DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

4.2.1.20 Integrated Landscape Management

04/04/2023

Data Modeling and Analysis

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Project Overview

- **Background:** Project started in 2014 as an extension of WBS 1.1.1.2
- **Historical Focus:** Efforts have been focused on herbaceous biomass production systems tangential to conventional agricultural production systems.
  - Agricultural producers and land managers are potential major suppliers of biomass materials for energy conversion.
  - The agricultural landscape represents a significant opportunity to source biomass feedstocks from excess crop residues and cultivated perennial energy crops such as switchgrass and miscanthus.
- **FY21 Shift:**
  - Expand beyond agriculture and herbaceous feedstocks to include additional feedstocks
  - Maintain a focus on providing management solutions that optimize outcomes based on competing objectives

Project Overview (cont’d)

1 – Approach

Technical Approach

- Assess opportunities for the establishment and cultivation of short rotation woody crops on agricultural areas within forested regions
- Examine opportunities for the production of biomass feedstocks from the management of natural forest
- Establish a modeling framework that can simulate forest and biomass supply impacts from application of management activities

Technical Challenges

- Determining appropriate analysis scale
- Acquiring data at usable spatial resolution

1 – Approach

Go/No-Go Decision Point

- The Go/No-Go decision point was based on demonstrating the technical feasibility to model the impacts related to management activities on natural forests, incorporating potential for biomass production and forest health assessment.
- The Go decision point was met in Q2 of FY22
  - We were able to identify data sources needed to provide the information needed to develop required models

Risks and Mitigation

- Lack of subject matter expertise in fire risk and fire management
  - Worked with individuals from USDA Forest Service to identify methods and data needed to quantify appropriate metrics

Performance Metrics

- Biomass Cost
- Biomass Supply

1 – Approach

Team

- Rajiv Paudel – Sensors/Data Interface
- Lionel Toba – Data Scientist
- Cleve Davis – Project Coordinator

