PennState
College of Agricultural Sciences

PROPOSAL TRANSMITTAL

Date: 12/10/2018 **PSU Ref. No: 205981**

Title: Development of a High-Accuracy Digital Elevation Model for Orchard Sites; Improving Rootstock Performance with Terrain Analysis Using Drone Technology and Geographical Information Systems

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Proposed Project **7/1/2019 - 6/30/2020** **Total Project Request: $8,931**

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Please reference PSU Ref. Number in all correspondence.

RESEARCH GRANT PROPOSAL

STATE HORTICULTURAL ASSOCIATION OF PENNSYLVANIA

Development of a High-Accuracy Digital Elevation Model for Orchard Sites; Improving Rootstock Performance with Terrain Analysis Using Drone Technology and Geographical Information Systems (GIS)

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Duration: 1 year. New.

Justification: This proposal addresses the SHAP Research Committee priorities: **Integration of New Technology for Improved Farm Efficiency and Decision Making** and **Rootstocks**. This proposal seeks to enhance our knowledge of the interactions between orchard landscape variables and rootstock performance. Potential outcomes are enhanced fruit tree performance through rootstock selection appropriate to landscape variables, and better nutrient management strategies based on enhanced understanding of the influence of terrain on rootstock performance.

Predicting rootstock vigor and productivity under variable orchard sites is challenging. Along with biotic factors, such as nematodes and soil pathogens, sites with variable terrain present challenges because of variability of soil physical properties, (density, oxygenation, water and mineral nutrient holding capacity, etc.) and micro-climate. For instance, soils in low areas in funnel-shaped landscapes tend to receive accumulations of organic matter, water nutrients, and fine-textured soil particles from adjacent upslope contributing areas over geologic time. Trees planted in these soils have distinct vigor and fruiting habits when compared to trees planted in soils in upslope contributing areas. When assessing fruit tree rootstock productivity, it is important to distinguish vigor attributable to rootstock genetics from vigor attributable to soil and landscape differences.

A commonly-used tool to quantify landscapes is analysis of terrain in Geographical Information Systems (GIS) using digital elevation models. The current digital elevation model used at the Fruit Research and Extension Center is inadequate for quantifying landscape at a scale relevant to within-orchard variability. The topographical wetness index can be calculated for sites, but the elevation model isn't adequately precise to be fully useful.

We propose to fly a sensor-equipped drone over the relevant acreage at the Fruit Research Extension Center (Fig. 1A) to develop a more accurate and detailed digital elevation model (Fig. 1B). This new model will help researchers quantify landscape differences that lead to variation in tree growth so that rootstocks can

be assessed accurately after the effects of landscape variables have been accounted for. In this initial project, the model will be used to evaluate tree vigor and productivity in an established peach rootstock trial with observed variation attributed to soil differences (Figs. 1C and 1 D).

Potential benefits of a highly accurate digital elevation model include:

- Better understanding of the soil variables that influence rootstock performance in an established rootstock x tree spacing study
- A better understanding of the performance of rootstocks at different landscape positions
- Development of new technology that can help growers make better decisions about orchard planting sites and selection of appropriate rootstock vigor.

Objectives: The objectives of this study are to develop a high-accuracy digital elevation model which can provide accurate variables of landscape features. These variables will be useful in analyzing datasets about the performance of rootstocks of all tree fruit species and could have other uses in orchard management.

Procedures: Drone coverage of the north orchards at the Fruit Research and Extension Center will be obtained. The drone will collect distance reflectance data to be integrated into a GIS. The software will integrate the distance reflectance data collected by the drone to make a high-accuracy digital elevation model. The output of the model will be used to make improved landscape terrain analysis useful for evaluating the effects of landscape position on peach rootstock performance. The usefulness of the topographical wetness index and other values derived from the model will be evaluated as explanatory variables for tree vigor and yield.

Budget:

Wages:	$6800
Fringe (7.81%):	$531
Professional Services:	$1600
Total:	$8931

Budget Justification: Wages and associated fringe are needed to evaluate the new model relative to existing data for tree vigor, yield, fruit size, as well as leaf and soil analyses for mineral nutrients. Professional services are needed for drone flight, mapping and processing the resulting data.

