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$457,536

Project Summary:

Major goals and objectives

Estimating time since death, or the postmortem interval (PMI), is one of the most critical questions after the discovery of human remains. However, PMI estimation remains an enduring challenge to medicolegal death investigations despite decades of research and the creation of six U.S. human decomposition facilities created explicitly to inform this looming question. Current methods for estimating the PMI lack the scientific rigor required within the medicolegal realm as they are often based upon small sample sizes in environmentally homogeneous regions, and the definitions of the gross morphological changes associated with the decomposition process are inconsistent. For these reasons, existing methods are not statistically robust and cannot adequately account for the wide variation and influence of external and internal variables that are known to influence the rate of decay postmortem.

The major goal of this project was to demonstrate a proof-of-concept data collection method to capture observations of decomposition along with weather and environmental data to create a reference dataset. Once the data collection method, geoFOR, was created and tested, the geoFOR application was used to create a large forensic taphonomy reference database through mass collaboration efforts of practitioners within medical examiner and coroner's offices and human decomposition research facilities. Subsequently, the reference dataset was used to create a machine learning model to provide PMI estimates along with an 80% prediction interval based on observations of decomposition characteristics and historical weather data. Finally, the machine learning model was, and continues to be updated as new data is added to the reference dataset.

Research goals (as stated in the original award proposal):

1) Develop an application to allow forensic practitioners to efficiently submit reliable and accurate information about the characteristics observed in forensic casework with embedded georeferenced information in order to build a data repository.

2) Use the data repository from submitted forensic casework to develop robust models for calculating time since death [the PMI] to provide accurate estimates with known error rates by utilizing georeferenced data, and other curated environmental data.

3) Make the data repository available to researchers to test, refine, and improve models for estimating time since death. Refine the application to provide information about PMI (i.e. time since death estimate) based on the data entered by the forensic practitioner in the field.

Summary of project design, methods, and data analysis techniques

geoFOR application design and methods:

A proof-of-concept data collection method to capture observations of decomposition along with weather and environmental data was created. A secure prototype GIS application built on Survey123 for ArcGIS software was developed, which eventually became the geoFOR case entry platform where consistent and reliable anonymized forensic case details could be entered into a database. This is modeled on a similar approach used by the Forensic Data Bank (FDB) to develop methods for estimating aspects of the biological profile in human skeletal remains. The geoFOR case entry platform and survey utilized a spatially coded GIS application accessible from mobile devices, tablets, and desktops. The ArcGIS platform provided a secure system utilized by multiple industries and governmental organizations for storing sensitive data. Python code was developed for individuals to request access to geoFOR and to have a unique username and temporary password assigned that is automated and reviewed by project personnel. The data collection platform employed a user-friendly and intuitive design that enabled quick and accurate data collection. To minimize data input errors, pulldown menus and checkboxes were provided where appropriate. The demographic data collected were generalized to anonymize the case information.

The method for collecting observations about decomposition was novel in comparison to previous studies . Previous methods using gross morphology of decomposition tend to group characteristics observed on the body into stages of decomposition (Cockle and Bell, 2017; Galloway et al., 1989; Rodriguez and Bass, 1983) or apply an arbitrary scoring system based upon observations of decay on various regions of the body (e.g., Ceciliason et al., 2018; Gelderman et al., 2018; Giles et al., 2020; Gunawardena et al., 2023; Megyesi et al., 2005; Roberts et al., 2017). However, our project evaluated the advantages of collecting information about the individual characteristics of decomposition observed on human remains. It was hypothesized that this method of data collection would allow for more robust statistical and machine learning modeling, a more comprehensive understanding of the decomposition process, provide ease of use for practitioners, and greater interobserver reliability.

After the case entry platform was finalized, the app was disseminated through various coroner and medical examiner's offices to build the initial reference dataset to be used to train the machine learning model. A postdoctoral researcher traveled to two universities that maintain human decomposition research facilities (see: collaborating organizations) to collect longitudinal decomposition data to further build the database with known PMI information. The postdoctoral researcher also trained practitioners at various medical examiner and coroner's offices to spread awareness of the application (see: collaborating organizations). Following a simple registration process, cases were entered by forensic investigators and researchers across the United States, which contributed data to the ongoing forensic taphonomy reference dataset.

To encourage a wider breadth of users to participate in the amassing of cases for the database, the application included an option to provide the calendar date associated with accumulated degree days (ADD) or a total body score (TBS). Manual calculation the calendar date associated with ADD or TBS remains one of the most commonly used methods for estimating the PMI (Megyesi et al., 2005; Suckling et al, 2016; Wescott et al., 2018) but is tedious and time consuming due to having to manually collect historic weather data. The geoFOR application used a Python script coupled with spatial analysis techniques via ArcGIS to gather the historical weather information from the RSS feed to compute the average temperature until the ADD entered by the user was calculated. GeoFOR provides a calendar date based on the corrected TBS formula published by authors involved in this project (Smith et al., 2023). If users submit TBS data, the app uses the corrected formula to provide a PMI estimate. To further provide a useful tool to encourage participation, a summarized report of the case entry was created to be emailed directly to users after submission to be included in their case notes (Figure 2).

After the geoFOR reference database had amassed ~1500 cases, the data scientists trained a machine learning model that could provide a PMI estimate directly to users, ultimately included in their emailed summarized results. A process to automate the preprocessing of the input data along with historical weather information was developed to provide PMI estimates to users following case submission. Python code was created using the National Oceanic and Atmospheric Administration (NOAA) Centers of Environmental Information climate data archive of global historical weather. Several stations in this archive have missing values, therefore a method for pulling data from nearby weather stations within a set boundary was created to minimize missing data. To avoid overfitting the model, the weather data was aggregated into a smaller number of the mean and standard deviation inputs for each of several time intervals, which increased in length logarithmically preceding the data of discovery to best capture the data structure.

