Mid-term Project Report

Statewide Assessment of Lands Suitable for Vineyards and Map Books for State, Regional, and Local Economic Development Efforts

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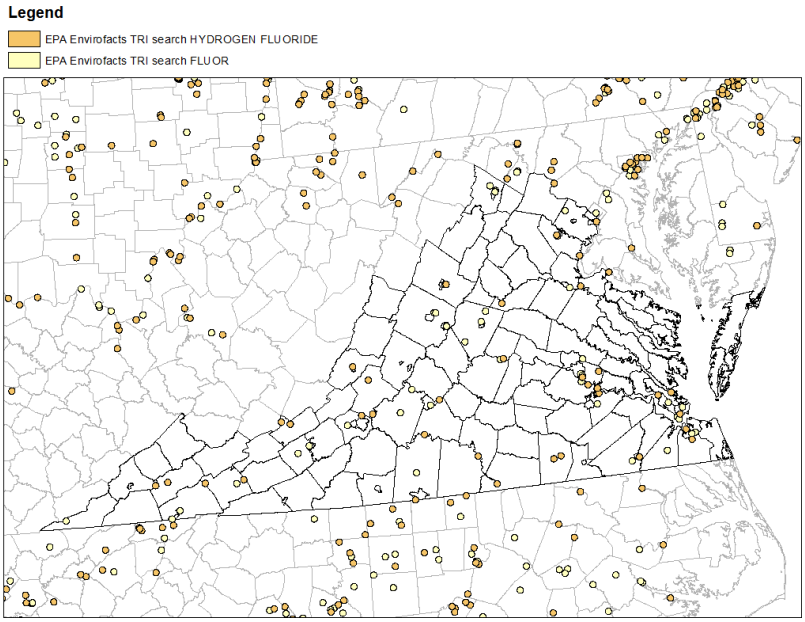
a. *Objectives defined in proposal:*
   1. *Apply the current generation of site assessment criteria and models developed for the Eastern US and Virginia to identify and rank the most suitable locations in each region of Virginia.*
   2. *Enhance the site assessment tools using best available geospatial data for Virginia, including a new high resolution statewide terrain and surface model.*
   3. *Using the new statewide elevation data available in 2014, research and develop a suite of solar modeling products and a cold air drainage model for site assessment.*
   4. *Enhance site assessment tools by planning and implementing a policy database as a collection of available boundaries, zones, and other features in the legal environment, which is linked to a catalog of the policies, laws and ordinances that are relevant to vineyard establishment and operation at local, county, regional, state, and federal levels.*
   5. *Update the existing Virginia Viticultural Site Assessment Tool from the results of objectives 1-4. Include on the website a series of digital map books highlighting key themes in the natural, legal, and built environment related to vineyard siting for distribution and use by local government officials, planning commissions, and economic developers. The user will be able to download a comprehensive package of maps, analytics, and resources for the geographic areas of interest (state, region, county, AVA), or to produce a detailed report for a specific user defined site.*

The selection of appropriate sites and grape varieties (Vitis spp.) are key factors for the growth and sustainability of the Eastern U.S. grape and wine industry. Current research is focused on developing a modeling and simulation strategy with multi-criteria decision analysis (MCDA) methods for identifying the grape varieties best suited to a site based on a wide range of objectives. A substantial collection of geospatial and environmental data (soil and geology, climate and weather, topography, land cover, biological threats) have been processed for the Eastern United States.

