IGEM-HERC Full Proposal Cover Sheet

Idaho State Board of Education

PROPOSAL NUMBER: **(to be assigned by HERC)**	**TOTAL AMOUNT REQUESTED:** $350,000

Proposal Track (select one): Initial Startup

TITLE OF PROPOSED PROJECT: Demonstration of soil thickness and carbon (STC) method

SPECIFIC PROJECT FOCUS: We propose to take a proof of concept of a model predicting soil thickness and carbon stocks to demonstrate its utility across diverse terrains for commercial marketing. This proposal builds on a discovery by Patton et al. (2018, 2019) and patent by Lohse et al. (2023) in which an empirical method to predict soil thickness and carbon is based on high-resolution elevation data and as few as one excavated soil pit. However, validation of this proof of concept was limited to three locations. Here we propose to test the soil thickness and carbon (STC) method across a diverse range of terrains, lithologies or soil types, and land uses (e.g., agriculture, rangeland, forest) in the United States and develop a visual demonstration model that can be used to market this method to investors and stakeholders with our business plan. Our specific objectives are as follows: 1) Conduct elevation terrain analysis to identify field areas across the contiguous United States, 2) Evaluate predicted soil thickness and carbon based on STC method to observed values, 3) Develop a demonstration model exhibiting use of method across diverse terrain and also identify limitations, and 4) Simultaneously conduct market research and develop a business plan. Easily obtainable soil thickness estimates have broad commercial application to transportation, mitigation, and developing planning models across the United States and can be marketed globally.

PROJECT START DATE: 8/1/24	**PROJECT END DATE:** 7/31/25
NAME OF INSTITUTION: Idaho State University	**DEPARTMENT:** Biological Sciences
ADDRESS: 921 S. 8th Ave, Mail Stop 8007, Pocatello, ID 83209-8072	
E-MAIL ADDRESS: isuaor@isu.edu	**PHONE NUMBER:** 208-282-2592

	NAME:	**TITLE:**	**SIGNATURE:**
PRINCIPAL INVESTIGATOR	Dr. Kathleen Lohse	Professor	[signature]
CO-PRINCIPAL INVESTIGATOR	Dr. Nicholas Patton	Postdoctoral Associate	[signature]

NAME OF PARTNERING COMPANY:	**COMPANY REPRESENTATIVE NAME:**

	NAME:	**SIGNATURE:**
AUTHORIZED ORGANIZATIONAL REPRESENTATIVE:	Dave B. Harris	[signature]

1. Name of primary Idaho public institution: Idaho State University

2. Project Title: Demonstration of soil thickness and carbon (STC) method

3. Name and project-related credentials of Principal Investigator directing the project: Dr. Kathleen Ann Lohse (PI) is a professor in the Department of Biological Sciences at Idaho State University and holds a joint appointment with the Department of Geosciences. Lohse has a PhD in Soil Science from UC Berkeley with an emphasis in Soil Biochemistry and Hydrology. Lohse will be the principal investigator (PI) and supervise postdoctoral associate (Dr. Nicholas Patton), oversee communication, reporting, management of research specialist and seasonal technicians, as well as develop the business plan.

4. Name and project related credentials of other key personnel: Dr. Nicholas Patton (Co-PI) is a postdoctoral associate in the Department of Geosciences at Idaho State University. He has a PhD from the University of Canterbury, New Zealand with a focus in landscape evolution and soil science. Patton, together with Lohse, Crosby and Godsey, discovered the soil thickness and carbon method as part of his MS thesis at Idaho State University and will oversee the terrain analysis and evaluating of the model predictions to observations and co-supervise two soil research technicians in collecting, processing and analyzing soil thickness and soil carbon, nitrogen and organic matter.

5. Project objective(s) and total amount requested: Soil thickness and carbon are fundamental properties for many earth science and technology disciplines but difficult to predict. For example, soil thickness is a key factor in slope failure (landsliding) yet this parameter is often unknown. If thickness can be predicted, it has sweeping commercial application to decision support models for risk management (e.g., landslide susceptibility, transportation hazard), best practices for landscape mitigation (e.g., mining, landfills, housing developments, road construction), vehicle mobility in military operational scenarios and can be used in hydrologic models to estimate soil-water storage. Moreover, soil carbon estimates may be used in carbon banking and trade initiatives and assist in determining nationally determined contributions identified in the Paris Climate Agreement. As part of the Reynolds Creek Critical Zone Observatory, we developed an empirical method to predict soil thickness and carbon based on high-resolution elevation data and as few as one excavated soil pit and published this proof of concept (Patton et al. 2018, 2019) and subsequently patented this process for its commercial use (Lohse et al. 2023).

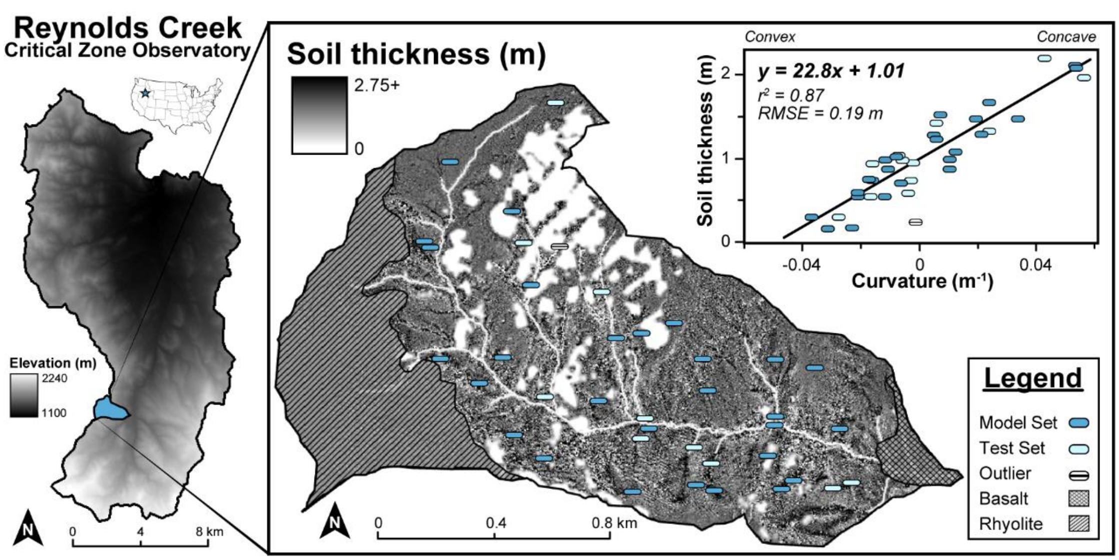

Figure 1: *Relationship between soil thickness and curvature at a site in southwest Idaho and our model output of soil thickness across this catchment at a 3 m resolution. Modified from Patton et al. (2018).*

In particular, Patton et al. (2018) found that soil thickness was linearly related to curvature, a measure of hillslope shape (e.g., convex, planar, concave) (Fig 1). Patton et al. (2018) then combined a limited set of available soil thickness and high-resolution elevation Light Detection and Ranging (LiDAR) data to evaluate the generality of the soil thickness-curvature functions from nine (9) sites in the western United States and Australia (Fig 2a) and showed that this varied with location and appeared to be related to the distribution in curvatures within a catchment, hereafter referred to as field area. Indeed, Patton discovered that the soil thickness-curvature slope functions were significantly related to the standard deviation (SD) of curvature within the entire area of interest (Fig 2b). Based on this empirical relationship (equation in Fig 2b), we could estimate the soil thickness-curvature slope function for any site with available high-resolution elevation data and determine the intercept value from one soil pit on a planar (flat) surface. Three independent site locations with multiple soil pits were used to verify this method as a proof of concept (Fig 2c). As expected, soil thickness predictions in field areas with narrow curvature distributions (small SD in curvature) matched soil thickness observations whereas those in areas with broad curvature distributions (large SD in curvature) did not. Patton et al. (2019) later showed that these same principles could be applied to estimating soil carbon using a minimal number of soil pits. The clear benefit of these findings is that other extrapolation methods, such as kriging, require a large quantity of soil pits (>50) to derive similar spatially distributed estimates of soil thickness and carbon. As a result, our STC method enables rapid assessment, improves predictive models, and reduces resources (e.g., personnel and funds).