Several machine learning models were evaluated to determine the best model for predictions through various model validation methods. Ultimately, XGBoost was identified as the model with the best performance. The initial iterations of the model demonstrated that the model performed well across a wide range of PMI values up to around 1000 days. In predicting log-transformed PMI, the model achieved an R^2 of 0.815, cross-validated with a 95% confidence interval [.803, .826]. The outputs of the machine learning model, including a predicted date of death, predicted PMI, 80% prediction interval of dates, and PMI range, were generated for each case and emailed to the user as part of the case summarized report. Periodically as additional decomposition data is included in the reference data set, the model was and continues to be retrained and validated and then deployed within the geoFOR application.

Expected applicability of the research

As previously discussed, estimating the PMI is a critical aspect of a medicolegal death investigation to further the process of determining an unknown decedent's identity and contribute to reconstructing events surrounding the time of death. Existing methods for estimating the PMI are laborious, devised using insufficient and homogenous sample sizes, and thus cannot provide data-driven, statistically robust predictions. The geoFOR application offers an unparalleled, fieldable mechanism for estimating the time since death with an associated prediction interval for medicolegal death investigators and other law enforcement personnel following the discovery of human remains. The application is free and accessible to academic researchers, forensic practitioners, coroners, medical examiners, and various relevant law enforcement personnel working with human remains cases. GeoFOR cases can be entered quickly and efficiently at a scene or retrospectively and the user receives a PMI estimation shortly thereafter, which provides a quick deliverable during a medicolegal death investigation case, thus potentially expediting the process of identification or the next reasonable step required amidst the investigative process. In sum, the project expands beyond academic research and through the pipeline to applied forensic practice, which has culminated in an application that is freely available for practitioners to use in cases of an unknown time of death where they can receive almost immediate data-driven PMI results to readily assist in a forensic case.

Participants

Name: Katherine Weisensee
Project Role: Principal Investigator (PI)
Contribution to Project: Oversight and management of project

Name: Tue Vu
Project Role: Co-PI
Contribution to Project: Artificial Intelligence/Machine Learning implementation and oversight

Name: D Hudson Smith
Project Role: Co-PI
Contribution to Project: Artificial Intelligence/Machine Learning implementation and oversight

Name: Carl Ehrett
Project Role: Co-PI
Contribution to Project: Artificial Intelligence/Machine Learning implementation and oversight

Name: Patricia Carbajales-Dale
Project Role: Co-PI
Contribution to Project: Technical support for application development

Name: Patrick Claflin
Project Role: GIS Sys Admin/Developer, Clemson University (CCGT)
Contribution to Project: Technical support for incorporating machine learning models into the PMI calculator

Name: Madeline Atwell
Project Role: Postdoctoral Fellow
Contribution to Project: Assist with oversight and management of the project; train and supervise interns; data collection; manuscript writing and editing, dissemination of product and results, collaboration with coroner and medical examiner's offices

Name: Cristina Tica

Project Role: Postdoctoral Fellow
Contribution to Project: Assist with oversight and management of the project; train and supervise interns; data collection; manuscript writing and editing, dissemination of product and results, collaboration with coroner and medical examiner's offices

Name: Noah Nisbet
Project Role: Undergraduate Student Intern, Clemson University
Contribution to Project: Artificial Intelligence/Machine Learning implementation intern

Other Collaborating Organizations

University of Tennessee, Department of Anthropology
1621 Cumberland Avenue
Knoxville, TN 37996
Participation: Anthropological Research Facility—allowed for data collection

Texas State University, Department of Anthropology
601 University Dr.
San Marcos, TX 78666
Participation: Forensic Anthropology Research Facility—allowed for data collection

Western Carolina University, Forensic Anthropology Program
101B McKee Building
Cullowhee, NC 28723
Participation: Forensic Anthropology Facilities—allowed for data collection

Pickens County Coroner's Office
147 Kay Holcombe Rd, Liberty, SC 29657
Participation: Intern training of the geoFOR app. Collaborative research and data entry

Oconee County Coroner's Office
302 Memorial Dr, Seneca, SC 29672
Participation: Collaborative research and data entry

Richland County Coroner's Office
6300 Shakespeare Rd, Columbia, SC 29223
Participation: Intern training of the geoFOR app. Collaborative research and data entry

Charleston County Coroner's Office
4000 Salt Pointe Pkwy, North Charleston, SC 29405

Participation: Collaborative research and data entry

Greenville County Coroner's Office
890 W Faris Rd #110, Greenville, SC 29605
Participation: Intern training of the geoFOR app. Collaborative research and data entry

Denver Office of the Medical Examiner
500 Quivas St, Denver, CO 80204
Participation: Intern training of the geoFOR app. Collaborative research and data entry

Clark County Coroner's Office
1704 Pinto Ln, Las Vegas, NV 89106
Participation: Intern training of the geoFOR app. Collaborative research and data entry

Outcomes

Activities and Accomplishments

- Created a case submission entry platform (geoFOR).
- 182 requests for access to geoFOR user registration by end of project period.
- 3251 cases entered into reference dataset from geographically diverse settings.
- Automation of weather information for case entry.
- Validated machine learning estimates delivered to users.
- Multiple conference presentations and workshops to promote awareness of the project (see: Artifacts and Dissemination Activities)
- Mentored two postdoctoral fellows, 10+ forensic science undergraduate interns, and 10+ data science undergraduate interns.

<u>Summary of results and findings</u>

A novel case entry platform, geoFOR, was created, tested, and validated in the initial stages of the research. To develop this novel data collection method for decomposition characteristics, several steps were undertaken. The first was a comprehensive literature review of forensic pathology and forensic anthropology studies to develop a list of decomposition characteristics used in the stage and body score methods. This review uncovered much variation in the existing descriptions and revealed a general lack of uniform characteristics used across publications. Following this review, a list of commonly observed decomposition characteristics was compiled for pilot testing.