Communication/Collaboration

- Bi-weekly Team meetings to discuss progress
- Monthly updates with BETO

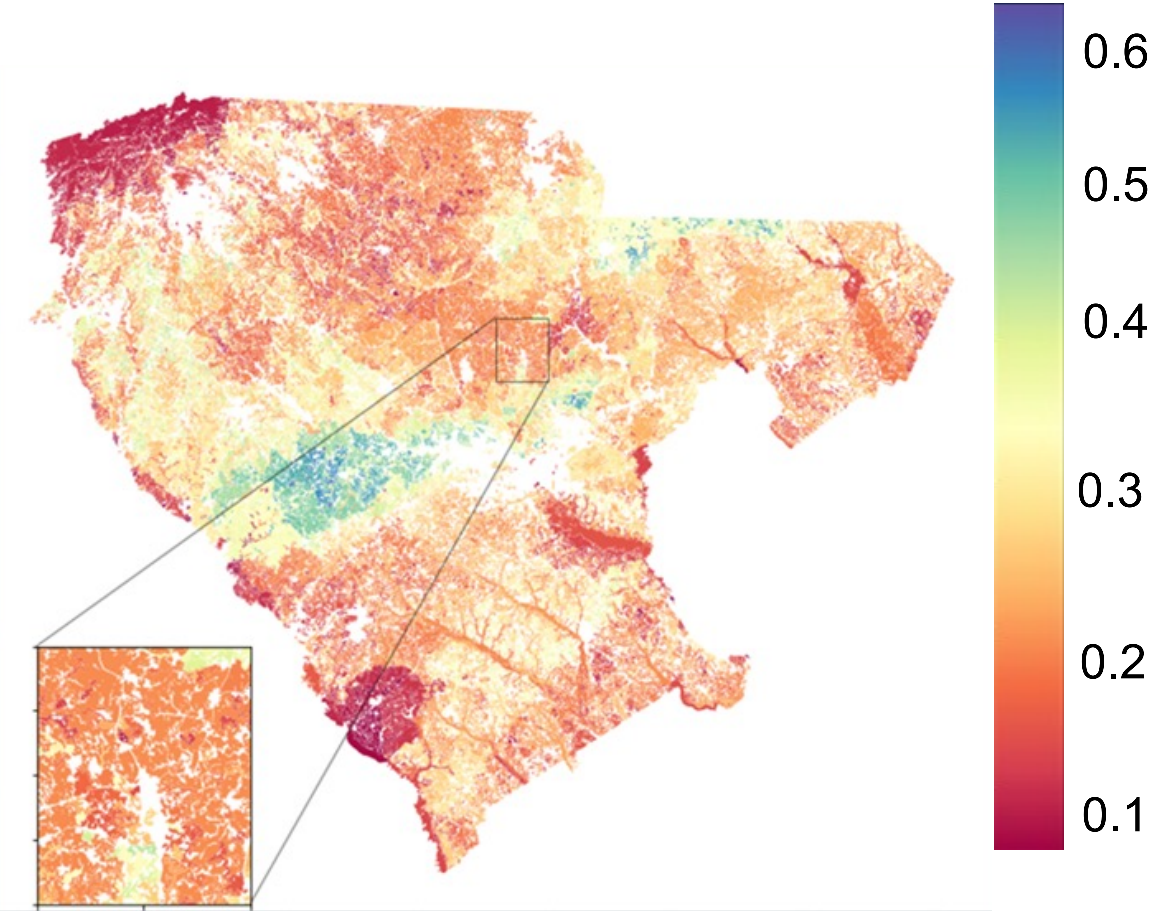
Dissemination of Results

- Peer reviewed manuscripts
- Public and Licensable Software repositories

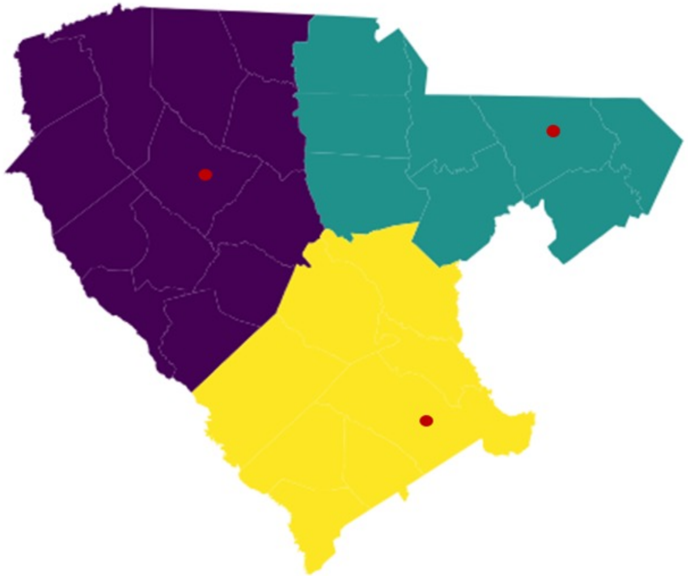
Diversity, Equity and Inclusion: While diversity, equity and inclusion is not a formal goal of this project, success in this project with help rural businesses and increase the wealth in rural communities

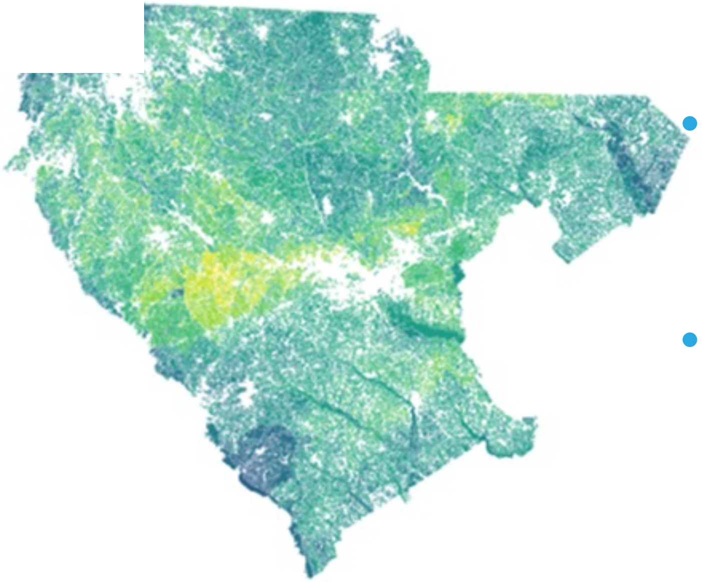
2 – Progress and Outcomes
Site Suitability for the Production of Short Rotation Woody Crops

- Site Suitability Index
  - Quantify, Compare and Rank locations
  - $SSI_i = \sum(f_{m,i} w_m) * \prod b_n$
  - Factors Considered:
    - Current Landcover
    - Slope
    - Soil Productivity
    - Soil Texture
    - Erodibility Factor
    - Water availability