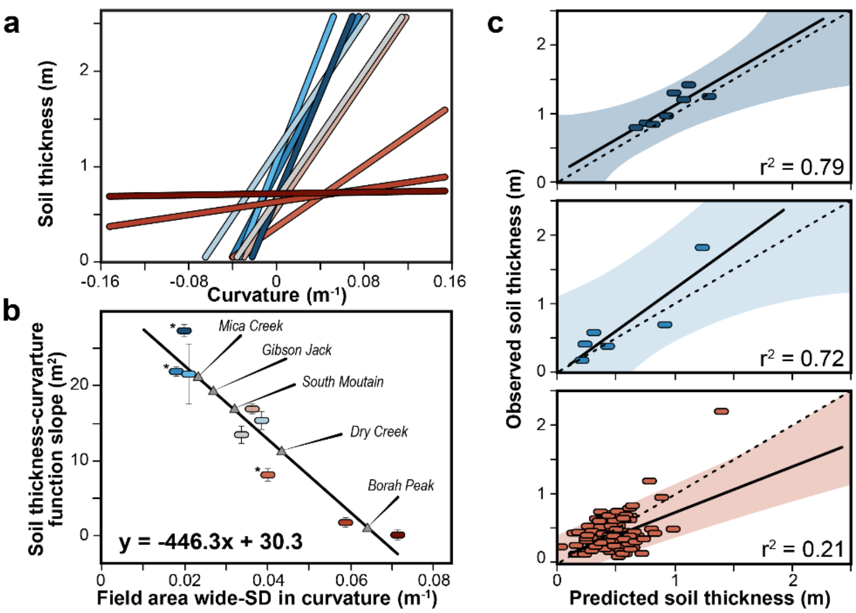

***Figure 2: a)** Relationships between soil thickness and curvature across 9 sites, **b)** soil thickness-curvature slope functions and their respective field area-wide standard deviation (SD) in curvature, and **c)** proof of concept of predicted STC model and observed values. Asterisk (*) in panel b refers to validation sites in panel c but are not utilized in the construction of our model. If funded, additional sites across Idaho (triangles in panel c) and the United States will be selected to test our STC method across a diverse range of terrains, lithologies, and landscapes. Modified from Patton et al. (2018).*

Since the publication of our novel proof of concept, our team has been making substantial headway in accurately predicting these soil properties by developing innovative procedures to more efficiently apply our predictive soil thickness and carbon (STC) approach to complex landscapes. However, despite our positive progression, we are at a pivotal point for the STC method's development that requires further assessment to better define the scope of the method's utility, application and limitations.

<u>We are requesting a total of $350,000 over a two-year period</u>, beginning in FY24, to expand our STC method across the United States and develop a visual demonstration model that can be used to market this method to investors and stakeholders with our business plan. Specifically, our objectives are as follows:

1) Conduct elevation terrain analysis to identify field areas across the contiguous United States.
2) Evaluate predicted soil thickness and carbon based on STC method to observed values.
3) Develop a demonstration model exhibiting use of method across diverse terrain and also identify limitations where multiple disturbances or inputs might limit its utility.
4) Perform market research and develop a business plan for the STC method.

6. Resource commitment: The objectives of this proposal are aligned with Idaho's Higher education research strategic plan (2023-2027) in the advancement of agriculture and national security that are both economically and environmentally sustainable. Our work parallels emerging strengths/opportunities in Idaho's future research involving 'natural resources and agricultural utilization and conservation'. This proposal builds the capacity for Idaho researchers and students to work alongside landholders, private companies, and department of defense personnel to develop productive relationships and foster scientific collaboration.

If this proposal is granted, data will strengthen relationships amongst universities within the Idaho State higher education system by targeting collaborative research that will benefit from our proposal efforts. For example, Idaho contains a wide variety of landscape and ecosystems that represent a large proportion of the United States. This provides our group with a fantastic opportunity to not only test our model's application locally but also contribute to Idaho's ongoing research and future research. This includes but is not limited to Dry Creek, Mica Creek, South Mountain and Reynolds Creek Experimental Watersheds with partnerships amongst Boise State University, University of Idaho, and Idaho State University.

7. Specific project plan and timeline: We currently assess our STC method at a Technology Readiness Level five (TRL 5) due to its proven utility in 9 catchments. The basic principles and proof of concept were observed and reported in Patton et al. (2018), its practical application was formulated in Patton et al. (2019), and later patented in Lohse et al. (2023). To date, our models have contributed to predicting soil thickness and carbon estimates for scientific endeavors across the globe (e.g., Yan et al., 2021), highlighting our STC methods demand. In order to advance through the 'Development' stage of the TRL spectrum (4-6), we must conduct a more exhaustive testing of the STC method in additional landscapes. This will provide us with the necessary information to assess our procedural updates and modifications (TRL5), evaluate our model's uncertainty, and limitations (TRL6). Moreover, we plan to progress through the 'Deployment' stage of the TRL spectrum (7-9), in so doing avoiding the '*Valley of Death*', by engaging with businesses, landowners, and government personnel (hereafter referred to as clients) to demonstrate our model's effectiveness in commercial application (TRL7). These partnerships will provide two critical needs: 1) allow us to tailor our models' outputs based on the client's requests and interest (i.e., maps, reports, data and professional recommendations) and 2) identify new lines of services that would contribute to broadening the STC models commercial application (TLR8 and TLR9). Below we organize our proposed project plan around our four objectives that are subdivided into Tasks A-H, see *Section 13* Table 1.

Objective 1 - Conduct elevation terrain analysis to identify sites across the contiguous United States:

Task A) Project Coordination (FY24 Q1 - FY25 Q4): Dr. Lohse will oversee all operations to ensure that Objectives 1-4 and associated Task A-H are completed.

Task B) Hire Technicians (FY24 Q1-Q2): Initial efforts will primarily focus on hiring two seasonal soil research technicians and one 1 yr. full-time research specialist to assist with field coordination, analyses, and data management. Dr. Lohse will lead the hiring process while Dr. Patton will oversee training and field activities. The seasonal technician positions will be targeted at individuals with a passion for research in soil and environmental science. Technicians will be expected to contribute to field activities (e.g., soil pit excavation, sample collection) and subsequent laboratory analyses (e.g., carbon, nitrogen, and organic matter stocks). Therefore, we will prioritize the hiring of individuals that are proficient within the laboratory setting, have experience with geospatial data, and a strong ability to conduct field work. We anticipate hiring the full-time research specialist will take 5-6 months to complete such that we will on-board this individual in Feb-Mar 2025. Thus, Patton will supervise the seasonal technicians and lead the FY24 efforts and focus on more local sites in Idaho to reduce the complexity of the field logistics in the first field season.

Task C) Terrain analysis to identify areas of interest (FY24 Q1-Q2): Both Dr. Lohse and Patton are in contact with researchers associated with Long-term Ecological Research (LTER), Critical Zone Observatories (CZO), National Ecological Observatory Network (NEON), and Long-term Agroecosystem Research (LTAR) sites across the United States to determine their interest in our STC model and scientific collaboration. We have already obtained confirmations of interest from numerous sites (see Fig 3). These localities will expedite permitting processes and add the most value to existing sites thereby contributing meaningfully to science. Additionally, we are currently seeking businesses, landowners, and government personnel to see if partnerships can be formed. For instance, we are in communication with Department of Defense (DOD) personnel within the U.S. Army Engineer Research and Development Center (ERDC) labs to run our model at several military training areas (i.e., in CA and NY) (Fig 3 - Sites not shown). The goal of this collaboration is to provide critical spatio-temporal information for models to better predict vehicle mobility and limitations across varying soil conditions (i.e., soil thickness and organic matter) and landforms (McDonald et al., 2009); thereby strengthen decision making regarding military operations scenarios in foreign theaters (Sion et al., 2021; 2022).