The initial iterations of the survey were sent to multiple forensic and medicolegal death practitioners and researchers for evaluation of the data collection method. Based on the feedback, additional decomposition characteristics were added, and the language used in the collection instrument was altered. The data collection instrument was finalized and made available to registered collaborators (Figure 1). A data manual, uniform definitions of the data collected, and example images from previous publications were created to maximize data repeatability across users. Following this stage of the research design, two interobserver error studies were conducted with observers recording data on the same cases. The results from both studies demonstrated that this data collection method for documenting decomposition characteristics is reliable and repeatable (Fleiss' kappa=0.76). The beta version of the data collection instrument was deployed for initial data collection. The postdoctoral fellow trained interns at medicolegal agencies on the protocol and collected longitudinal data from human decomposition research facilities.

geoFOR PMI Estimation Tool

This project was supported by Award No. 2020-DQ-BX-0025, awarded by the National Institute of Justice, Office of Justice Programs, U.S. Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this survey are those of the authors and do not necessarily reflect those of the Department of Justice.

The information accrued in this database will be deposited into the National Archive of Criminal Justice Data curated by the National Institute of Justice following the geospatial guidelines whereby the ESRI shape files will be aggregated to the block level.

Enter information as completely as possible.
Questions marked with an asterisk * are required.

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geoFOR PMI Estimation Tool

Date and Location of Discovery

Name of person inputting data*

Weisensee

Case type

Recorded during investigation, from retrospective case file, or at outdoor research facilities

In the field

Date of discovery*

In case of a longitudinal study (cases from outdoor research facilities) this is the **date of observation**

8/6/2024

Date of death

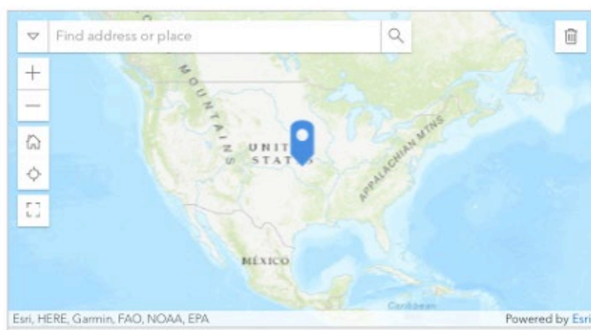
-Please select-

Date last known alive

-Please select-

Location of discovery*

If the exact location of the body is known, use your mobile device location and/or pinch and drag to zoom in and out on the map. Move the map until the pushpin is in the precise location of discovery. Use the search bar to help locate as needed.
If you are not allowed to disclose the exact location of the body, please enter a nearby location (close to the scene or local office responding).



Lat: 37.799073 Lon: -95.836654

Please specify the address entered above

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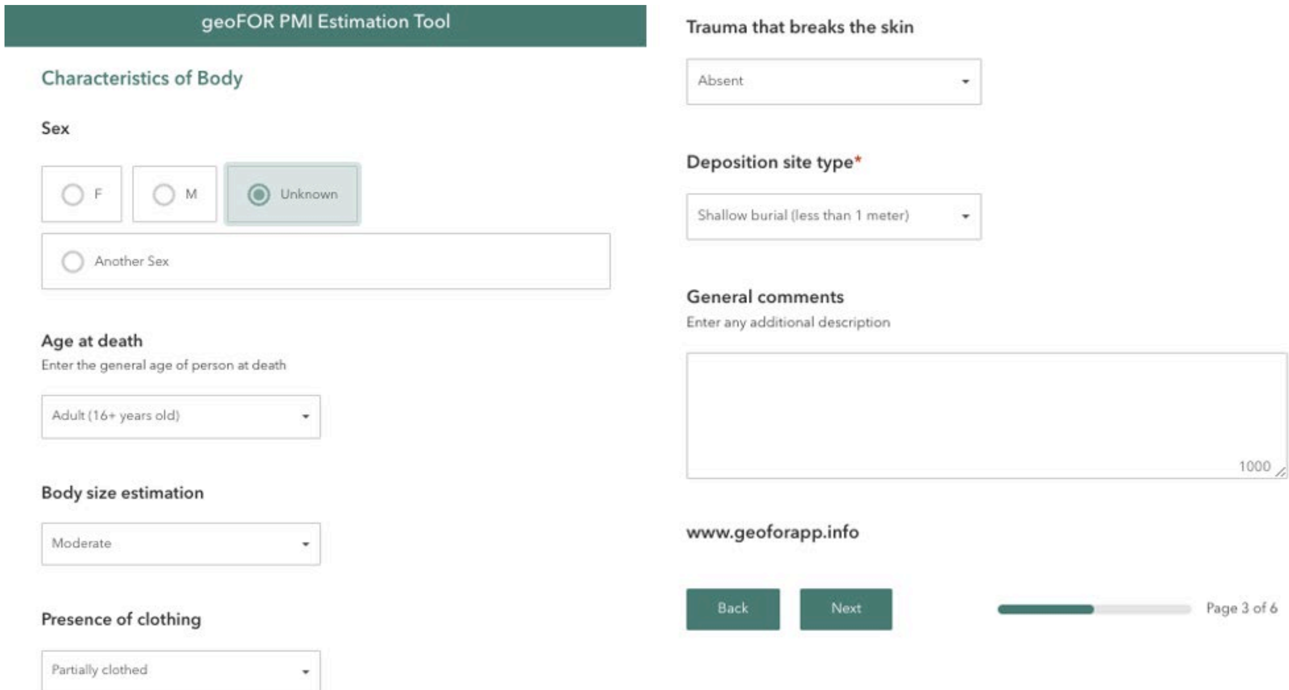
geoFOR PMI Estimation Tool
Characteristics of Body
Sex
F
M
Unknown
Another Sex
Age at death
Enter the general age of person at death
Adult (16+ years old)
Body size estimation
Moderate
Presence of clothing
Partially clothed
Trauma that breaks the skin
Absent
Deposition site type*
Shallow burial (less than 1 meter)
General comments
Enter any additional description
1000
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geoFOR PMI Estimation Tool

Decomposition

Characteristics of decomposition*

Check **all** characteristics of decomposition currently observed on the body. **IMPORTANT NOTE:** Do not select characteristics of stages that have already passed. Refer to Helpful Definitions.

