight the educational and recreational opportunities the Grant can offer members of both communities.

This chapter will consider the wider social context of the Grant and identify new and existing mechanisms for the College to engage more meaningfully with the local community surrounding the Grant. Fostering a stronger and more positive relationship between these two communities would be mutually beneficial.

A large portion of our research is the result of personal interviews with residents of Errol and Wentworth Location, local community organizers from NGOs as well as members of the Grant Management Committee, OPO staff and Grant staff. These interviews were conducted in person, over the phone and via email. Individuals were asked to share their experiences with interrelations between the College/Grant and the local community, with a particular interest in past initiatives to build a relationship between these two groups. These interviews were very helpful sources of feedback in the development of the following recommendations.

For the purposes of this paper, mention of the local community and its members will refer to those living and working in Errol, the largest town in close proximity the Grant's gate. Errol is used as the umbrella community name for Errol

and Wentworth Location. However, in certain cases peoples from other surrounding communities may also be included (usually to a lesser degree) in our discussion.

a. Errol And Coos County

The Grant is situated along the border of Maine in the northernmost county of New Hampshire, Coos County. The history of the area has played a distinct role in shaping the unique characters of the communities in the region today.

Incorporated in 1803 the original census data revealed a population of roughly 3,000 individuals in Coos County (History 2013). The industry was originally comprised of small-scale agriculture and farming, but around 1850 papermaking took off. This business had an incredible influence on the county, and the next 75 years saw a boom in production and population, particularly in Berlin. Unfortunately, after the stock market crash of 1929, the paper making industry of Berlin slowly collapsed leaving many unemployed. The lore goes that the Northern Forest were silent the winter of 1931 and 1932 because the paper companies could not finance their winter logging operation. As the paper making industries continued to fall apart in the 1940's, the population began to slowly decline, a trend that has continued up to the present day (Upham-Bornstein 2011).

In 1964, the James W. Sewall Company of Maine in conjunction with the University of New Hampshire published a comprehensive analysis of Coos County that highlighted several key issues facing the area. This creation of this manuscript was most likely prompted by the slow population and economic degradation of Coos County. The study revealed that Coos County residents generally had lower levels of education then the rest of the state. The industries in the area focused on timber,

agriculture and manufacturing (paper, logging apparel and rubber), but job availability was decreasing and white-collar occupations were low in number. Population trends showed an outmigration of young adults and few employment opportunities available to women. The study also showed that while outdoor recreation in northern New Hampshire was increasing, because of the lack of highway infrastructure to Coos County, the area was seeing less tourism. (James W. Seawall Company 1964)

These trends recognized by the Sewall Company are trends that are still apparent in the community demographics today as taken from the 2010 Census. Despite being the largest county in New Hampshire, Coos County has the smallest population with 18.4 people per square mile. Relative to the rest of New Hampshire, Coos County has an older, less racially diverse population, a lower median household income and more people living below the poverty line (13%). There is higher unemployment, with a low percentage of the population working in white collar or office jobs and a higher percentage working in manufacturing, natural resource extraction, transportation and construction. In addition, Coos County has a lower level of education then the rest of New Hampshire with fewer people graduating from high school or college (New Hampshire Census Data 2013, Coos County Census Data 2013)

In considering Errol - the community that borders the Grant - across the board the issues that are present in Coos County are amplified. Errol has a population of 291 and 25% of the residents are 65 or older. The unemployment rate is high at 9.1%, and the median household income of $35,833 is roughly 1/3 less

than the national average (Errol Town Census Data 2013, New Hampshire Census Data 2013). After speaking with several community members it is clear that the community is highly aware of their predicament as a small aging population with limited employment opportunities. They are frustrated with the minimal job opportunities especially for the young adults who have to leave the community to find work (Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon4, 2013; Anon5, 2013).

Although it is small, Errol does have a downtown with a few businesses, gas stations and restaurants. There also is some public infrastructure that includes a Public Library and a K-8 school that services 13 children of various ages (Community Profiles: Errol, NH 2013). Above all, Errol's (and Coos County's) greatest asset is its beautiful landscape that attracts a large amount of visitors. Errol's proximity to the Androscoggin, Lake Umbagog and large forested properties attracts many recreational tourists (fisherman, hunters, paddlers, snowmobilers, hikers etc.). There are several campgrounds in the area and most of the businesses rely on the tourism to stay open (Anon1, 2013).

The socio-economic future of Errol and Coos County is uncertain. On one hand there is an aging, financially stressed community whose traditional means of employment are slowly decreasing. On the other hand there is a growing tourism and outdoor recreation industry. As one resident mentioned, the community is transitioning into a retired population and many of the residences are now second homes for vacation or rental purposes (Anon1, 2013; Anon4, 2013). This demographic shift has been difficult for the residents who have grown up in the area who are seeing their traditional livelihoods and the close knit, family community

slip away (Anon1, 2013; Anon3, 2013; Anon5, 2013). It is unclear what will happen in Errol in the coming future, but as a large landowner in the community, Dartmouth, through the Grant, will continue to play a significant role in this social-ecological system.

b. Community Development Opportunities

Education is currently a major hindrance to the success and stability of the local community. Young people are leaving the area in search of better education and employment opportunities. If these young people were able to find a better education closer to home, they might be more willing to stay in the area and work to develop new industries offering better employment options. However, the existing elementary school (grades K to 8) and public library in Errol represent crucial infrastructure for any efforts to strengthen and increase educational opportunities within the local community. The community sends students at the high school level to larger, neighboring locations such as Berlin.

Education is a great place to start an initiative to stabilize and revitalize a community such as Errol because it can serve as a building block for the improvement of the whole local socio-ecological system. For example, working to preserve and revitalize the local forests is an important priority in local communities: this might be achieved by increasing access to educational programs and resources designed to develop a better understanding of the systems thinking and forest management skill sets. These newly developed educational assets would increase employment options for local young people in natural resource

management (a major sector of the Northern Forest economy) while also providing communities with the tools to protect vital ecosystems and watersheds.

The beautiful forests and waters of Coos County and in particular Errol are also a very valuable asset upon which the local community might consider building further. There is presently a strong snowmobile tourism culture in Errol. The local community could promote year round tourism by highlighting other great outdoors activities such as fishing and canoeing that could be enjoyed in the spring, summer and fall. There are several precedents for successful year round tourism towns in the area such as Bethel, Maine and the Balsams.

Additionally, there is very little agriculture in the area at this time. And while the soils here are well suited to timber cultivation, the local communities could explore small-scale agricultural uses. Home gardens and a community garden would be helpful in providing the local community with better access to nutritious foods.

While Errol and the local community have much potential for further economic and educational development, such advances must come from internal motivations. Therefore any efforts to initiate community improvement programs of any kind must be the result of conscious and careful conversations within the community.

The goal in encouraging such community development projects would be to create greater resiliency within the local community. Resiliency refers to a community's ability to adapt to change. The Northern Forest has undergone dramatic economic and demographic changes in the last several decades. It will

likely continue to change, perhaps more rapidly than the current community structures are able to accommodate.

By working with these communities to design programs and projects to strengthen their understandings of the systems within which they operate, they will be better able to identify leverage points for effective change in these complex and interrelated socio-ecological systems. Increasing the resiliency of these communities will better poise them to not only bounce back, but also thrive once again as they once did a century ago.

The Grant is an integral part of this socio-ecological community and the resiliency of the local community is connected to the Grant's future.

c. Current Interactions with Local Communities

Over the years, a controversial dynamic has formed between the Errol community and Dartmouth. While Dartmouth has been fairly unconscious of its effect on the local community, there is a lot of animosity directed at the College from the local residents (Nelson et al, 2013; Evans, 2013a; Evans, 2013d; Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon4, 2013; Anon 5, 2013).

There are many reasons why this negative relationship has formed and from various interviews with OPO staff and local residents, this ill will most likely results from a blending of several issues that include Grant accessibility, the lack of genuine communication and interaction between both parties and local frustration over livelihood difficulties in the Northern Forest.

For the most part, the College and Dartmouth community members that use the Grant appear to be rather indifferent to the local community. Although the

members of the Grant Management Committee and OPO have acknowledged the community relationship, it appears that there are no official policies recognizing Dartmouth's relationship to the community.

While Dartmouth has found ways to interlink its academics, service projects, work programs and extracurricular activities with the local Upper Valley Community, despite being a large landowner in the North Country there are no programs that engage the Errol community. Most of the Grant visitors are oblivious to the local community, seeing the Grant as an isolated entity in the North Country. According to College Forester Kevin Evans, "We [Dartmouth College community members] look a lot at what we do around Hanover but have never thought of our influence in other areas of the State. We are a big part of the watershed and should be engaged more" (Evans, 2013d).

d. Accessibility

The biggest source of contention between the Errol community and Dartmouth has been the access policies in place at the Grant. Currently, there are locked gates on all the entrances to the property, and the only people who have key access are the Dartmouth affiliates that rent cabins. Thus local community members are unable to drive or snowmobile into the Grant. Although it is within Dartmouth College's rights as a property owner to block vehicle access, the majority of the other large properties in the area owned by various logging and real estate companies allow access to their properties on the logging trails (Nelson et al, 2013; Evans, 2013d; Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon4, 2013; Anon 5, 2013). In a community that has always had open access to the large land parcels, not

allowing access to local property is highly contentious. The gate is not only a physical barrier, for the locals it also is a symbol that they are unwelcome on land that is part of their hometown.

The college has legitimate reasons for having the gates. Road maintenance incurs serious annual costs and the management committee is worried about road use, particularly during the muddy hunting season. Access is also limited for safety reasons, keeping people away from active logging areas. Additionally, the Grant has always been valued for its remote wilderness setting; it represents a place of peace and quiet, a prized property in the developed world. The management committee is concerned that open access would bring too much traffic, not just from locals but also from tourist all over, ruining the isolated peace (Nelson et al, 2013; Evans, 2013c; Anon1, 2013; Anon 3).

The access rules are not intentionally targeted at local residents. It is true that no matter who wants to enter - locals, Dartmouth affiliates or northern forest tourists - they are not allowed key access unless they have rented a cabin (and only Dartmouth community members can rent a cabin). Anyone who wishes to, however, is more then welcome to walk, bike, ski or snowshoe into the property (Nelson et al, 2013). Although these activities are in line with Dartmouth's intended land use policy, from local conversations, they are not as popular as motorized recreation for Northern Foresters. The non-motorized activities are not feasible for the older population and since the community is financially struggling, it is difficult to outfit and find time to pursue these non-motorized pastimes (Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon 4, 2013).