We are limited to a maximum of 12 to 15 catchments for our proposal endeavors; therefore, it is necessary that we have developed a criterion for the final site selection. All field areas must have: 1) full spatial coverage of high-resolution elevation data (1 to 5 m) that can be obtain by either the clients or downloaded through the United States Geological Survey (USGS) website (https://www.usgs.gov/3d-elevation-program), 2) contain a diverse terrain that spans the full range of field area-wide SD in curvature, 3) have a direct contribution to ongoing/future research and/or commercial applications, and 4) although not mandatory, we will place a priority on Idaho catchments to establish local engagement and investment. As mentioned in *Section 6*, Idaho's panoply of landscapes/ecosystems that represent areas across the United States provides a great opportunity to test our STC approach locally. This allows us to work directly with Idaho residents, students, businesses and universities while simultaneously showcasing Idaho's beauty and natural resources. These criteria will ensure that all sites will progress our patented approach through the TRL spectrum and foster ties amongst the scientific community and industry.

The finalized selected catchments will have elevation data obtained and the datasets will be reprocessed to 5 m resolution, based on sensitivity analyses conducted by Patton et al. (2018). Utilizing our patented approach, we will identify one (1) site location on a planar (or flat) hillslope to construct our model and ten (10) sites across the range of curvature values to verify the method. When possible, we will use a nested sampling design to observe how the curvature-slope function relationship scales with field area size and to improve estimates.

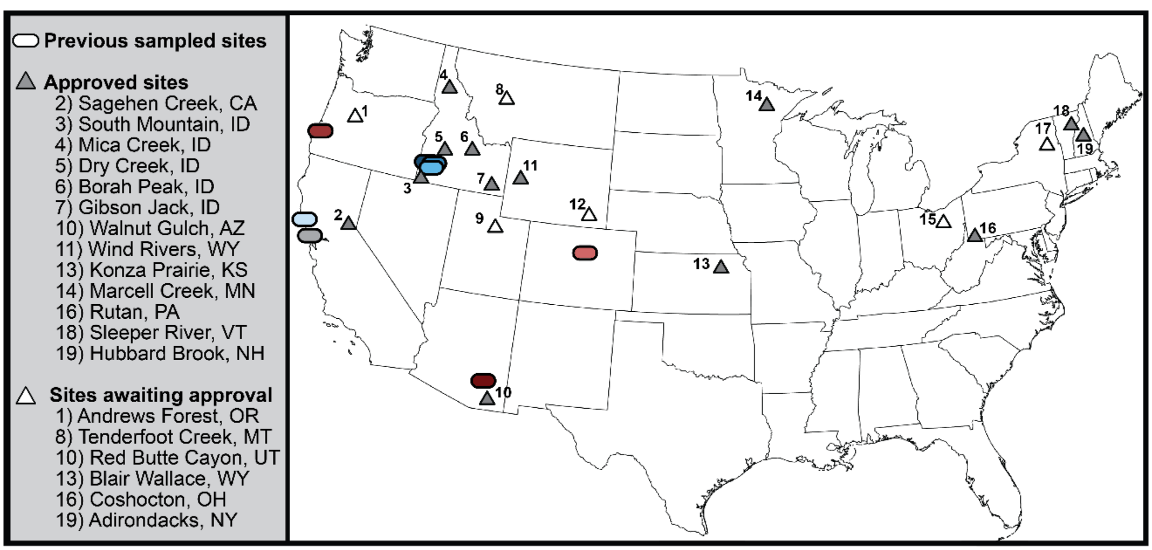

Figure 3: *Location of all sites used in Patton et al. (2018; 2019) (colored ovals) with cool to warm colors indicated low to high field area-wide standard deviation (SD) in curvature, respectively. Numbered triangles represent all potential new sites that will be considered if the proposal is funded. Gray triangles sites indicate if sites have been preapproved and white triangles are still awaiting approval. Sites selected cover a wide range of landscapes, ecosystems and land use across the United States associated with several universities, businesses, landowners, and government agencies.*

Objective 2 - Evaluate predicted soil thickness and carbon based on STC method to observed values:

<u>*Task D) Collect soils across sites (FY24 Q2 - FY25 Q1):*</u> In FY24, Patton will initially schedule field activities with clients for each field area and pass this role onto the full-time specialist when hired. As mentioned above, we will focus FY24 on Idaho sites and if time permits, we will travel to warmer

regions in the fall and winter, and then to snow dominated regions in the spring and summer of FY25. The full-time soil specialist will be accompanied by both seasonal technicians and either Dr. Lohse or Dr. Patton. The site evaluations conducted in *Task C* will provide the site location for soil pit excavation and sample collection. It is important to note, soil augering will be avoided due to its inconsistency in reaching required depths due to the presence of large rocks or extremely hard soils.

Eleven total soil pits (1 x 1 m) will be excavated per field area to record soil thickness and soil attributes. Samples and bulk density measurements will be collected at predetermined depths for the entire soil profile, as described by Patton et al., (2019), and sent to the Idaho State University's Soil and Aqueous Biogeochemistry Research (SABR) Laboratory. A total of 176-209 soil pits will be excavated in FY24 and FY25 which includes approximately 1392-1653 samples, depending on nested design and total soil depths. It is important to note that several identified catchments will grant access to personnel and equipment (i.e., backhoes and/or excavators) to aid with field activities, if needed. Moreover, we will allocate rental funds for excavation of pits at sites where it is feasible and soils are deep and cohesive.

Task E) Analyze soils for soil carbon (FY24 Q2 - FY25 Q2): Immediately after field activities, the full-time specialist and seasonal technicians will register all collected samples to the System for Earth Sample Registration (SESAR) database and assigned an International Geo Sample Number (IGSN) following their online protocol (https://www.geosamples.org/). In FY24, Patton will oversee seasonal research technicians registering these samples. Once completed, samples will be sieved, dried and homogenized under standard soil operating procedures for the determination of organic matter, rock, and moisture contents, bulk density, color, pH, amongst other soil attributes. Additionally, a 20 g ground subsampled will be sent to Idaho State University's Center for Archaeology, Materials and Applied Spectroscopy (CAMAS) Stable Isotope Laboratory for elemental and isotopic analysis. Samples will be analyzed using a Costech ECS 4010 elemental analyzer interfaced with a Thermo Delta V Advantage continuous flow isotope ratio mass spectrometer (EA-IRMS) to determine percent organic carbon and nitrogen and their associated isotopes ($\delta^{13}C$ and $\delta^{15}N$) with an analytical precision of ≤ ± 0.2‰ and ± 0.5%, respectively. Total soil carbon, as well as nitrogen and organic matter, will be determined utilizing the workflow described by Patton et al. (2019). Remaining samples will be archived in our long-term soil inventory with all ancillary information made publicly available through Boise Scholar Works (https://scholarworks.boisestate.edu) at the end of FY25, ensuring data accessibility, transparency, and future scientific endeavors.

Task F) Evaluate soil thickness and carbon (STC) model (FY24 Q2 - FY25 Q4): Soil thickness and carbon estimates will be extrapolated across each field area utilizing one soil profile and our STC model. Postdoctoral associate (Patton) will oversee the evaluation of our model outputs by relating our observed measures (10 or 30 per site depending if the standard or nested sampling design was used, respectively) to predicted values. Additional procedural development may be needed to estimate our models' uncertainty/performance, and therefore will be considered based on a site per site basis.