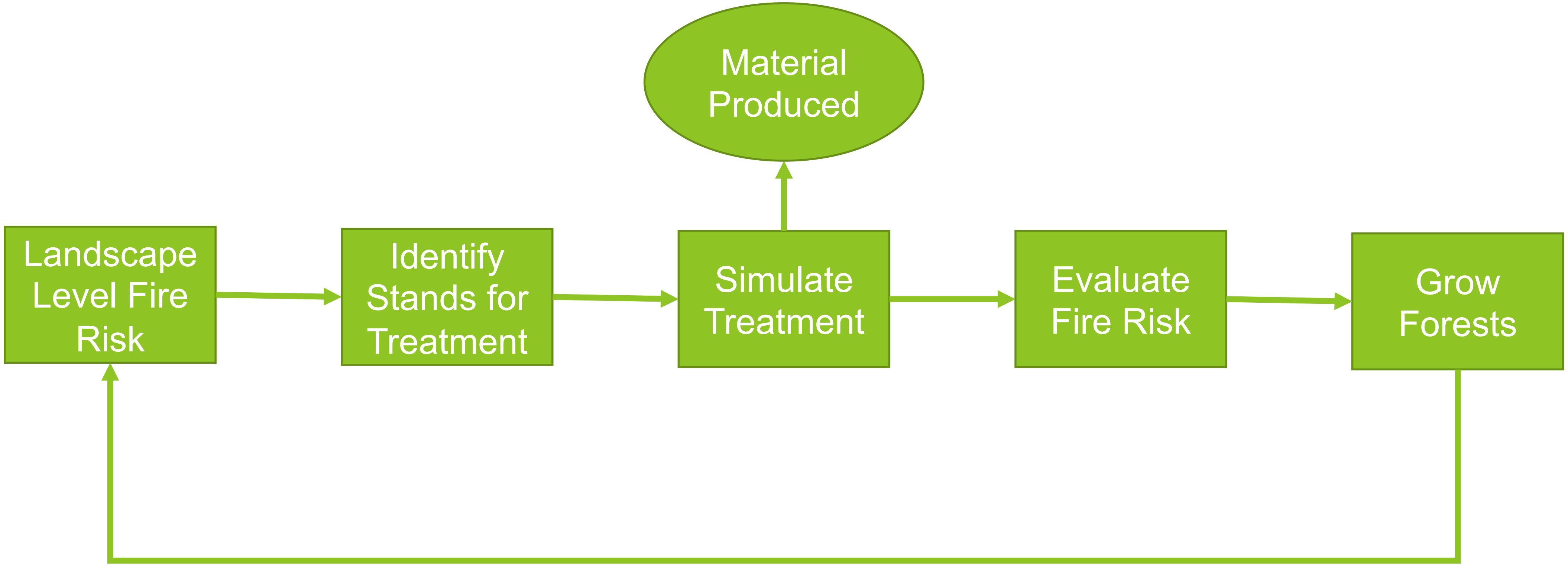
2 – Progress and Outcomes
Impact of transportation concerns on suitability calculations





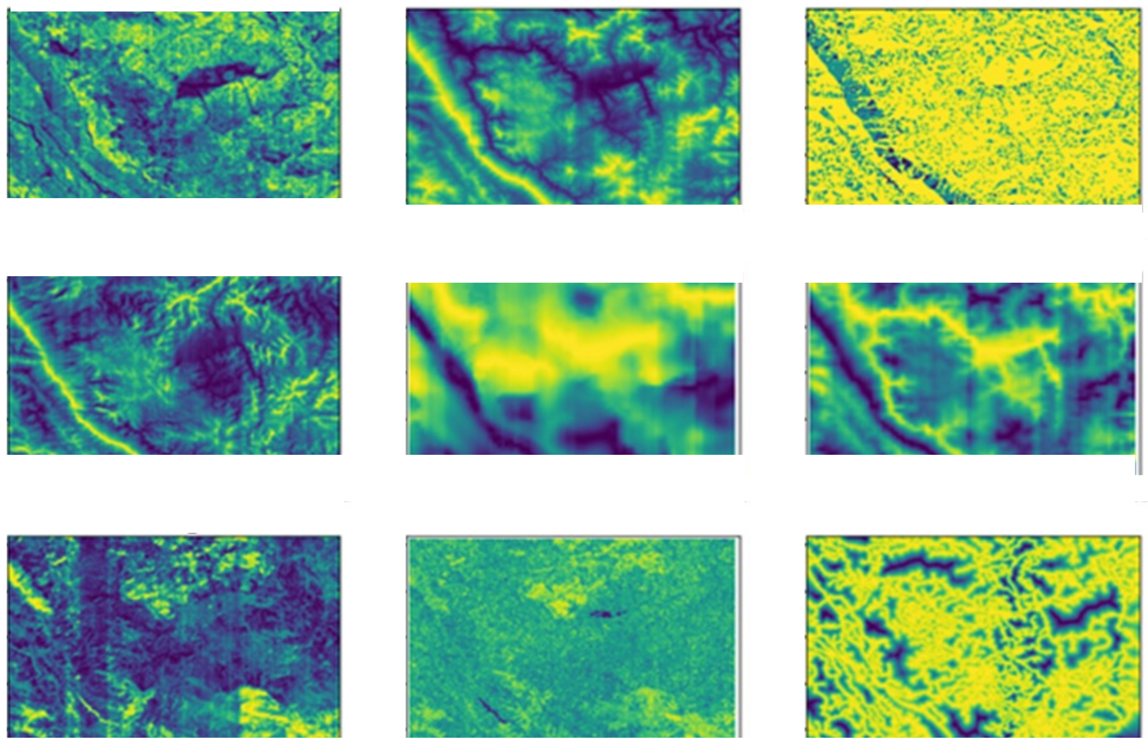
- In addition to environmental sustainability, the ability to transport and associated cost impact ultimate suitability.
- Depot locations determined based on population and proximity to transportation modes and clusters of suitable fields
- Used graph theoretic approach to add suitability score to fields based on transportation cost.
- Resulted in increases of suitability in areas nearer to depot locations