Snowmobiling and four wheeling are common outdoor recreation interests in the North Country and not allowing that access to the Grant is aggravating, but for the local community, the fact that there is no vehicle access during hunting season is potentially more infuriating. If a community resident were to kill a deer or moose, they would have to carry it all the way out of the Grant. As previously mentioned, the local communities are generally older and potentially have difficulty carrying their animals out of the woods. In the past, there used to be a rule that when a community member shot a deer on the property, they were allowed to drive in and pick it up. Local community members were quite upset when the Grant changed this policy several years back (Nelson et al. 2013; Anon1, 2013; Anon2, 2013; Anon3, 2013). One resident mentioned in an interview, that if they shoot something large, they sneak an ATV in anyway to pick it up (Anon 3, 2013). OPO staff mentioned that there is a policy that lets one community member have access to the Grant for the day (Nelson et al, 2013). It is unclear what the official nature of this policy is, as it is not found in the Hunting and fishing rules of the Grant, and when mentioned to local community members, they had not heard of this opportunity. This speaks to the inaccessibility of information about the Grant and it's policies to the local community.

The animosity around this issue is extremely pronounced, even from local residents who do not hunt. The gate as a symbol of exclusion is extremely powerful especially when compounded by other issues. Several people expressed anger towards the fact that they are not allowed through the gate when they wish to go, but when the Grant has a fire or ambulance call (which there have been) volunteer

community members are expected to go help out the Dartmouth members Several people stated that they would flat out not go to help out which is an incredibly powerful statement. (Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon 4, 2013; Anon 5, 2013). It would be terrible if the relations deteriorated so much that local community members would not respond to a distress call.

While this is a significant statement that should be taken seriously by the Grant Management committee, there was also simultaneous positive feedback about the gate. While they were annoyed that they could not drive into the area, at the same time they appreciated the solitude of the Grant and the gated off areas inside of the Grant to hunt (Anon1, 2013; Anon3, 2013; Anon 4, 2013).

Another thing to consider when thinking about the gate is dealing with non-Dartmouth, non-local visitors. Allowing increased access to the local community might be fine with only a minimal increase in traffic, but this increased access might also bring even more visitors or stimulate tourism businesses that would include the Grant in their business plan (Nelson et al, 2013). Thus it is clear that accessibility is a complex argument and any policy decision will always anger some groups.

e. Lack of Interaction and Dialogue

While accessibility is a serious issue that has to be considered by the Management committee, the interviews with Dartmouth and local people revealed that there is a lack of understanding of the mutual economic and social benefits the groups provide each other (Nelson et al, 2013; Evans, 2013c; Anon1, 2013; Anon 2, 2013; Anon3, 2013; Anon 4, 2013; Anon 5, 2013). This lack of understanding stems from limited, genuine interaction and unclear Grant policies.

There are several positive economic and social benefits Dartmouth brings to the area through the Grant. As previously mentioned, the Grant has been managed in a sustainable manner to insure a healthy timber stock, flourishing wildlife and a clean watershed. In a rural community that has a growing outdoor tourism area a healthy ecosystem is key. From interviews, local residents mentioned that although they did have their issues with the Grant, they did appreciate the serenity and the quiet that they would find when walking through the property (Anon1, 2013; Anon 3, 2013; Anon 4, 2013).

The Grant also brings money to the area by employing several local people to manage and log the property and bringing up guests the use the restaurants, stores and services in town (Nelson et al, 2013; Evans, 2013c; Evans, 2013d). During the class conversation with the Grant Management committee, this net influx was projected to be roughly $750,000 per year into the local economy. The effect of this income in the economy is then multiplied many times over as the income passes through local households and firms.

Over the years there also have been a few instances where Dartmouth has reached out to the community. This includes events such as an invitation to several BBQs in the Grant and forest ecology field trips for local schools (Nelson et al, 2013; Evans, 2013d). All of these are positive components that Dartmouth brings to the community, but there is a lack of local awareness about it (Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon 4, 2013; Anon 5, 2013).

Local conversations also revealed that information was skewed resulting in more animosity. For instance, the local residents believe that Dartmouth does not

pay taxes, but in fact Dartmouth (Anon 2, 2013; Anon 3, 2013; Anon 5, 2013) pays approximately $30,000 in taxes (Evans, 2013d) but these taxes go to the state rather then one of the local towns. Clarifying these issues in some manner would allow for several issues to be cleared up.

While motivations for improving relations with the local community are outlined more fully below, there are a few smaller benefits that Dartmouth gets from the community that are highlighted here. These include access to services, food, gas and goods in the nearby area as well as medical and safety help when necessary (Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon 4, 2013; Anon 5, 2013). Though these could be disregarded, they really are a safety net for daily activities at the Grant. Thus there are opportunities to both expose and increase these services in a manner that is mutually beneficial to the college and to the local community.

f. Regional Economic Difficulties

Lastly, interviews have suggested that part of the animosity towards Dartmouth is overspill of frustration from the economic difficulties of the region. As detailed by the demographics of the local Grant communities, the population is aging, there is a lack of industry and jobs and young people are leaving the area. The communities are extremely conscious of this shift and are concerned for the future of their home (Anon1, 2013; Anon2, 2013; Anon3, 2013; Anon 4, 2013; Anon 5, 2013).

Included in these worries are controversial concerns about the new refuge and conservation lands. In the past 20 years, wildlife refuges have been popping up all across the North Country. Although most people would see the creation of

wildlife protection areas as positive, the land now owned by the government is not taxed and thus does not go towards the community's tax base. Thus property taxes for the local community have skyrocketed in Wentworth Location in particular, and many of the people are concerned about affording to stay in their homes that have been in their families for generations (Anon 1, 2013; Anon 3, 2013). This is a controversial issue and the community is split in their support of conservation of their local land. As discussion occurs regarding the establishment of a conservation easement on the Grant and Dartmouth's support of other conservation efforts in the North Country, the local opinion should be taken into account.

g. Motivations for Improved Relations with Local Communities

The local communities are a powerful agent of change in the Northern Forest. These communities feel very connected to the forests and waters in this area and are deeply dedicated to their preservation and protection, in large part due to a deep respect for the cultural and provisioning services provided to these communities by their environment. As a result, many of these communities have teamed up with the Northern Forest Center to purchase lands in their areas and place conservation easements on them (Evans, 2013b). This demonstrates the potential for the local communities to become allies of the College in support of sustainable forest management in the Northern Forest.

Support for sustainable practices is extremely important because the management of surrounding forests, watersheds and ecosystems that the College does not currently control intricately influences the Grant. The College could try to purchase all of these lands, but it could also work to empower the local peoples to

help encourage more sustainable management practices among other large landowners. The better the relationship with the local community, the more support the College will receive and the better protected and preserved the Grant may become.

Locals also hold unique community-based knowledge, or a more intimate understanding of local social, cultural, political, economic and ecological systems simply as a result of living within and interacting with them every day. Very few Grant policy and decision makers actually live in the local communities surrounding the Grant, which means they often lack community-based knowledge that could be very helpful to the College in its efforts to manage the Grant more effectively. Good relations with the locals would make it easier for the College to share in this "inside" information and formulate policy that accurately reflects the community context of the Grant in addition to the values and goals of the College.

Increasing outreach to the local community could also help to shift the local perception that the Grant is an exclusive and elitist institution in which locals are not welcome. Stronger connections with the local community could help the members of both the local community and the Dartmouth community view the Grant more clearly as a place for recreation, research and education in addition to resource extraction. Overcoming the paradigm that the Grant is first and foremost about resource extraction will allow the College to engage more fully in the local community and receive the benefits of its friendship and support.

Building off the recommendation for a research center or program at the Grant, the College might consider expanding this to include a community education

component. A community education initiative could serve both Dartmouth visitors, such as alumni groups, as well as local groups.

In particular, it would be worthwhile to focus on providing additional opportunities for local school groups to engage with Dartmouth and the Grant through visits to the Grant or research projects. Precedents for such a center or program include current institutional efforts to redevelop the Organic Farm to create a home for environmental research and education there. Additionally, the College Forester, Kevin Evans, has taken Northern Forest elementary school students into the Grant for field trips in the past.

Such education programs fit well with Dartmouth's dedication to education and leadership both inside and outside of the classroom. Depending on how the College wished to develop this program, it could draw on a lot of existing social and academic capital to help make this happen, which could be coordinated as a special project by the Education Department. Both students and staff could engage with the local community in the Northern Forest to develop curriculums for different aged visitors to the Grant.

These programs and lesson plans could also be used with Dartmouth community visitors to the Grant. This sort of programming would therefore be easily feasible as it would require very little physical infrastructure. However, if it were successful in these preliminary stages, it may be easier to secure a Grant to develop the program further and perhaps build a physical home for such a program in conjunction with the research center proposed above.

Locals are currently allowed to enter the Grant on foot. However, this is not widely advertised, so community members do not feel as welcome as they otherwise might. Additionally, they are displeased that they may not drive into the Grant because they are used to having unrestricted access to Northern Forest lands regardless of ownership (Evans, 2013b). The presence of the locked gate at the entrance to the Grant thus creates a lot of cultural tension. Please see below recommendation on "Gateway Creation" for details on how the College might transition the current gate location from a place of exclusivity to a place of welcome and inclusivity, while still limiting environmentally and economically damaging activities.

To help diffuse some of these tensions and make the locals feel more welcome, the College could increase awareness for those activities which are judged to be less-impactful on the environment than driving into the Grant and encourage locals to partake in these activities instead. This might mean labeling snowshoeing, skiing, or biking and hiking trails immediately within the gate so that those entering on foot felt like they had exciting and interesting options for entering the Grant. This might also help contain human impact on the Grant to a small geographic area near the gate and also keep people away from dangerous logging activities further in. The annual Summer Grant Crew of student workers could be utilized to clear and mark new trails for low-impact recreational activities that would also help keep the costs of road maintenance down.

Additionally, to help promote such environmentally responsible recreation options, the College could consider marking canoe and kayaking trails. This effort

could be coordinated with the assistance of the Northern Forest Canoe Trail, which already promotes many existing boating opportunities in the immediate vicinity of the Grant (Backler, 2013). The Dead River would work best for kayaking and canoeing recreation in the Grant since it is less rocky and deeper than the Swift River. However, this route may require the implementation of a "hell gate" at the gorge, requiring a half-mile portage. Local community boaters would also have to carry their canoes or kayaks about 2 miles to the exit of the Grant if they were not able to secure a day pass to drive in (Evans, 2013d). However, there is still significant potential for many parts of the Dead River to make for an enjoyable boating setting for both local and Dartmouth community members visiting the Grant.

Given the many benefits of increasing awareness and opportunities for recreational activities that do not require expensive upkeep on the Grant's part or cause much environmental disturbance, the Grant might also consider offering seasonal rentals during peak visitor times. Making gear such as snowshoes, skis, bikes and hiking poles easily available could encourage additional participation in these activities by members of both the local community and the Dartmouth community at the Grant. The DOC is very closely tied to the Grant and has already set a precedent for such gear rentals by renting ice skates and cross country skis at the DOC House in Hanover.

All of these practices would also help Dartmouth community members visiting the Grant reduce their impact and enjoy a greater diversity of recreational activities in the Grant. These recommended actions draw on existing College and Grant infrastructure, making them more affordable and feasible. However, a more

detailed study of the economics and implementation practicality behind the above mentioned initiatives is recommended as such analysis is beyond the scope of this report.

