**BACKGROUND INFORMATION**
**The Alaska Soil Data Bank (ASDB): A database for delivering non-NRCS legacy data for digital soil mapping initiatives in Alaska**

## i. Investigator's qualifications. Include resumes of the PI(s)

**PI Jelinski**

*Professional Preparation:*

| | | |
|---|---|---|
| University of Minnesota-Twin Cities | LAAS – Soil Science | Ph.D. 2014 |
| University of Wisconsin-Madison | Land Resources | M.S. 2007 |
| University of Wisconsin-Madison | Botany/Biology | B.S. 2004 |

*Appointments*:
2021 – present: Associate Professor, Dept of Soil, Water, and Climate, University of Minnesota
2015 – 2021: Assistant Professor, Dept of Soil, Water, and Climate, University of Minnesota
2010 – 2014: EPA STAR & NSF Graduate Research Fellow, University of Minnesota

*Publications most closely related to project:*


Jelinski, N.A., Ping, C.-L. Cold Region Soils: Part I – Properties and Processes. *In Final Editorial Review*. Encyclopedia of Soils and the Environment, 2nd Edition. Elsevier, Amsterdam, Netherlands.

Jelinski, N.A., Ping, C.-L., Tedrow, J.C.F. Cold Region Soils: Part II – Genesis and Classification. *In Final Editorial Review*. Encyclopedia of Soils and the Environment, 2nd Edition. Elsevier, Amsterdam, Netherlands.

Sousa, M.J., Jelinski, N.A., Windmuller-Campione, M., Williams, A., GreyBear, E., Finnesand, K., Zachman, V. 2021. Long-term recovery of organic layer thickness but not soil carbon stocks and permafrost depth following fire in black spruce forests of the Copper River Basin, Alaska. Canadian Journal of Forest Research 51(3): https://doi.org/10.1139/cjfr-2020- 0194.

Acree, A, Weindorf, DC, Galbraith, JM, Jelinski, NA, Paulette, L. Characterization of Gelolls in northern Alaska, USA. Soil Sci Soc Am J. 2020; 1– 14.

Jelinski, N.A., M.J. Sousa, A. Williams, E. GreyBear, K. Finnesand, D. Mulligan, C. Cole, M.D. Stillinger, J.M. Feinberg. 2019. Cryoturbation and carbon stocks in Gelisols under late-successional black spruce forests of the Copper River Basin, AK. Soil Science Society of America Journal 83(6) 1760-1778.

Jelinski, N.A., K. Yoo, and J. Klaminder. 2017. Utilizing a Suite of Isotopic and Elemental Tracers to Constrain Cryoturbation Rates and Patterns in a Non-Sorted Circle. Permafrost and Periglacial Processes 28:634-648. DOI: 10.1002/ppp.1944.

Jelinski, N.A. 2013. Cryoturbation in the Central Brooks Range, Alaska. *Cover Article - Soil Horizons 54(5): 01-007.

Jelinski, N.A. and K. Yoo. 2016. The distribution and genesis of eroded phase soils in the conterminous United States. Geoderma 279: 149-164.

*Synergistic activities*:

1. Associate Editor of *Permafrost and Periglacial Processes.* Additional duties include organizing special issue on cryopedology "Cryopedology Across Scales: Integrating Experiments, Observations, and Models" for 2022-2023.
2. Co-PI on project with U.S. Department of Energy (Argonne National Laboratory – PI J. Jastrow): "Organic carbon stocks in Permafrost Region Soils". This project has generated an extensive dataset of soil morphology and carbon data that does not currently exist in NASIS. Additionally, this project has involved working closely with Dr. Chien-Lu Ping (University of Alaska-Fairbanks Professor Emeritus) to annotate and archive data and photos from previous projects.
3. Working closely with Alaska Village Intiatives (AVI) staff to coordinate field sampling activities and produce useable digital data for villages on the Yukon-Kuskokwim Delta.
4. Chair: SSSA Cryopedology Working Group, 2019 to present.
5. Undergraduate soil science teaching responsibilities include SOIL 2125 (Basic Soil Science), SOIL 4511 (Field Study of Soils), and SOIL 3521 (Soil Judging).

**Co-PI Sabine Grunwald**

*Education*

| | | |
|---|---|---|
| University Giessen, Germany | Environmental Science | Ph.D. 1996 |
| University Giessen, Germany | Environmental Science | M.S. 1992 |
| University of Wisconsin-Madison | Soil Science | Post-Doc 1997-2000 |
| Fielding Graduate University | Integral Studies | Grad. Certificate 2013 |
| Naropa University | Authentic Leadership | Grad. Certificate 2015 |

*Academic Experience*

2010 – present: Professor, Soil and Water Sciences Department, University of Florida (UF)
2009 – 2011: Director of Distance Education, Soil and Water Sciences Department, UF
2006 – 2010: Associate Professor, Soil and Water Sciences Department, UF
2001 – 2009: Distance Education Coordinator, Soil and Water Sciences Department, UF
2001 – 2006: Assistant Professor, Soil and Water Sciences Department, UF
2000 – 2001: Research Scientist and GIS Manager, Heidelberg College, OH

*Research Expertise* (Faculty research program: https://www.sgrunwald.org/)
Pedometrics, artificial intelligence (AI) (machine learning, deep learning): 13+ years of experience, digital soil mapping, soil and terrestrial carbon modeling, soil health, soil security, soil spectral sensing (visible/near-infrared and mid-infrared spectroscopy), remote sensing, pedo-econometrics, GIS and geoscience technologies, and modeling of ecosystem processes.