Objective 3 - Develop a demonstration model exhibiting use of method across diverse terrain and also identify limitations where multiple disturbances or inputs might limit its utility:

Task G) Develop demonstration model (FY25 Q2 - Q4): Dr. Patton, will develop visual demonstration models for final client reporting and future marketing campaigns. We plan to create interactive soil thickness and carbon maps produced by our STC approach utilizing software such as ArcGIS Pro, story maps, and/or 3D scenes, amongst others (available at Idaho State University). We envision our georeferenced demonstration model to be easily downloadable to mobile devices, tablets or computers so the clients will have real-time, expert-based knowledge at their fingertips (Fig 4). These visualizations will highlight our novel datasets, demonstrate their spatial components, educate our clients so they can make better informed decisions, and be utilized to market to investors and stakeholders at the end of FY25.

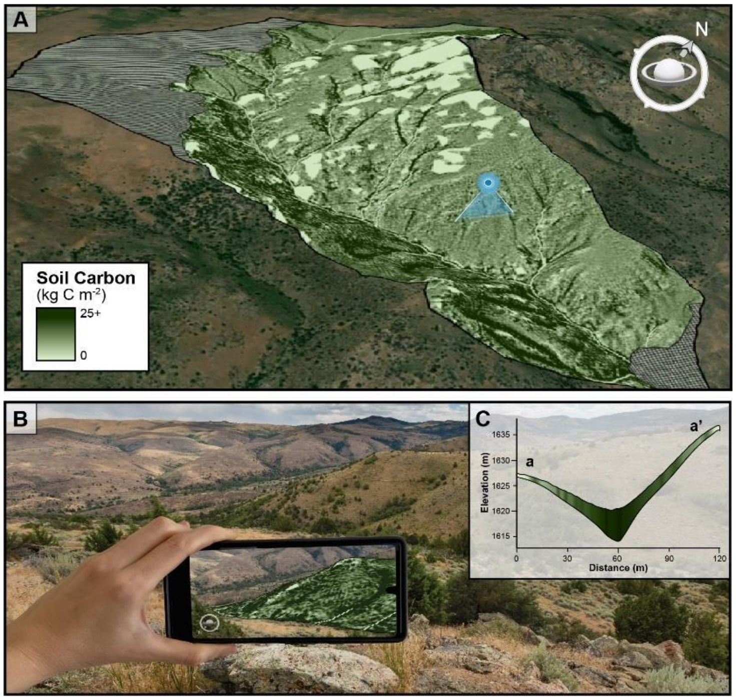

Figure 4: *Conceptual example how clients can utilize our data in real-time on mobile devices.* ***a)*** *3D interactive map tied to current location and* ***b)*** *perspective that allows clients to draw profiles and* ***c)*** *extract data.*

Based on our previous efforts, we expect the STC model to work well in most soil-mantled landscapes such as plains or foothills where their SD of curvature is less than <0.4 m^2 (Fig 2b), because the model is rooted in the fundamental principles of sediment transport theory. In contrast, our approach may be limited in rock dominated localities such as steep mountains where SD of curvature is large. This also includes aeolian or fluvial dominated areas, due to the sequential deposition of sediment and carbon inputs. Consequently, we plan to utilize chronological sampling techniques (e.g., ^{14}C radiocarbon or optically stimulated luminescence dating) to identify such inputs and to better understand these systems. Further model development during this proposed time period may allow us to rectify this limitation and thus account for this conundrum.

Objective 4 - Perform market research and develop a business plan for the STC method.

<u>*Task H) Market research and business plan (FY24 Q1 – FY25 Q4):*</u> We will participate in the I-Corps 4-week program and systematically develop a business concept, conduct market research of competing technologies, and develop a business plan over the 2-year period. We view the I-Corps program as critical for the PIs (Lohse, Patton) to develop a basic level of business acumen. Specifically, we will work to define our business concept, refine the '*unmet need in the marketplace'*, and develop an advisory board. This will involve researching our competitors and prospective customers. We believe that our product will be cheaper and better than what competitors can provide, because our approach requires less resources (i.e., a minimum of one soil pit within a defined area compared to >50 soil pits) while producing a higher resolution product with increased accuracy.

In FY24, we will look at different business models and how they might function in producing the product (soil thickness map or soil carbon map, for example) and providing them to the customer. We will run through several scenarios to look at the business work-flow model to examine the logic and need for different business elements starting with personnel, computing power, and ending with the sale of the product. In sum, this demonstration project will allow us to experiment through the process of adaptive management to determine the best model. Moreover, we will also conduct informal market research and call on knowledgeable individuals to review our ideas and progress. If this business concept appears fruitful, we may pursue a formal investigation and involve consultants to assess our business model. Our product is specialized but has interest from the commercial, military, and private sector.

In FY25, we will develop a business plan with an appropriate exit strategy. This plan will involve identifying a business as well as legal structure. By the end of this year, we will register the business and look to secure market access as well as raise financial funding for moving into the implementation plan.

8. Potential economic impact: The project will bring jobs and revenue to Idaho. While several components of the project such as the LiDAR acquisition and analysis may be automated in the future by AI or machines, other elements such as soil excavation and expert consulting cannot be replaced. Our business has the potential to grow and build a large number of entry level jobs (both seasonal and other full-time) as well as high-level supervisor and analyst positions. We envision a short-time frame to shift from implementation to profitability because of our low startup costs. PI Lohse and co-PI Patton already have a patent on the STC method (Lohse et al. 2023). Lohse holds the entire right, title and interest in the patent with agreed upon distributions among the inventors to facilitate selling of patent and business (30% Lohse, 30% Patton, 20% Godsey, 20% Crosby). Initially, we require a high-performance workstation (already available), expertise provided by Patton and Lohse to identify the location of the soil pits to be excavated, and the people-power to dig the soil pits. Additionally, we plan on applying for several larger NSF grants and government contracts that would result in revenue, see *Section 15* for more details.

9. Criteria for measuring success: Below we provide the metrics by which we will measure our project progression and economic success (Milestones).

Table 1: *Metrics, organized by objectives and task, to reach targeted milestones identified for FY24 and FY25. See Section 7 and Table 3 for more details.*

OBJ.	TASK	METRIC	Milestones		
			FY24	FY25	TOTAL
1	A)	Submit IGEM-HERC proposal (submitted or not)	Yes	NA	Yes
	B)	Hire specialist / technicians (# hired)	3	2	5
	C)	Obtain agreements / commitments for field area (# sites)	5-6	7-9	12-15
		Acquire elevation datasets for field areas (# sites)	5-6	7-9	12-15
		Select sites for soil pit excavation (# GPS locations)	55-66	77-99	132-165
2	D)	Travel to field areas (# sites)	5-6	7-9	12-15
		Excavate and sample soil pits (# pits)	73-84	103-125	176-209
		Collect soil samples (# samples)	580-661	812-992	1392-1653
	E)	Register samples in SESAR (# samples)	580-661	812-992	1392-1653
		Process samples (# samples)	580-661	812-992	1392-1653
		Analyze for carbon (# samples)	580-661	812-992	1392-1653
		Produce publicly available, online datasets (# products)	NA	12-15	12-15
	F)	Generate high-resolution STC outputs (# maps)	5-6	7-9	12-15
		Evaluate STC model uncertainty (# sites)	5-6	7-9	12-15
3	G)	Develop visualization model (completed or not)	NA	Yes	Yes
		Document limitations and possible steps forward (completed or not)	Yes	Yes	Yes
		Produce client reports (# reports)	5-6	7-9	12-15
4	H)	Attend the 4-week I-Corps program (attended or not)	Yes	NA	Yes
		Contact individuals for market research (# contacted)	1-5	1-5	5
		Develop a legal business structure (completed or not)	Yes	NA	Yes
		Register business (completed or not)	NA	Yes	Yes
		Total number of future clients engaged (# clients)	0-2	0-2	0-2

10. Briefly describe anticipated development challenges/barriers and how you will deal with unanticipated research and development challenges: As part of our plan, we will develop an external advisory board (EAB) and have a succession plan to help anticipate development challenges or barriers should one of the PIs move to another position or need to step down. The EAB will consist of a network of business people and our patent lawyer (5) who can help us navigate business development challenges. For example, we can use this EAB to ensure there is no conflict of interest and that the research is conducted without bias given our patent holding. The succession plan stipulates that should Lohse need to step down as lead PI, Patton (co-PI) will lead the project as PI. If Patton leaves for a new position, Patton will actively negotiate time in his new position to complete this project. Both PIs are clearly invested in the project and work well together and will schedule weekly meetings to ensure communication and execution of this venture.