To make the Grant even more welcoming to locals and Dartmouth community members, the College could create a "gateway" to the Grant. This would mean taking steps to help visitors identify the entrance to the Grant, parking options and potential recreation options. The addition of a welcome sign is an example of one way the College could make the Grant more welcoming by inviting locals to enter on foot, and by adding a bulletin board to point out great recreational options for those entering the Grant on foot. Formalizing the parking area, even with just a few stakes and rope, might also make the idea of parking and walking in more acceptable to locals. The signage and parking options would likely also help Dartmouth community members feel even more welcome in the Grant.

The design and construction of such a gateway could be undertaken by Dartmouth students in the Architecture and Engineering programs. Both of these programs have long-standing histories of incorporating class projects to benefit local communities in New Hampshire. And one of the Engineering classes has already designed and built a suspension bridge in the Grant. (Evans 2013c)

To help initiate such programs and projects, the College may want to create a Grant Intern position. A Dartmouth student on an off-term who would work on developing programming for both local and Dartmouth community members could fill a Grant Intern position. This could take form in many ways, but would ideally

raise awareness of the opportunities in the Grant offered to members of both communities.

The intern could be very useful in organizing recreation trips for Dartmouth students or research visits for students as well as staff and faculty. According to College Forester Kevin Evans, the College would like to see more student use of the Grant, and yet it has not designated any specific resources on this in the memorable past and it is not something that the current Grant staff has time to do themselves (Evans, 2013d).

The intern could also set up field trips for local classes to visit the Grant, meet the forester, and facilitating other visits. Julie Evans of the Northern Forest Center recommends that the College take time to create relationships with the local school children so that they better understand, enjoy, appreciate and respect the beauty and benefits of a healthy, sustainable forest such as the Grant (Evans, 2013b).

The intern should work with The Dartmouth, the College newspaper, to have articles written on research activities in the Grant. These could be published on campus and in local Northern Forest newspapers to help connect the communities. Julie Evans, a local community organizer from the Northern Forest Center, stated in a phone interview that she believes local community members would be interested in learning more about what goes on in the Grant, particularly in the areas of wildlife and forest health research (Evans, 2013b).

Similarly, the Intern could produce pamphlets for cabin guests to help them identify local attractions and encourage them to support the Grant's local business partners. Encouraging increased economic participation in the local community on

the part of the Grant's visitors will improve the College's visibility in the community. Increased visibility in the community may to help ease existing tensions that stem from the current conclusions of many local community members that the Grant does not do much to support the local economy. Thus, with such a simple and affordable step as including a printed pamphlet for cabin guests, the College could encourage the patronization of local businesses while also helping local community members understand the positive economic impact of the Grant on their community (Evans, 2013b). Such initiatives to support local businesses have the support of the OPO staff (Nelson, 2013).

An intern would be a great way to support additional programs for local and Dartmouth community members in the Grant without having a heavy impact on the College's economic resources. The Grant has requested additional support to help develop such programs in the past and has not received it as a result of many bad budget years. The Grant is currently a self-supporting Department. As timber has stayed flat and operation costs in the grant have risen over recent years, it has become increasingly difficult to balance the budget, leaving very little room to support new or additional programs or activities (Evans, 2013d). Interns can be hired for short periods of time (such as a ten ek academic term) or on a per-project basis and will generally be willing to work for less pay than non-students and without benefits. A student intern is also a good option to offer additional support to the Grant team because there are funds available to perform such internships through Dartmouth-affiliated foundations and institutions that would not negatively impact the Grant's already-tight budget. In these ways, an intern would allow the

Grant team to explore the potential for additional programming in the Grant without a significant, long-term economic commitment from the College of the self-sustaining Grant department itself.

From the interviews with local residents and OPO staff, it became clear that the policies and the mission of the Grant are unclear to the local community. Residents mentioned that some community members know very little about what goes on at the Grant and don't really understand the distinction between the Grant and the Refuge (Anon 5, 2013). Thus there are opportunities for Dartmouth to take some steps to clear up miscommunication and improve relations.

In order to make the mission of the Grant and the policies clear to the local community information should be provided in convenient local spaces. This could include putting up an information pamphlet in a community building or the Library or perhaps including a small mission statement at the gateway to the Grant. It is noted that the Grant Management Committee does not want to publicize the public recreation opportunities of the Grant, but providing some accessible information to the community would be helpful. The policies surrounding local accessibility to the Grant seem to be unclear even among the Management Committee and the OPO staff. Research has uncovered a day pass that may be allocated to one local resident per day. If the Management Committee actually wants to allow this policy, discretely publicizing this benefit to the local community (without stirring the interest of other tourists) would be a generous gesture towards the local community.

Miscommunication between Dartmouth and the local community can also be improved by facilitating places for official and unofficial interaction and dialogue.

Several residents mentioned they would like an opportunity for local leaders to talk to College officials. Select members of OPO and the Grant Management Committee should attend a few important community meetings every year. These community meetings could include anything from town meetings to snowmobile association meetings. Although there could be hostility in some of these meetings, opening up dialogue and showing a serious commitment to the community is important.

Any sustained genuine interaction between the Dartmouth community and the local community can really improve the relationship. It has been noted by Grant staff that there are some alumni who might prefer that the Grant only be used by themselves and other members of the Dartmouth community (Evans, 2013d). Creating healthy dialogue and interactions may help individuals with such perspectives better understand the unique nature of the Grant's interconnectivity with the rest of the Northern Forest watershed and its residents.

The recommendations listed above, particularly the education initiative or the events created by the Grant Intern, are opportunities where this positive interaction can take place. In the past, community members have been invited to a BBQ up in the Grant and although the event has not been well attended by residents in the past, it has the potential to slowly become a fun and welcoming tradition. One of the tricks to making this a success will be finding ways in which to make the local peoples feel comfortable around the Dartmouth community members that ideally would also attend such an event (Evans, 2013d). This might be achieved, at least in part, by pursuing the other recommendations here designed to make locals feel welcome entering the Grant more often so that they could feel like they held the

same shared experiences as the Dartmouth community members who also valued and enjoyed use of the Grant.

According to Julie Evans of the Northern Forest Center, "Dartmouth has a model of good forest ownership and I do think the communities appreciate that – but there is rarely any dialogue about this" (Evans, 2013b). By encouraging Grant staff to attend local community planning meetings, offering an annual BBQ or similar community event and increasing participation in the local economy by Grant visitors, there will be ample opportunities for local community members to see past the Grant's locked gate and express an appreciation for the College's shared respect for the land.

Furthermore, the College could also consider opportunities for engagement with the local community outside of the Grant. Such efforts could offer new and unique educational and employment options to members of both communities for mutually beneficial economic and educational enrichment. Possible ideas include: and advancement. A few ideas for such programs might include:

- Expand the SEAD program to include high school students from Northern Forest communities.
- The development of a scholarship or grant fund to bring students and classes and teachers from the Northern Forest to Dartmouth College for academic and/or cultural programs and events
- The support of an internship for a Dartmouth College student in a local library (such as in Errol) through Tucker or another service learning grant
- Work with the Education Minor to place students on off-terms in local schools
- Team up with ENVS professor Terry Osborne's class COVER stories to promote responsible and sustainable homeownership and maintenance
- Coordinate with the Organic Farm to do a workshop on home gardening
- Organize a program with the student group Growing Change to help local school children establish a school garden

The recommended Grant Intern position could facilitate such initiatives.

5. Potential For Carbon Offsets and Biomass Calculations

A. Biomass Calculations at the Grant

Forests have the capacity to sequester carbon dioxide (CO2), one of the central greenhouse gases that contribute to climate change. Carbon is stored in forests for a period of time in different forms before it returns to the atmosphere through the decomposition of plants and animals, as well as the burning of woods. Enormous amounts of carbon in the forests are stored in wood biomass, as almost 50% of the weight of dry trees is carbon. For example, one large Red Oak tree could have as much as 2 tons of C02 stored within it. Forests can play a big role in fighting climate change by sequestering carbon dioxide from the atmosphere through the process of photosynthesis. The equation is C6H12O6+6O2+6H2O, which demonstrates how CO2, when combined with water and sunlight, can be converted into glucose (plant biomass) with the byproducts of oxygen and water vapor (Ward and Worthley 2004: 23). As trees grow they absorb C02, and as trees decompose (or burn) they give off CO2. Because of this natural sequestration, forests can be grown to offset CO2 emissions from fossil fuels.

In the early 1990s, the United States launched a voluntary program to monitor and estimate the quantity of carbon sequestered in forests. The program aimed to motivate private forest owners to improve the management of their land. The monitoring program also allowed forest owners to calculate how much CO2 their forests are sequestering with the potential of selling this sequestration capacity in voluntary markets to those interested in offsetting their own emissions. The main concern about voluntary carbon markets is the quality of the offsets when counting. It

is very important to monitor forest carbon inputs and outputs to avoid over estimating carbon offset capacity. Thus far, all carbon offsets in the United States have been sold to voluntary markets (Beane 2012: 14). There is a possibility in the United States that legally mandated emission reductions occur in the near future, which would drastically increase the demand and price of carbon offsets. However, this form of government action is motivated by highly unpredictable variables, such as political elections and weather events. Still, states such as California are expanding individual goals to reduce net green house gas emissions, and these efforts are substantially increasing demand in offset markets.

The Second College Grant has some potential for creating carbon offsets. However, markets for healthy forests such as that of the Grant are relatively weak. The CAR Forest Project Protocol is one program that favors well stocked forests, particularly those with higher timber volumes than the regional average, which will likely favor the Second College Grant, depending upon the properties used to define the regional average. However, given the Grant's high growth rate, idealized tree types, and sustainable rotation regime, opportunity for improving timber volumes at the Grant are fairly low. This is in part due to the decrease in growth rate of trees as they age.