*Publications* (Total peer-reviewed journal articles: 124+; book chapters: 41; books: 2)

- ORCID: 0000-0002-9023-1720
- Google Scholar Grunwald's publication list (H-index: 49; i10-index: 104): http://scholar.google.com/citations?user=XnTnqZ8AAAAJ&hl=en
- Number of total citations of her published articles: 8,792
- Research Gate Grunwald's publication list: https://www.researchgate.net/profile/Sabine_Grunwald

*Publications most closely related to project*

Grunwald S. 2021. Grand challenges in pedometrics-AI research. Frontiers in Soil Science J. – Pedometrics section, 1: 1-5. doi:10.3389/fsoil.2021.714323

Mizuta K., S. Grunwald, M.A. Phillips, C.B. Moss, A.R. Bacon and W.P. Cropper Jr. 2021. Sensitivity analysis of metafrontier data envelopment analysis for soil carbon sequestration efficiency. Ecological Indicator J. 125. Article 107602. doi: 10.1016/j.ecolind.2021.107602.

Mizuta K., S. Grunwald, M.A. Phillips, A.R. Bacon, W.P. Cropper Jr. and C.B. Moss. 2021. Emergence of the pedo-econometric approach. Frontiers in Soil Science J. Pedometrics Section. doi:10.3389/fsoil.2021.656591

Ross C.W., S. Grunwald, J.G. Vogel, D. Markewitz, E.J. Jokela, T.A. Martin, R. Bracho, A.R. Bacon, C.W. Brungard, and X. Xiong. 2020. Accounting for two-billion tons of stabilized soil carbon. Science of the Total Environment 703. No. 134615. doi:10.1016/j.scitotenv.2019.134615

Adi S.H. and S. Grunwald. 2020. Integrative environmental modeling of soil carbon fractions based on a new latent variable model approach. Science of the Total Environment 711, No. 134566: 1–15. doi:10.1016/j.scitotenv.2019.134566.

Keskin H., S. Grunwald and W. Harris. 2019. Digital mapping of soil carbon fractions with machine learning. Geoderma, 339: 40-58. doi:10.1016/j.geoderma.2018.12.037.

Knox N. and S. Grunwald. 2018. Total soil carbon assessment – Linking field, lab, and landscape through VNIR modelling. Landscape Ecology 33: 2137-2152. doi:10.1007/s10980-018-0729-6.

Mizuta K., S. Grunwald and M.A. Phillips. 2018. New soil index development and integration with econometric theory. Soil Sci. Soc. Am. J. 82: 1017-1032. doi:10.2136/sssaj2017.11.0378.

Kim J. and S. Grunwald. 2016. Assessment of carbon stocks in the topsoil using Random Forest and remote sensing images. J. of Env. Qual. 45: 1910-1918. doi:10.2134/jeq2016.03.0076.

Viscarra Rossel, R.A., …… S. Grunwald, et al. 2016. A global spectral library to characterize the world's soil. Earth-Science Reviews 155: 198–230. doi:10.1016/j.earscirev.2016.01.012.

Xiong X., S. Grunwald, D.B. Myers, J. Kim, W.G. Harris and N.B. Comerford. 2014. Holistic environmental soil-landscape modeling of soil organic carbon. Environmental Modeling and Software J. 57: 202-215. doi:10.1016/j.envsoft.2014.03.004

*Synergistic activities*

1. Chief Editor of Frontiers Soil Science/Pedometrics J.; and Associate Editor of Sensors J. Vice Chair of Commission 1.5 Pedometrics of the International Union of Soil Science (IUSS) and present member of the Global Soil Map Initiative; Global Spectral Working Group (IUSS); Global Working Group Digital Soil Mapping (IUSS), Chair of the Global Digital Soil Map (DSM) Community (ASA); and Chair of the DSM Workgroup (SSSA).
2. Principal Investigator of several large-scale interdisciplinary projects, among them AFRI-NIFA research project focused on soil carbon and climate change in Florida (Core project of the North American Carbon Program), NSF-EAGER 'Development of a geospatial soil-crop inference engine' (2012-2014); co-PI of NIFA-USDA 'CAP Integrating research, education and extension for enhancing southern pine climate change' (2011-2017).

Grunwald developed the Terrestrial Carbon Information System (TerraC) which supports carbon data management.

3. As Director of Distance Education Programs (2001-2011) Grunwald coordinated distance education courses and programs (M.S., Ph.D. and Graduate Certificates) offered by the Soil and Water Sciences Department, UF. She participated in the Int. Open Agricultural Curriculum and Learning Initiative (AgroCuri) and Int. Agricultural Learning Repositories Task Force (AgLR-TF) to foster development of online learning repositories and e-tools in support of learning and instruction.
4. Engagement in several international development and capacity building projects in India (U.S.-India Agricultural Knowledge Initiative) and Strengthening Environmental and Agricultural Capacity through Distance Education (SAEC-DE) in Africa (Uganda and Kenya); and soil health and carbon research in India, Indonesia, Peru, and Brazil.
5. Director of the interdisciplinary UF Mindfulness Program in support of human flourishing, well-being and personal growth in higher education.

