# STUDENT ORGANIZATION SUSTAINABILITY INITIATIVE PROPOSAL FORM

## Part I- General Information:

| | |
|---|---|
| **Name of Student Organization** | Stroubles Creek Coalition (SCC), VT StREAM Lab, The Environmental Coalition at VT |
| **Contact/Responsible Person** | Tom Saxton (SCC Planner) |
| **Contact Office Held/Title** | Cully Hession - Biosystems Engineering, StREAM Lab coordinator |
| **Contact Email Address** | thomascsaxton@gmail.com, chession@vt.edu |
| **Contact Telephone Number** | 540-449-6968, 717-495-8402 |

## Part II- Project Cost Information

| | | |
|---|---|---|
| Estimated Cost of this Proposal | $5,500 | See III.C. below |
| Estimated Savings - | See report, sec. D | See III.D. below |
| Net Cost of this Proposal = | $5,500 | |

## Part III- Supporting Information

**A. Please describe your sustainability initiative and attach supporting documentation.**

This proposal seeks funding to support the Stroubles Creek Coalition (SCC) for ongoing riparian restoration efforts along portions of Stroubles Creek owned by Virginia Tech. The requested funding will be used for a variety of projects including large scale bare-root seedling plantings, urban container grown tree plantings, a native plant propagation project at the VT Urban Horticulture Center, public education/outreach, and restoration effectiveness monitoring and research conducted by courses at Virginia Tech. This is an extension of the 2016/17/18 Green RFP grants submitted for the Stroubles Creek Restoration Project. This request will fund project work through 2020. Our success at restoring Stroubles Creek's riparian habitat to date is largely in thanks to historic funding from Green RFP grants.

The sections of Stroubles Creek within the watershed boundaries of this project are listed as an impaired waterway by the Virginia Department of Environmental Quality (VA DEQ). The VA DEQ identified 10 sources causing the impairment, and this project will positively impact the top three sources from that list[11]:

1. Lack of streamside forest
2. Agricultural runoff
3. Increasing development and peak flows from stormwater runoff

This project will effectively and economically address all three of the above sources of impairment. Ensuring the health of the community's watershed is the foundation to a sustainable and resilient system economically, socially, and environmentally.

This funding is needed for various riparian habitat/watershed restoration projects that will be led and conducted by SCC and associated partners:

- Projects including bare root tree plantings, river clean ups, and invasive vegetation management conducted by the Environmental Coalition at VT, the American Water Resource Association at VT, and the Society of American Foresters at VT
- Funding for Conservation Services Inc. (contractor) to plant trees. This is an efficient and effective means of getting a high quality planting accomplished with reduced logistical planning for SCC.
- Funding for materials used for VT's annual 'Big Plant' event co-sponsored by SCC and the Environmental Coalition
- Project work and research conducted by the VT StREAM Lab led by Professor Cully Hession on VT land in addition to VT Foundation Land (if permission is granted to proceed on Foundation Land)
- Support of research and thesis work related to Stroubles Creek restoration work conducted by both undergraduate and graduate students from the College of Natural Resources and Environment, Agriculture and Life Sciences, Biological Systems Engineering (BSE), and Landscape Architecture
- Funding of several undergraduate curriculum course labs and student projects within the College of Natural Resources and Environment (CNRE). Classes currently participating in project work include:
    - Dr. Eric Wiseman's Urban Forest Management class
    - Dr. Sarah Karpenty's Conservation Biology course
    - Dr. Marc Stern's Environmental Interpretation course
- Native Plant Propagation Project conducted by Landscape Architect students and members of the VT Department of Horticulture at the Virginia Tech Urban Horticulture Center (UHC). Plants raised through this project will be planted within the Stroubles Creek watershed. This is the most economical and environmentally sustainable method of raising planting stock for our projects
- Funding for hourly technician wages of $10/hour for field work and coordinator logistical planning for a maximum of 50 hours. This will help us accomplish work beyond typical volunteer duties requiring specialized skills. We often require paid StreamLab field technician help during periods when there are no students on campus to help on time sensitive tasks that require operating heavy machinery. We also rely entirely on our coordinators pulling long hours planning projects, having meetings with University staff, and leading events. The costs for this time and travel for our coordinators is entirely out of their own pockets and this will offer a small reimbursement for a small fraction of their time. If we were to contract out this work between field technicians and coordinator planning it would be an enormous cost far beyond the scope of the funding in this proposal.