There are many methods to calculate CO2 in forests. In order to find the amount of CO2 we need to find the weight of a living tree. Each tree species has different formulas to calculate mass depending on the location. The formula is W = 0.25D2H, but if the diameter is more than 11-inches, we use W = 0.15D2H. The W is the aboveground weight of the tree in pounds. D represents the diameter of the tree in

inches, and H represents the height of the tree in feet (Afzal 2013: 22). These numbers are very helpful in determining the carbon sequestration capacity of individual trees, however acquiring data on the individual trees within forests is extremely time consuming and expensive, and it is not available at the Grant. Therefore, we have averaged the sequestration capacity by three forest types: Hardwood, Softwood, and Mixed wood. We have focused on these timber inventories because they are by far the largest above-ground carbon pools at the Grant, and other carbon pools are very hard to quantify and less useful. We have taken information on acreage, forest cover type, and current forest inventory values from the 554 Timber Stands that make up the 25,242 acres of forested land at the Grant (Master Plan 2011). We used several calculation processes and conversion factors to change the original Timber Stand data and convert all of it into consistent units (Haynes, 1990). Below are our results, with more detailed calculations in the Carbon Offset Calculations section of the Appendix:

Calculated Total Weight of Aboveground Living Biomass

1) Total Tons: **989,866 tons**
2) Ratio**: 786,194 Hardwood vs. 203,672 Softwood = (3.86:1)**
3) Converted to Total sequestered C02 **= 849,330.392 Metric Tonnes C02**
4) Total Sequestered C02 (849,330.392 Metric Tonnes) / Total Acres at Grant (25,242 acres)= **33.647 Tonnes/Acre**

- Ratio At Grant: 1999 Inventory: 55% Hardwood, 30% Mixedwood, 14% Softwood (3.92:1)
- Complete Ratio At Grant (Based on our calculations): 786,194 Hardwood vs. 203,672 Softwood = (3.86:1)
- The difference in the ratios can be accounted for in part by increasing Hardwood volumes at the Grant.
- Current Sustainable Harvest Volume at SCG: 7,800 cords per year.
- Main Hardwood Species: *sugar maple, yellow birch, red amble, American beech, white birch, and aspen*
- Main Softwood Species: *balsam fir, red spruce, white spruce, black spruce, larch, white pine, cedar.*

a. Offsets and the Bayroot Properties:

Dartmouth's interests in carbon offsets lie in offsetting its own emissions, in part because reducing Dartmouth's carbon emissions is a central goal of the college, and in part because carbon markets are not yet very strong or stable. Dartmouth's annual carbon emissions from heating, electricity, and other fuel use are very high. Dartmouth's geographic isolation and poor capacity for renewable energy generation have made it heavily dependent on Number 6 fuel oil and electricity supplied by National Grid Electric (Ager 2008). These contribute heavily to the campus's high per-capita emissions, but are fairly hard to avoid. Therefore, the College's investment in the Bayroot property presents a tremendous opportunity for Dartmouth to offset its greenhouse gas emissions.

b. The Diamond Watershed:

The Dixville Grant, the Atkinson and Gilmanton Academy Grant, and the Dix's Grant are three properties bordering the Second College Grant that are owned by Bayroot LLC. These properties amount to 47,548 acres, and are heavily deforested. The value of the properties to Bayroot LLC is in the timber stocks, which will soon be low enough to incentivize Bayroot to sell the land in the near term. The cost of purchasing all three properties would be substantial given typical land values in the Northern Forest, however Federal Forest Legacy funds can provide a 35% reimbursement of this purchase, and conservation easements can likely generate several million dollars in additional price reductions. Therefore, the ultimate price could be less than half of the initial.

Extending the Grant's management territory by 47,548 acres and restoring the lands exploited by Bayroot has a multitude of benefits to Dartmouth. Restoring the health of the forest will have enormous ecosystem perks for the entire Diamond Watershed area, from improving animal habitats to restoring balance to the watershed as a whole. Adding continuity to the forest ecosystem will also enhance the recreational value of the Grant, and contribute to the sense of solitude and natural peace felt by visitors. These properties also provide Dartmouth with substantial educational opportunities, from watershed restoration research to animal migration and forest regeneration studies. However, the primary reason Dartmouth must capitalize on this opportunity is that it provides an extremely cost-effective, high-quality, local, and easily advertised means of offsetting Dartmouth's carbon emissions.

Expanding the Grant is a long-term investment. Certainly, there are other investments the College could purse that might bring about a quicker return. However, the point of purchasing the Bayroot properties is not to maximize fiscal returns. It is to reshape Dartmouth's image as a forward-thinking, sustainability-oriented, and pragmatic institution. While our analysis demonstrates significant paybacks in the next few decades, the value of the project lies in offsetting Dartmouth's own carbon emissions. The timber will return: healthy soil and other regenerative ecosystem dynamics are expected to quickly restore timber volumes, increasing the Grant’s current yield many times over. As the value of this timber rises over time, average timber revenue at the Grant is expected to increase significantly above inflation. Input costs are expected to be low: strong soil health

and existing road infrastructure will minimize management costs. When this timber returns, the school will also have many other options: sell the carbon offsets in expanding carbon markets (Offsets of this type will be able to be sold in California's cap-and-trade program under the profitable Afforestration/Reforestation Project Type [Current: 52]), utilize the vegetation sustainably in a wood-burning power plant, preserve the forest for the state, or utilize the forest for recreation, to name a few.

c. Forest Regeneration:

There are many factors involved in forest regeneration, and two main strategies in addressing forest regeneration. Managed forest regeneration involves external forces, primarily people replanting tree seedlings. Natural forest regeneration involves no external forces, and allows forests to grow on their own. Birds, wind, animals, and other factors permit seed dispersal to effectively re-plant tree seeds. In both regeneration strategies there are several factors that are important in ensuring successful regeneration. Sunlight, soil type, location, and climate are some of the factors that allow trees to regenerate successfully. All trees require sunlight for photosynthesis. Therefore, trees always compete with one another for sunlight. In most Northeast forests, availability of sunlight is a limiting factor for success of regeneration. “Species that compete best in full sunlight have the capacity for rapid height growth and are often found in the upper layers of the forest canopy. Species that are able to compete in the shade of other trees can occupy lower layers in the canopy, and each canopy layer will intercept additional sunlight” (Ward and Worthley 2004: 13). Soil is also important for the regeneration

of the forest. Soil fertility, moisture, and texture determine how well a species can grow at any area. “Elements such as carbon, nitrogen and hydrogen usually cycle through the organic material present in the forest, while potassium and phosphorous come from the mineral portion (Ward and Worthley 2004: 14). As the Bayroot properties and the Grant both exist within the Diamond Watershed (Dead Diamond and Swift Diamond Rivers), are adjacent properties, and have similar topography, they have similar soil makeups. While the degraded lands of the Bayroot properties have more outwashed and degraded soils, especially near rivers, the primary soil type of both properties is loamy and fertile, although some sections are especially sandy or poorly drained depending on location. The initial trees expected to grow are the fast-growing softwoods that can take advantage of the limited competition, particularly the fast growing Fir trees, and later the slower growing Spruce trees, followed by Hardwoods. These softwoods will likely occupy basal areas where erosion and soil steepness is limited. Diagram 6 in the Appendix demonstrates how quickly the forest is expected to regenerate until 2055 (significant Timber harvesting incorporated in diagram after 2055).

B. Dartmouth’s Emissions

Dartmouth College currently emits about 80,000 MTCDE (metric tons of carbon dioxide equivalent equivalent) per year (ENVS 50 2004: 80). The College's commitment to reduce emissions by 30% by 2030 proves the College has strong commitments to sustainability initiatives. Dartmouth received an A- on its recent Sustainability Report Card, owing primarily to its strong scores on "food and recycling, green building, student involvement, endowment transparency,

investment priorities, and shareholder engagement" (Dartmouth College 2009). Isolated from natural gas pipelines, wind and solar farms, and significant hydropower sources limits alternative energy potential at Dartmouth, making it very dependent upon the fossil fuel burning power plant and fossil fuel-based electricity from the national grid. According to research included in Dartmouth's Environmental 50 report in 2004, the power plant on campus emits between 50,000 and 60,000 MTCDE per year. Clearly, Dartmouth has the desire and the motivation to progress on its sustainability initiative, but gaining independence from this power plant in the short term is very unlikely. Therefore, in addition to increasing energy efficiency on campus, additional reductions are necessary. If Dartmouth truly wishes to be a dynamic and progressive sustainability leader nationwide, it needs to find ways to offset its emissions. Purchasing and preserving the Bayroot properties provides Dartmouth with an incredible opportunity to do this. Our research indicates that restoring these properties to health simply by allowing the forest to regenerate on its own will offer almost 14,000 tons of C02 equivalent per annum on average in the next 60 years, which is when forest stocks reach their maximum. We based these numbers on the Second College Grant's current sequestration capacity of 9,800 tons of C02 equivalent per annum multiplied by the increased number of acres, but included several other variables. We found that the initial low quantity of C02 sequestration caused by the heavy cutting will later by offset by the rapid forest growth and much larger sequestration rates than emission rates per acre (much less emitted carbon from decomposition, etc. than sequestered carbon from forest regeneration. Several diagrams that helped us quantify this sequestration potential

are included in the Appendix). Therefore, if Dartmouth succeeds in attaining its 30% reduction in emissions by 2030, this project will then offer an additional 25% reduction in Dartmouth's emissions per annum.

The College must be prepared financially to purchase the Bayroot LLC properties if and when they go on the market. Once acquired and restored, these properties have the potential to significantly reduce Dartmouth's emissions and transform the College into a pragmatic nation-wide leader in the realm of sustainability. Forest Legacy Funds and conservation easements should be utilized to reduce the true cost of this purchase, and the acquisition should be made and publicized on the upcoming 250th birthday celebration of Dartmouth College.

C. Current Logging and Market Trends

Over the past few decades, timber values have increased dramatically for all types and species of wood. The price of timber in the Northern Forest has gone up an average of 1000% since 1959 (Irland, Lloyd 2011). This varies with species and types of wood; white pine pulpwood, going from $0.58 per ton in 1959 to $4.00 per ton in 2009, had the lowest percentage increase and sugar maple veneer, going from $3.24 per ton in 1959 to $106.11 per ton in 2009, had the highest percentage increase (Irland, Lloyd 2011). These changes are also occurring on time scales as small as weeks. A metric ton of (northern forest) softwood pulp has increased in value from $900.73 to $929.12 in just four weeks (O'Brien, John 2013). Price trends for saw logs typically show decreases in 2012 numbers from 2011 prices. Hard maple and yellow birch saw log prices showed decreases of $88 and $121.59 per MBF, respectively. However overall trends from 2007 onward show a slow increase

in prices. Spruce and fir saw log prices showed an increase of $45 from 2011 to 2012, and have been steadily increasing since 2010. While prices for saw logs appear to be decreasing, the prices for pulp have shown increases. Hardwood and softwood pulp have seen increases in prices from 2011 to 2012 by $1.69 and $4.71, respectively. Hard maple and yellow birch pulp harvests have shown dramatic changes in price from 2011 to 2012 numbers by $134.60 and $86.68, respectively. In general, annual harvest data shows that since 1995, pulpwood harvests exceed saw log harvests by an average of 2463 cords annually. After prices for both saw logs and pulpwood plummeted in 2008, they have since shown general increasing trends since 2012 (Evans , Kevin 2013).

In addition to these market trends over time, it is important to note that the value of different types of wood is very different. One cord of softwood pulp sells for $25-40 depending on the species – Pine for example is more valuable than Spruce. The range of values for hardwood pulp is very close to those of softwoods. A very clear distinction in value of wood is the difference between pulpwood and sawlogs. One thousand board feet (MBF) of pine can sell for about $140, that's more than 5 times the value of pine as pulpwood. A drawback of harvesting sawlogs, however, is that they take much longer to grow in order to have such values. A pine tree harvested for pulpwood needs to grow about 20-30 years whereas a pine tree harvested for sawlogs needs to grow at least 100 years.