**Co-PI Brungard**

*Professional Preparation*

| | | |
|---|---|---|
| Utah State University | Soil Science | Ph.D. 2014 |
| Utah State University | Soil Science | Ph.D. 2014 |
| Utah State University | Soil Science | Ph.D. 2014 |

*Academic Experience*

2016 – present: Assistant Professor, Dept of Plant and Environmental Sciences, New Mexico State University

2014 – 2016: Post-Doctoral Research Scientist, Dept. of Plants, Soils, and Climate, Utah State University

*Publications most closely related to project*

Brungard, C.W., Nauman, T.W., Duniway, M.C., Veblen, K., Nehring, K., White, D., Salley, S., and Anchang, J. 2021. Regional Ensemble Modeling Reduces Uncertainty for Digital Soil Mapping. Geoderma. 397, 114998. https://doi.org/10.1016/j.geoderma.2021.114998

Pahlavan-Rad, M.R., Dahmardehb, K., Hadizadehb, M., Keykhab, G., Moham- madniab, N., Gangalic, M., Keikhad, M., Davatgare, N., Brungard, C. 2020. Prediction of soil water infiltration using multiple linear regression and random forest in a dry flood plain, eastern Iran. Catena. 194. 104715. doi: 10.1016/j.catena.2020.104715

Jamshidi, M., Delavar, M., Taghizadehe-Mehrjerdi, R., Brungard, C. 2019. Disaggregation of conventional soil map by generating multi realizations of soil class distribution (case study: Saadat Shahr plain, Iran). Environ Monit Assess 191, 769 (2019). https://doi.org/10.1007/s10661-019-7942-x

Brungard, C.W., *Allan, M.J., 2019. Predictive Soil Mapping to Improve the Physical Basis of Distributed Ecohydrological Models in Arid Environments. NM WRRI Technical Completion Report No. 382. https://nmwrri.nmsu.ed u/tr-382/

Zeraatpisheh, M., Ayoubi, S., Brungard, C., Finke, P. 2019. Disaggregating and Updating a Legacy Soil Map Using DSMART, Fuzzy c-means and K- means Clustering algorithms in Central Iran. Geoderma, 340. pp. 249-258. doi/10.1016/j.geoderma.2019.01.005

Malone, B.P., Minasny, B., Brungard, C. 2019. Some methods to improve the utility of conditioned Latin hypercube sampling. PeerJ 7:e6451 https://doi.org/10.7717/peerj.6451

Pahlavan-Rad, M.R., Dahmardeh, K., Brungard, C.W.. 2018. Predicting soil organic carbon concentrations in a low relief landscape, eastern Iran. Geoderma Regional. 15. https://doi.org/10.1016/j.geodrs.2018.e00195

Fan, Zhasheng, Wills, S., Herrick, J., Nauman, T., Brungard, C.W., Beaudette, D., Levi, M, O'Geen, A. 2018. Approaches for improving field soil identification. Soil Sci. Soc. Am. Journal. 82:871-877. doi:10.2136/sssaj2017.09.0337

Ramcharan, A., Hengl, T., Nauman, T., Brungard, C.W., Waltman, S., Wills, S., Thompson, J. 2018. Soil Property and Class Maps of the Conterminous United States at 100-Meter Spatial Resolution. Soil Sci. Soc. Am. Journal. 82:186-201. doi:10.2136/sssaj2017.04.0122

Brungard, C.W., Boettinger, J.L., Duniway, M.C., Wills, S.A., Edwards Jr.,T.C. 2015. Machine learning for predicting soil classes in three arid landscapes. Geoderma, 239–240, pp. 68-83.

**ii. Brief description of existing facilities.**

*University of Minnesota*: This proposed project does not require field sampling or laboratory analysis. Therefore, the focus of this existing facilities section is on database and computational support.

Minnesota Supercomputer Institute (MSI). MSI, established in 1983, is the University of Minnesota's (UMN) principle center for computational research. MSI provides services to over 560 active groups that sponsor more than 3,300 unique users from 19 different university colleges, maintaining an array of systems dedicated to the computational needs of investigators in the state of Minnesota's higher education institutions and their collaborators. MSI currently has two main flagship supercomputers, Itasca and Mesabi. Taken together, these systems are comprised of 26,560 compute cores with 92 TB of RAM and can support over 800 TFLOPS of peak performance. All MSI researchers have access to a high-performance parallel storage platform. This system provides 2.4 PB (PetaBytes) of storage with sustained read and write speeds of up to 25 GB/sec. The integrity of the data is protected by daily snapshots and tape backups. High value data sets are backed up to an off-site facility as a part of the institute's disaster recovery plan. A distinguishing feature of MSI is its rich staff support structure. MSI has 16 dedicated consulting staff, all of whom have advanced degrees and a wealth of experience working on a wide variety of research and development projects.