**Image 1:** Picture of Holtan Branch in March 2016 prior to livestock exclusion fencing and riparian vegetation plantings funded through Green RFP funds.

**Image 2:** Image near the same location on Holtan Branch as Image 1 after 1.5 years of livestock exclusion (December 2017). Since this image was taken, Green RFP funds have funded more plantings here as well as maintenance work on historic plantings.

The selected restoration sites are located in historically disturbed riparian areas, existing wetlands, and floodplains which are regularly inundated with stormwater runoff. These sites are experiencing a rapid influx of non-native, invasive vegetation such as autumn olive, multiflora rose, and tall fescue. These invasive species threaten

biodiversity, severely hamper natural successional processes, and do not filter out pollutants from surrounding land uses or absorb stormwater runoff as effectively as a native riparian forest would be able to. By planting native seedlings we can ensure the healthiest and most resilient riparian habitat which will provide the greatest benefits to humans, water quality, and wildlife for years to come[7,8,9,10]. Other restoration sites are areas within the Stroubles Creek watershed where tree plantings could positively impact the health and condition of Stroubles Creek, largely through stormwater mitigation. These sites can include urban tree plantings on campus.

The below maps outline current target restoration sites to be funded by this proposal. Future sites could be added to this list as restoration priorities evolve and expand in collaboration with Virginia Tech's Department of Site and Infrastructure Development, Landscape Architect, grounds maintenance staff, and StREAM lab.

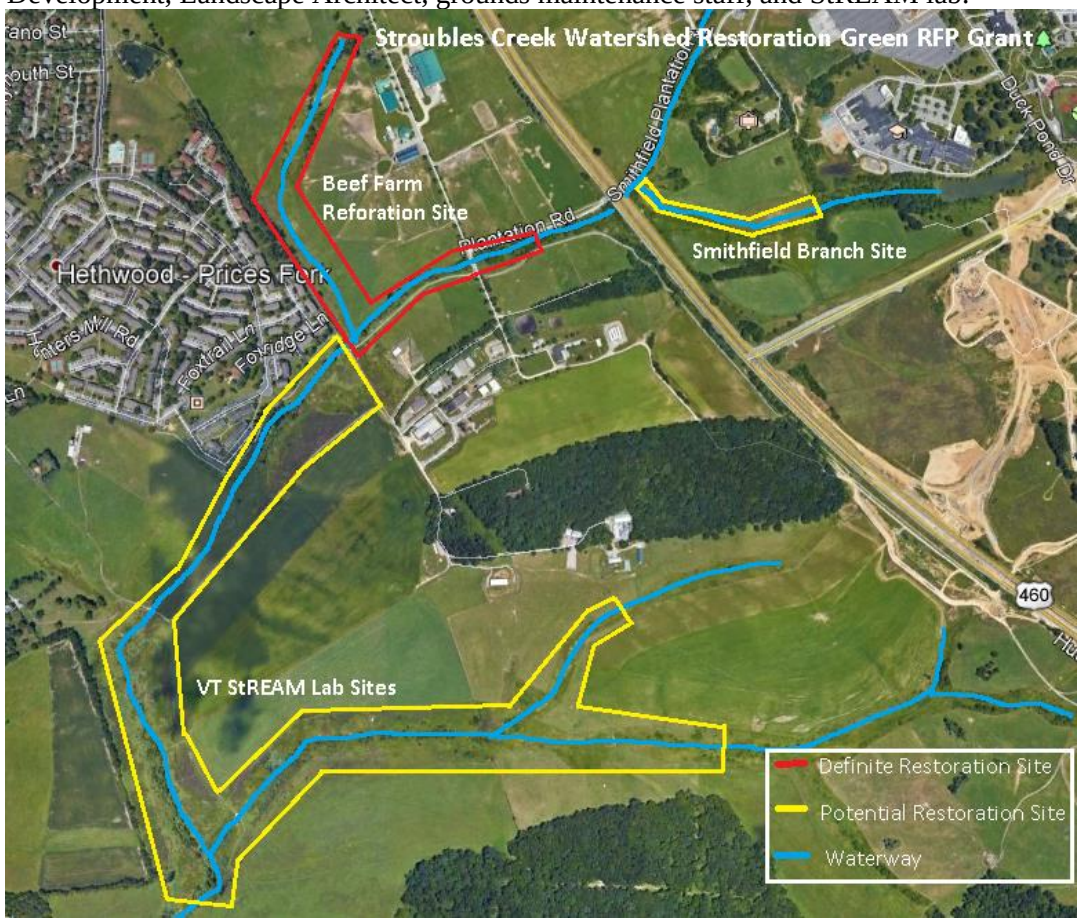


**Figure 1:** An overview map of the proposed Stroubles Creek restoration project on Virginia Tech Property. The sites outlined in red are definite restoration sites while the areas outlined in yellow are potential future sites with funding/permission pending.