Cutting practices are designed to diversify forest age classes, to improve stand structure, and to maintain or increase species diversity. Before each harvest the College Forester consults with wildlife biologists to ensure the harvest will have

the most benefit and least impact to the ecosystem. Harvesting has occurred since 1828. Since 1985, Dartmouth has harvested an average of 7,047 cords of wood annually. The newly calculated sustainable level of harvest is now 7800 cords annually. The newly calculated sustainable level of harvest is now 7800 cords annually. Growth data show that gross growth rates are at .495 cords per acre per year. Net growth rate is .119 cords per acre per year. Removal is .119 cords per acre per year and mortality is .376 cords per acre per year (Master Plan 2011: 72; Forest Management Plan). These rates are based upon 5 year measured growth, and must be reevaluated often and applied with caution.

Annual timber harvest yields over time are typically not constant but rather show fluctuations in the form of peaks and valleys over time cycles as short as two year periods. While this is observed, it is also important to note that within the last two decades (since 1994), average harvests have not exceeded sustainable harvest volume limits. Just within the last decade (since 2000), average annual harvests hit below the sustainable levels. The 2012 value for sustainable harvest volume is set at 7,475 cords while 2012 harvests are recorded at 7,019 cords for a difference of 456 cords (Evans, Kevin 2013).

The Grant has been considering converting a portion of the hardwood pulp into sawlogs because the value of sawlogs is five times higher than pulpwood. In addition to the higher value, having a stand with older trees allows for a more stable ecosystem (Irland, Lloyd 2011). Since sawlog stands require fewer harvests, the forest can be maintained in a more pristine condition with less negative impacts on ecosystem services that result from disturbances caused by harvesting activities. As

of 1986, the cutting practices changed to more heavily harvest hardwood pulp and leave hardwood logs behind, since only 1% of hardwoods were sawlogs at the time (Evans, Kevin 2013).

The most recent cruise (timber inventory) of 1999 showed that these logging practices changed the demographic of the Grant to 23% hardwood being sawlogs (Dartmouth College Woodlands 2011). This 23% represented about 38 million board feet and the goal was to reach 40-50 million board feet of hardwood sawlogs. Having continued with this cutting practice of cutting pulpwood more heavily than sawlogs, the current estimate for hardwood sawlogs lies at about 45 million board feet.

Since switching pulpwood out for sawlogs is not only beneficial for the ecosystem and its services but also for the Grant's economic profits, the idea was to look for ways to increase the Grant's hardwood sawlog stand beyond 50 million board feet. In 1947, the Grant experienced its maximum hardwood sawlog amount at 70 million board feet (Evans, Kevin 2013). Researchers examined the feasibility of increasing the hardwood sawlog number to 50-60 million board feet. Their rationale considered that cutting down additional large extents of hardwood pulp and replacing it with hardwood sawlogs would earn the Grant more profits in the long run, due to the higher value of sawlogs versus pulp. Keeping in mind carbon offsets as a potential suggestion, speeding up this conversion would also allow the Grant to lower its baseline for carbon credits, which means that its profits from these could be much higher. Moreover, getting a conservation easement in addition to the carbon credits could further maximize these profits. Finally, the lifespan of carbon

credits is 100 years, which is how long it would take for the sawlogs to grow before they can be cut down to maximize profits (Irland 2011).

Further consideration of this idea allowed the plan to be examined in more detail. Increasing the yearly harvest in the Grant is difficult, as it is already a challenge to harvest at the minimum 7,000 cords needed for a sustainable harvest. In fact between 1994 and 2012, the Grant's total harvest was below the sustainable harvest for 10 of those years (Evans, Kevin 2013). The reasons for this are that physically going into the forest to harvest and remove the timber takes a lot of time, labor and money. If too much timber is cut, some timber may remain in the forest without being removed. Also, if more pulpwood trees are cut down, there is no guarantee that that same land will be able to grow higher quality wood needed for sawlogs. The soils are not able to maintain a larger stand of sawlogs with the current sustainable management practices, unless the Grant is willing to give up ecosystem services and the health of the environment. Furthermore, harvests must drop following a period of high timber harvest. During those following years, it is very possible that the Grant's management costs will exceed its earnings, which can make the Grant a liability as opposed to an asset for the college. Conclusions reached from an analysis of these results determine that reaching beyond 50 million board feet would be difficult as well as economically and environmentally unsustainable.

In the 1940s, the Grant maintained 70 million hardwood sawlog board feet because the demographic and management of the Grant was drastically different than the current management plan. At that time, the Grant was managed to produce high revenues to pay for students' financial aid, and the management gave little

consideration to the environment and the value of ecosystem services. Today, the Grant is very sustainably managed and still earns some profits—though much lower profits, since students' tuitions are no longer paid through profits collected from this resource. Attempting to cut down more pulpwood and switching to sawlogs is risky because the Grant is close to its current maximum sawlog levels, the growth rates of sawlogs will be slower and yield lower quality of wood, and large scale harvests create disturbances that can damage ecosystem services.

As a result of the issues regarding the increase of hardwood sawlogs, it is recommended that this additional conversion between sawlogs and pulpwood not occur. It is also recommended that another cruise take place as soon as possible. The Grant Management Plan suggested having cruises every 10 years, however, the Grant has not had a cruise in 14 years. Conducting a new cruise would allow the College to evaluate if there is another possibility for lowering the baseline for carbon credits or changing the harvesting practices in order to earn more profits directly from harvesting.

It is important to keep in mind that, regardless of the forestry practice, getting a conservation easement will still be possible without additional stipulations for harvesting. In addition to sponsoring a cruise in the coming year, analysis in this report suggests having these cruises take place with shorter time lapses. Having a fairly recent timber inventory of the Grant and updating it regularly allows the Grant Management Committee to pick up on trends present in the Grant's timber stands. This data can also be used for research projects by students and faculty as a way to increase the involvement of the Dartmouth community at the Grant. While

lowering the Grant's baseline currently may seem out of reach, completing new cruises will provide further information on alternative options to make the most out of all the resources on the Grant without damaging the environment and the services it provides.

D. Evaluation of Carbon Markets

Carbon Markets increasingly have been proposed as a way to mitigate the effects of climate change in national policy debate. For the Grant, markets offer the opportunity for payment through offsets, which allow participants to buy reductions from a third party to compensate for emissions occurring elsewhere. Markets consist of *compliance* markets, which fulfill obligations within a cap-and-trade system, and *voluntary* markets, which allow individuals or companies to achieve carbon neutrality (net zero carbon emissions).

Currently, much of the U.S. market is voluntary. Most notably, the *Chicago Climate Exchange* (CCX) traded greenhouse gas emission allowances from 2003 to 2010. However, compliance markets have become more prevalent on the regional level; since 2009, seven Northeastern states (including New Hampshire) have participated in the *Regional Greenhouse Gas Initiative* (RGGI), which limits CO_2 emissions from energy utilities. In 2006, California passed the *Global Warming Solutions Act* (AB 32) and has since launched a cap-and-trade under the California Air Resources Board (CARB) in conjunction with the Western Climate Initiative. CARB began quarterly auctions of emissions allowances in November 2012, and compliance obligations took effect January 1st, 2013. National policy concerning compliance markets has been more stagnant; the 2009 Waxman-Markey bill (the

American Clean Energy and Security Act), which proposed a national emissions trading plan, was approved by the House of Representatives but ultimately defeated in the Senate.

California's state cap-and-trade system indicates likelihood that a national carbon-trading scheme will be adopted in the future over other proposed mitigation policies, like a carbon tax. If the Grant were to pursue carbon offsets, it would mostly likely participate through the Californian markets; currently, RGGI and several voluntary markets only accept offsets through Afforestation (planting of new trees) projects, which would be incompatible the existing sustainable forest management plan implemented at the Grant.

Currently, participation in Carbon Markets carries some degree of risk and uncertainty due to U.S inexperience in compliance markets. A consideration of markets in Europe, which has been more robust in its climate change mitigation efforts, illustrates potential problems of stability. The *European Union Emissions Trading Scheme* (EU ETS), launched in 2005, plays a critical role in EU climate policy, covering majorly emitting installations in all 27 EU member states. Since its initial launch however, the program has been criticized for price volatility, windfall profits, and failure to achieve emissions reductions, largely associated with an over-allocation of allowances due to grandfathering in Phase 1 of the program. Similar concerns may arise if the Grant were to participate in the California market. While CARB has implemented measures to prevent volatility and instability-- set floor prices ($10/allowance at first quarterly auction on November 14th, 2012), purchase limits, and an independent market monitor for example-- the exact outcomes of the

California cap-and-trade system, launched officially just this year, are yet unclear. The factor of unpredictability, in conjunction with significant upfront costs for offset certification, and future monitoring costs, make the sale of offsets not recommendable at the present time.

However, future participation in carbon markets remains a possibility. As detailed in the previous section, the existing management plan of the Grant poses a challenge to receiving offset verification; potential reductions through avoided deforestation are limited, as current timber harvest practices on the Grant are fairly sustainable. However, California markets also accept *Avoided Conversion Projects* that prevent the conversion of forestland to non-forest land among private owners through a *Qualified Conservation Easement*. Furthermore, the recommendations for an easement option can include stipulations that qualify the Grant as a certifiable Forest Offset Project under the Air and Resources Board's requirements. The specific requirements and processes for pursuing an Easement are detailed further detailed at length later in this document.

For the College, achieving carbon neutrality through offsets may also be of interest. Currently the College at large depends on Number 6 Fuel oil for most of its heat and electricity needs; with its dependence on a heavy and dirty fuel source, Dartmouth has the largest carbon footprint among all Ivy League schools. The goal of carbon neutrality--achieving zero net Carbon Dioxide emissions—through avoided deforestation may be for future management of the Grant. Several peer institutions, including Middlebury, Colby, and Harvard, have committed to goals of achieving carbon neutrality within the next 5-10 years. Furthermore, as discussions

of "sustainability" become increasingly common on college campuses nation-wide, achieving carbon neutrality is certainly well within Dartmouth's goals as a leading educational institution. The following section explores in detail the full carbon sequestration capacities of the Grant.

6. Possibility of a Conservation Easement

The Grant provides Dartmouth students and alumni with significant opportunity to experience recreational and educational endeavors on pristine land that is exceptionally well kept. The Grant is a luxury for members of the College, and should be protected against too much change in the future. Various meetings with the Grant Management Committee suggest the Committee's commitment to maintaining the exclusivity and natural state of the Grant. With this in mind, it seems logical that the College should pursue a conservation easement in order to protect and preserve the Grant in a way that would ensure its continued existence for all future members of the College.

Example of posted land protected by an easement.
Source: Mellette Forestry Group LLC, "A Closer Look At Conservation Easements." Accessed May 25, 2013. http://www.melletteforestry.com/a-closer-look-at-conservation-easements.