☐ Fresh - Livor mortis absent	☐ Livor mortis unfixed	☐ Livor mortis fixed
☐ Fresh - rigor mortis absent	☐ Rigor mortis partial	☐ Rigor mortis full
☐ Body intact but rigor mortis has passed	☐ Corneal clouding	☐ Drying of fingertips, lips, and/or nose
☐ Greening of the abdomen	☐ Skin bullae/ slippage	☐ Skin discoloration
☐ Marbling	☐ Bloat	☐ Purging (eyes, nose, mouth, ears, etc.)
☐ Decomp fluid surrounding body	☐ Abdominal caving	☐ Liquified organs
☐ Desiccation/ Mummification	☐ Exposed bone with moist tissue	☐ Exposed bone w/ dessicated tissue
☐ Bone with grease	☐ Adipocere	☐ Mold
☐ Dry bone	☐ Weathered bone	☐ Burned
☐ Embalmed		
☐ Other Decomp		

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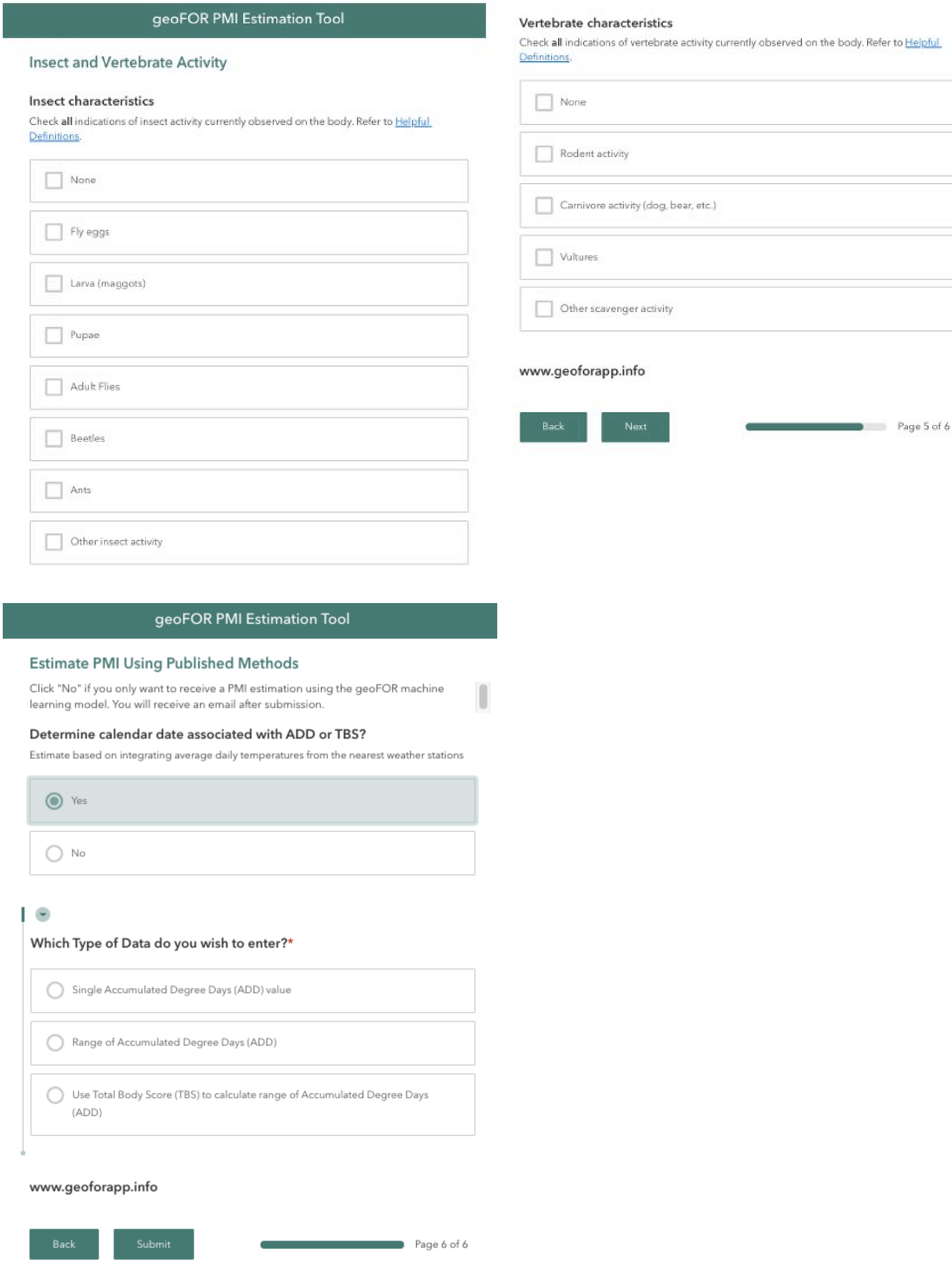

Figure 1. Pages 1-6 of the geoFOR survey.

The creation of the geoFOR application resulted in a fully functioning free forensic case entry platform that automates the collection of weather data from the location of the discovery of a body using the Global Historical Climatology Network (GHCN) through the National Oceanic and Atmospheric Administration (NOAA) along with a machine learning model to deliver statistically robust PMI predictions directly to registered forensic practitioners. An example of

Date and Location of Discovery	
Case Type	Test
Date of Discovery	2023-10-11
Date of Death	None
Date Last Known Alive	None
Geospatial Location	**Latitude** 33.99882000000002 **Longitude** -81.04536999999993
USA NLCD Land Coverage for that location	Developed, High Intensity
Supplementary Location Information	None

Characteristics of Body	
Sex	F
Age at Death	adult
Body Size Estimation	Moderate
Presence of Clothing	Fully Clothed
Evidence of Trauma	undetermined
Evidence of Burning	None
Deposition Site Type	Surface
General Comments	None

Decomposition	
Decomposition Characteristics	Adipocere, Abdominal caving, Exposed bone with moist tissue, Bone with grease
Other Decomposition Characteristics	None

Insect and Vertebrate Activity	
Insect Characteristics	Larva
Vertebrate Characteristics	Carnivore activity

PMI Calculation

PMI Prediction Using the Machine Learning Model	
Predicted PMI Date Range	2023/08/03 - 2023/09/28
Predicted PMI Days Range	13 - 69
Predicted PMI Date	2023-09-09
Predicted PMI Days	32

Figure 2. Example of a survey report emailed directly to users following case submission.

the report and PMI prediction is shown in Figure 2. Cases entered into geoFOR contribute to an ongoing, large collaborative forensic taphonomy database (n= 3221) used to train and update the machine learning predictive model. The process of user registration, through data case entry, and receipt of the PMI results is illustrated in Figure 3. Each step in this process required process development, testing, refinement, validation, and deployment.