11. Budget: We are requesting $350,000 over two years. Please see attached IGEM-HERC budget form that accompanies this proposal for more detail.

Table 2: *Summary of project budget.*

LINE-ITEM REQUEST	TOTAL AMOUNT
Personnel salary (*fringe*)	$183,546 (*$46,905*)
Equipment	$0
Travel	$42,410
Participant support	$0
Other direct costs	$77,138
	$350,000

12. Budget justification:

Personnel Salary: Consist of Principle and Co- Investigators, Research Specialist and Technicians.

Principle Investigator: Professor Kathleen Lohse is in the Department of Biological Sciences at Idaho State University and holds a joint appointment with the Department of Geosciences. Lohse has a PhD in Soil Science from University of California Berkeley with an emphasis in Soil Biogeochemistry and Hydrology. Lohse will supervise postdoctoral associate (Patton) in collection and analysis of soil thickness and carbon. Lohse will lead hiring of a full-time research specialist and co-supervise with Patton the full-time soil research specialist and two seasonal technicians (12 weeks). Lohse requests 0.6 months of summer salary in FY24 and FY25 and then requests 20% of her academic salary for FY24 to develop a business plan. Lohse will be on a year-long sabbatical from ISU and only paid at 50% during FY24 by ISU; therefore, this request of 20% of her academic salary will allow her to devote 20% of her effort to this project.

Co-Principal Investigator: Dr. Nicholas Patton is in the Department of Geosciences at Idaho State University. Patton is a postdoctoral associate and has a PhD in Geosciences from University of Canterbury in Christchurch, NZ. Patton is a soil geomorphologist with expertise in paleoclimate, chronology and remote sensing. His research focuses on the complex interaction between biotic and abiotic processes that drive landscape, climate, and ecosystem evolution. Prior to this postdoctoral position, Patton worked on multiple military contracts and bases domestically and internationally as part of DRI's Soil Characterization and Quaternary Pedology Laboratory. Patton will co-supervise the full-time research specialist and the seasonal technicians in the collection and analysis of soils for thickness and carbon. We are requesting 40% of his salary in year 1 at $56,650 and 50% in year 2 at $58,350 to reflect his efforts on this project and 3% increase in salary each year.

Research Specialist: An individual (to be later named) with a MS or BS in soil science or geology will be hired as a full-time employee to process samples and coordinate data management. We request 75% of this salary ($47,133) for FY24 in anticipation of hiring this individual by Feb-Mar 2025 (after advertising, interviewing and completing HR forms) so that this person can be trained prior to the field season. We ask for the remaining 25% of this year-long position to be allocated to FY25.

Seasonal technicians: Two individuals (to be later named) will be hired in the summer/fall of FY24 at $23/hr for 12 weeks at 40 hrs to assist with the collection of soils from around Idaho and then another set of seasonal technicians will be hired again in the spring of FY25 for the second set of field campaigns.

Fringe: Thirty-nine percent (39%) of salaries and wages for all full-time employees (Patton and Research Specialist) with an additional 3% increase each year. Nine-point seven percent (9.7%) of salaries and wages for all part-time employees (less than 50% time) including Lohse, who is on sabbatical. Students/seasonal workers are considered part-time employees.

Equipment: None.

Travel: We request a total of $42,410 in funds to support in-state and out-of-state travel ($20,000 in FY24 and $22,410.38 in FY25). This includes 60 total travel days for ~3 personnel, $950 in transit cost per person (i.e., vehicle rentals, mileage, fuel, and/or flights), $113.75 in lodging cost per person per day, per diem ($55 per day), and conference/meeting cost. Truck rentals at ISU are rated at $150/day or minivan to accessible sites at $35/day (plus mileage).

Participant Support: None.

Other Direct Cost: Consist of materials & supplies, sample fees, rentals, services, publication fees, consultant services and computer services.

Materials & Supplies and sample fees: We request a total of $42,000 in funds to cover field, supplies, and sample fees. We allocate $20,000 to cover carbon analyses and geological dating. Between 1392-1653 samples will be run for percent carbon and nitrogen and their associated isotopes at $9.50/sample within Idaho State University's Center for Archaeology, Materials, and Applied Spectroscopy (CAMAS) (totaling $13,224-$15,704). The remaining $4297-$6776 will be used for either ^{14}C radiocarbon ($400/sample) or OSL ($1000/sample) dating at the University of California Irvine's W. M. Keck Carbon Cycle Accelerator Mass Spectrometer Facility and the Utah State University Luminescence Laboratory, respectively. The remaining $22,000 will be used for other items that could include: shovels, pick axes, gloves, coolers, ice, grinders, pipettors, pipette tips, plastic bags, glass and plastic ware, filters, reagents and tin capsules.

Rental and services: We request a total of $18,000 for rentals and services. $10,000 in FY24 and FY25 will be used to cover rental of backhoes or excavators to assist with digging sites that are accessible and permissions obtained. We allocate $4000 in FY24 and FY25 in the budget to service the water purification system and balance calibration services.

Publications fees: We request $4138 total for publication cost, $2000 in FY24 and $2138 in FY25.

Consultant services: We request a total of $8000 ($4000 in both FY24 and FY25) to cover possible lawyer fees related to the patent and to provide a small honorarium to our external advisory board.

Computer Services: We request $5000 in FY24 for computer service / purchasing of software.

Indirect Costs: Zero percent (0%) indirect costs are requested.

13. Project management:

Table 3: *Project schedule to achieve milestones. Lead initials are indicated with Lohse (KAL), Patton (NRP), and research specialist/technicians (TEC).*

Project Schedule			FY24				FY25			
OBJ.	***TASK***	***LEAD***	***Q1***	***Q2***	***Q3***	***Q4***	***Q1***	***Q2***	***Q3***	***Q4***
1	A) Project coordination	KAL	X	X	X	X	X	X	X	X
	B) Hire technicians	KAL	X	X						
	C) Terrain analysis	NRP	X	X						
2	D) Collect soils across sites	TEC		X	X	X	X			
	E) Analyze soils for soil carbon	TEC		X	X	X	X	X		
	F) Evaluate STC model	NRP		X	X	X	X	X	X	X
3	G) Develop demonstration model	NRP						X	X	X
4	H) Market research and business plan	KAL	X	X	X	X	X	X	X	X

14. Additional institutional and other sector support: Idaho State University is committed to our use of lab space and facilities and we have access to the Research Data Center (RDC) for high-performance computing if needed. See *Appendix A - Facilities and Equipment* for more information.