The Genetic, Environmental, Management, and Socioeconomic (G.E.M.S®) data platform is an agroinformatics initiative jointly led by the College of Food, Agricultural and Natural Resources Sciences (CFANS) and the Minnesota Supercomputing Institute (MSI) at the University of Minnesota. With core, long-term MNDrive funding from the Minnesota State Government, augmented with additional project and partner resources, GEMS is under continuous development and re-invention by university programmers, data scientists and external collaborators.

*University of Florida*: This proposed project does not require field sampling or laboratory analysis. Therefore, the focus of this existing facilities section is on database and computational support.

UF HiPerGator 3.0 Research Computing (https://www.rc.ufl.edu/services/hipergator/). is currently the fastest supercomputer at a public university globally. UF just invested $70 million in an AI Partnership with NVIDIA, a Silicon Valley based technology company to expand AI capabilities. An AI Research Computing Center has been established at the UF reflecting its commitment in AI research across disciplines including—computer science, engineering, agriculture and life sciences, environmental sciences, humanities and social sciences. Numerous graduate and undergraduate level courses, workshops, and seminars focused on AI (theory, programming, ethics, critical theory, and applications) are offered at UF providing a stimulating environment for teaching and research. The HiPerGator 3.0 provides a total of 66,000 cores, 608 new NVIDIA RTX 2080TI and RTX 6000 GPU's, it features the latest NVIDIA GPU technology of Ampere A100 GPU, 4 Petabytes (PB) of new Blue fast storage, double precision LinPack (HPL) with about 1 Petaflops.

Pedometrics, Landscape Analysis, and GIS Laboratory - PLG (Core Lab), Soil and Water Sciences Laboratory, Institute of Food and Agricultural Sciences (IFAS). The PLG Laboratory provides state-of-the art workspace for environmental modeling, advanced statistical analyses, such as machine learning and deep learning algorithms (Artificial Intelligence, AI); geostatistical modeling; geographic information systems (GIS); remote sensing; and mechanistic simulation modeling. The lab provides 6 workstations with computers and a collaborative workspace. All PCs in the lab use a shared server space operated by IFAS with triplicate differential backup system, which provides a secure environment for storage of data. Multiple color laser printers are available for printing as well as a HP DesignJet 2500CP poster printer. The lab provides the following:

1. Available software packages: MS Office Suite; SQL database; GIS software (ArcGIS Desktop and ArcGIS PRO, ESRI; and SAGA GIS); ERDAS IMAGINE for remote sensing analysis.
2. Statistical analysis is conducted in R.
3. Programming and applications are written in Python.
4. Trimble high resolution global positioning with submeter accuracy for georeferencing of field samples or ground truthing of remote sensing images.
5. Diffuse Reflectance Spectroradiometer (visible/near-infrared spectral range, VNIR) (Analytical Spectral Devices Inc., Malvern Panalytical) and mid-infrared Fourier transform analyzer, MIR (Agilent Inc.).

**iii. Existing collaborative agreements/relationships with NRCS.**

*PI Jelinski.* Dr. Jelinski actively engages with the NRCS as a cooperator in the National Cooperative Soil Survey. He has served on the NCSS West Region taxonomy committee and has been asked to serve on the Alaska specific 2026 taskforce (led by Dave White – see attached letter of collaboration). Dr. Jelinski has the following active collaborative agreements with NRCS:

Agreement # NR183A750025C018. "Comparative development of products for the North Copper River and Yukon-Kuskokwim Delta to advance soil survey initiatives in Alaska". 2018-2021. In this study we have been actively providing soil morphology, laboratory and characterization information to an ongoing survey area (North Copper River) in close

collaboration with NRCS Alaska staff. Already, this has resulted in two peer-reviewed publications with three additional publications in preparation. Additionally, this study is providing pre-mapping support and sampling design research for the Yukon-Kuskokwim Delta region, an area with sparse data coverage in NASIS. This work formed a portion of the M.S. thesis for Michael Sousa (NRCS Soil Scientist, Wasilla Alaska) and will be published within 18 months.

Agreement # NR213A750023C007: "Soil characterization support for MIR predictions". 2021-2025. This agreement provides a modest amount of support for laboratory characterization of soil samples to produce MIR predictions in collaboration with the NRCS Soil Survey Region 10 Office (St. Paul, MN).

*Co-PI Grunwald.* S. Grunwald is not currently a PI or Co-PI on any NRCS funded agreements/grants.

*Co-PI Brungard.* Dr. Brungard actively engages with the NRCS as a cooperator in the National Cooperative Soil Survey. He currently serves on the NCSS DSM Focus Team, on the NCSS initial mapping team, and has served as the chair of the NCSS Western Region Research Needs committee, and as a member of the NCSS National Research Needs committee. Dr. Brungard organized and hosted the western region cooperative soil survey conference in 2020. He also actively supports the Las Cruces, NM NRCS soil survey office in digital soil mapping update projects. Dr. Brungard has the following active collaborative agreements with NRCS:

"Digital Soil Mapping of Ecological & Edaphic Properties in the Rio Puerco Watershed, NM" (USDA-NRCS agreement number NR203A750023C005). In this study, we are investigating the use of digital soil mapping techniques to produce a high-resolution digital soil survey for the Rio Puerco watershed in NM. We have produced initial soil maps, assembled ~ 350 pedon observations from legacy datasets, and are conducting fieldwork, and conductive extensive correlation.