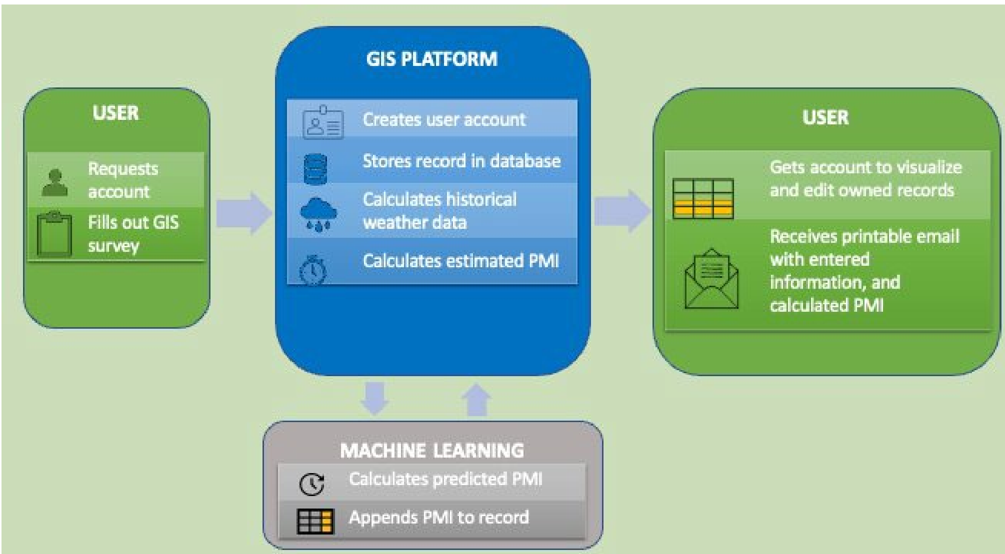

Figure 3. Graphic demonstrating how geoFOR's case entry platform and machine learning model operates.

Reference Dataset Results

To date (August 2024), our method of data collection has yielded a diverse set of forensic and human decomposition facility cases that facilitate a more nuanced understanding of how individual and extrinsic characteristics impact the decomposition process. We have collected data about variables including sex, case type, general age-at-death, body size, clothing presence, trauma, deposition site, decomposition characteristics, insect, and scavenger activity.

The leading case type in the geoFOR reference dataset is retrospective (60.75%), followed by longitudinal cases (from human decomposition facilities) (37.2%), and cases entered while at a scene (1.99%). Most of the cases involve decedents reported to be male (65.22%), followed by females (34.16%), and unknown (0.28%). Adults (16+ years) comprise 98.2% of the reference dataset, with only 0.53% of infant (0-3 years) cases, and 0.22% of data including those of a child (4-15 years). Most data involving body size were entered as moderate (63.39%), followed by obese (6.08%), and emaciated (2.58%).

Clothing presence on the decedent varied and mostly included unclothed individuals (43.68%), unknown (7.44%), fully clothed (22.68%), and partially clothed (26.21%). Skin penetrating trauma was largely absent (66.3%), present in 26% of cases, and undetermined 4.31% of the time. Deposition site types (where the body was discovered), were most frequently located within structures (47.5%), with the ground surface following closely behind (46.11%). Less common deposition locations include water (3.26%), vehicles (2.11%), hanging (0.59%), shallow burials (less than 1 meter) (0.16%), other (0.12%), and deep burials (more than 1 meter) (0.06%).

Due to the unique nature of geoFOR's decomposition characteristics, we can see how common specific decomposition characteristics are observed in casework. Figure 4 provides a broad understanding of the frequency across all cases (n=3221) of specific features of decomposition observed on the body.

