

Submission ID #: 70523

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Project Page Link: <https://review.jove.com/account/file-uploader?src=21509563>

Title: Semi-Automated Method for Mapping and Classifying Boreal Coastal Wetland Plant Communities using Drone and Ground Data

Authors and Affiliations:

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Author Questionnaire

1. We have marked your project as author-provided footage, meaning you film the video yourself and provide JoVE with the footage to edit. JoVE will not send the videographer. Please confirm that this is correct.

☒ Correct

☐ Incorrect

2. Microscopy: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **NO**

3. Software: Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes**

If **Yes**, we will need you to record using screen recording software.

We recommend using the screen capture program [OBS](#). JoVE's tutorial for using OBS Studio is provided at this link: <https://review.jove.com/v/5848/screen-capture-instructions-for-authors?status=a7854k>

As these files are necessary for finalizing your script, **please upload all screen captured video files to your project page as soon as possible.**

Note from authors: We will wait for the script to be approved to start the screen capture.

4. Proposed filming date: To help JoVE process and publish your video in a timely manner, please indicate the proposed date that your group will film here: 07/02/2026

NOTE from authors: We have a mixture of video filming settings: screen captures and on-site/outdoor footage. For the on-site/outdoor filming session, we must wait until the vegetation reaches the optimal stage of growth, which will be July. We have set the date for 2nd July, but in case of rain, we will have to postpone and film on the day with no precipitation forecast. However, before the on-site/outdoor filming, we can do screen recordings.

When you are ready to submit your video files, please contact our Content Manager, [Utkarsh Khare](#).

Current Protocol Length

Number of Steps: 21

Number of Shots: 45

Interviews

INTRODUCTION:

~~REQUIRED: Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Vineta Gailite**: Our research utilizes machine learning on drone- and field-survey data to map coastal wetland vegetation and improve plant community classification accuracy.

- 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~Describe the research contexts or systems in which this protocol can be applied.~~

- 1.2. **Vineta Gailite**: This protocol applies to herbaceous-dominated ecosystems, including Baltic Boreal coastal meadow plant communities such as Open Pioneer, Lower Shore, Upper Shore, and Tall Grass.

- 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

CONCLUSION:

~~What does this protocol allow researchers to study or measure?~~

- 1.3. **Kaupo Kokamägi**: This protocol enables the creation of a geospatial dataset to study vegetation patterns, ecological processes, habitat structure, and support coastal ecosystem management.

- 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~Describe the most important consideration or challenge when performing this protocol.~~

- 1.4. **Kaupo Kokamägi**: Obtaining precise coordinates for drone and field-observation data is crucial for accurate plant community classification and reliable land-cover mapping.

- 1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

- 1.5. **Raul Sampaio de Lima:** Future studies can test alternative vegetation-index combination workflows, integrate satellite data, and scale this workflow across diverse coastal wetlands globally.
 - 1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

Protocol

2. Ground Data Collection for Georeferencing Baltic Boreal Coastal Meadow Habitat

Demonstrators: Vineta Gailite, Kaupo Kokamägi

2.1. To begin the stratified quadrat sampling procedure, visually identify plant communities across the study site based on experiential field knowledge [1]. Identify four plant communities characteristic of a Baltic Boreal coastal meadow habitat based on key vegetation species and structure [2].

2.1.1. WIDE: Talent surveying the field site and visually identifying a plant communities.

2.1.2. TXT ON A PLAIN BACKGROUND

Plant Communities:

- Open Pioneer (OP)
- Lower Shore (LS)
- Upper Shore (US)
- Tall Grass (TG)

2.2. Place a 1-by-1-meter quadrat frame on the ground at a representative location for the plant community being sampled, avoiding areas with significant disturbance [1]. Record the survey date, surveyors' names, plant community type or class, and number code for each sample quadrat [2]. Establish number codes in the order of study field code, plant community code, and sample quadrat sequence number to link biophysical field observations to the geospatial dataset and coordinates [3].

2.2.1. Talent placing the quadrat frame on the ground.

2.2.2. Talent recording the survey information for the sample quadrat.

2.2.3. Talent writes the number code for the sample quadrat.

2.3. Use Global Navigation Satellite System, or GNSS (G-N-S-S), receiver and land surveying software to record the coordinates on each corner of the sample quadrat [1]. Enter the number code corresponding to the quadrat code and save the coordinates [2].