"Develop state and transition models for predicting ecological sites in the Southwest US" (USDA-NRCS agreement number 68-3A75-18-035). This project applies sequential association rule mining techniques to extract soil surveyors' underlying conceptual soil-landscape relationships when these rules have been lost. Progress is extremely promising. Initial method development has been presented at three scientific conferences by the Ph.D. student supported on this grant.

"Seamless, Regionally-Specific Raster Soil Property Maps to Support Interpretations" (USDA-NRCS agreement number NR193A750025C013). This project applies novel algorithms to produce NASIS interpretations on raster soil survey. These interpretations are 1) Hydrologic soil group (HSG), 2) soil vulnerability index (SVI), 3) wind erodibility index (WEI), 4) dwellings with basements (DWB), and 5) valley-fever habitat (VFH). We believed that interpretations 1 – 3 would be simpler to implement than interpretations 4 and 5 because interpretations 4 & 5 involve a fuzzy-logic component. Interpretative engines for 4 of these 5 interpretations were coded (WEI was too difficult) and are available as R scripts. Work is ongoing to apply Valley Fever habitat models to the southwestern USA

**iv. Results from prior NRCS support.**

*PI Jelinski.* PI Jelinski has not been a PI or Co-PI on any completed NRCS funded agreements/grants, but is currently a PI on agreement # NR183A750025C018. This award is ongoing (period of award is 2018-2022), and has produced the following products to date:

- Jelinski, N.A., M.J. Sousa, A. Williams, E. GreyBear, K. Finnesand, D. Mulligan, C. Cole, M.D. Stillinger, J.M. Feinberg. 2019. Cryoturbation and carbon stocks in Gelisols under late-successional black spruce forests of the Copper River Basin, AK. Soil Science Society of America Journal 83(6) 1760-1778.
- Sousa, M.J., Jelinski, N.A., Windmuller-Campione, M., Williams, A., GreyBear, E., Finnesand, K., Zachman, V. 2021. Long-term recovery of organic layer thickness but not soil carbon stocks and permafrost depth following fire in black spruce forests of the Copper River Basin, Alaska. Canadian Journal of Forest Research 51(3): https://doi.org/10.1139/cjfr-2020- 0194.

We anticipate a minimum of two additional manuscripts from this agreement related to digital soil mapping work on the Yukon-Kuskokwim Delta.

*Co-PI Grunwald.* Co-PI Grunwald had a funded NRCS-USDA National Soil Survey Center project "U.S. soil carbon assessment" (2011-2014) through the Cooperative CESU Gulf Coast 68-7482-8-383 (Award No: 68-7482-11-532; Grunwald, PI). This award produced the following products:

- Kim J. and S. Grunwald. 2016. Assessment of carbon stocks in the topsoil using Random Forest and remote sensing images. J. of Env. Qual. 45, 1910-1918. doi:10.2134/jeq2016.03.0076.
- Xiong, X., Grunwald, S., Corstanje, R., Yu, C., Bliznyuk, N., 2016. Scale-dependent variability of soil organic carbon coupled to land use and land cover. Soil Tillage Res. 160, 101–109. doi:10.1016/j.still.2016.03.001Peng Y., X. Xiong, K. Adhikari, M. Knadel, S. Grunwald and M.H. Greve. 2015. Modeling soil organic carbon at regional scale by combining multi-spectral images with laboratory spectra. PlosOne 10(11): e0142295.doi:10.1371/journal.pone.0142295
- Xiong X., S. Grunwald, D. B. Myers, J. Kim, W. G. Harris, N. B. Comerford, and N. Bliznyuk. 2015. Assessing uncertainty in soil organic carbon modeling across a highly heterogeneous landscape. Geoderma 251-252: 105-116

*Co-PI Brungard.* NRCS supported projects and agreements to Dr. Brungard as PI or Co-PI have produced the following products:

"Digital soil mapping of soil properties and historical aerial photo analysis as tools for developing and testing ecological site concepts (2012)". In this study, it was discovered the important role soil depth plays in mediating sagebrush and grassland resilience to drought and herbivory. Results from this work have been conveyed to stakeholders at one national meeting and several local to regional meetings, including an inter-agency state-and-transition model workshop. Additionally, the new digital soil depth map of the study area has been used by the BLM in targeting sagebrush restoration. Project results have been submitted for publication: "Veblen, K., Nehring N.C., Duniway, M., Knight, A., Monaco, T., Schupp E., Boettinger, J., Villalba, J., Fick, S., Brungard, C., Thacker, E. (Submission # REC-21-413.R1). Soil textural effects on sagebrush seedling survival are moderated by soil depth and precipitation. Submitted to Restoration Ecology.