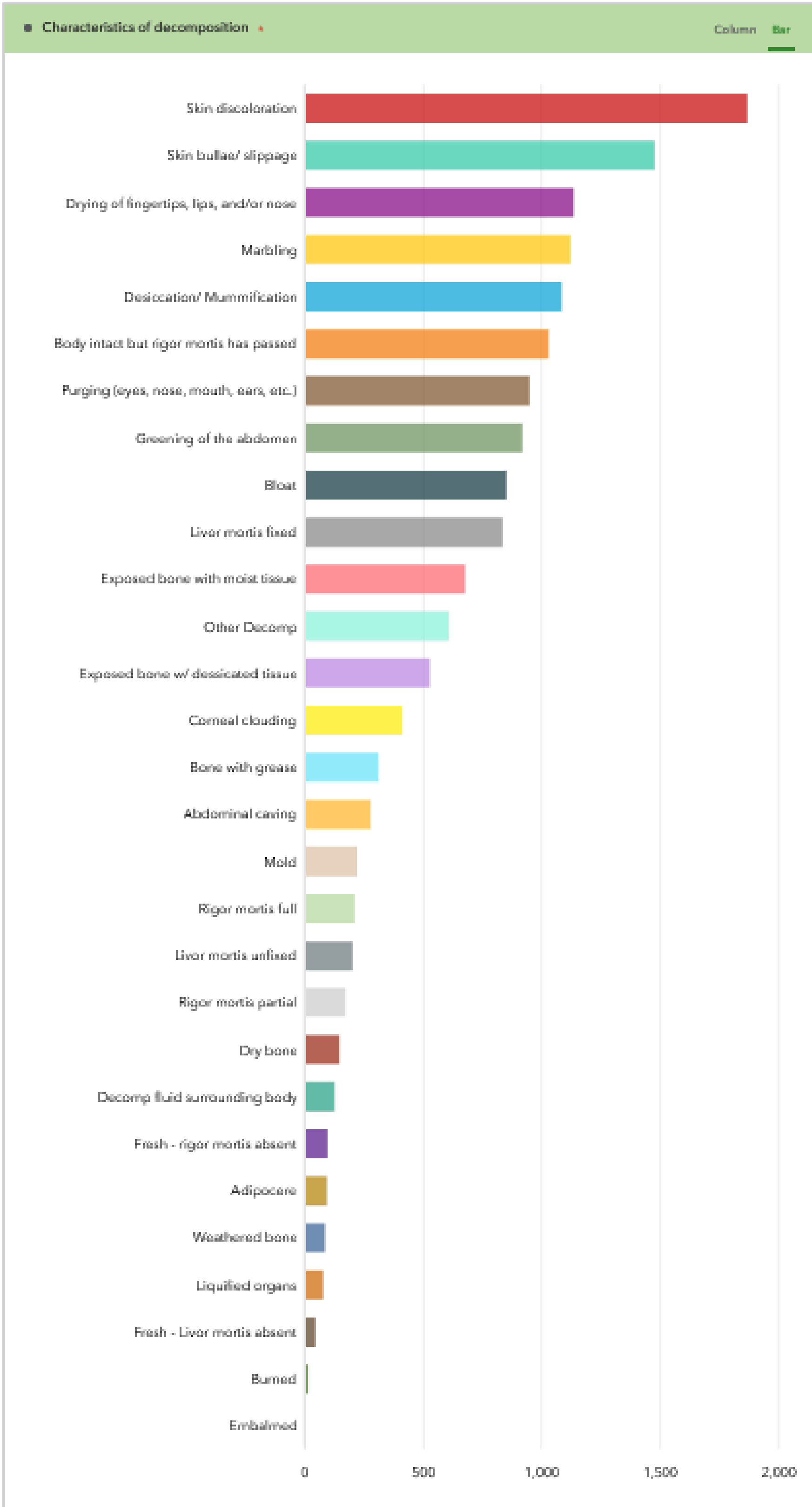

Figure 4. Bar graph displaying frequencies of decomposition characteristics across the geoFOR database.

Machine learning model and weather tool methods and analysis

Using the reference dataset created through the geoFOR case submission platform, a machine learning model was created. This model takes the decomposition characteristics and other inputs from the geoFOR case submissions, preprocesses the data and adds weather covariates to produce a prediction of log (PMI + 1) which is then converted to the scale of days (Figure 5).

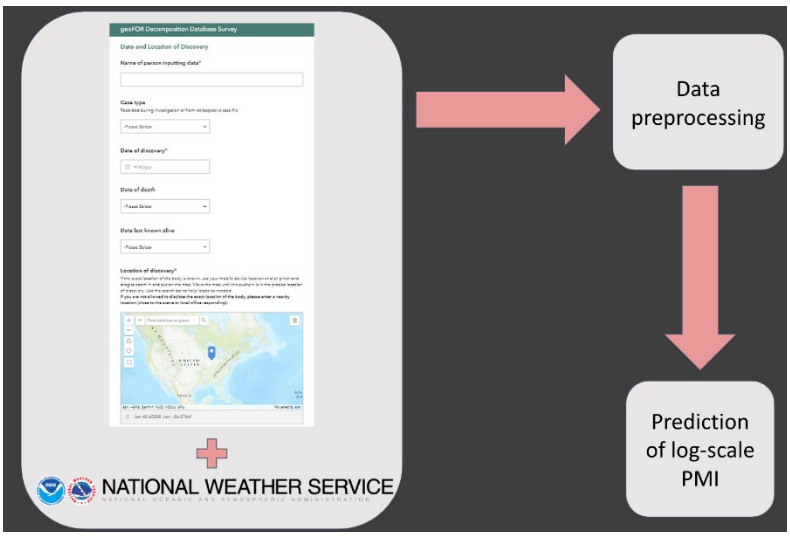

Figure 5. Graphic demonstrating how the machine learning prediction is processed and produced.

Data preparation for this process involved preparing the geoFOR input covariates through one-hot encoding. The PMI was calculated as a log of PMI+1 to account for cases where the PMI is 0, or observations that were made on the day of discovery. The log scale is used here to account for the fact that as PMI increases, the error also increases as a function of the data. This process is shown in Figure 6.