**Figure 2:** Overview of historic and future restoration sites near Virginia Tech's Beef Center that have been funded through Green RFP grants. These sites are located along Stroubles Creek and Holtan Branch, a tributary of Stroubles. The sites along Stroubles Creek and the southern half of Holtan Branch were planted between 2014-2017 while the northern 1,300' of Holtan Branch has not yet been planted. Historic Green RFP funding has been largely used in this area. Future funding at this site will be used for additional plantings and maintenance work on the site. Projects like this take continuous work and monitoring to be effective. This site will likely expand Eastward along Plantation Road to 460 in the future.

Work within the sites where previous plantings have occurred would be composed of existing seedling maintenance, invasive species management, and additional plantings in areas that currently have a low vegetation density. Historically, low density plantings have experienced an influx of aggressive non-native vegetation, and by planting a second wave of slower growing, shade tolerant species, we can effectively out-compete aggressive, understory, invasive species and better ensure a healthy riparian forest. Our work on the northern 1,300 feet of Holtan Branch will include improving livestock exclusion fencing and planting native species.

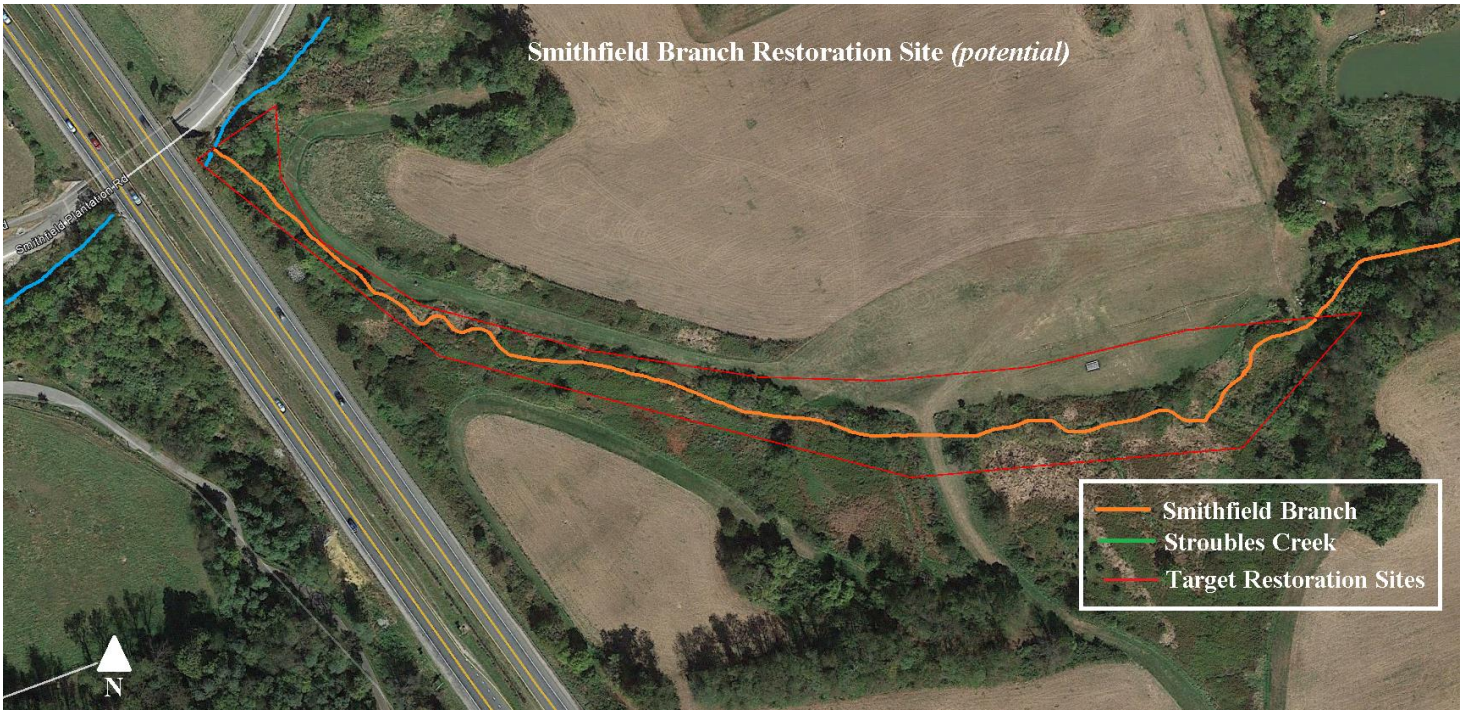


**Figure 3:** Overview map of potential restoration sites along Smithfield Branch. The permission to conduct work here is currently being pursued by SCC. Stakeholders include the Preston Foundation, VT Athletics Department, the Facilities Department, Site Infrastructure and Development, and the sewer authority. Currently, much of this site is completely lacking a riparian forest buffer and is composed of wetland soils. We would plant a narrow riparian buffer on the north side of Smithfield Branch, opposite a broader buffer on the south side. We intend to combine the use of the cross country trail with a healthy stream buffer, while retaining the cultural heritage of Smithfield Plantation. This project would have tremendous positive impacts on the water quality of Stroubles Creek and would absorb excess stormwater runoff from an increasingly urbanized portion of the VT campus upstream.

**Figure 4:** Overview of riparian habitat managed by the VT Biosystems Engineering's VT StREAM lab (outlined in yellow). This area is of immense priority for restoration work along Stroubles. As campus expands westward, it is imperative that we combine campus growth with investment into the health and condition of the riparian habitat downstream of the Virginia Tech campus.