2 – Progress and Outcomes
Developing Fire/Biomass Model

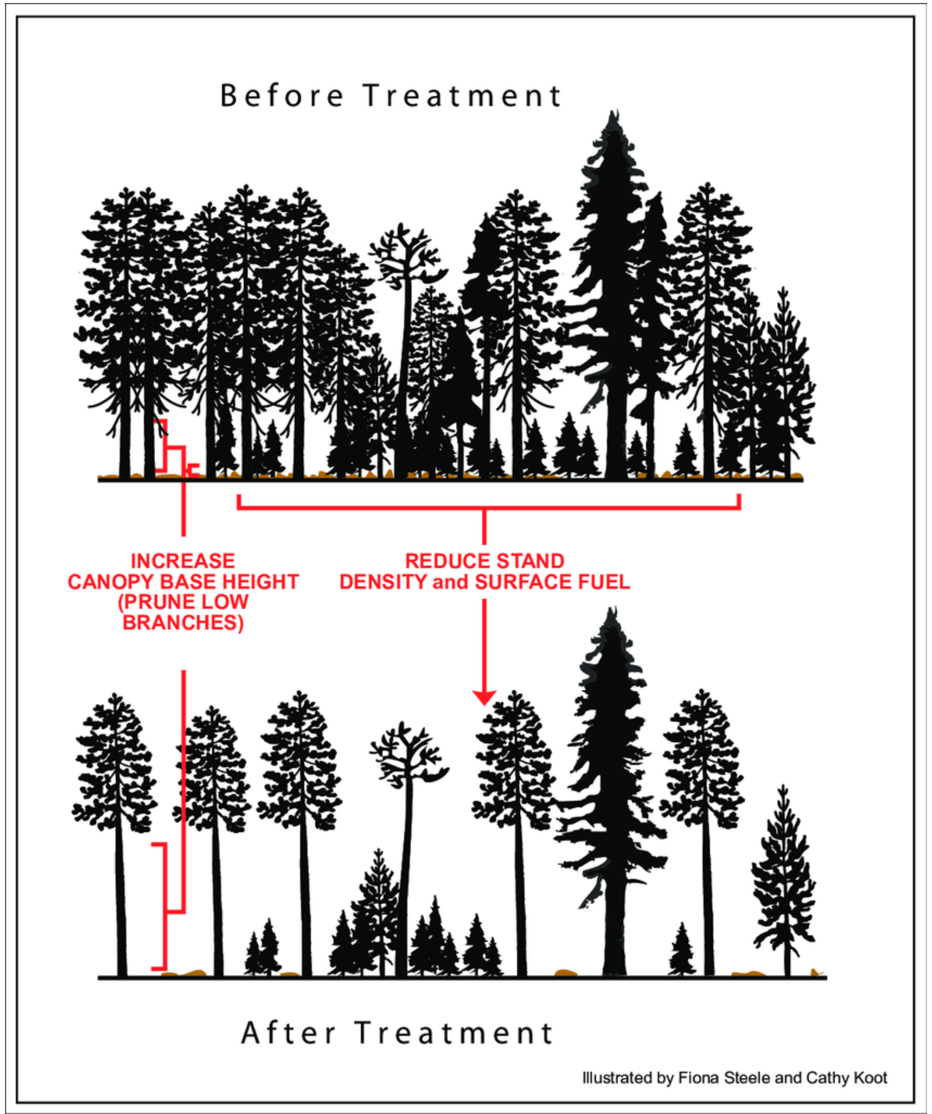


2 – Progress and Outcomes
Assessing Wildfire Risk

- Utilized a multicriteria approach to identify areas prone to wildfire
- Worked with Matt Thompson from the USDA Forest Service to identify risk factors
- Map layers are overlaid to determine where factors that increase risk intersect spatially.
  - Considered: human, topographic, vegetation and climatic features
- Forest Landscape data based on Tree M



