OSAC RESEARCH NEEDS ASSESSMENT FORM

Title of research need:	**Leveraging existing spatial soil data sets for forensic soil applications**
Keyword(s):	**Soil, crime scene, remote sensing, Artificial Intelligence, soil survey, geological maps**
Submitting subcommittee(s):	Trace Materials
Date Approved:	June 27, 2024

(If SAC review identifies additional subcommittees, add them to the box above.)

Background Information:

1. Does this research need address a gap(s) in a current or planned standard? (ex.: Field identification system for on scene opioid detection and confirmation)

Yes: Interpretation standard (planned), ASTM E3272 − 21 "Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications"

2. Are you aware of any ongoing research that may address this research need that has not yet been published (e.g., research presented in conference proceedings, studies that you or a colleague have participated in but have yet to be published)?

No

3. Key bibliographic references relating to this research need: (ex.: Toll, L., Standifer, K. M., Massotte, D., eds. (2019). Current Topics in Opioid Research. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-88963-180-3)

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2. Suarez MD, Southard RJ, Parikh SJ. Understanding Variations of Soil Mapping Units and Associated Data for Forensic Science. J Forensic Sci. 2015 Jul;60(4):894-905. doi: 10.1111/1556-4029.12762. Epub 2015 Mar 24. PMID: 25808848.
3. Hirijete, I., Najdoski, M. & Igor Kuzmanovski, I. "Classification of urban soils for forensic purposes using supervised self‐organizing maps." Journal of Chemometrics: e3328. https://doi.org/10.1002/cem.3328
4. Pirrie, D., Ruffell, A., Dawson, L. and J. McKinley "Crime Scenes: Geoforensic Assessment, sampling and examination" Chapter 4: of A Guide to Forensic Geology Edited by Donnelly, L.J., Pirrie, D., Harrison, M.A., Ruffell, A., and Dawson, L., Geological Society, London, 2021 pp. 87-110. DOI.org/10.1144/GFG.4
5. ASTM E3272 − 21 Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications
6. "Collection of Forensic Soil Evidence" 2019, https://youtu.be/o9dWZOj1U5A
7. Min, Jisook, et al. "Forensic comparison of soil samples." Soil in Criminal and Environmental Forensics: Proceedings of the Soil Forensics Special, 6th European Academy of Forensic Science Conference, The Hague. Springer International Publishing, 2016.
8. McKinley, J. , Ruffell, A. "Contemporaneous spatial sampling at scenes of crime: Advantages and disadvantages" Forensic Science International 172 (2007) 196–202
9. McKinley, J. 2013. How useful are databases in environmental and criminal forensics? Geological Society, London, Special Publication, 384, 109-119.

10. de Caritat, P., et al. (2021). Forensic soil provenancing in an urban/suburban setting: A sequential multivariate approach. Journal of Forensic Sciences, 66(5), 1679-1696.
11. European Union Soil Strategy 2030. https://environment.ec.europa.eu/publications/eu-soil-strategy-2030_en
12. China National Soil Survey. Website insecure, summary here: https://resoilfoundation.org/en/environment/china-soil-analysis/
13. Africa Soil Information Service (AfSIS). https://www.isric.org/projects/africa-soil-information-service-afsis
14. Aberle, M. G., Troitzsch, U., Robertson, J., & Hoogewerff, J. A. (2023). Conjunctive use of mineralogy and elemental composition for empirical forensic provenancing of topsoil from Canberra, Australia. Forensic Chemistry, 36, 100524.
15. Aberle, M.G., de Caritat, P., Robertson, J. and Hoogewerff, J.A., 2023. A robust interpolation-based method for forensic soil provenancing: A Bayesian likelihood ratio approach. Forensic Science International, 353, p.111883.
16. Aberle, M. G., Robertson, J., & Hoogewerff, J. A. (2023). Voronoi Natural Neighbours Tessellation: An interpolation and grid agnostic approach to forensic soil provenancing. Forensic Chemistry, 35, 100522.

4. Review the annual operational/research needs published by the National Institute of Justice (NIJ) at https://nij.ojp.gov/topics/articles/forensic-science-research-and-development-technology-working-group-operational#latest? Is your research need identified by NIJ?

Fundamental understanding of how environmental factors can affect trace evidence;
New foundational data to support the fundamental scientific basis for analysis and conclusions.

5. In what ways would the research results improve current laboratory capabilities?

Numerous data sets from non-forensic sources (examples include NRCS, USGS, EU Soil Strategy 2030, the China National Soil Survey and the Africa Soil Information Service) could inform the spatial variations of geological material relevant for interpretation in a forensic or intelligence context. However, these agriculture- or environmental vulnerability based surveys sample at lateral scales and depths which are not directly relevant to forensic geology. Nonetheless, they contain valuable baseline information. Proxy modeling tools such as remote sensing, artificial intelligence and geostatistics may be able to extract information from pre-existing and ongoing soil surveys to inform sampling for forensic casework (see for example Digital Soil Mapping). Previous work has been done in this area but now highly sophisticated modeling capabilities exist affording forensic opportunities to better inform sampling and identifying the possible source of an unknown sample. One example to illustrate: we examine lateral variability from an extant soil survey of geochemistry at 15 cm or 30 cm depth; we compare this to remotely-sensed multispectral imagery of surficial soil/vegetation and use co-kriging to assess relationships, as a proxy for variability. This would advance and inform ASTM E3272 − 21 “Standard Guide for Collection of Soils and Other Geological Evidence for Criminal Forensic Applications” and allow a fundamental casework question to be answered: was the soil sample or samples taken reflective of their diversity across the search area and or crime scene? Results of this research need would optimize the most appropriate analytical soil attribute to use.

6. In what ways would the research results improve understanding of the scientific basis for the subcommittee(s)?

This research would provide those performing forensic soil examinations with a better understanding of the control samples required to enable better conclusions (associations, exclusions, inconclusive findings) for cases involving soil from different land use types, geomorphic position/age, and bedrock characteristics. It would also assist the subcommittee in developing an improved statistical approach to estimating population size for comparisons. This would enable the subcommittee to make informed interpretation and report writing recommendations to forensic practitioners in future standards and/or guidelines. It would improve on predictions of geo provenancing and best choice of analytical method to use for examination.

7. In what ways would the research results improve services to the criminal justice system?

The fundamental question of representative sampling during search or specifically at crime scenes would be substantially improved, providing reassurance to the court. This research would significantly improve sampling strategy design and success in provenancing.

8. Status assessment (I, II, III, or IV): II

	Major gap in current knowledge	Minor gap in current knowledge
No or limited current research is being conducted	I	III
Existing current research is being conducted	II	IV

This research need has been identified by one or more subcommittees of OSAC and is being provided as an informational resource to the community.