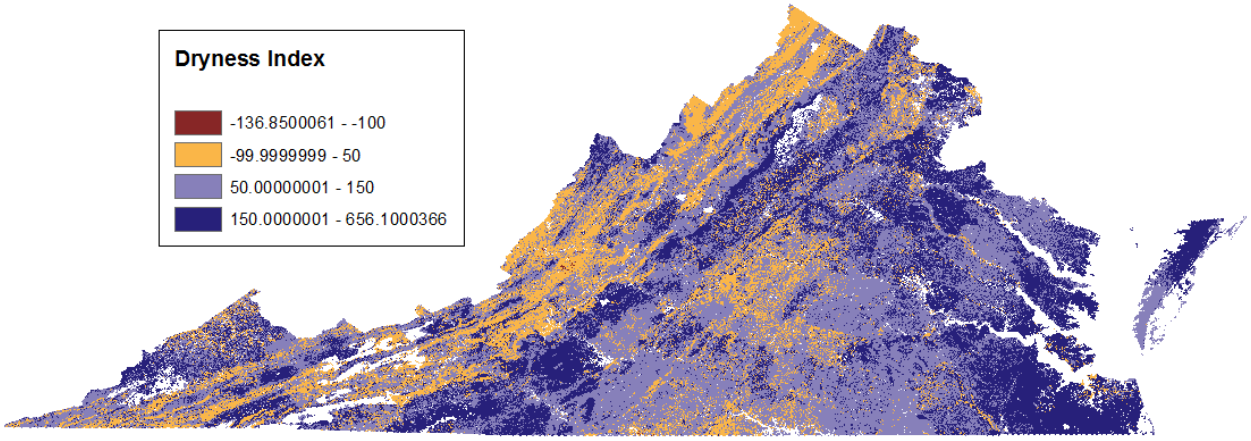
Approximately 90% of data layers required for statewide site suitability analysis have been collected for Virginia as of January 2014. This includes up-to-date **National Elevation Data** (10-meter resolution) and a brand new collection of **digital terrain models (DTM)** and **digital surface models (DSM)** that represent the ground as bare-earth and the top height of the surface features (tree heights, buildings, etc), respectively, at 5-foot resolution or better for the entire state of Virginia. These datasets are now prepared for solar radiation analysis at a finer resolution, with a surface height and bare earth elevation, and with improved currency of data than previously available using NED. The next steps are to complete the geoprocessing and analysis software that will produce the slope, aspect, solar radiation and shadow analysis using Virginia Tech's Blue Ridge high performance computing system.

Previous land cover data in the analysis represented 2006 period, and this was updated to the most recent 2011 National **Land Cover Data** provided by USGS. The data includes the standard Anderson classification for land cover types, an impervious surface layer, and analytical canopy product.

Utilizing the EPA Envirofacts Database, we have create a data layer representing sites that are registered emitters of **Hydrogen Fluoride** and created a 2-mile buffer around all sites in Virginia. Other important air pollutants include Ozone and sulfur dioxide, which are from non-point sources. NASA, EPA, and NOAA, have measurements and estimates for these pollutants, but other challenges remain to effectively incorporate those data into the vineyard site analysis.



The **Dryness Index** is based on Riou's index and combines soil moisture, rainfall and evaporation. In our representation, we have attempted two separate sources for soil moisture estimates, including 1. NOAA weather data and 2. Full column available water capacity data from USDA NRCS.

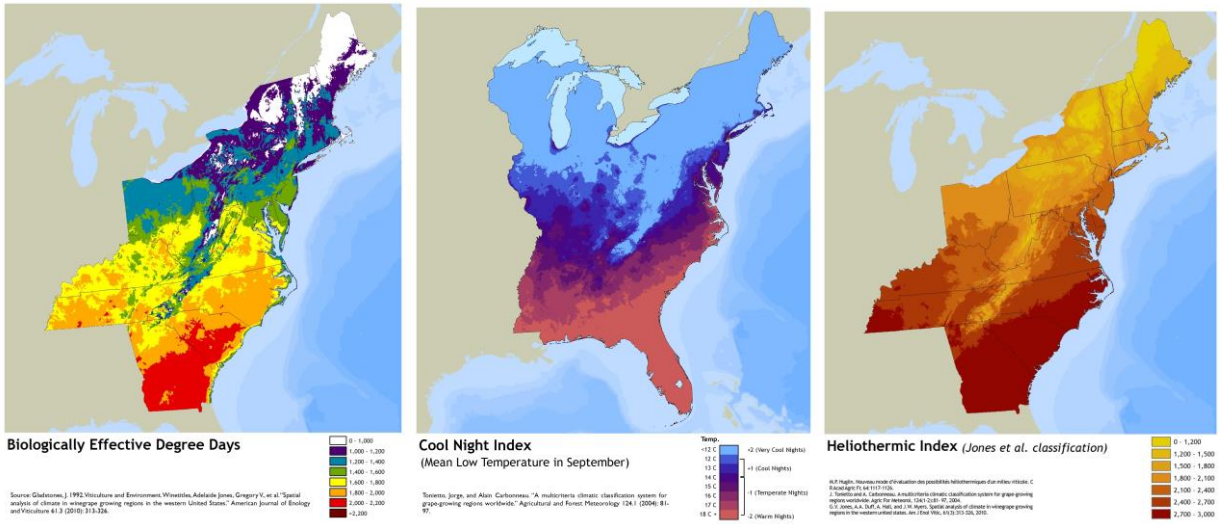


Biologically Effective Degree Days, which is similar to Degree Days but takes into account the latitude (day length) factor and that the physiological response to temperature is not linear.