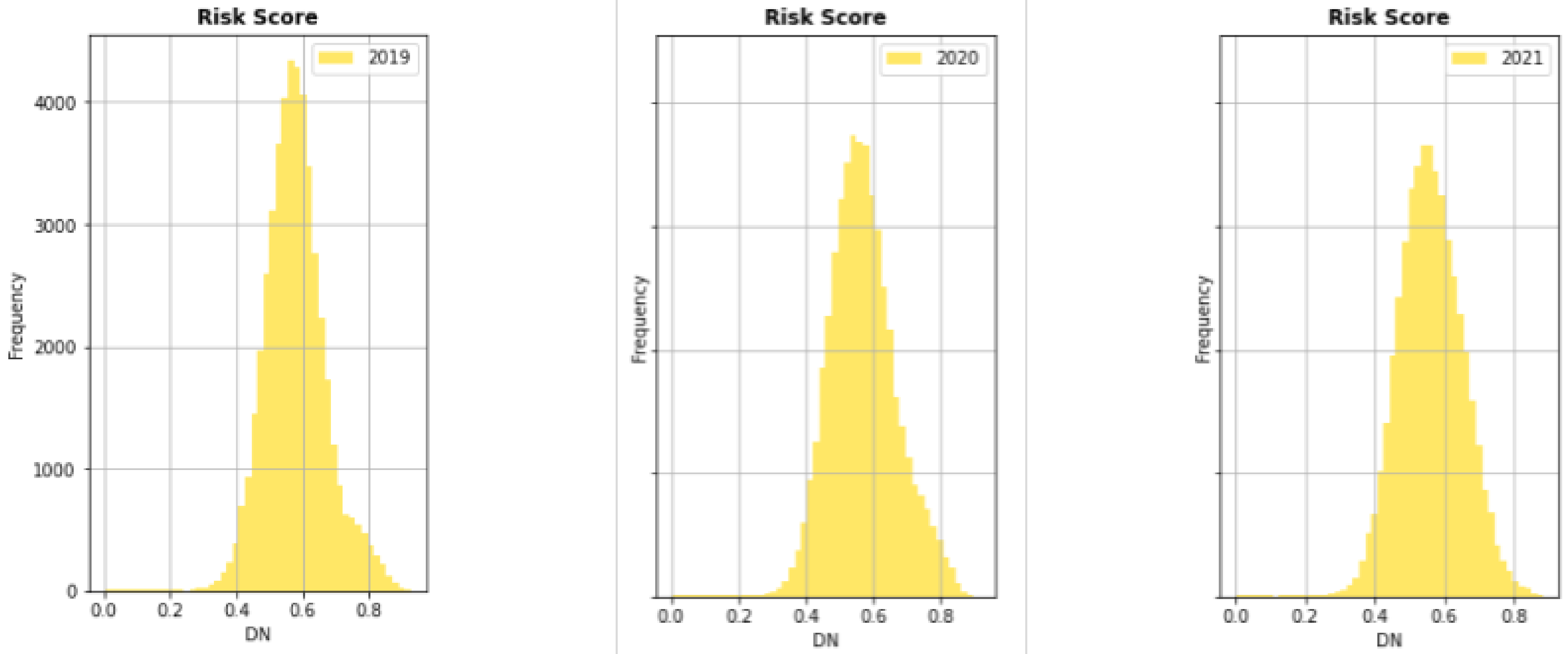
2 – Progress and Outcomes
Treating Fire Prone Stands and Evaluating Effects