15. Future funding: Soils are the foundation of terrestrial ecosystems and are of the utmost importance for the future of agriculture, infrastructure and the environment. Therefore, the proposed IGEM-HERC project is the catalyst that will showcase our novel approach and its full utility for future clients and funding sources. During FY24, we will submit a Department of Energy (DOE) MONet soil sampling call that would result in a full suite of soil properties analyses (beyond what is budgeted here). In this way, we can augment the value of this project and resultant datasets and products. Lohse and Patton also plan to apply to the National Science Foundation (NSF) Accelerating Research Translation (ART) program through the NSF Directorate of Technology, Innovation and Partnerships (TIP). This grant would provide up to $6M for 4 years to accelerate translation of ideas to market. Lohse has been successful with securing and managing NSF grants of this size. Other possible grants/contracts include the DOD Strategic Environmental Research and Development Program (SERDP) that would assist DOD to manage its land and meet environmental challenges. Lohse was a co-PI on a prior SERDP contract/award on military bases (i.e., Fort Huachuca and Barry Goldwater in AZ) so this may facilitate developing contacts and contracts. Additionally, Patton also has multiple contacts and experience working at several military installations during his time at the Desert Research Institute's (DRI) Integrated Terrain Analysis Program (ITAP) (i.e., Fort Hunter Liggett in CA, Fort Greely and Fort Wainwright in AK, Fort Drum in NY, Camp Grayling in MI, and Yuma Proving Grounds in AZ). By the end of HERC funding (FY25), we anticipate securing a contract(s) with DOD and/or DOE. We also will have identified prospective customers in the commercial or transportation sectors. Lohse has several commercial contacts via Lohse's patent lawyer and developing contacts for investors. An example is Third Nature Investments that invests in earth's critical systems technology and innovation. All of this possible new funding and contracts would generate revenue for Idaho.

References:

Lohse, K. A., Patton, N. R., Godsey, S. E., & Crosby, B. T. (2023). Soil depth measurement system and method. United States Patent, US 11567055.

McDonald, E.V., Bacon, S.N., Baker, S., & Jenkins, S.E., 2009, Landforms and Surface Cover of Vehicle Endurance and Dust Courses at the U.S. Army Yuma Proving Ground. Report prepared for Natural Environments Test Office, U.S. Army Yuma Proving Ground, 206 p.

Patton, N. R., K. A. Lohse, M. Seyfried, B.T. Crosby, & S.E. Godsey. (2018). Predicting soil thickness on soil mantled hillslopes. Nature Communications, 9(1), 1-10. https://doi.org/10.1038/s41467-018-05743-y

Patton, N. R., K. A. Lohse, M. Seyfried, S.E Godsey, & S.B Parsons. (2019). Topographic controls of soil organic carbon on soil-mantled landscapes. Scientific Reports, 9(1), 1-15. https://doi.org/10.1038/s41598-019-42556-5

Sion, B., Weir, W. B., & McDonald, E. V. (2021). Assessment of numerical vadose zone models and empirical relationships between soil moisture and soil strength for vehicle mobility applications, 25. U.S. Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, W913E5-19-C-0009

Sion, B., Shoop, S., & McDonald, E. V. (2022). Evaluation of in-situ relationships between variable soil moisture and soil strength using a plot-scale experimental design, Journal of Terramechanics, 103, 33-51, https://doi.org/10.1016/j.jterra.2022.07.002

Yan, Q., Wainwright, H., Dafflon, B., Uhlemann, S., Steefel, C.I., Falco, N., Kwang, J., & Hubbard, S.S. (2021). A hybrid data–model approach to map soil thickness in mountain hillslopes. Earth Surface Dynamics, 9 (5), 1347-1361.

Appendix A: Facilities and Equipment

A1. Idaho State University (ISU):

A1.1. Soils Biogeochemistry Laboratories: Laboratory space for chemical analyses of soil is located in the Soil and Aqueous Biogeochemistry Research (SABR) Laboratory at the Idaho State University directed by Kathleen Lohse (Department of Biological Sciences). Lohse has a wet biogeochemistry lab and soil laboratory (1000 sq ft). The wet lab is equipped with a SmartChem Discrete Analyzer, DIONEX ion chromatograph, Shimadzu TOC-V, Horiba Aqualog for nutrients, anions, DOC/TN, and dissolved organic matter (DOM) characteristics, respectively. The soil lab is equipped for sampling, processing, and preparing soil and plant material for compositional and isotopic analyses and also includes an infrared gas analyzer (IRGA) PP system, Gas chromatography with ECD, methanizer, and FID, and access to a LiCOR system. The wet lab has a Millipore water system, shaker table, drying ovens, a muffle furnace, analytical balances, refrigerator, and freezer.

A2. Other Facilities:

A2.1 Center for Archaeology, Materials, and Applied Spectroscopy (CAMAS): The CAMAS facility is a research center at Idaho State University, which contains the Interdisciplinary Laboratory for Elemental and Isotopic Analysis (ILEIA). The mass spectrometer laboratory in ILEIA is directed by Bruce Finney (Departments of Biological Sciences and Geosciences) and contains a ThermoElectron Corporation Delta V Plus stable isotope ratio mass spectrometer with a ConFlo IV Universal Interface and EA, TCEA and Gas Bench II sample introduction systems. This instrumentation provides analyses of $\delta^{18}O$, $\delta^{13}C$, $\delta^{15}N$, δD, C (%), N (%) on organic materials, carbonates and water. The stable isotope facility has wet and dry lab space and equipment for sample preparation, and is supported by a laboratory manager and technical laboratory assistant positions responsible for instrument maintenance, calibration and sample processing.

A2.2 The ISU Molecular Research Core Facility (MRCF): The MRCF provides ISU's molecular scientists with the resources necessary for successful and productive research pursuits in this rapidly growing field. The MRCF also acts as a center of intellectual exchange for ISU's community of scientists and serves to promote collaboration and multidisciplinary approaches to specific research initiatives. Routine activities in the MRCF include automated DNA sequencing and microsatellite analysis (Genotyping), PCR, electrophoresis, and gel documentation and analysis. The MRCF also maintains two advanced, BIOTEK multi-reader absorbance and flouresence spectrophotometer, digital imaging microscopy systems; a Leica DMRB fluorescence microscope and a Leica DMRA deconvolution and three-dimensional processing scope.

A2.3 Plant Sciences Research Facility: This facility includes four independently controlled greenhouse bays, a headhouse, a growth chamber room, and two offices. The second stage includes a research laboratory, a 120-seat lecture room, and a teaching laboratory. Research equipment housed in the facility includes walk-in and reach-in growth chambers, soil sterilization equipment, a root washer, a leaf area meter, an electronic balance, drying ovens, a microscope, computers, and supplemental lighting in three greenhouse bays.

A2.4 Center for Ecological Research and Education (CERE): The CERE was established in 1989 to serve as a focus for a strong program in basic and applied ecology in the Department of Biological Sciences at Idaho State University. The primary goals for CERE are ‘to facilitate individual research in Ecology, and to provide a framework for collaborative, interdisciplinary teaching and research that is focused on ecological principles and problems’. The CERE lab contains multiple incubators, FIZON Elemental Analyzer, fine point balances, automated water samplers, gas chromatograph with FID and ECD, YSI multi-probe sensors.

A2.5 Laboratory in Environmental Geology (LEG): The LEG facilities that support the work in geosciences. LEG will ultimately include four principal components: [1] analytical instrumentation; [2] field, sampling, and sample preparation equipment; [3] technical support staff; and [4] faculty release time. Specific acquisitions include ICP-MS (inductively coupled plasma-mass spectrometry) for multiple elemental analysis, MS (mass spectrometry) for stable isotopes and XRD/XRF (X-ray diffraction and X-ray fluorescence spectroscopy) for bulk chemical and crystallographic characterizations.

A2.6 GIS Training and Research Center (TReC): The TReC is a university-wide facility serving the Idaho GIS community. TReC maintains an enterprise GIS Server constellation with ArcIMS, ArcSDE & IBM DB2, GIS Web, Spatial Library, GIS Web Mirror, Archive, GPS, and Research and Development servers. TReC also has 20 workstations, 11 GPS receivers and a community base station phase corrected receiver. Extensive GIS, remote sensing, GPS, and database software are available. GB Ethernet with dark fiber network from the TReC to the ISU backbone is in place.