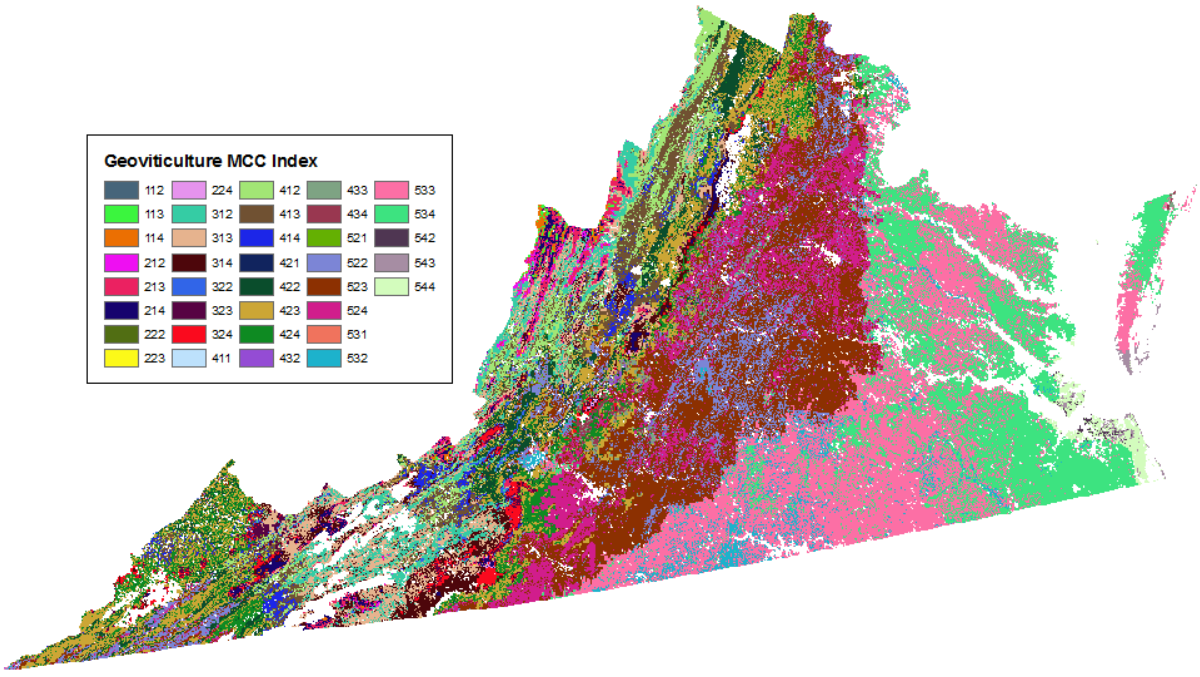
The **Cool Night Index** is based on the mean minimum temperature for September. It is an indicator of appropriate low temperature available at night for maturation and provides an assessment of the

qualitative potentials of wine-growing regions, notably in relation to secondary metabolites (polyphenols, aromas) in grapes.

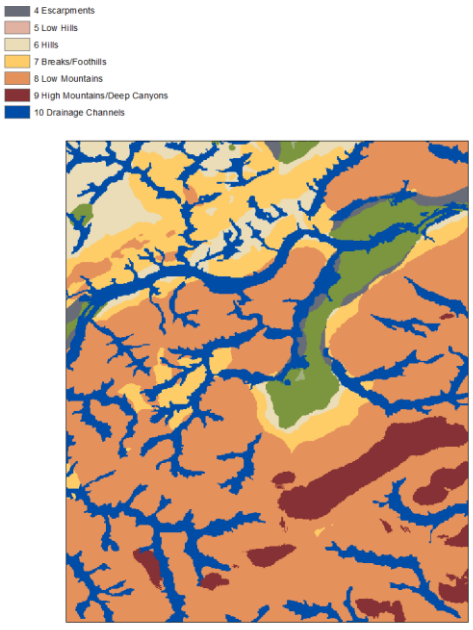
Heliothermic Index of Huglin combines temperature with a latitude factor that takes into account the longer growing season days at higher latitudes.