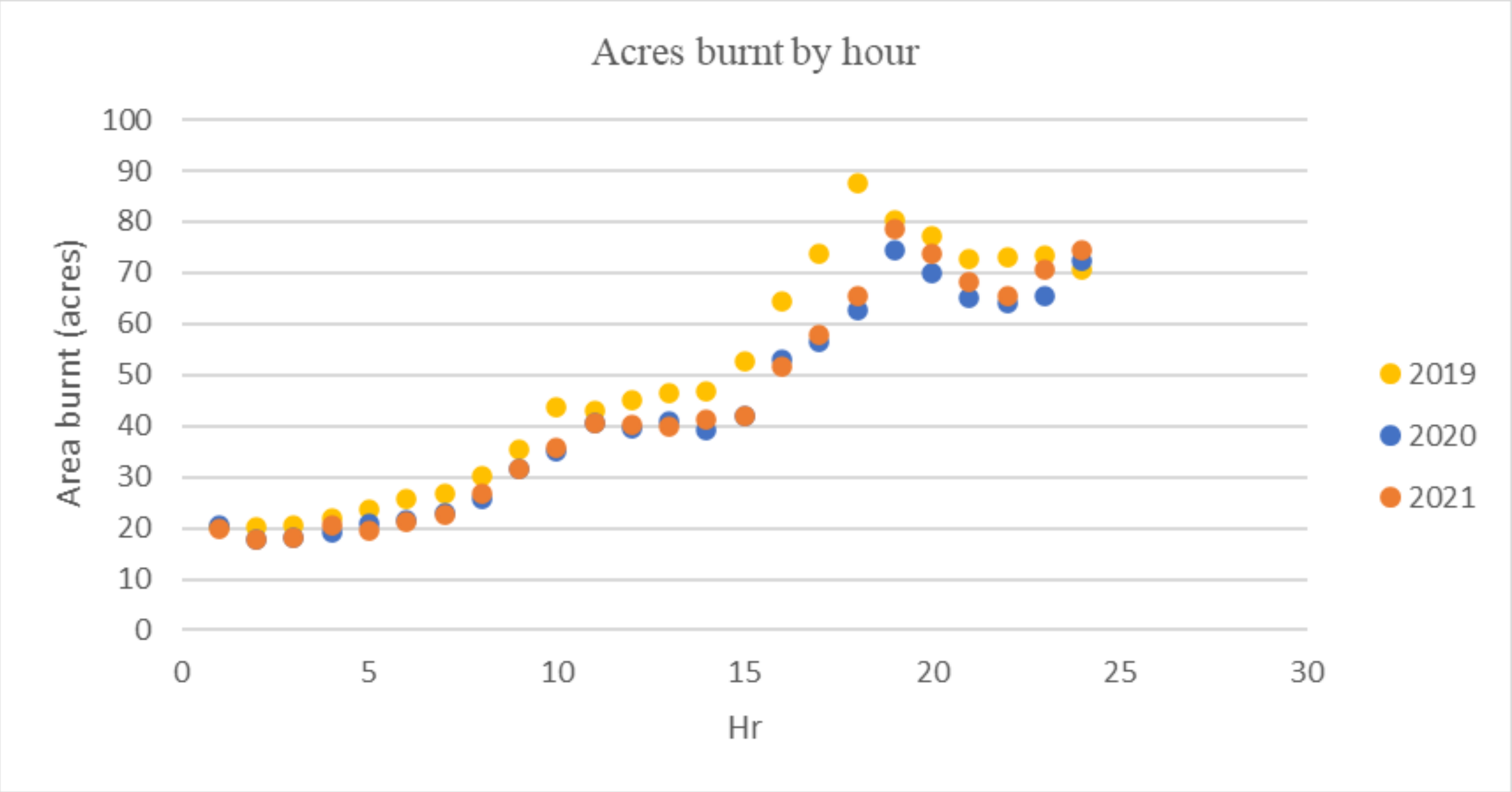
- Uniform management scenario
  - Thinning from below
  - Focus on removal of trees < 12” Diameter Breast Height
  - Residual Density 60 trees per acre
- Use USDA Forest Service, Forest Vegetation Simulator to simulate stand conditions post-harvest and as stand grows
- Through simulation, identify material size classes and products produced.
- Evaluate long term effectiveness of treatments

2 – Progress and Outcomes
Treating Fire Prone Stands and Evaluating Effects

- Treatment causes the risk profile to shift to the left indicating a reduction
- Effect remains following growing seasons