**Image 3**: Stroubles Creek flooding on VT StREAM lab in October 2018. This area is downstream of the VT campus. The common and drastic flooding here is largely aggravated by development of impervious surfaces within the watershed and the channelization of Stroubles Creek through Blacksburg and campus upstream. *All stormwater from VT's campus drains to here.* The culmination of these circumstances contributes to the poor health and condition of Stroubles Creek, leading to this section of the stream being listed as an impaired waterway by the VA DEQ. Through investment in a healthy, native riparian forest through this area, we can offset many of the environmental impacts of the Virginia Tech campus on the Stroubles Creek watershed. Furthermore, this investment will help protect not only the Virginia Tech community, but all communities downstream from stormwater and major flooding events.

For all of these project sites, SCC is working closely with Virginia Tech's Landscape Architects, Site and Infrastructure Development, and VT StREAM Lab. We are proceeding only with permission being granted on a site by site basis. Our goal is to support campus development and aid in afforestation efforts pre and post development, wherever needed.

Restoring riparian buffers is the most reliable and cost effective approach to improving water quality and managing stormwater runoff. By supporting our initiative, you can help us take a major step forward to ensuring fresh, clean water for generations to come while working to remove Stroubles Creek from the VA DEQ's list of impaired waters.

B. **How does this initiative help to achieve the goals of the Virginia Tech Climate Action Commitment and Sustainability Plan?**

1. This project reflects positively on Virginia Tech's efforts to have Stroubles Creek removed from the state's impaired waters list, while further enhancing our reputation of being a Leader in Campus Sustainability *(#1 & 14 VT Climate Action Commitment).* In order to continue moving forward as national Leaders in Campus Sustainability, it is imperative we focus on improving the health and condition of our watershed - the foundation of our community.
2. It increases carbon GHG sequestration with increased vegetation biomass on campus[1,5]. According to the National Tree Benefits Calculator, upon reaching 10 inches in diameter (approximately 30 years in age), a single silver maple (*Acer saccharum)* will result in 503 pounds of atmospheric CO2 absorbed annually[4]. Silver maples are one of the native species to be planted in the vegetation restoration phase of the project. There will be around 4,100 trees planted in total through this funding *(#3 & 4 VT Climate Action Commitment).*