2.3.1. Talent recording a quadrat corner location with the Global Navigation Satellite System.

2.3.2. SCREEN: JOVE_SCREEN_70523_2.3.2.mp4: 01:15-01:20 and 01:58-02:07

2.4. Within the sample quadrat, record estimated cover percentages for each observed plant species [1]. Record the cover of other indicative variables like bare ground, plant litter, moss, and algae, ensuring that the total is between 95 and 105 percent, within the accepted range for phytosociological surveys [2]. Use a measuring tape to take 5 random measurements of vegetation height to determine the average

sample height [3].

- 2.4.1. Talent recording plant species cover percentages within the quadrat.
- 2.4.2. Talent recording the cover of bare ground, plant litter, moss, and algae.
- 2.4.3. Talent measuring vegetation height with a measuring tape.
- 2.5. With the same sample quadrat, collect optional biophysical observations, such as soil moisture percentage [1]. To collect vegetation biomass, cut vegetation at the soil level, place it in a paper bag [2], and weigh it on a battery-operated, leveled scale. Record all observations for future reference [3]. **NOTE: The VO is edited for the deleted shots**
 - 2.5.1. Talent recording soil moisture percentage within the sample quadrat.
 - 2.5.2. Talent cutting vegetation at the soil level.
 - 2.5.3. Talent weighing biomass on the battery-operated, leveled scale and recording observations.
 - ~~2.5.4. Talent calculating the true biomass weight and recording all weights.~~ **NOTE: Not filmed**
- 2.6. Replicate the stratified quadrat sampling procedures, a minimum of 10 times within each of the plant community classes, including Open Pioneer, lower shore, upper shore, and Tall Grass, maintaining distance to provide consistent, comprehensive sampling [1].
 - 2.6.1. Talent setting up additional quadrats across the study site.
- 2.7. After completing all field observations, digitize the quadrat sampling records [1]. Organize the data in a table with a header row that labels each variable, creating a dataset for analysis [2]. Input all values accordingly [3] and transcribe all fieldwork notes into spreadsheet software [4].
 - 2.7.1. Show the field observation records for digitalization.
 - 2.7.2. SCREEN: JOVE_SCREEN_70523_2.7.2 00:35-00:40
 - 2.7.3. SCREEN: JOVE_SCREEN_70523_2.7.3 00:15-00:18, 00:45-00:47 *Video editor: Please speed it up!*
 - 2.7.4. SCREEN: JOVE_SCREEN_70523_2.7.4 06:35-06:43 and 07:19-07:21
- 2.8. Save the spreadsheet file [1] and export it as a comma-separated values, or CSV (C-S-V) file [2].
 - 2.8.1. SCREEN: JOVE_SCREEN_70523_2.8.1.mp4: 00:06-00:10
 - 2.8.2. SCREEN: JOVE_SCREEN_70523_2.8.2.mp4: 00:02-00:11
- 2.9. Download all recorded coordinates of the sample quadrat corner locations as a CSV file from the GNSS receiver used in the field [1].
 - 2.9.1. SCREEN: JOVE_SCREEN_70523_2.9.1.mp4: 00:27-00:42 and 00:45-00:50
- 2.10. Create a new project in Geographic Information System, or GIS (G-I-S) software, and

save it as a .qgz (*dot-Q-G-Z*) file in the project folder [2].

2.10.1. SCREEN: JOVE_SCREEN_70523_2.10.1 AND 2.10.2.mp4: 00:05-00:29

- 2.11. In the GIS workspace, import a CSV file containing the quadrat corner coordinates as a **Delimited Text Layer** [1]. Confirm that the imported coordinates appear as point shapes [2].

2.11.1. SCREEN: JOVE_SCREEN_70523_2.11.1 AND 2.11.2.mp4: 00:04-00:25

2.11.2. SCREEN: JOVE_SCREEN_70523_2.11.1 AND 2.11.2.mp4: 00:37-00:45

- 2.12. Join the coordinates of each quadrat corner point as a polygon shapefile [1] and save the shapefile [2].