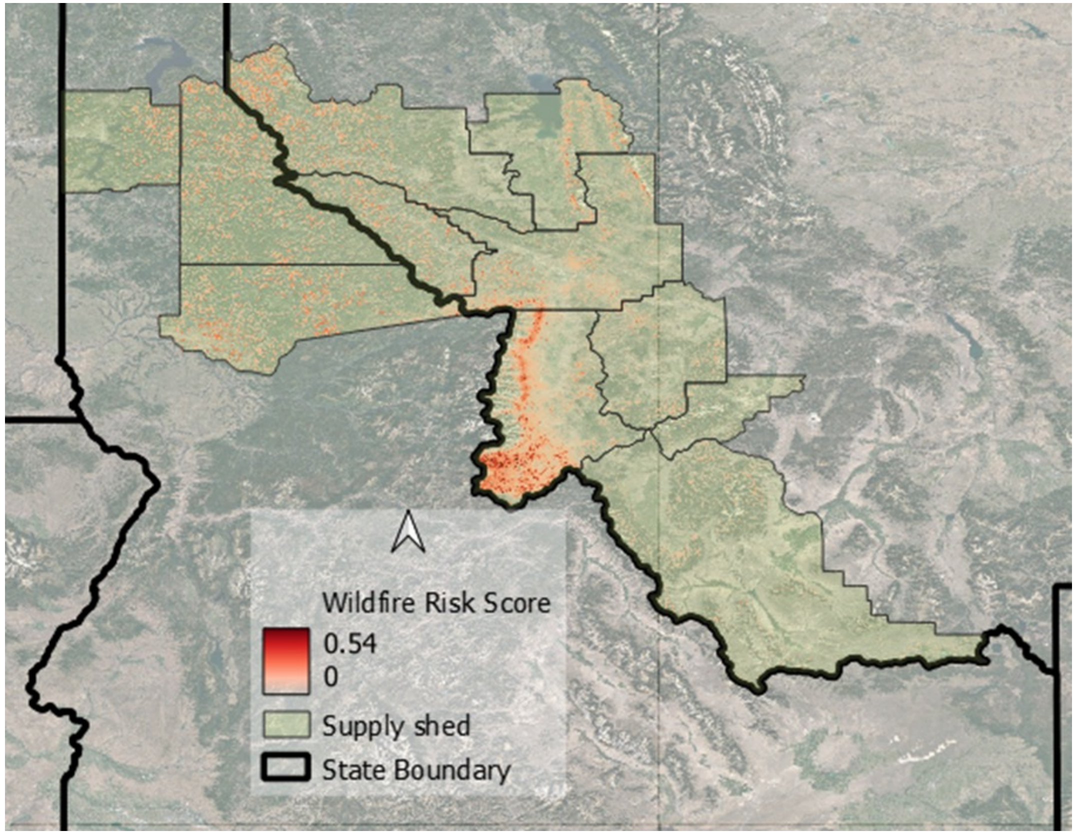
2 – Progress and Outcomes
Simulating Fire Behavior Before and After Treatment



- Fire behavior simulated using the FARSITE Model
- Untreated run results in higher rate of burn and higher total acres
- Lowest acres and slowest rate immediately after harvest
- One year after treatment, fire intensity begins to increase

2 – Progress and Outcomes
Establishing Baseline Conditions

- Identified potential supply region that represents a "typical" forested region in the Western U.S.
- Current Conditions:
  - On going drought
  - Pest outbreaks
- Average of 42 ton/ac Biomass, with tree density ranging from <20 to >2500
- Baseline Rate of Spread 3.06 ft/min
- Baseline Intensity: 155 kW/m



Impact

- This project impacts the state of technology by developing novel and industrially relevant modelling capabilities to support the integration of biomass feedstock production into the landscape and current industrial practices.
- These tools and methods can be used to support supply chain development for an emerging bioeconomy in ways that mitigate economic and environmental concerns.
- This project has generated or contributed to multiple publications, technical reports, conference presentations, and a patent.
  - Received U.S. Patent for CropAIQ (2020 R&D 100 Winner)
    - Currently in negotiations to license
  - 5 Peer Reviewed Journal Articles
- The tools that we develop are of interest to industry:
  - Negotiations are ongoing with two industrial partners to utilize previously developed modelling capabilities..

Summary

- **Challenge:** There is potential to produce usable feedstocks for bioenergy and bioproduct production from nearly all portions of the natural landscape.
- **Goal:** Identify management strategies that increase the accessibility of biomass feedstocks while providing benefits to the producers, surrounding communities and larger environment
- **Actions:**
  - Develop tools required to answer specific questions associated with feedstock production and management scenarios
  - Integrate tools, as necessary, to develop frameworks for scenario analysis on the effect of alternative management and production scenarios
  - Disseminate results highlighting alternative management schemes comparing and contrasting to “Business as Usual”
  - Make tools available to interested users
- **Next Steps:**
  - Shift modeling efforts to focus on decarbonization and carbon sequestration potential within the Agriculture and Forestry Sectors
  - Focus on balancing Carbon Management and Feedstock Production

Quad Chart Overview

Timeline

- *Project Start: 10/1/2020*
- *Project end date: 9/30/2023*

	FY22 Costed	Total Award
DOE Funding	*$357,501*	*$900,000*
Project Cost Share *		

Project Goal

The overarching project goal is to develop and apply ILM tools and analysis capabilities supporting the integration of at least two additional woody feedstock sources within a modelled biomass supply system

End of Project Milestone

Incorporation of naturally-produced woody feedstocks into ILM multi-criteria site suitability framework. Comparisons will be made on biomass material produced, reduction in fire risk, and forest health. The incorporation of ILM will increase feedstock supply by 25%.