A **Geoviticultural Multi-Criteria Classification** (MCC) Analysis (Tonietto and Carbonneau) combines the Heliothermic Index, Dryness Index, and Cool Night Index to produce zones that are distinct based on similarities of those viticultural climate indicators that may partially relate to the quality and type of grapes that may be produced in a zone. The boundaries are not fixed, and analysis is required to determine the appropriate factors and indexes to best represent Virginia grape growing regions. Our own multi-criteria classification will differ from the MCC show here by accounting for additional indicators and providing a more robust statistical treatment of the combination of multiple layers of spatial data. Further validation would be possible with detailed information regarding the specific location of grape varieties grown in Virginia.



The USGS Terrerstrial Ecosystems data provides a suitable representation of **Land Forms**, **Topographic Moisture Index**, **Isobioclimate**, and **Lithology**.



Other significant data layers include updated **USGS Geologic Maps of Virginia**, digital geologic maps of the Virginia with consistent primary and secondary lithology of the unit, a description of the geologic age of the unit. Soil data has been prepared from USDA NCRS including **Soil Component Name**, **Bulk Density**, **Depth to bedrock**, **Texture**, **Drainage**, **Organic Matter**, **pH**, Total Available Water Holding Capacity (AWC), and many other soil indicators. These soil parameters are intended to be interpreted at coarse scales and may not accurately represent the actual conditions. Climate and weather data includes **Daily Temperature Range, Day Length**, **Dryness Index**, **Evapotranspiration**, **Growing Degree Days**, **Growing Season Temperature**, **Spring Frost Index**, **Fall Frost Index**, **Annual and Ripening Period Precipitation**, and **Temperature During Ripening**.

The approach for the site assessment is to define the general and specific objectives in a hierarchy, determine attributes that are quantifiable indicators of the extent to which an objective is realized. Then test for interdependence of every pair of attribute maps, develop attribute weights, and perform a weighted overlay analysis with constraints to obtain a score for a site. The correlation analysis is an important step often overlooked in weighted overlay analysis that can lead to misrepresentation and misinterpretation; for example, over/under representing the influence of a factor if layers are simply scored and combined.

Approximately 20 primary objectives have been identified to date, with multiple sub-objectives and associated attribute maps available as GIS data. These objectives have been grouped in the following categories:

1. Vine survival, vigor
2. Bud survival
3. yield

4. potential for producing high quality grapes
5. consistent ripening of grapes
6. resilience to climate change
7. Ease of establishment, design, and management of a site
8. Surrounding land and topography