A2.7 ISU Clusters: The College of Science and Engineering (CoSE) maintains four different computer clusters for use in academic research open free of charge to CoSE faculty, staff, and students. These clusters include multiple compute nodes and utilize the TORQUE software for compute job queuing. Additional clusters are maintained at ISU’s Research and Innovation in Science and Engineering (RISE) and College of Business. ISU’s GIS Training and Research Center (above) maintains an enterprise GIS server constellation for compute research, data serving, and data backup/mirroring (used in this project, see data management plan).

Appendix B: Biographical Sketches

IDENTIFYING INFORMATION:

NAME: Lohse, Kathleen

ORCID iD: https://orcid.org/0000-0003-1779-6773

POSITION TITLE: Professor

PRIMARY ORGANIZATION AND LOCATION: Idaho State University, Pocatello, ID, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
UC Berkeley, Berkeley, CA, United States	PhD	12/2002	Soil Science
Cornell University, Ithaca, NY, United States	BA	05/1993	Urban and Regional Studies
Cornell University, Ithaca, NY, United States	BS	05/1993	Biology

Appointments and Positions

2010 - present	Professor, Idaho State University, Biological Sciences, Pocatello, ID, United States
2007 - 2010	Assistant Professor, University of Arizona, School of Natural Resources and the Environment, Tucson, AZ, US
2005 - 2006	Postdoctoral Fellow, Arizona State University, Tempe, AZ, US
2003 - 2005	Postdoctoral Fellow , UC Berkeley, Environmental Science, Policy and Management, Berkeley, CA, US

Products

Products Most Closely Related to the Proposed Project

1. Lohse K, Patton N, Godsey S, Crosby B. Soil depth measurement system and method. US Patent 11,567,055; 2023.
2. Patton N, Lohse K, Seyfried M, Godsey S, Parsons S. Topographic controls of soil organic carbon on soil-mantled landscapes. Scientific Reports. 2019; 9:6390.
3. Patton N, Lohse K, Seyfried M, Will R, Benner S. Lithology and coarse fraction adjusted bulk density estimates for determining total organic carbon stocks in dryland soils. Geoderma. 2019; 337:844-852. issn: 0016-7061
4. Patton N, Lohse K, Godsey S, Crosby B, Seyfried M. Predicting soil thickness on soil mantled hillslopes. Nature Communications. 2018; 9:3329.
5. Pierson D, Lohse K, Wieder W, Patton N, Facer J, de Graaff M, Georgiou K, Seyfried M, Flerchinger G, Will R. Optimizing process-based models to predict current and future soil organic carbon stocks at high-resolution. Scientific Reports. 2022; 12(1):10824. issn: 2045-2322

Other Significant Products, Whether or Not Related to the Proposed Project

1. Lohse K, Pierson D, Patton N, Sanderman J, Huber D, Finney B, Facer J, Meyers J, Seyfried M. Multiscale responses and recovery of soils to wildfire in a sagebrush steppe ecosystem. Scientific Reports. 2022; 12(1):22438. issn: 2045-2322

2. Lohse K, Sharon A. Soil Signals Tell of Landscape Disturbances. Eos. 2020.
3. Perdrial J, Brooks P, Swetnam T, Lohse K, Rasmussen C, Litvak M, Harpold A, Zapata-Rios X, Broxton P, Mitra B. A net ecosystem carbon budget for snow dominated forested headwater catchments: linking water and carbon fluxes to critical zone carbon storage. Biogeochemistry. 2018; 138:225-243. issn: 0168-2563
4. Harman C, Lohse K, Troch P, Sivapalan M. Spatial patterns of vegetation, soils, and microtopography from terrestrial laser scanning on two semiarid hillslopes of contrasting lithology. Journal of Geophysical Research: Biogeosciences. 2014; 119(2):163-180. issn: 2169-8953
5. Dove N, Arogyaswamy K, Billings S, Botthoff J, Carey C, Cisco C, DeForest J, Fairbanks D, Fierer N, Gallery R. Continental-scale patterns of extracellular enzyme activity in the subsoil: an overlooked reservoir of microbial activity. Environmental Research Letters. 2020; 15(10):1040a1. issn: 1748-9326

Synergistic Activities

1. Director Reynolds Creek CZO 2013-present
2. Participant Critical Zone Collaborative Network 2020-presnt
3. Associate Editor in Chief Ecosphere, Ecology and Critical Zone track 2020-present
4. Steering Committee member Soils and Critical Zone AGU Tech committee 2021-2023
5. Associate Editor Vadose Zone Journal 2020-present

Certification:

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Lohse, Kathleen in SciENcv on 2024-03-06 23:08:11

IDENTIFYING INFORMATION:

NAME: Patton, Nicholas R.

ORCID iD: https://orcid.org/0000-0002-4137-0636

POSITION TITLE: Postdoctoral Associate

PRIMARY ORGANIZATION AND LOCATION: Idaho State University, Pocatello, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
University of Canterbury, Christchurch, Canterbury, New Zealand	PHD	08/2022	Geology
University of Queensland, St. Lucia, Queensland, Australia	N/A	04/2020	Geology
Idaho State University, Pocatello, Idaho, United States	MS	05/2016	Geology
PennWest California, California, Pennsylvania, United States	BS	12/2013	Geology and Chemistry

Appointments and Positions

2023 - present Postdoctoral Associate, Idaho State University, Geosciences, Pocatello, Idaho, United States

2022 - 2023 Postdoctoral Researcher, Desert Research Institute, Earth and Ecosystem Sciences, Reno, Nevada, United States

2016 - 2017 Lab/Field Manager for the Center for Ecological Research and Education, Idaho State University, Pocatello, Idaho, United States

2016 - 2017 Hydrologic Technician, USDA-ARS Boise Office , Boise, Idaho, United States

2013 - 2014 Hydrologist, Hatch Mott MacDonald , Waynesburg, Pennsylvania, United States

Products

Products Most Closely Related to the Proposed Project

1. Patton N, et al. Predicting soil thickness on soil mantled hillslopes. Nat Commun. 2018 Aug 20;9(1):3329. PubMed Central PMCID: PMC6102209.
2. Patton N, et al. Lithology and coarse fraction adjusted bulk density estimates for determining total organic carbon stocks in dryland soils. Geoderma. 2019 March; 337:844-852. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0016706117315859 DOI: 10.1016/j.geoderma.2018.10.036
3. Lohse KA., Patton NR., Godsey SE., Crosby BT.., inventors. Kathleen A. Lohse, assignee. Soil depth measurement system and method. United States of America 18/090327. 2023 May 25.
4. Patton N, et al. Topographic controls of soil organic carbon on soil-mantled landscapes. Scientific Reports. 2019 April 23; 9(1):-. Available from: https://www.nature.com/articles/s41598-019-42556-5 DOI: 10.1038/s41598-019-42556-5
5. Pierson D, et al. Optimizing process-based models to predict current and future soil organic

carbon stocks at high-resolution. Scientific Reports. 2022 June 25; 12(1):-. Available from: https://www.nature.com/articles/s41598-022-14224-8 DOI: 10.1038/s41598-022-14224-8

Other Significant Products, Whether or Not Related to the Proposed Project

1. Ellerton D, et al. Fraser Island (K'gari) and initiation of the Great Barrier Reef linked by Middle Pleistocene sea-level change. Nature Geoscience. 2022 November 14; 15(12):1017-1026. Available from: https://www.nature.com/articles/s41561-022-01062-6 DOI: 10.1038/s41561-022-01062-6
2. Florin S.A, et al. Pandanus nutshell generates a palaeoprecipitation record for human occupation at Madjedbebe, northern Australia. Nat Ecol Evol. 2021 Mar;5(3):295-303. PubMed Central PMCID: PMC7929916.
3. Patton N, et al. Measuring landscape evolution from inception to maturity: Insights from a coastal dune system. Earth and Planetary Science Letters. 2022 April; 584:117448-. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0012821X2200084X DOI: 10.1016/j.epsl.2022.117448
4. Patton N, et al. Reconstructing Holocene fire records using dune footslope deposits at the Cooloola Sand Mass, Australia. Quaternary Research. 2023 May 11; 115:67-89. Available from: https://www.cambridge.org/core/product/identifier/S0033589423000145/type/journal_article DOI: 10.1017/qua.2023.14
5. O'Bryan CJ, et al. Unrecognized threat to global soil carbon by a widespread invasive species. Glob Chang Biol. 2022 Feb;28(3):877-882. PubMed PMID: 34288288.