Funding Mechanism

Annual Operating Plan

Project Partners*

- Idaho Forest Group

*Only fill out if applicable.

Quad Chart Overview

Project Goal

End of Project Milestone

Funding Mechanism

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Idaho National Laboratory

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.

Additional Slides

Responses to Previous Reviewers' Comments

Weakness: Early in the presentation agricultural producers and land managers are identified as potential major suppliers of biomass materials for energy conversion - how is this research going to be disseminated to these stakeholders?	This is an excellent point. Part of the future work scope it to develop novel pathways to develop this type of analysis and results to stakeholders to support the development of a bioeconomy.
Weakness: It's not entirely clear what the actual future work is ("develop subfield yield variability prediction models"). Also, the PIs only acknowledge that if their improved models work (i.e. a "go"), they will be incorporated into LEAF, they omit much larger potential benefits (e.g. aforementioned scalability). The PIs may also want to consider the newly available USDA NCCPI (National Commodity Crop Productivity Index) data, it may be helpful. I'm very interested in the western Nebraska results, where a lot of the sensitive land that may be converted to support biomass production are found. I'd like to see the Pis dig into those results further.	The NCCPI data has been a core component of delineating inter- and intra-field crop yield metrics and variability. However, it is a "static" metric that is not often updated and is not suitable for irrigated agricultural systems. Development of new yield modelling capabilites derived from electromagnetic reflectance signals captured at global scales returned from real crop phenology states provide a higher and more accurate assessment of crop yield at a high spatial/temporal resolution. This, in turn, will make ILM more industrially relevant to agricultural stakeholders.
Go/No-Go Develop subfield yield variability prediction model based upon remotely sensed data of standing crop parameters. Compare against baseline subfield yield estimates derived from SSURGO data.	The Go/No-Go decision point was met on March 31, 2019 with the successful development of the crop yield prediction model (Crop AIQ).

Publications, Patents, Presentations, Awards, and Commercialization

Toba, Ange-Lionel, Rajiv Paudel, Yingqian Lin, Rohit V. Mendadhala, and Damon S. Hartley. "Integrated Land Suitability Assessment for Depots Siting in a Sustainable Biomass Supply Chain." Sensors 23, no. 5 (2023): 2421.

Griffel, L. Michael, Ange-Lionel Toba, Rajiv Paudel, Yingqian Lin, Damon S. Hartley, and Matthew Langholtz. "A multi-criteria land suitability assessment of field allocation decisions for switchgrass." Ecological Indicators 136 (2022): 108617.

Griffel, Lloyd M., Damon S. Hartley, and Matthew R. Kunz. "Systems and methods for improved landscape management." U.S. Patent 11,170,219, issued November 9, 2021.

Burli, Pralhad H., Ruby T. Nguyen, Damon S. Hartley, L. Michael Griffel, Veronika Vazhnik, and Yingqian Lin. "Farmer characteristics and decision-making: A model for bioenergy crop adoption." Energy 234 (2021): 121235.

Griffel, L. Michael, Hartley, Damon S., Lin, Yingqian, and Langholz, Matthew. Integrated Landscape Management to Reduce Biomass Feedstock Access Costs. United States: N. p., 2021. Web. https://www.osti.gov/biblio/1756895-integrated-landscape-management-reduce-biomass-feedstock-access-costs.

Griffel, L. M., Vazhnik, V., Hartley, D. S., Hansen, J. K. and Roni, M. (2020). Agricultural field shape descriptors as predictors of field efficiency for perennial grass harvesting: An empirical proof. Computers and Electronics in Agriculture, 168, p.105088. DOI: 10.1016/j.compag.2019.105088.

Toba, A. L., Griffel, L. M., & Hartley, D. S. (2020). Devs based modeling and simulation of agricultural machinery movement. Computers and Electronics in Agriculture, 177, 105669. doi.org/10.1016/j.compag.2020.105669.