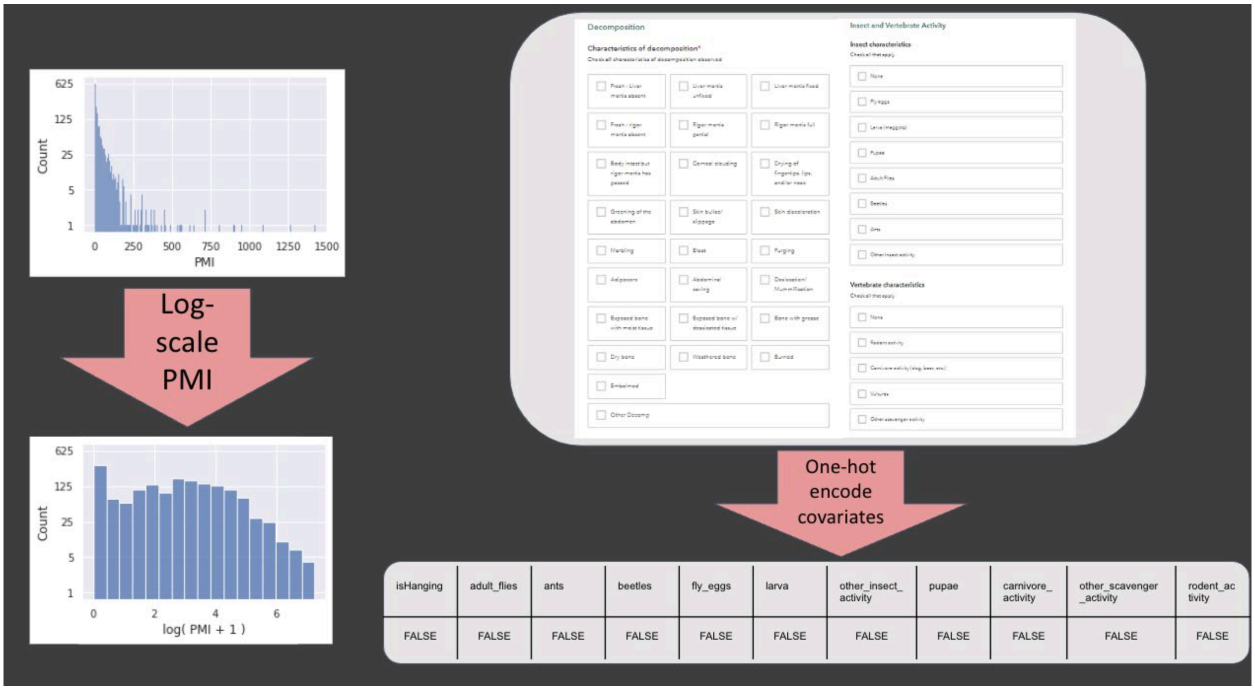

Figure 6. Process of preparing the data to train the machine learning model including preparing the PMI and the covariates.

Various weather covariates were gathered for 154 days prior to the date of discovery of the body using the GHCN, as described earlier. This date range was selected as it represented the 0.95 quantile of the PMI values in the data when the model was initially developed. The binned weather data and geoFOR case input information were used to train a machine learning model. Several different machine learning models were evaluated to determine the best performance. These included CatBoost, Random Forest, SVM, LightGBM, KNN, and XGBoost. XGBoost provided the most reliable results and was used to provide estimates of the PMI and associated 80% prediction intervals to users.

Weather features	Time windows	Aggregations
Average wind speed Maximum wind speed Precipitation Snowfall Percent possible sunshine Total sunshine Minimum temperature Maximum temperature	Days 1 to 3 Days 4 to 7 Days 8 to 21 Days 22 to 56 Days 57 to 154	Mean Standard deviation

Figure 7. Graphic demonstrating how weather features are processed and incorporated into the model.

XGBoost is an ensemble of decision trees. To visualize how the XGBoost machine learning model works to produce PMI predictions, a decision tree was created to show how the model acts as an ensemble of decision trees. Each individual decision tree is a flow chart that that ends on a node that corresponds with a particular PMI day estimation (Figure 8).

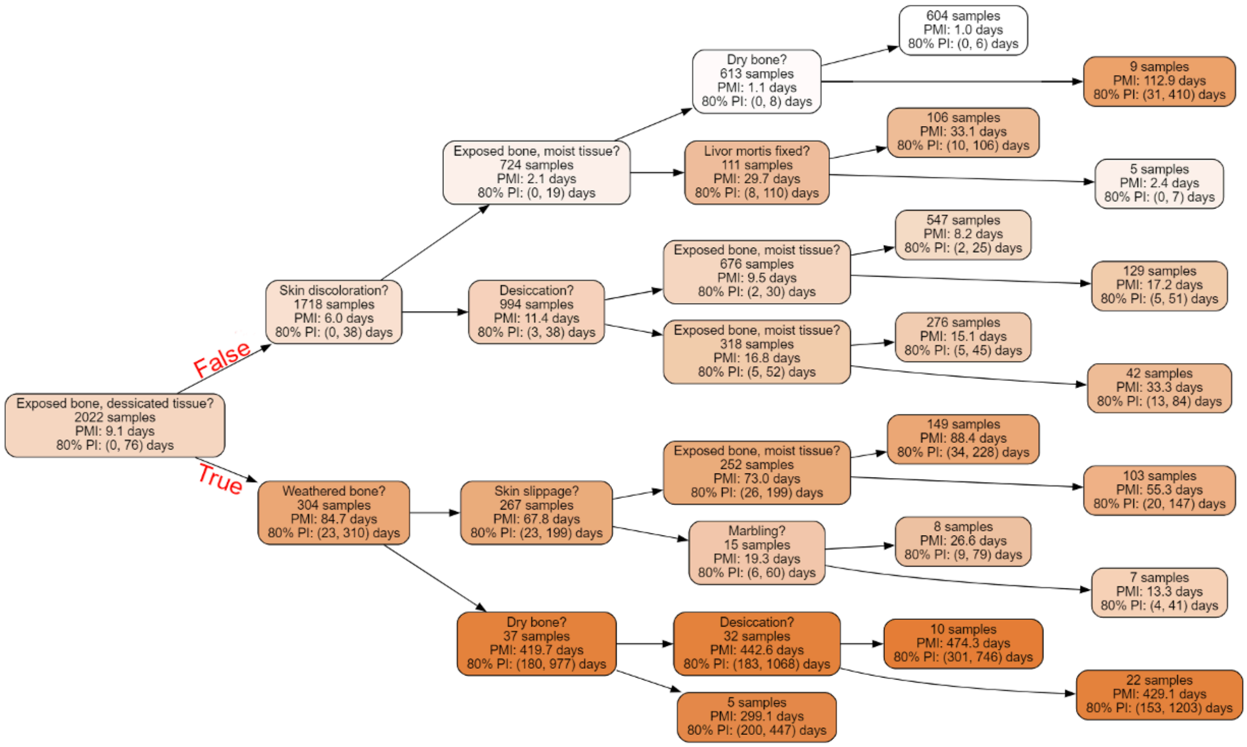

Figure 8. Decision tree example demonstrating how geoFOR's machine learning model operates.

The model performance was tested and performed well across a wide range of PMI values up to around 1000 days. In predicting log-scale PMI, the model achieved an R^2 of 0.815, cross-validated with a 95% confidence interval [.803, .826] (Figure 9).