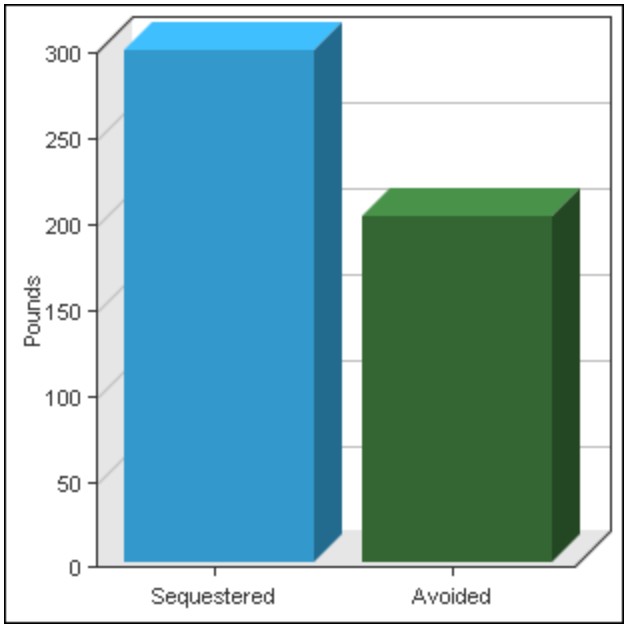


**Figure 7[4]:** CO2 sequestered or avoided annually at 10" diameter.

3. Our project engages Virginia Tech students, faculty, and staff through a collaborative, multi-disciplinary restoration effort to optimize efficient and sustainable use of university resources *(#10 VT Climate Action Commitment).*

a. Students from the College of Natural Resources & Environment (CNRE), the VT Chapter of American Water Resources Association (AWRA), the VT Environmental Coalition, and the Society of American Foresters at VT, the Stroubles Creek Coalition, and the BSE StREAM lab will provide labor for the vegetation restoration phase. Additional labor will be provided by volunteers during community service events hosted by the Stroubles Creek Coalition.

4. This project is being incorporated into academic programs at Virginia Tech. It offers immense educational opportunities for students to gain hands-on experience with real world environmental challenges which has the potential to propel them to excellence in their careers *(#12 VT Climate Action Commitment).*

a. Students within the CNRE's Department of Forest Resources & Environmental Conservation of Dr. Wiseman's Urban Forestry Management course will support the project through lab periods dedicated to learning how to manage wetland and riparian habitat restoration projects.

b. Students from CNRE's Department of Fish and Wildlife Conservation of Dr. Sarah Karpanty's Conservation Biology course will support habitat restoration phases of the project for semester-long capstone projects.

c. Students from the Biological Systems Engineering's StREAM Lab will support all aspects of the project and conduct research to provide valuable insights into the effects of land management practices on stream health and water quality.

d. Students from CNRE's Dr. Sterns Environmental Interpretation course and Myers-Lawson School of Construction will collaborate on creating interpretive signs along this portion of Stroubles Creek to educate the community on the project.

e. Graduate students from the College of Agriculture and Life Sciences and Landscape Architecture will help plan and lead vegetation restoration efforts in the project and work to manage invasive species. Students will also manage a native plant propagation project and the VT Urban Horticulture Center to support project work

f. A large amount of additional courses at VT offer extra credit for students who assist in our project work.

f. Additional courses from a wide array of disciplines across Virginia Tech are currently being identified to assist with this project.

5. The riparian vegetation that will be established along Stroubles Creek from this project will improve water quality by:

a. Mitigating pollutants from Virginia Tech's agriculture fields and livestock, golf courses, runoff from impervious surfaces, and current and future campus development projects - these pollutants include nitrogen, phosphorus, heavy metals, pesticides, oil and grease, fecal coliforms, etc. [1,2,3,5].

i. Eg. Nitrogen from livestock manure entering waterways through an ineffective (small) riparian area eventually goes through a process of nitrification and turns to gaseous nitrous oxide.

The impact of 1 pound of nitrous oxide on warming the atmosphere is almost 300 times that of 1 pound of carbon dioxide[6] *(#3 & 4 VT Climate Action Commitment).*

b. Absorbing stormwater runoff from impervious surfaces[1,2,3,5]. According to the National Tree Benefits Calculator, upon reaching 10 inches in diameter (approximately 30 years in age), a single silver maple (*Acer saccharum)* will absorb 917 gallons of stormwater annually[4].

i. The great capacity of a healthy riparian buffer to absorb stormwater runoff is a huge step towards ensuring the resiliency of our communities to flooding events and similar natural disasters, particularly as these events become more extreme or unpredictable with future changes to the region's climate

c. Stabilizing soil to prevent stream bank erosion and sedimentation in the water [1,2,3,5].

d. Providing shade over the water which keeps water temperatures low and oxygen levels high for aquatic species [1,2,3,5].