- "New Tools for the Evaluation of Conservation Practice Effectiveness" (2019). A major obstacle to determining conservation practice effectiveness is the lack of established landscape controls. Lack of controls prohibits the robust assessment of outcome success or failure. This obstacle was overcome by deriving synthetic controls (a tool developed in the social sciences) combined with time series bare ground and tree cover indices derived from the Landsat archive. One peer-reviewed presentation was given and two papers were published:
    - Fick, S.E, Nauman, T.W., Brungard, C.W., Duniway, M.C. 2022. What determines the effectiveness of Pinyon-Juniper clearing treatments? Evidence from the remote sensing archive and counter-factual scenarios. Forest Ecology and Management. 505(119879). https://doi.org/10.1016/j.foreco.2021.119879
    - Fick, S.E., Nauman, T.W, **Brungard, C.W**, Duniway, M.C. 2020. Evaluating natural experiments in ecology: using synthetic controls in assessments of remotely-sensed land-treatment effects. Ecological Applications 31(00): e02264. https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/eap.2264.
- "West Region Cooperative Soil Survey Conference" (2020). Dr. Brungard hosted and organized the (Virtual) West Region Cooperative Soil Survey Conference under COVID-19 pandemic restrictions. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/partnership/ncss/?cid=nrcseprd1578844

United States Department of Agriculture

April 4, 2022

Research Proposal Review Committee

RE: The Alaska Soil Data Bank(SDB): A database for delivering non-NRCS legacy data for digital soil mapping initiatives in Alaska.

Dear Review Committee:

I am writing to you in support of Dr. Nic Jelinski's proposal on developing a database for storage, harmonization, and transferability of non-NRCS legacy data for Alaska. The work in this project directly benefits nearly 300 million acres of NOTCOM slated for completion as a part of the Soils2026 Initiative. It will also support the development of statewide continuous soil property maps, and add to a baseline of dynamic soil property data. The remote nature and limited resources available to SPSD staff in AK, make it imperative to capture any "legacy" soils information. This work can then serve as a template for future work to incorporate cooperator data into NCSS products.

The 2026 working committee has created an Alaska specific 2026 taskforce, that will be utilizing digital soil mapping techniques, to assist in the completion of NOTCOM areas in AK. As a co-lead on the taskforce, I have identified Dr. Jelinski as a key individual for our team. His work will contribute to a more "complete" soils database, aid in the development of statewide raster class models, as well as show methods for utilizing segmentation to develop both raster and polygon soil survey products. We will work together to ensure project deliverables meet agency needs, NCSS standards, and promote collaboration between federal partners, private entities, and cooperators.

Sincerely,

Dave White
Soil Scientist (DSM Specialist)
National Soil Survey Center
USDA-FPAC-NRCS
Las Cruces, NM

Proposed Scope of Work:

# The Alaska Soil Data Bank: A Framework for Harnessing Big Data for Digital Soil Mapping Initiatives

Prepared for:
**Nic Jelinski**
Assistant Professor Department of Soil, Water and Climate
University of Minnesota-Twin Cities
558 Borlaug Hall
1991 Upper Buford Circle
Saint Paul, MN 55108

**P.O. Box 80410**
**Fairbanks, AK 99708**

06 April 2022

ABR, Inc.—Environmental Research & Services (ABR) will provide professional services to support the University of Minnesota-Twin Cities (UMN) in developing novel techniques to leverage big data for applications in soil surveys. UMN will be conducting this work for the Natural Resources Conservation Service (NRCS) as part of the 2022 Soil Science Collaborative Research Proposals (USDA-NRCS-NHQ-SOIL-20-NOFO0001124). Our objectives are as follows:

- Compile historical soils data from Alaska into a PostgreSQL database, and perform quality assurance and control (QA/QC) review.
- Integrate our database of historical soils data with a complementary soils database that will be developed by UMN as part of this NRCS funding opportunity; work with UMN to develop an application program interface (API) that will allow the 2 databases to seamlessly share data; and advise UMN on developing a public web portal for data access.
- Perform a desktop pilot study, a segmentation analysis, and several random forest models in Google Earth Engine (GEE) to assess the feasibility of using historical soils data for the preparation of a soils map for Katmai National Park and Preserve (KATM).

## Statement of Work

### Project Year 1: October 1, 2022–September 30, 2023

We will compile historical soils data collected by ABR in Alaska from 1995–2021 into a PostgreSQL database. These data represent a significant (~7,000 field plots) portion of the non-NRCS soils data available for Alaska. Once the data are compiled, we will perform QA/QC review to ensure data consistency and completeness.

Aggregation of queries from multiple databases into a single output requires that all databases include common fields in common formats. To ensure common fields between the ABR and UMN databases, we will work with UMN to harmonize our databases to the extent possible. UMN and ABR will collaboratively compile constrained field values and identify necessary metadata fields for inclusion in both databases.

To facilitate programmatic access to the data, we will work with UMN to develop a single web service to aggregate query results from both databases. Our role in this process will focus on providing programmatic access to the ABR database. UMN will take the lead on the development of the web service, with ABR serving in an advisory capacity. Both databases will be replicated from the authoritative copy to read-only copies hosted on the same server as the web service. The web service will send queries to both databases according to an application programming interface (API), which can then be interpreted by the requesting application into a display, export, or analysis. While the web service and API will provide abstracted programmatic access to data in both databases, end users may often prefer to access the data using a web-based graphic user interface (GUI). UMN will take the lead on developing the GUI, with ABR serving in an advisory capacity.