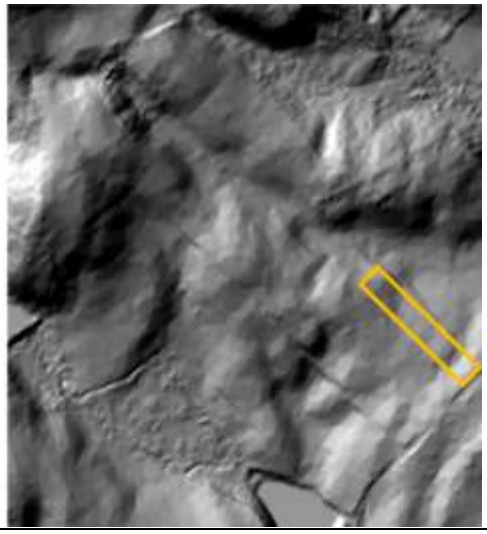
Fringe benefits are computed using the fixed rates of 38.97% applicable to Category I Salaries, 14.74% applicable to Category II Graduate Assistants, 7.81% applicable to Category III Salaries and Wages, 0.18% applicable to Category IV Student Wages, and 25.34% for Category V, Postdoctoral Scholars and Fellows, for fiscal year 2019 (July 1, 2018, through June 30, 2019). If this proposal is funded, the rates quoted above shall, at the time of funding, be subject to adjustment for any period subsequent to June 30, 2019, if superseding Government approved rates have been established. Fringe benefit rates are negotiated and approved by the Office of Naval Research, Penn State's cognizant federal agency.

Other Support: Faculty salary and orchard maintenance costs paid by Penn State University. If the results of these investigations warrant, additional external sources of funding will be sought, and this project will be expanded.

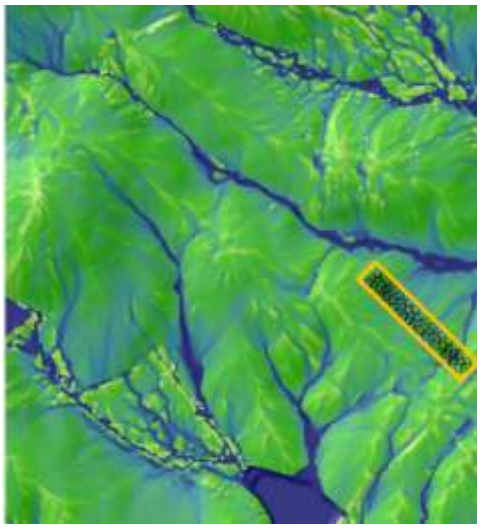
Fig. 1. Photo (A) of north orchards at the FREC, and several relevant topographic features (B-D).

A

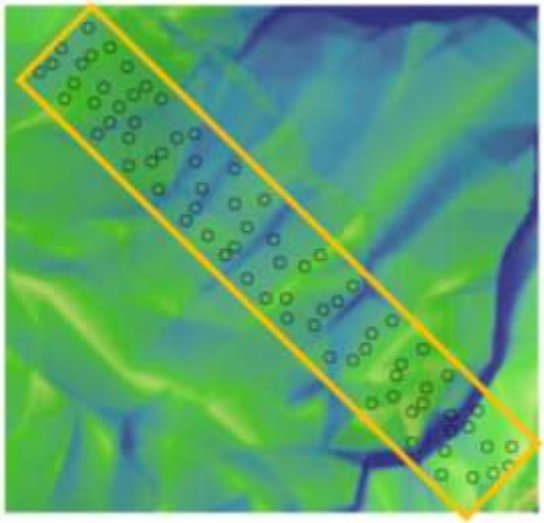
B



C



D



A. An aerial photograph of the north orchards at the Fruit Research and Extension Center
B. The digital elevation model of the same area
C. The topographical wetness index (twi) calculated from the digital elevation model showing landscape areas with high values for upslope contributing areas, these are quantifiable wet areas. The twi can be calculated for each tree in an orchard to estimate the propensity of the landscape to be wet or have other properties associated with convergent flow.
D. The peach rootstock site of interest, showing low areas with convergent water and higher areas contributing flow to lower areas. The elevation model has numerous inaccuracies, leading to "choppy" and unrealistic triangular flow patterns. The dots represent data trees where measurements of soil and leaf nutrients were taken.