Synergistic Activities

1. Conducted research within Critical Zone Observatories and Experimental Watersheds.
2. Led Department of Defense (DOD) contracts both domestically and internationally.
3. Developed courses on Geomorphology, Soil science, and Environmental Biogeochemistry.
4. Experienced in analytical protocols from the Australia's Nuclear Science and Technology Organisation, British Geological Survey, and Utah State University Luminescence laboratories.
5. Advised and mentored Undergraduate, Honours, and Master students research projects.

Certification:

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Patton, Nicholas R. in SciENcv on 2024-03-12 12:44:43

Appendix C: Senior Personnel

Senior Personnel: Consist of Principle and Co- Investigators, Research Specialist and Technicians.

Principle Investigator: Professor Kathleen Lohse is in the Department of Biological Sciences at Idaho State University and holds a joint appointment with the Department of Geosciences. Lohse has a PhD in Soil Science from University of California Berkeley with an emphasis in Soil Biogeochemistry and Hydrology. Lohse will supervise postdoctoral associate (Patton) in collection and analysis of soil thickness and carbon. Lohse will lead hiring of a full-time research specialist and co-supervise with Patton the full-time soil research specialist and two seasonal technicians (12 weeks). Lohse requests 0.6 months of summer salary in FY24 and FY25 and then requests 20% of her academic salary for FY24 to develop a business plan. Lohse will be on a year-long sabbatical from ISU and only paid at 50% during FY24 by ISU; therefore, this request of 20% of her academic salary will allow her to devote 20% of her effort to this project.

Co-Principal Investigator: Dr. Nicholas Patton is in the Department of Geosciences at Idaho State University. Patton is a postdoctoral associate and has a PhD in Geosciences from University of Canterbury in Christchurch, NZ. Patton is a soil geomorphologist with expertise in paleoclimate, chronology and remote sensing. His research focuses on the complex interaction between biotic and abiotic processes that drive landscape, climate, and ecosystem evolution. Prior to this postdoctoral position, Patton worked on multiple military contracts and bases domestically and internationally as part of DRI's Soil Characterization and Quaternary Pedology Laboratory. Patton will co-supervise the full-time research specialist and the seasonal technicians in the collection and analysis of soils for thickness and carbon. We are requesting 40% of his salary in year 1 at $56,650 and 50% in year 2 at $58,350 to reflect his efforts on this project and 3% increase in salary each year.

Research Specialist: An individual (to be later named) with a MS or BS in soil science or geology will be hired as a full-time employee to process samples and coordinate data management. We request 75% of this salary ($47,133) for FY24 in anticipation of hiring this individual by Feb-Mar 2025 (after advertising, interviewing and completing HR forms) so that this person can be trained prior to the field season. We ask for the remaining 25% of this year-long position to be allocated to FY25.

Seasonal technicians: Two individuals (to be later named) will be hired in the summer/fall of FY24 at $23/hr for 12 weeks at 40 hrs to assist with the collection of soils from around Idaho and then another set of seasonal technicians will be hired again in the spring of FY25 for the second set of field campaigns.

Appendix D: Other

Abbreviations:

ART	Accelerating Research Translation
CAMAS	Center for Archaeology, Materials and Applied Spectroscopy
Co-PI	Co-Principal Investigator
CZO	Critical Zone Observatories
DOD	Department of Defense
DOE	Department of Energy
EAB	External Advisory Board
ERDC	Engineer Research and Development Center
FY24	Fiscal Year 2024
FY25	Fiscal Year 2025
GPS	Global Positioning System
LiDAR	Light Detection and Ranging
LTAR	Long-term Agroecosystem Research
LTER	Long-term Ecological Research
NEON	National Ecological Observatory Network
NSF	National Science Foundation
PI	Principal Investigator
Q1	Fiscal Year Quarter 1
Q2	Fiscal Year Quarter 2
Q3	Fiscal Year Quarter 3
Q4	Fiscal Year Quarter 4
SABR	Soil and Aqueous Biogeochemistry Research
SD	Standard Deviation
STC	Soil Thickness and Carbon
TIP	Technology, Innovation and Partnerships
TRL	Technology Readiness Level
USGS	United States Geological Survey

FORM D: IGEM-HERC Full Proposal Budget Sheet

Track (select one): *Initial Startup*

PI First & Last Name: Kathleen Lohse

Project Title: Demonstration of soil thickness and carbon (STC) metho

Milestone description: *Tasks A, B, C, D, E, F and H*

Insert more rows in each section, as needed. *Copy/paste cell formulas, as needed.*

Do not remove or hide rows. *Shaded areas have preset formulas.*

Personnel

Name	FTE (opt)	Months	Base Salary	Salary Request
Kathleen Lohse (Acad)		1.8	$119,478.00	$23,895.60
Kathleen Lohse (Sum).		0.6	$119,478.00	$7,965.20
Nicholas Patton		4.8	$56,650.00	$22,660.00
Research Specialist		9	$47,133.00	$35,349.75
Seasonal Technician		12	$11,040.00	$11,040.00
Seasonal Technician		12	$11,040.00	$11,040.00

Equipment

Item Description	Units	Unit Cost
	1	
	1	
	1	
	1	
	1	
	1	

Travel

Tentative Date(s)	# persons	Total days	Transit cost/ person	Lodging/ day
	4	24	$950.00	$113.75

Participant Support

Description	# persons	Cost/ Stipend

Other Direct Costs

Item	Units	Cost
Materials/ Supplies	1	$11,000.00
Publication Charges	1	$2,000.00
Consultants (add consultant travel here)	1	$4,000.00

Computer Services	1	$5,000.00
Subcontract 1	1	
Subcontracts 2		
Other (list specifics if over $1,000)	1	
Sample fees	1	$10,000.00
Equipment rental	1	$5,000.00
Water purification system	1	$4,000.00

d

See cell notes for additional information.

Fringe Rate	Other Ben Rat	Fringe Reques	Total
0.097		$2,317.87	**$26,213.47**
0.097		$772.62	**$8,737.82**
0.39		$8,837.40	**$31,497.40**
0.39		$13,786.40	**$49,136.15**
0.097		$1,070.88	**$12,110.88**
0.097		$1,070.88	**$12,110.88**
			$139,806.61

	Total
	$0.00
	$0.00
	$0.00
	$0.00
	$0.00
	$0.00
	$0.00

Meal per diem	Total
$55.00	**$20,000.00**
	$0.00
	$0.00
	$0.00
	$0.00
	$0.00
	$20,000.00

	Total
	$0.00
	$0.00
	$0.00
	$0.00
	$0.00
	$0.00

	Total
	$11,000.00
	$2,000.00
	$4,000.00

	$5,000.00
	$0.00
	$0.00
	$0.00
	$10,000.00
	$5,000.00
	$4,000.00
	$41,000.00
TOTAL DIRECT COST REQUEST	**$200,806.61**