A conservation easement is a voluntary legal contract that can be entered or donated by a landowner and given to a specific land trust or government entity to achieve specific conservation purposes. The easement will set a limit on how the land can be altered, such as development or subdivision of the land. The main purpose is to preserve the land to align with the intentions of the current landowner. The Grant is intended to provide College members with the opportunity to experience nature in its most simple form, which means that limitations to development would be negligible and would align with the Management Committee's ideology. Easements are voluntary and can thus be customized to meet the personal and financial needs of the landowner. This implies that the College can include any amount of development in the easement as it wishes and can receive significant tax advantages through the donation of the Grant. The easement can also cover an entire property or just a few parcels of the land in order to identify any rights the landowner wishes to limit or maintain.

The origin of donating lands to reservations began in Massachusetts in 1891 (Dana, Ramsey 1989). Since the establishment of these land trusts, the United States has protected over two million acres from development. Though traditional forms of property law call for limited rights to landowners, conservation easements encompass a donation executed in perpetuity in order to maintain the integrity and purpose of the land as wanted from the donee. Conservation easements have been used since the 1920s but it is not until the 1980s that their use became popular (Gustanski, Squires 2000). During the 1980s the National Conference of commissioners on Uniform State Laws began to put efforts toward a Uniform

Conservation Easement Act (UCEA). The act was ultimately approved in August 1981, and a number of states began to adopt the statutes of the UCEA. Enforcement of the act remains in the hands of each state and many states tweaked or customized the act to fit with their preferences. The IRS remains the ultimate authority in determining compensation value for each easement contract. (Gustanski, Squires 2000)

According to one land trust, Tall Timbers, their typical conservation easement contains any or all of the following: (1) Follow the Internal Revenue Code for conservation easements; (2) Specifications for how the easement meets the goals of Tall Timbers; (3) Establishes criteria where the easement meets the guidelines as a natural habitat, productive forestry, scenic values, or a historically important land area; (4) Protects against development; (5) Continual use of the land as it stands now is maintained for the future; (6) Allow timber harvesting in conformance with "best management" standards; (7) Establish a maximum number of buildings allowed on the property; and (8) Conserve a special animal or plant habitat, wetland feature, or historic resource (Tall Timbers, 2013). These stipulations render the Grant as an ideal candidate to qualify for a conservation easement with Tall Timbers.

A landowner would want to donate a conservation easement in order to protect, preserve, and maintain their land in a way that aligns with their interests. This would imply that the landowner appreciates a landscape in its current state, and they want to maintain their land for future generations. There is also significant monetary compensation that can come from donating an

easement. Potential tax breaks include a significant decrease in federal and state income and estate taxes and could include property tax relief as well. Knowing the Grant Management Committee's goal to maintain the current state of the Grant and the College's incentives to decrease costs and potentially generate income, it would seem that an easement could appeal to both parties.

There are a number of organizations an easement could be donated to. The decision is ultimately at the hands of the landowner, and can often coincide with the land trust that offers the best stipulations built into the easement. Some land trusts will accept certain donations with stronger benefits such as more tax breaks with relatively less strict easements. It would be up to the College and their attorneys to perform their due diligence to donate to an institution that incorporates the best interests of the College and the Grant into the easement. The ultimate decision comes down to Internal Revenue Code guidelines, however each land trust can utilize this code in different ways. New Hampshire has many organizations the College could pursue for the donation of the Grant. Among these are Moose Mountain Regional Greenways, New Hampshire Audubon, Trust for Public Land, The Nature Conservancy, etc. A full list can be found on New Hampshire's Department of Environmental Services website, www.des.state.nh.us.

The rights and responsibilities of the landowner depend upon the stipulations agreed upon in the easement contract. The easement will maintain specific limitations on the land and the responsibility that these limitations are kept is up to the landowner. There can be random inspections performed by the land trust where they survey the land and ensure the land is being maintained as

specified in the easement. A violation of the easement will mean a correction must be made in the short term and continuous violations could lead to condemnation of the land. Because the land trust is not the landowner, the land trust must first notify the landowner that an inspection will occur and they also have limited rights to access the property annually.

Making changes to a conservation easement can be arduous and often not possible. Once an easement is entered, the initial goal of the easement will have to be maintained. There are often subcontracts that include some sort of conservation management plan that can be legally altered so long as the initial conservation goals are not violated. These changes are often very small because making large changes is quite difficult and in many cases is not possible unless the changes to the land are built into the easement. It would be in the College's best interest to build any future buildings or infrastructure into the easement if that is the course the College chooses to pursue.

While not all land trusts will accept certain provisions in an easement, it is not difficult to find a land trust or government entity that would be willing to enter an agreement. These institutions are interested in preserving the land and preventing any future development by landowners. Entering an easement does not mean that it becomes public land; it depends on the contract and the wishes of the landowner. The costs associated with entering an easement are relatively small. There are essentially three main costs that would be rendered negligible as long as the easement is ultimately entered and appropriate tax breaks are given. These costs include (1) hiring of an attorney for advice and drafting of the

easement, (2) hiring of appraisers to determine the value of the easement, and (3) an accountant to determine any income tax implications. (Tall Timbers, 2013).

A. Conservation Easement Success in Hanover and Lebanon

Rapid urban development in Hanover and Lebanon led Dartmouth College and the town of Lebanon to purchase nearly 4000 acres of contiguous forestland in Lebanon to protect the natural resources in the area. Known as the "Landmark Complex," the property contains some of the most ecologically important areas in the region, including the Boston Lot Lake and other significant wetlands. With a diversity of ecosystems, the Landmark Complex is home to a wide range of animal habitats, including major deer wintering yards and habitat for bear and moose (Van de Poll, 2010, Pg. 29). The lake contains largemouth and smallmouth bass, both fish that were introduced from the Midwest and compete with yellow perch, lake chub, and golden shiners (Van de Poll, 2010, Pg. 35). To ensure the perpetuity of such a vital natural resource in the midst of increasing urbanization, three conservation easements have been placed on the property, protecting about 470 non-contiguous acres of forest and wetlands. The Town of Hanover is the holder of the 19-acre Medical Center Pond easement, part of an important wetland area that has been threatened by development. The 326-acre Boston Lot Lake easement is held by the Society for the Protection of New Hampshire Forests and creates a significant protected buffer zone uphill from the Boston Lot Lake, and the Indian Ridge easement is held by the Town of Hanover (National Conservation Easement Database, 2013). The placement of three conservation easements on this land could alone be considered a great success, but the title of a conservation easement does

not prohibit visitors from breaking the easement rules; thus in order to be deemed successful, scheduled monitoring and evaluation of the land management by experts is required.

The conservation easement placed on the Boston Lot Lake must be well stewarded per heavy usage by the community and college, and the success of this easement can be measured based on the conservation easement steward's report. In his monitoring statement to the City of Lebanon's Conservation Commission and Planning Departments, Paul Gagnon remarks on the success of the Boston Lot Lake easement, while also making recommendations for future management strategies on the property. Stipulating the difficulties associated with managing a property that receives high-use from the community, Gagnon then remarks that the city's stewardship of the property is exemplary. His report on the Boston Lot Lake easement details some concerns with litter and campsite over usage, but, overall, he was impressed with the conservation and monitoring efforts in action there (Agenda Conservation Commission, 2011). Those in charge of monitoring an easement on the Grant will not experience many problems that face the land stewards in managing the easements within the Landmark Complex because the isolation and size of the Grant helps to eliminate some of the over-usage and litter issues experienced at the Landmark Complex. However, the impetus for placing a conservation easement on the Landmark Lands revolved around providing protection of important ecological areas, and, as stated above, several significant ecosystems exist on the Grant; thus, considerations for the implementation of a conservation easement on this property should begin immediately.

B. Compensation from Donation or Sale of an Easement

Conservation easements create a balance between the preservation of important natural resources and the economic activities associated with the land. In donating or selling an easement, the landholder relinquishes some rights for future land development; but, by classifying a conservation easement more specifically as a Working Forest Conservation Easement (WFCE), Dartmouth would retain much of the current public and financial value it garners from the land, while insuring the protection of significant natural resource (Dan Tesini, 2009). In a region with one of the last remaining undeveloped watersheds in New England, and an economy driven by forest related products, an easement on the Grant would not only bolster Dartmouth's reputation in the community, but also act an impetus for adjacent properties to sell or donate their land to a land trust. Furthermore, the process of selling a conservation easement to a land trust, as opposed to donating one, usually requires the landowner to provide evidence that the property has significant ecological importance in the region. And as the Grant property has been sought out by regional land trusts in the past for its ecological value, selling an easement to the appropriate land trust should be relatively simple. The success of a conservation easement relies on the landowner and the land buyer coming to an agreed-upon management plan for the specific site, but the financial compensation to Dartmouth must be appropriate for the transaction to be finalized.

After finding a suitable Land Trust whose mission coincides with that of the Grant's management plan, Dartmouth must then choose the best method for land transfer. Dartmouth can donate or sell an easement to a land trust and, in turn, will

receive compensation for any loss of land value. The price of a conservation easement is determined by an independent appraisal from a reputable company, which measures the value of the land before and after the easement would be in place. In this assessment, the appraiser takes into account the potential developmental value of the land, which is described as the collection of activities a landowner could conduct on their property. In selling or donating an easement, Dartmouth would receive due compensation for the difference in the property value before and after implementing the easement. Reimbursement for the loss in property value can be received either through tax deductions for a charitable donation or through financial compensation from a purchasing land trust.

Although land trusts are becoming increasingly numerous, conservation

Connecticut Headwaters Project Case Study

Oftentimes Land Trusts and other conservation organizations urge the landowner to donate their land for tax deductions because the funding for these non-profits is minimal. Therefore, these easement-purchasing funds are mostly limited to buying small, ecologically important tracts of land, but combined conservation efforts by multiple entities can succeed in purchasing extremely large areas of land for sustained conservation. The recent Connecticut Headwaters project stands as an example of this type of conservation effort when a working forest conservation easement was placed on almost 200,000 acres of forestland in Northern New Hampshire.

As the Northern Hardwood Forest is the backbone of the regional economy, the State of New Hampshire and the Trust for Public Land sought measures to protect this vital resource, and when International Paper decided to sell this tract of land in the early 2000's, a combined conservation effort began to protect this contiguous resource from urban development. The local community utilizes this land for timber-related jobs and recreational opportunities; this property also serves as a popular tourist destination for snowmobiling, fishing, hunting, and other recreational options. Moreover, the land contains valuable ecological resources by being home to three of the Connecticut River's four headwater lakes where at least 20 rare species exist. In 2001, International Paper sold the 171,000 acres property to the Trust for Public Land, a national non-profit conservation agency, who served the Connecticut Headwaters Projects as a pass-through entity and facilitator of this complex conservation effort.