6. Trees planted in urban areas within the watershed reduce gas emissions through improving energy efficiency needs for building cooling through providing shade. Maximizing energy efficiency through landscape design is a large part of sustaiable development and takes steps forward for LEED certifications *(#3,4,6,7 VT Climate Action Commitment).*

A 10 inch Silver maple will conserve 121 Kilowatt hours of electricity for cooling and reduce consumption of oil or natural gas by 16 therm(s).[4]

Trees modify climate and conserve building energy use in three principal ways (see figure at left):

- Shading reduces the amount of heat absorbed and stored by buildings[4].
- Evapotranspiration converts liquid water to water vapor and cools the air by using solar energy that would otherwise result in heating of the air[4].
- Tree canopies slow down winds thereby reducing the amount of heat lost from a home, especially where conductivity is high (e.g., glass windows)[4].

7. The project makes every effort to re-using planting material (tree tubes, stakes, flagging etc.) as many times as possible before eventually recycling the materials. By funding this proposal we will be able to organize proect maintenance event days. This reduce waste and increases material re-use and recycling *(#8 VT Climate Action Commitment).*

**C. What is the cost of your proposal? Please describe in adequate detail the basis for your cost estimate.**

$5,500 – This is the third phase of an initially requested $16,500. This will continue our work as outlined in Section A as well as the Green RFP proposal from 2018. This will support our work in having funding to purchase trees, tools, contract work, etc. to continue our initiative to restore Stroubles Creek riparian forest habitat.

**D. Please describe in adequate detail the basis for your savings estimate.**

The funding for the final phase of this proposal, which will plant between 2,500 and 10,000 native trees, results in a savings of $215,500 (if the minimum number of trees are planted (2,500)). This project will give countless students at Virginia Tech the powerful educational opportunity of tackling real world problems in their local community. This experience will go a long way to shaping the next generation of leaders with an environmental conscience.

- **$215,000** - The trees planted through the funding of this proposal offer many ecosystem services. Their benefits increase overtime. For the sake of this proposal, the annual benefits of a 10" silver maple (30 years old) were used ($86 annually), as calculated by the National Tree Benefits Calculator[4]. *This benefits figure used at 30 years is merely a benefit of year 30 and does not include the benefits up to and beyond year 30.* Without these benefits, Virginia Tech would need to resort to more expensive and less effective means of achieving the same results that the ecosystem services of a healthy riparian forest can provide.

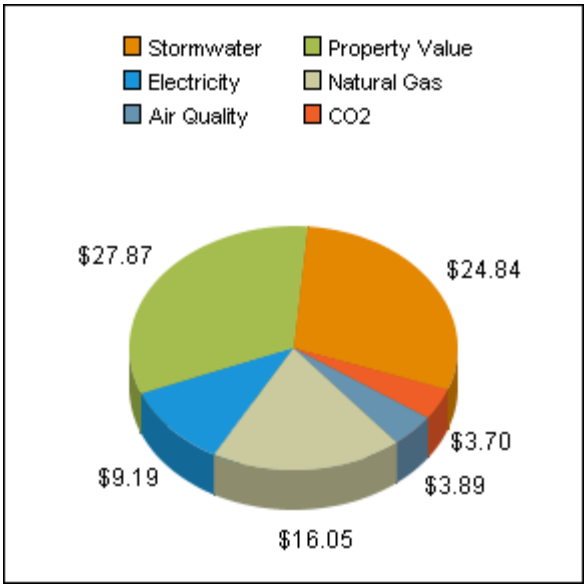


**Figure 8[4]:** Benefits breakdown provided by the National Tree Benefits Calculator[4]

Total Savings- **$220,500**

An additional benefits not added to the cost savings estimate is *t*he psychological benefit for humans were not taken into consideration. In a time of increase risk of psychological illnesses, the restoration and retention of riparian and urban forests have tremendous benefits on improving stress management and happiness for humans.

**E. Is this funding request an Ongoing or One-Time change (please check one)?**

- **One-time** - Ongoing

F. **Is funding available for this request from another source? If yes, describe the funding (source, amount, etc.)**
Other than Green RFP grants, our other funding source has been the Virginia Tech Department of Site and Infrastructure Stormwater Management department. They typically fund an average of $2,000 annually for project work.