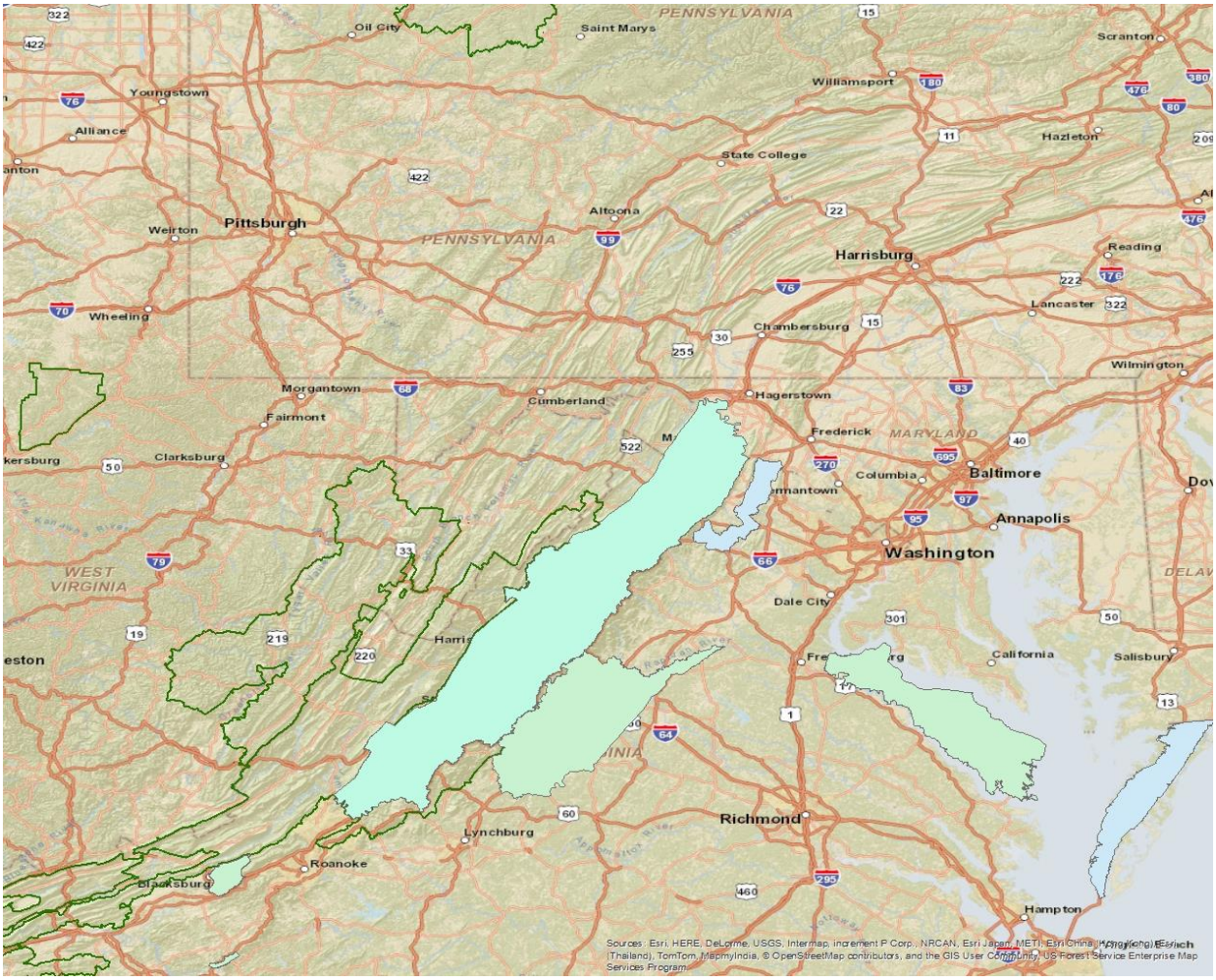
A partial example is provided using the primary objective of Healthy Root Function and Structure:

1. Objective: Healthy Root Function and Structure
    1. Aeration and Drainage
        1. Total Available Water Holding Capacity (AWC) of soils
        2. Texture class
    2. Water for transpiration
        1. precipitation
        2. soil moisture
    3. Oxygen for respiration
    4. High quality, non-toxic penetrable root volume
        1. Depth to Bedrock (SSURGO)
        2. Organic Matter
        3. Bulk Density

Additional socio-economic and tourism objectives could be included in the future to address legal and regulatory, labor, supply chain issues, etc. At this time, we are focused on grape production and the selection of high quality sites, which may or may not be adjacent to a winery or destination.

Solar radiation models are in development that simulate and analyze heat and incident radiation with variables of row orientation, spacing and trellis type across a range of slope, aspect, and latitudes (day length) for Virginia. A simple prototype model was developed in GIS that creates geometric surfaces representing the canopy in different treatments and measure the total WH/m2 and duration for each surface element, which could be reported at various aggregations (leaf, vine, row, block, etc) depending on the level of detail in the geometric representation of those units. The solar radiation models could be coupled with VitiSim, a model developed by Alan Lakso (Cornell U.) using classic light attenuation by leaf area to estimate total canopy light interception. The model then uses a daily canopy light response curve to estimate daily photosynthesis and respiration of different organs (root, stem, leaf, berry), to estimate net dry weight growth. The model requires daily max, min and total radiation. Virginia's estimated productivity could be modeled using a "standard vineyard" similar to what is typically done with a reference grass or crop for ET modeling.