Modern high-resolution (≤ 2-m pixel) satellite imagery mosaics, combined with the computing power and analytical tools available in tools such as GEE (Gorelick et al. 2017), and a team of skilled satellite imagery interpreters, make it possible to classify and map broad areas rapidly and at a relatively fine scale (1:10,000–1:24,000), which was previously limited to hand-digitized maps. We will use a high-resolution (≤ 2-m pixel) satellite imagery mosaic, such as the normalized, high-resolution Pleiades mosaic prepared by ABR for KATM, to prepare a soil map using existing field data. To prepare the map, we will perform a segmentation

analysis on the high-resolution imagery using Simple Non-Iterative Clustering (SNIC; Achanta and Susstrunk 2017) or similar methods, and develop soil map-unit concepts by classifying existing field data using multivariate statistical analysis techniques in R (R Core Team 2022). Our team of skilled imagery interpreters will (1) select and annotate training segments representative of the existing field plots, and (2) assign soil map-unit and component classes to a stratified, random sample of segments.

### Project Year 2: October 1, 2023–September 30, 2024

The training data prepared in project year 1 will be used to classify the segments to soil map-unit components using random forest models (Breiman 2001) based on spectral metrics from high-resolution imagery and Landsat data, as well as ancillary data such as elevation and climate metrics. The end product will be a soil map equivalent to a traditional hand-delineated NRCS vector-based soil map, at the scale of an order 2 soil survey (1:24,000), but prepared using a digital soil mapping approach for an approximately 4-million acre study area. The final map product will have attributes of both vector- and raster-based soil maps. The map product resulting from this pilot study will represent a significant advance in the rate of completion and spatial resolution of soil mapping for an area of this size and complexity. We will work with UMN to co-author a manuscript describing the methods and results and submit the manuscript to a peer-reviewed journal.

## Budget and Assumptions

### Budget Detail

See attached annual budgets.

### Budget Justification

***Salaries and Wages***

We request funds to support our PI and Remote Sensing scientist, Matthew Macander, our ecologist, Gerald Frost, and a team consisting of a web developer, senior scientists, and a research biologist, each of whom will serve in the dual capacities of data analyst and imagery interpreter. Direct costs are adjusted for 3% annual inflation.

***Publication Costs***

We are not requesting funds for open-access publication costs, as these costs will be covered by UMN.

### Assumptions

- UMN will take the lead on the development of the web service, with ABR serving in an advisory capacity.
- UMN will take the lead on developing the GUI, with ABR serving in an advisory capacity.

## Literature Cited

Achanta, R. and Susstrunk, S., 2017. Superpixels and polygons using simple non-iterative clustering. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 4651-4660).

Breiman, L. 2001. Random forests. Machine Learning, 45:5–32.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D. and Moore, R., 2017. Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote sensing of Environment, 202, pp.18-27.

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

# Matthew J. Macander, M.S.

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**22 Years Experience**

## Education

- M.S., Forest Science, University of Alaska, Fairbanks, 2005
- B.S., Environmental Sciences, University of Buffalo, New York, 1996
- B.A., Geography, University of Buffalo, New York, 1996

## Certifications and Affiliations

FAA Remote Pilot Certificate, Small UAS Rating, 2017

## Statement of Expertise

Matt Macander is a geographer specializing in wildlife, vegetation and habitat studies and landscape ecology. He leads ABR's remote sensing group and has over 22 years of mapping experience in Alaska. Expertise includes vegetation and habitat mapping, environmental data management and visualization, quantitative vegetation sampling, small UAS data collection and processing, field spectroscopy, image classification, phenology and time-series analyses, spatial modeling, and snow studies. He has worked extensively with industry, government, and university resource managers to ensure that advanced remote sensing capabilities are utilized in the responsible development and management of Alaska's natural resources. Matt performs field work focused on calibration/validation of snow and vegetation remote sensing map products. He holds an FAA Remote Pilot Certificate with a Small UAS Rating and has performed hundreds of mapping flights with a small UAS.

## Project Experience

**Resiliency and Vulnerability of Boreal Forest Habitat** to the Interaction of Climate and Fire Disturbance across Department of Defense Lands of Interior Alaska. Northern Arizona University for USACE Humpherys Engineering Center. Co-Investigator. (2018-2022)

**Mapping and modeling attributes of an arctic–boreal biome shift**. Resource management implications within the ABoVE domain. University of Maine Fort Kent for NASA Arctic Boreal Vulnerability Experiment (ABoVE). Co-Investigator. ABR and collaborators compiled systematic vegetation plot data for arctic Alaska and northwest Canada. We are applying the field data, high-resolution satellite imagery, and seasonal Landsat reflectance composites to map fractional shrub and lichen cover for two epochs. (2010, 2015, 2016–present)

**Land Cover Mapping for the North Slope of ANWR.** Produced a land cover map of the North Slope of ANWR using a classification of satellite imagery that was refined by new field data collected in July-August 2019 and other relevant GIS and tabular data. Prepared a final map accuracy assessment using a subset of the 2019 field data that was withheld from the land cover map development phase. The map provides land cover and vegetation information useful for making resource management decisions, including the identification of habitat types and their distribution and abundance. The land cover classes were developed so that they dovetail with classes used on other maps produced recently for the North Slope and Brooks Range regions. (2018–2020)