**G. Conclusion**
The health and condition of a stream is a reflection of the health and condition of the entire watershed of that stream and the communities that live within that watershed. The poor health and condition of Stroubles Creek is among the greatest ecological challenges our community faces and has faced for many decades now. Despite the critical nature of this issue, it is often ignored or simply unknown to the majority of our community.

This proposal seeks to demonstrate Virginia Tech's leadership in sustainability by protecting and restoring the riparian areas along Stroubles Creek and its tributaries through collaborative community restoration efforts. In order to continue carrying the torch as national Leaders in Campus Sustainability, it is imperative we focus on improving the health and condition of our watershed - the foundation of our community. The costs on behalf of Virginia Tech are minimal, yet the benefits are abundant and will increase over time. Restoring riparian areas and wetlands is the most cost effective and reliable solution to improving water quality, managing stormwater runoff, reducing impacts of catastrophic flooding, and having Stroubles Creek removed from the Virginia DEQ's list of impaired waterways.

Many projections of potential effects of climate change on our region point to an increase in storm events and annual precipitation. It is absolutely critical we work diligently to restore a native, riparian forest along Stroubles Creek now, to ensure a more resilient community in order to rise and meet these challenges. As Virginia Tech's campus rapidly expands westward across State Route 460 towards our restoration areas and the last non-urbanized, un-paved, and un-piped reaches of Stroubles Creek on Virginia Tech's campus, our chance to reduce and offset the ecological impacts of this expansion on the already critically impaired stream system (and thus watershed system) is upon us.

There are few areas of greater priority to conservation than riparian areas along waterways. Clean water is the scarcest natural resource we have on our planet. In the spirit of *Ut Prosim* is it our responsibility to take every means necessary to protect this precious resource for present and future generations. We ask for your continued support and partnership in a collaborative effort to demonstrate Virginia Tech's continued commitment to environmental, economic, and social sustainability.

**Part IV**

**SUSTAINABILITY INITIATIVES BY STUDENT ORGANIZATIONS FUNDING PROPOSAL**

| Part IV- Requestors/Reviewers | |
|---|---|
| Maria Laxton<br>Prepared By (Name of Contact for Student Organization) | 11/03/2019<br>Date |
| W.C. Hession<br>Reviewed By (Name of Appropriate University Official) | 11/05/2019<br>Date |
| **Denny Cochrane**<br>Reviewed By (Name of Office of Sustainability Representative) | **1/15/20**<br>Date |

**2016/2017/2018 Green RFP Proposals**

Our Green RFP proposals from 2016 and 2017 have been huge successes and major steps forward to improving the health and condition of Stroubles Creek. With the awarded funds, the VT College of Agriculture and Life Sciences successfully installed 1,000 feet of livestock exclusion fencing along Stroubles Creek. This fencing has already gone a long way to improving water quality by completely eliminating livestock manure entry into the stream during recent storm events. With the help of these grants, we have planted 5,300 native trees along Stroubles Creek and its tributaries and included hundreds of VT students and many courses in our project work. An additional 15,300 native trees are scheduled to be planted in February/March 2020, largely funded through our 2018 Green RFP grant funding which was awared in May 2019.

The benefits from this project are numerous and will only increase with time, and are currently being monitored by faculty and students from VT's StREAM lab and the College of Natural Resources and Environment.

**Image 5:** SCC volunteers planting seedling trees. The fence in the background is the new livestock exclusion fencing to keep livestock away from Stroubles Creek. This project was through the Green RFP grant.

**Image 6:** Volunteer planting bare root seedlings between the new fence and Stroubles Creek funded by the Green RFP grant.

**Image 7:** Green RFP Funded SCC tree planting event on Stroubles Creek - December 2017

**Image 8:** Restoring riparian habitats with Green RFP funding - December 2017.

Our 2017 Green RFP has helped set up our native plant propagation program at the VT Urban Horticulture Center (UHC). Funding has been used to purchase materials such as soil medium, pots, tools, etc. to set up the project. Plants grown at the UHC center will be planted along Stroubles Creek or in strategic urban plantings over the next several years.

**Image 3:** Plants being grown at the UHC Center.

**Image 4:** Landscape Architect students working on the propagation project at the UHC center

**Image 5:** Setting up the space for the native plant propagation project at the UHC

Funds have also been used to purchase planting tools and materials for SCC projects.

Thank you for your previous support of this project by awarding us the 2016/2017/2018 funding for our proposal. Without the support from the Office of Sustainability, these projects would have never been possible. Together, we are taking great strides forward to ensure clean water for tomorrow. We appreciate your consideration for funding for the 2019 cycle.