After purchasing the 171,000-Acre property from International Paper, the TPL began work with the Society for the Protection of New Hampshire Forests, The

funding by these groups remains minimal; thus the typical land transfer technique is donation. By donating a conservation easement to a recognized, charitable land trust, the landholder becomes eligible for significant tax deductions, and, resultantly, by adhering to the necessary federal tax regulations regarding these charitable donations, Dartmouth would be eligible to receive proper tax credit for the donation. A brief overview of these rules and management restrictions provides a solid framework for how to consider the donation option, but consultation with a qualified legal expert on the specific guidelines for receiving tax credit is strongly encouraged. The IRS requires that conservation easements meet basic conservation standards to qualify as a charitable tax donation, and these standards require the easement to be:

Nature Conservancy of New Hampshire, and other support groups, to raise the 42 million dollars needed to purchase the Land. Further financial support came from critical loans from the Lyme Timber Company, the Open Space Conservancy, the Land and Community Heritage Investment Program, and Wainwright Bank and Trust Company. Following the land investment of the TPL, a conservation task force held public hearings in an effort to develop a vision for the future of this land. Convened by Senator Judd Gregg and then-Governor Jeanne Shaheen, the Connecticut Lakes Headwaters Partnership Task Force included local residents, state and federal officials, conservation organizations, and North Country Leaders. After coming into control of this extensive landmass, the TPL and the CLHPTF agreed upon a future management plan for the property that would preserve the local and regional benefit of this valuable resource.

The TPL purchased 171,000 acres to protect the valuable forest and ecological resources on the property, and after years of task force meetings and fund-raising activities, the TPL sold a 25,000-acre and a 146,000-acre easement to the State of New Hampshire Fish and Game Department and the Department of Resources and Economic Development respectively. The Fish and Game Department of New Hampshire bought the 25,000-acre tract from the TPL, and the Nature Conservancy holds the conservation easement on this land. Defined as a natural area, the land contains habitats for migratory songbirds, waterfowl, moose, and other mammals, and, resultantly, this property is managed as a nature preserve. 15,000-acres of this easement will be allowed to grow without human intervention, and trees will be allowed to grow large or to fall and rot in place. The remaining 10,000 acres will be maintained for the protection of wildlife in the area. The

perpetual, held by a qualified conservation organization, and serve a valid conservation purpose (Land Trust Alliance, No Date) Furthermore, the land appraisal must be conducted by a qualified party, which should be state certified and should not receive compensation by valuing the land. The most significant financial benefit to Dartmouth from donating a conservation easement to a land trust would be the federal income tax deductions received from making a charitable donation. To qualify for federal income tax deductions, the charitable donation (or bargain sale of land) must be received by a qualified conservation organization and must follow the conservation requirements described in US Tax Code Section 26 170(h) (Land Trust Alliance, No Date) (Jones, Jeff, William Wombacher, Lynne Sherrod, Heather McMillian, 2009) By

TPL sold a working forest conservation easement on the remaining 146,000 acres to the state of New Hampshire's Resource and Economic Development Department. Simultaneously, the TPL sold the 146,000 acres land tract, now under easement, to the Lyme Timber Company, who will manage the forest's timber resources under the terms of the easement. In short, the TPL purchased a 171,000-acre tract of land from International Paper, and after years of planning, the land was divided and sold to the State of New Hampshire Fish and Game Department and the Lyme Timber Company. At the same time, the Nature Conservancy and the State of New Hampshire Department of Resource and Economic Development bought conservation easements on the two sections of the original 171,000-acre land. Now, the 25,000-acre easement guarantees long-term protection from development, as well as protection for the wildlife, on the property. The 146,000-acre tract is also protected from long-term development, but the easement on this land allows for sustainable timber harvesting, which, in turn, bolsters the local economy.

In deciding the most appropriate easement type for the Second College Grant, the Grant Committee should consider the options available and use past easement examples in their decision. The Connecticut Headwaters project exemplifies the ability of conservation groups and government departments to raise the necessary funds for purchasing a large-scale conservation easement. Located in the same region as the Grant, the Connecticut Headwaters property exhibits many of the same ecological features found on the Grant; thus the successful completion of this project reveals the potential for Dartmouth to pursue a similar strategy for the placement of a conservation easement on the Grant.

-Source: TPL Press Release, 2003

donating a conservation easement that adheres to the IRS stipulations for land management, the landowner receives the financial benefits of tax deductions, as well as the qualitative benefits of protecting a valuable forest resource.

Rather than donate an easement to a recognized land trust, the landowner may choose to sell a portion of their land for conservation. The selling of an easement occurs when a land trust or other organization pays the landowner the full value of developmental rights on the land. Whereas, a donation benefits the landowner with a tax deduction of the difference between the land value with and without an easement, a landowner who sells a conservation easement will receive this monetary difference up front. As mentioned earlier, selling a conservation easement is often difficult due to lack of sufficient conservation funding, which, in turn, adds more specific restrictions on land usages (Vermont Land Trust, No Date). *See Connecticut Headwaters Project Insert.* Selling an easement may be more attractive to the landowner because the compensation for easement implementation is received in full at the time of sale, but a hybrid option, a bargain sale of land, incorporates compensation methods from both donating and selling an easement property.

A bargain sale describes a land transfer method that utilizes aspects of both charitable land donations and monetary purchasing of the easement. In a bargain sale easement, the purchasing organization agrees to raise the funds for an agreed upon purchase price, and the landowner agrees to donate an agreed upon percentage of the property value to charity. In order to qualify for federal tax deductions, the donating organization must include the government conservation

stipulations in their easement proposal. (Robert Ross, 2009) After ensuring that the proposal plan obeys the federal rules to qualify for tax deductions, the landowner and purchasing organization then create site-specific management strategies that help to perpetuate the vitality of the forest ecosystem.

C. Feasibility of Implementation

Land trusts and other conservation organizations often limit their land purchasing funds to significant ecological impact areas, so receiving financial compensation for an easement can sometimes be difficult to achieve. But Dartmouth College has received previous inquiries from regional land trusts as to the feasibility of implementing a conservation easement on the Grant. Discussions of selling conservation easements have occurred in the past and these forums found the most suitable location for an easement on the property to be in the northern boundary around the Dead Diamond River watershed. Lyme Timber Company and the Trust for Public Lands approached Dartmouth with a proposal to buy an easement from the college, provided that the funds received by the college contribute to further conservation projects in the area. Because the Grant is home to one of the last remaining undeveloped watershed in the northeast, a conservation easement at this site would further ensure that it remain undeveloped. Dartmouth could receive compensation from land purchases by willing land trusts, as well as compensation from federal income tax deductions; moreover, the college could use the financial benefit it receives from these methods of compensation to protect properties adjacent to the Grant from future development projects. The value of compensation for the land derives from a certified appraisal of the property, but the desired

ecological management goals, set forth in discussions between the seller and buyer, will ultimately affect the final price. A vital step in creating an easement proposal is to prepare site-specific recommendations for land use and conservation. After Dartmouth's conservation goals coincide with the conservations goals of the purchasing land trust, and after the management plan accounts for the federal regulations regarding charitable donations, the college will receive compensation for the sale while maintaining the financial benefit from the economic activities that occur on the land; furthermore, implementing a conservation easement in a vital ecological zone would serve to bolster Dartmouth's reputation in the territory, whereby generating a positive public and political opinion.

It is recommended that the College find the ideal land trust to donate to in order to protect the land for use by the College and its members now and in the future. By placing an easement of the Grant from a bargain sale of land, the College could receive significant monetary compensation, while at the same time maintaining the goals of the Grant Management Committee. Depending on the stipulations met by the College and the Grant Management Committee, the easement could provide the monetary compensation needed to incorporate new infrastructure on the Grant such as a research facility or Internet capabilities in the existing buildings. Due to the College's already sustainable forestry practices, the College would be allowed to continue any and all existing uses for the Grant so long as it is specified in the conservation easement contract. The ultimate consequence of the conservation easement on the Grant would be to give up development rights for most of the property, an act which would ultimately maximize potential

compensation. The management committee could then focus on certain core areas absent from the easement contract and include plan for infrastructure development in the future. It would be in the best interest of the College and the Grant Management Committee to protect this land from future development to maintain the goals of the Grant as they exist today.

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Appendix A – Dartmouth Community

Questions asked in the Campus-wide Survey

1) Please Select Your Class Year
2) How many hours per week do you spend outdoors?
3) How much do you value nature
4) Did you go on a first year trip?
5) If so, which trip did you go on?
6) What groups are you involved in on campus?
7) Have you heard of the Second College Grant?
8) Have you ever been to the Second College Grant?
9) If so, which group did you go to the Second College Grant with?
10) What prevents you from utilizing the Second College Grant more?

Publications of ecological research conducted at Second College Grant

More information available at: www.dartmouth.edu/~bio31

Examples of Undergraduate Research

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Appendix B - Carbon Offset Calculations

Final Data on Timber Stands
Source: Evans, Kevin. 2000. Total Stand Inventory in the Second College Grant. Department of Woodland Operations, Campus Planning and Facilities, Dartmouth College.

Total weight by wood type:

- Total Hardwood Veneer Board Feet: 987,207.55 = **1,658.50868 Tons**
- Total Hardwood Sawlog Board Feet: 24,855,762.26 = **41,757.6805 Tons**
- Total Softwood Sawlog Board Feet: 45,008,336.933 = **43,838.12 Tons**
- Total Boltwood Cords: = 80,282.96.00 = **128,452.736 Tons**
- Total Tielogs Cords: 11,858.72 = **18,973.9 Tons**
- Total Softwood Pulp Tons: **159,834.41 Tons**
- Total Hardwood Pulp Tons: **556,050.92 Tons**
- Total Poplar Pulp Tons: **39,304.37 Tons**

Total Tons: **989,866 tons**
786,194 Hardwood vs. 203,672 Softwood = (3.86:1)
(1999 Grant Inventory Stats: 55% Hardwood, 30% Mixedwood, 14% Softwood) = (3.9:1)

Total Area: 25,242 acres

Carbon Sequestration Capacity Calculations
Conversion Factors for Board Feet to Tons:
- 1,000 Softwood Board Feet = .974 Tons
- 1,000 Hardwood Board Feet = 1.68 Tons

Conversion Factors for Cord to Tons:
- 1 Softwood Cord = 1.4 Tons
- 1 Hardwood Cord = 1.6 Tons

1) Green Biomass converted to Dry Tons
Conversion factors:
Softwood: .463 = 94,300.136 Dry Tons
Hardwood: .529 = 415,896.626 Dry Tons

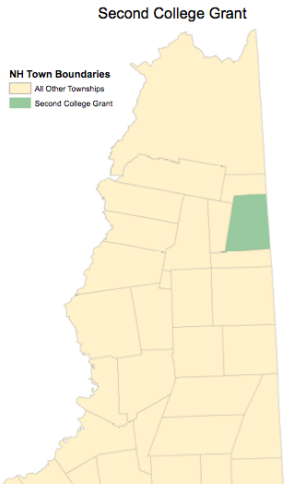
2) Dry weight converted to Sequestered Carbon (Divide by 2)
(Softwood Dry Tons)/2 = 47,150.068 Tons Carbon
(Hardwood Dry Tons)/2 = 207,948.3 Tons Carbon

3) Convert Carbon to Carbon Dioxide Equivalent (multiply Sequestered Carbon by 3.67)
(Softwood Sequestered Tons) x 3.67 = 173.040.75 Tons C02
(Hardwood Sequestered Tons) x 3.67 = 763,170.261 Tons C02