CGIT completed creation of a detailed AVA data layer for Virginia accurately reflecting legal descriptions of the AVAs from the Code of Federal Regulations (CFR).



Policy Analysis & Economic Development Opportunities

A scope of work is being developed for policy analysis and economic development opportunities. In late January, CGIT hired Karen Drake to assist in the design and completion of work in the policy and economic development section.

I. Policy Summary and Analysis

The goal of this policy analysis section is to highlight existing regulations affecting Virginia vineyards and wineries. By categorizing, summarizing, and analyzing legislation, key regulations can be identified that support the Virginia Wine industry. Contradictory regulations can also be

identified, as well as pending regulations to be monitored in the future.

The policy analysis will be divided into four major categories. The first two categories are **National** and **Virginia** legislation. The third area and fourth areas categories are detailed below.

Regional and Local government zoning regulations and comprehensive plan

With more than 100 counties and independent cities in Virginia, each with their own zoning regulations and comprehensive plans, creating an applicable database of continually changing legislation affecting vineyards and wineries would be a challenging undertaking for future consideration. Instead for this grant, three regional case studies are proposed to review local regulations in/around the Northern Virginia Region, the Monticello AVA, and the Blue Ridge Region.

Other Legislation

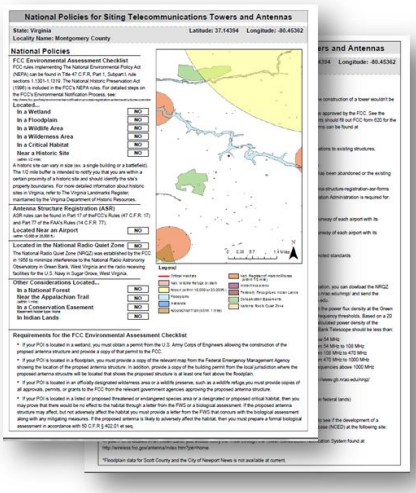
This category includes identifying legislation and regulations areas that can transcend the traditional government hierarchy levels, while complimenting Virginia wineries. Areas identified to review at this time but are not limited to historic and scenic conservation areas, national and state parks, and critical habitats and conservation areas. Another example include regulations and buffer zones for riparian zones and runoff, including those related to Chesapeake Bay TMDLs.

II. Identify Pending Events/Developments to Monitor

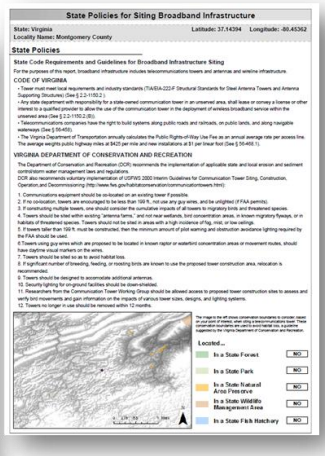
III. Economic Development Opportunities

As policies are researched and analyzed, this last section will include a general discussion and recommendations of future economic development opportunities and partnerships for the Virginia Wine Industry. Recommendations will be general in nature, highlighting issues warranting further discussion. The discussion will also include the challenges of how to best use this information gathered in this grant including, how to keep the information current and how to present information (i.e. map books) to the general public. Future research and partnership opportunities may also be identified.

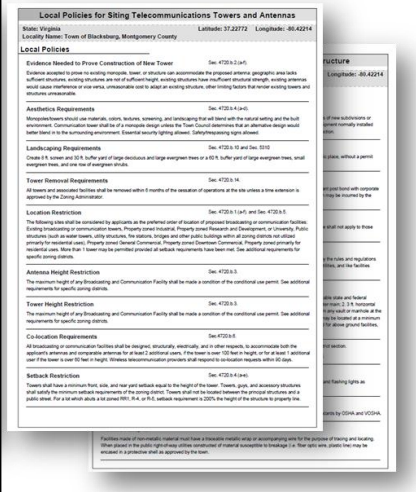
National Policies



States Policies



Local Policies



In conclusion of this mid-term report, the project is on track to complete all deliverables in the specified time frame. A new web site for the Virginia site assessment tool is being developed at Virginia Tech CGIT. The web site and draft map books will be provided to the board for feedback in March 2015. We look forward to any feedback at any time and would like to express our appreciation for the support provided for this project.