**About the Stroubles Creek Coalition**

STROUBLES CREEK COALITION

@STROUBLESCREEKCOALITION

The Stroubles Creek Coalition (originally the Stroubles Creek Restoration Initiative) was formed in 2014 by forestry students in the College of Natural Resources and Environment (CNRE) with the mission to improve the health and condition of Stroubles Creek by restoring heavily damaged riparian habitats through university wide collaboration. Since 2014, the SCC has worked with partners to plant 7,000 native trees and improve livestock fencing around Stroubles Creek and its tributaries. The SCC has collaborated with Virginia Tech's Department of Site and Infrastructure Development, Biosystems Engineering, CNRE, the Office of Sustainability, the College of Agriculture and Life Sciences, Department of Horticulture, Virginia State Department of Forestry, Virginia Department of Environmental Quality, Conservation Services Inc., and hundreds of VT students, alumni and Blacksburg locals. Funding and projects are supporting work conducted by student groups including the Environmental Coalition and VT and the American Water Resources Association at VT, as well as curriculum courses and graduate students within the College's of Natural Resources and Environment, Landscape Architecture, and Agriculture and Life Sciences.

Our work has been covered by media sources such as the Roanoke Times, the Collegiate Times, and VT News. This has reflected positively on Virginia Tech as the university continues to be a global leader in advancing the science and implementation of sustainability.

**Image 9:** Volunteers conducting a planting event along Holtan Branch, a tributary to Stroubles Creek - April 2016.

**Image 10A**: Holtan Branch Restoration Site just after livestock exclusion and tree planting on near the VT Beef Center - Holtan Branch, April 2016

**Image 10B:** Holtan Branch Restoration Site After 1 year, 30 feet upstream of image 8 - Holtan Branch Dec 2017

## Appendix


1. Castelle, A. J., Johnson, A. W., and Conolly, C. (1994). Wetland and Stream Buffer Size Requirements – A Review. *Journal of Environment Quality, 23,* 878-882.
2. Easton, Z.M. (2012). *How Do Stream Buffers Reduce the Offsite Impact of Pollution?* Retrieved from http://pubs.ext.vt.edu/BSE/BSE-38/BSE- 38P-PDF.pdf
3. Klapproth, J. and Johnson, J. (2009). *Understanding the Science Behind Riparian Forest Buffers: Effects on Water Quality.* Retrieved from https://pubs.ext.vt.edu/420/420-151/420-151_pdf.pdf
4. National Tree Benefit Calculator. (n.d.). *National Tree Benefit Calculator.* Retrieved from http://www.treebenefits.com/calculator/
5. Neary, D.G., Smethurst, P.J., Baillie, B., and Petrone, K.C. (2011). *Water Quality, Biodiversity and Codes of Practice in Relation to Harvesting Forest Plantations in Streamside Management Zones.* Canberra, Australia: CSIRO, National Research Flagships.
6. EPA (2010). *Methane and Nitrous Oxide Emissions from Natural Sources*. Washington, DC: U.S. Environmental Protection Agency.
7. Schultz, R. C., Isenhart, T. M., Simpkins, W. W., Colletti, J. P. (2004). Riparian Forest Buffers in Agroecosystems – Lessons Learned from the Bear Creek Watershed, Central Iowa, USA. *Agroforestry Systems, 61*, 1-3(35-50).
8. Lee, K. H., T. M. Isenhart, and R. C. Schultz. (2003). Sediment and Nutrient Removal in an Established Multi-Species Riparian Buffer. *Journal of Soil and Water Conservation, 58(1),*1-7.
9. Trozzo, K.E., Munsell, J. F., Chamberlain, J. L., and Aust, W. M. (2014). Potential Adoption of Agroforestry Riparian Buffers Based on Landowner and Streamside Characteristics. *Journal of Soil and Water Conservation, 69(2),* 140-150.
10. Bennett, A. F., Nimmo, D. G., and Radford, J. Q. Riparian Vegetation has Disproportionate Benefits for Landscape-scale Conservation of Woodland Birds in Highly Modified Environments. *Journal of Applied Ecology, 51(2),* 514-523.
11. Virginia Department of Environmental Quality. (2006). Upper Stroubles Creek Watershed TMDL

Implementation Plan Montgomery County, Virginia. Retrieved September 2015, from http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/stroubip.pdf