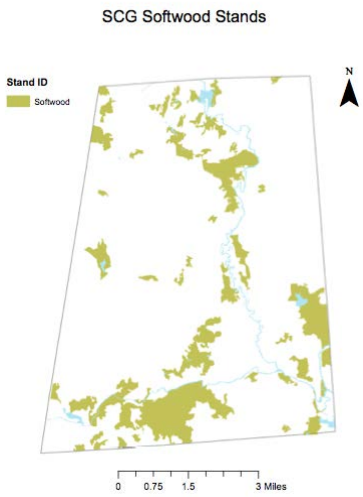
4) Convert Short Tons to Metric Tonnes (in case market place uses Metric Tonnes)
(Softwood Sequestered C02) x .9072 = 156,982.568 Metric Tonnes C02
(Hardwood Sequestered C02) x .9072 = 692,347.824 Metric Tonnes C02

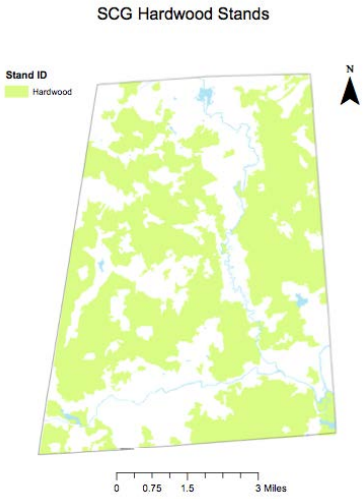
Total sequestered C02 that exists in aboveground timber biomass at Grant = 849,330.392 Metric Tonnes C02
Total Sequestered C02 (849,330.392 Metric Tonnes) / Total Acres at Grant (25,242 acres) = 33.647 Tonnes/Acre

Where is the Grant?

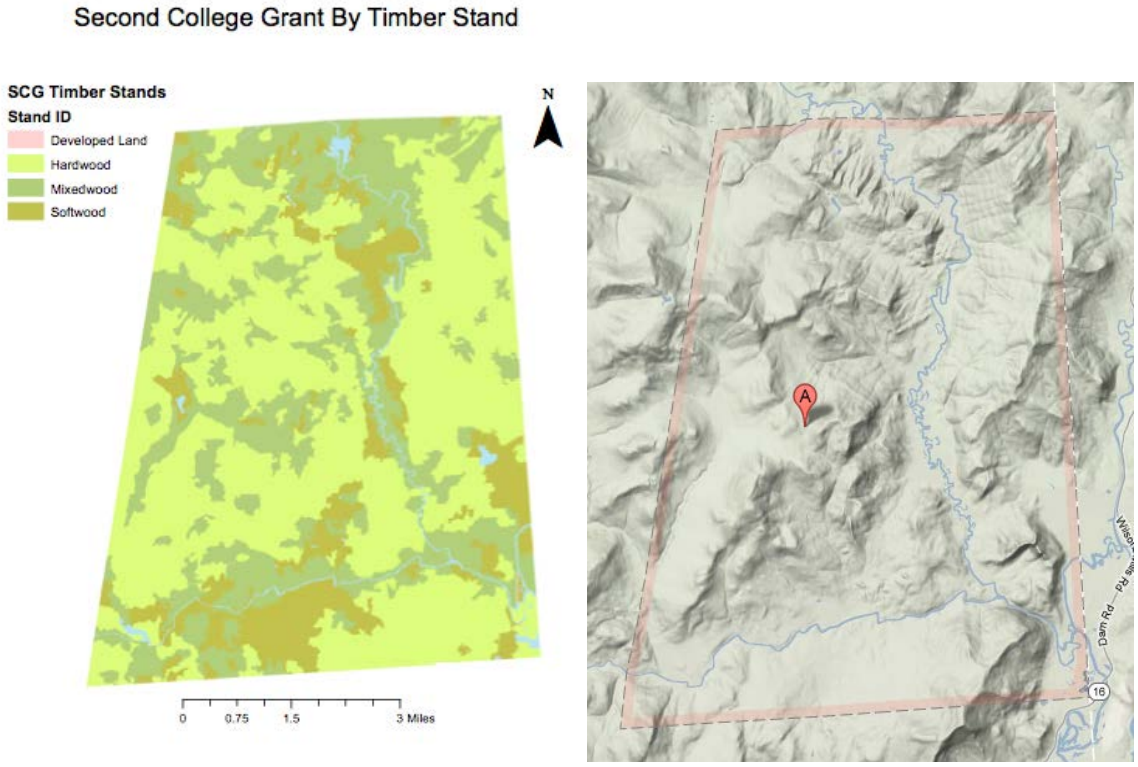


Hardwood vs. Softwood vs. Mixed Wood Stands





Full Stand Profile Vs. Topographical Map

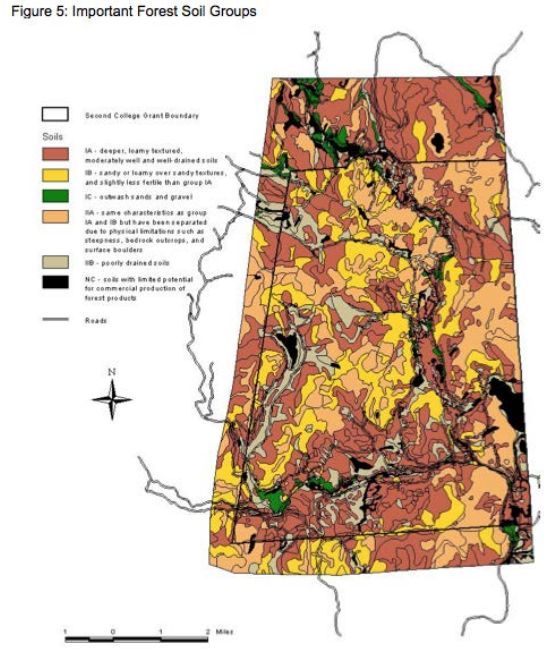


Explanation of Maps

Historically in regional Northern Forests, softwoods moved to occupy higher elevations where conditions were colder and competition was weaker, and hardwoods occupied lower elevations. "Softwoods" are broadly identified as higher elevation trees (for example, conifers dominate the summits of the White Mountains). However in the elevation ranges that exist at the Grant (1,300 to 2,800 ft), there's a plausible discrepancy in the opposite direction, since the areas of lower elevation are in the Dead and the Swift river watersheds. Softwoods in this relative range of elevation would be found down in those areas of high moisture and lower elevation, while the deciduous hardwoods - like the maples, oaks, beaches, etc. would occupy the areas of higher elevation.

Grant terrain is highly variable
ranges from level in the river valleys to very steep in on the mountains and in the gorges.

Diagram 1 (Soil Map)



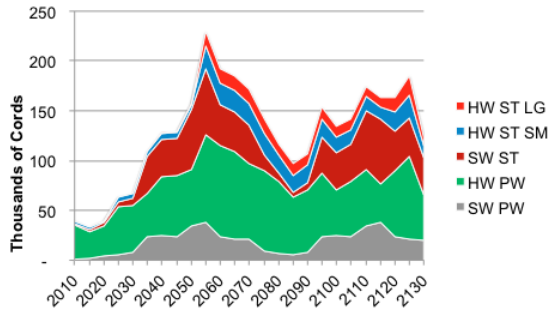
Soils and vegetation defined by 11,000 years of glacial development. Soils are well drained on hillsides, wet in valleys, stony overall. Best for forest development, as opposed to farmland.

Diagram 2 (Diamond Watershed and New Properties)

The Dixville Grant, the Atkinson and Gilmanton Academy Grant, and the Dix's Grant are located to the North and to the West of the Grant. These are the three large grey regions pictured within the Diamond Watershed. The properties are owned by Bayroot LLC and they amount to 47,548 acres.

Diagrams 3,4 (Future Timber Projection Graphics)

This graphic shows the expected increase in **timber volumes** by tree type at the Grant once Dartmouth has purchased and preserved the land.



This graphic shows the expected increase **in value** of the timber that is expected to exist at the Grant once Dartmouth has purchased and preserved the land.

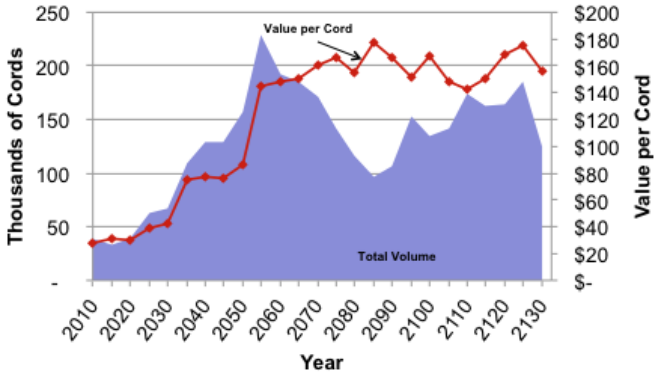


Diagram 5 (Estimated Future Carbon Stocks on New Properties)

This image shows the estimated future carbon stocks by year of a clearcut spruce-fir forest. Spruce/Fir trees are fast growing softwoods that are expected to dominate the initial forest regrowth at the Bayroot properties.

A5.— Regional estimates of timber volume and carbon stocks for spruce-balsam fir stands on forest land after clearcut harvest in the Northeast

Age	Mean volume	Mean carbon density						
		Live tree	Standing dead tree	Under-story	Down dead wood	Forest floor	Soil organic	Total nonsoil
years	*ft³/acre*	*tonnes carbon/acre*						
0	0	0.0	0.0	0.9	8.2	13.6	39.7	22.7
5	0	2.8	0.3	0.7	6.5	9.5	39.7	19.9
15	164	8.1	0.8	0.6	4.3	7.5	39.7	21.4
25	416	13.2	1.3	0.6	3.2	8.4	39.7	26.7
35	738	18.5	1.9	0.6	2.9	9.8	39.7	33.6
45	1,099	23.2	2.3	0.6	2.8	11.2	39.7	40.1
55	1,466	27.8	2.8	0.6	2.9	12.4	39.7	46.5
65	1,807	31.8	3.0	0.5	3.2	13.5	39.7	52.0
75	2,133	35.6	3.1	0.5	3.4	14.4	39.7	57.0
85	2,443	39.0	3.2	0.5	3.7	15.2	39.7	61.6
95	2,738	42.3	3.2	0.5	3.9	15.8	39.7	65.8
105	3,017	45.3	3.3	0.5	4.2	16.4	39.7	69.7
115	3,281	48.1	3.4	0.5	4.4	16.9	39.7	73.3
125	3,532	50.7	3.4	0.5	4.7	17.4	39.7	76.7

Diagram 6 (Approx. Carbon Accumulation Rates expected on Bayroot properties per acre)

Carbon Accumulation Rates
Metric tons CO2 per acre per year

Years Since Planting	**0-5**	**6-10**	**11-15**	**16-20**	
Northeast white/Norway spruce		1.28	1.28	1.40	2.56