**Biophysical drivers and socio-ecological impacts of environmental change** in the Yukon-Kuskokwim Delta region, western Alaska. NASA Arctic Boreal Vulnerability Experiment (ABoVE). Co-Investigator. Remote sensing lead for interdisciplinary studies integrating remote-sensing, field-based, and sociological approaches to address environmental change and their socio-ecological impacts in the Yukon-Kuskokwim Delta region of western Alaska. (2015–2020)

**Lichen cover mapping in Yukon–Charley Rivers National Preserve**. USGS. Principal Investigator. ABR applied detailed vegetation plot data, high-resolution satellite imagery, and Landsat reflectance composites to estimate the fractional cover of lichen in Yukon–Charley Rivers National Preserve. (2015–2017)

**Snow persistence and snow regime mapping in Alaska**. USGS and NPS, Alaska. Principal Investigator. ABR used Google Earth Engine and customized time-series analyses to summarize snow cover based on the entire 1999–2015 Landsat archive over Alaska. The climatological normal snow-free date and other snow regime metrics were mapped for most of Alaska. (2015–2018)

**Lichen cover mapping for the range of the Fortymile Caribou Herd in Alaska**. BLM and Yukon. Principal Investigator. ABR applied field plot data, very-high resolution aerial imagery, high-resolution satellite imagery, and Landsat reflectance composites to estimate the fractional cover of lichen. (2015–2017)

**Synthetic Aperture Radar (SAR) Data Evaluation for Alaska Satellite Facility, AK** . University of Fairbanks. Principal Investigator. Assessed the feasibility of applying SAR data in the quantitative mapping of tundra ecosystem properties using Alaska Satellite Facility (ASF) data products derived from Sentinel-1A/B satellite observations. (2018)

**Trend and Change analysis of Normalized Difference Vegetation Index (NDVI)** for Becharof and Alaska Peninsula National Wildlife Refuges. U.S. Fish and Wildlife Service, AK. Principal Investigator. Conducted NDVI analyses to provide refuge-wide spatial data products that depict recent changes in vegetation greenness for APBNWR, and provide historical context for assessing and monitoring future ecological change. (2017-2018)

**Katmai National Park and Preserve soils mapping**. National Park Service. Remote Sensing Lead. Preparing a normalized reflectance composite from midsummer Pleiades satellite imagery for Katmai National Park and Preserve, mapping snow persistence from Landsat time-series, and supporting spatial modeling of soil landscapes. (2015–2018)

## Other Experience and Qualifications

- Specialized training in ArcGIS, GPS, ENVI, and satellite image processing and classification.
- Radiometric and geometric calibration of multi-date, multi-sensor, multi-resolution satellite imagery including air photos (vertical and oblique), Landsat, MODIS, Quickbird, IKONOS, AVHRR and LIDAR.
- Extensive experience with generating maps and programming in Python, GDAL, ArcInfo, Erdas Imagine, Visual Basic, SQL, AML, Avenue, and specialized image processing algorithms.

## Publications

Macander, M. J., E. C Palm, G. V. Frost, J. D. Herriges, P. R. Nelson, C. Roland, K. L. M. Russell, M. J Suitor, T. W. Bentzen, K. Joly, S. J. Goetz, and M. Hebblewhite. (2020). Lichen cover mapping for caribou ranges in interior Alaska and Yukon. Environmental Research Letters 15:055001. DOI:10.1088/1748-9326/ab6d38.

Macander, M. J., G. V. Frost, P. R. Nelson, and C. S. Swingley. 2017. Regional quantitative cover mapping of tundra plant functional types in Arctic Alaska. Remote Sensing 9:1024, DOI:10.3390/rs9101024.

Macander, M. J., C. S. Swingley, K. Joly, and M. K. Raynolds. 2015. Landsat-based snow persistence map for northwest Alaska. Remote Sensing of Environment 163: 23–31. http://dx.doi.org/10.1016/j.rse.2015.02.028

Frost, G. V., T. Christopherson, M. T. Jorgenson, A. K. Liljedahl, M. J. Macander, D. A. Walker, and A. F. Wells. 2018. Regional patterns and asynchronous onset of ice-wedge degradation since the mid-20th century in Arctic Alaska. Remote Sensing 10:1312. DOI:10.3390/rs10081312.

Whitley, M. A., G. V. Frost, M. T. Jorgenson, M. J. Macander, C. V. Maio, and S. G. Winder. 2018. Assessment of LiDAR and spectral techniques for high-resolution mapping of sporadic permafrost on the Yukon-Kuskokwim Delta, Alaska. Remote Sensing 10:258, DOI:10.3390/rs10020258.

Wells A.F.,G.V.Frost, T.Christopherson, M.J. Macander, and E.R. Trainor. 2016. Ecological land survey and soil landscapes map for Aniakchak National Monument and Preserve, Alaska, 2014. National Park Service. Fort Collins, CO.

Wells, A., M. Macander, T. Jorgenson, T. Christopherson, B. Baird, and E. Trainor. 2013. Ecological land survey and soil landscapes map for Lake Clark National Park and Preserve, Alaska, 2011. National Park Service. Fort Collins, CO. Natural Resource Technical Report. NPS/LACL/NRTR—2013/693. 349 pp.