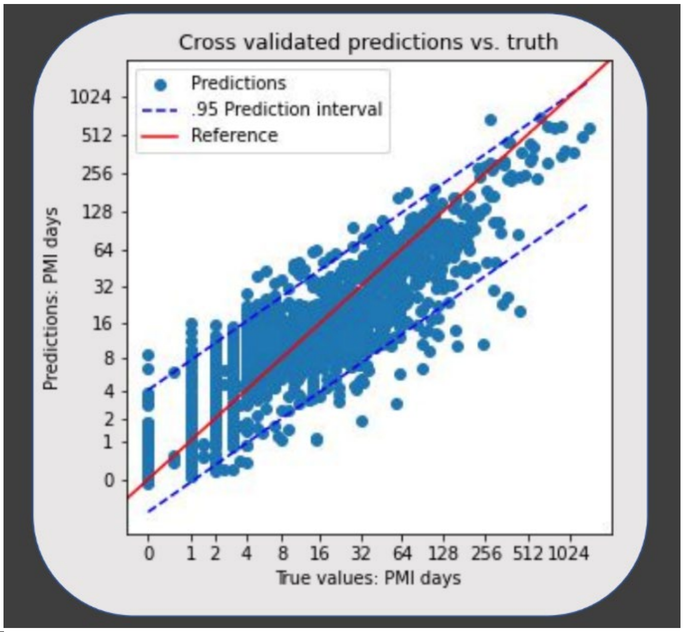

Figure 9. Model predictions vs. true PMI values.

Limitations

As with any mass collaborative data collection method, limitations include some decrease in data quality while maximizing data quantity. GeoFOR case entry seeks to limit this by only allowing registered users to enter cases, thus limiting who may contribute to the larger forensic taphonomy reference dataset (i.e., excluding those who do not practice forensics or medicolegal death investigation). Those who register for the geoFOR application are first vetted prior to being authorized and thus have been limited to those directly involved with medicolegal death investigations such as medical examiners, pathologists, coroners, deputy coroners, forensic anthropologists, and various law enforcement personnel who respond to death investigation scenes or autopsies, or university personnel and practitioners involved with human decomposition facilities who may also conduct forensic anthropological casework, along with their associated undergraduate and graduate student interns or employees. Despite these limitations, the geoFOR database, ML model, and PMI predictions are unprecedented in the field of forensic practice and provide a new paradigm for understanding the relationship between the decomposition process and time of death.

Artifacts and Dissemination Activities

Peer reviewed publications:

Katherine E. Weisensee, Cristina I. Tica, Madeline M. Atwell, Carl Ehrett, D. Hudson Smith, Patricia Carbajales-Dale, Patrick Claflin, Noah Nisbet. *geoFOR: A collaborative forensic taphonomy database for estimating the postmortem interval*, Forensic Science International, Volume 355, 2024, 111934, ISSN 0379-0738, https://doi.org/10.1016/j.forsciint.2024.111934

Conference presentations

Atwell, M.M., Weisensee, K.E. Ehrett, C., Nisbet, N. 2024. geoFOR: Comparative Trends Between Medicolegal Death Investigation & Human Decomposition Facility Cases Using a Large Forensic Taphonomy Database. Podium presentation presented at the 93rd annual meeting of the American Association of Biological Anthropologist, Los Angeles, California.

Weisensee, K.E., Atwell, M.M., Tica, C.E., Ehrett, C. Smith, D.H. Carbajales-Dale, P., Claflin, P., Nisbet, N. 2024. geoFOR: A Forensic Taphonomy Database for PMI Estimation Using a Machine Learning Model. Podium presentation presented at the 76th annual meeting of the American Academy of Forensic Sciences, Denver, Colorado.

Atwell, M.M., Weisensee, K.E. 2024. geoFOR: Applying Machine Learning to Improve Postmortem Interval Estimation. Poster presented at the Forensic Technology Center of Excellence National Institute of Justice Forensic Science R&D Symposium. Denver, Colorado.

Weisensee, K.E., Tica, C.E., Carbajales-Dale, P., Ehrett, C. Smith, D.H. 2022. geoFOR: A New Tool for Medicolegal Death Investigators to Use When Estimating Postmortem Interval. Podium presentation at the annual meeting of the National Association for Medical Examiners, Dallas, Texas. (October, 2022).

Weisensee, K.E., Tica, C.E., Carbajales-Dale, P., Ehrett, C. Smith, D.H. 2022. Introducing a new tool for PMI investigations: the geoFOR app. Poster presented at the International Association of Coroners & Medical Examiners Symposium, Las Vegas, Nevada (July, 2022).

Weisensee, K.E., Tica, C.E., Carbajales-Dale, P., Ehrett, C. Smith, D.H. 2022. geoFOR: A Clemson-led Forensic Anthropology Initiative Aimed to Improve the Medicolegal Practitioner's Toolkit for Death Scene Investigations. Poster presented at the 7th Annual Clemson Research Symposium, Clemson University (May, 2022).

Weisensee, K.E., Tica, C.E., Carbajales-Dale, P., Ehrett, C. Smith, D.H. 2022. Improving Estimates of Time Since Death Through Mass Collaboration, Spatial Analysis, and AI Methods. Podium presentation at the 5th Annual Watt Artificial Intelligence Symposium, Clemson University (April, 2022).

Tica, C. Weisensee, K.E., Claflin, P., Carbajales-Dale, P. 2022. An Innovative Geographic Information System (GIS)-Based Application and Accumulated Degree Days (ADD) Calculator. Podium presentation presented at the 74th annual meeting of the American Academy of Forensic Sciences, Seattle, Washington.

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Datasets generated

The datasets presented in this study can be found in the National Archive of Criminal Justice Data curated by Ann Arbor, MI: Inter-university Consortium for Political and Social Research following the geospatial guidelines whereby the ERSI shape files will be aggregated to the zip code (within the U.S.A) or administrative boundary (outside of the U.S.A) level.

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