2.12.1. SCREEN: JOVE_SCREEN_70523_2.12.1 00:03-00:06, 00:12-00:19, 00:40-00:43 and 01:23-01:29

2.12.2. SCREEN: JOVE_SCREEN_70523_2.12.2.mp4: 00:03-00:11

- 2.13. Then, join the polygon shapefile with the digitized field dataset CSV file by linking the number codes of both files [1].

2.13.1. SCREEN: JOVE_SCREEN_70523_2.13.1.mp4: 00:05-00:17 and 00:27-00:35

- 2.14. Save the newly created ground truth dataset as a GeoPackage, or .gpkg (*dot-G-P-K-G*) file in the folder created on the external hard drive [1]. Save the GIS project to update it [2].

2.14.1. SCREEN: JOVE_SCREEN_70523_2.14.1.mp4: 00:07-00:22 and 00:43-00:45

2.14.2. SCREEN: JOVE_SCREEN_70523_2.14.2.mp4: 00:07-00:10

3. Vegetation Index Calculation and Supervised Classification in R Using Random Forest Algorithm

Demonstrator: Raul Sampaio de Lima

- 3.1. To prepare unmanned aerial vehicle, or UAV (*U-A-V*)-based survey maps for vegetation indices, or VI (*V-I*), import all reflectance mosaics created using the UAV survey in the previously created GIS workspace containing ground data [1].

3.1.1. SCREEN: JOVE_SCREEN_70523_3.1.1.mp4: 00:04-00:12 and 00:35-00:52

- 3.2. Based on the sample quadrat distribution and experiential knowledge of the study site extent, create a polygon boundary surrounding the study site [1]. Clip the maps to the polygon's extent to reduce file size and increase processing speed [2].

3.2.1. SCREEN: JOVE_SCREEN_70523_3.2.1.mp4: 00:12-00:16, 00:21-00:24, 00:34-00:40, 01:14-01:16

3.2.2. SCREEN: JOVE_SCREEN_70523_3.2.2.mp4: 00:05-00:09, 00:15-00:20 and 06:14-06:16, 06:24-06:28

- 3.3. Use the **Raster Calculator tool** to compute the vegetation indices with the listed formulas [1]. For multispectral VI calculation, use RED, GREEN, near-infrared, or NIR

(*N-I-R*), and Red-edge GeoTIFF (*Geo-tiff*) files as input [2].

- 3.3.1. SCREEN: JOVE_SCREEN_70523_3.3.1_AND_3.3.2.mp4: 00:03-00:07, 00:18-00:20, 00:25-00:33
- 3.3.2. SCREEN: JOVE_SCREEN_70523_3.3.1_AND_3.3.2.mp4: 00:40-00:53 and 00:57-00:59
- 3.4. For red, green, and blue, or RGB (*R-G-B*)-based vegetation index formulas, normalize the red, green, and blue indices first [1], then calculate the new RGB vegetation indices with the listed formulas [2].
 - 3.4.1. SCREEN: JOVE_SCREEN_70523_3.4.1.mp4: 02:48-2:55 and 03:03-03:08, 03:13-03:15 and 06:46-06:51
 - 3.4.2. SCREEN: JOVE_SCREEN_70523_3.4.1.mp4: 00:08-00:11, 00:18-00:25 and 00:59-01:01
- 3.5. Save the new VI as GeoTIFF raster files in separate folders [1] and name each file using a multispectral or RGB prefix followed by the index name [2].
 - 3.5.1. SCREEN: JOVE_SCREEN_70523_3.5.1_AND_3.5.2.mp4 00:04-00:15 and 00:20-00:23 and 00:35-00:47
 - 3.5.2. SCREEN: JOVE_SCREEN_70523_3.5.1_AND_3.5.2.mp4: 00:56-01:02
- 3.6. Add the digital surface model, or DSM (*D-S-M*), and other automated VI, such as grayscale, to the RGB VI folder [1]. Then, save the GIS project to update it with links to the VI raster files [2].
 - 3.6.1. SCREEN: JOVE_SCREEN_70523_3.6.1.mp4: 00:06-00:21
 - 3.6.2. SCREEN: JOVE_SCREEN_70523_3.6.2.mp4: 00:20-00:34
- 3.7. To execute the supervised classification in R using the random Forest algorithm, open a statistical computing environment for R in RStudio (*R-Studio*) [1]. Select **File**, choose **Open File**, and select the script [2]. Run the entire script at once by clicking **Source** or pressing **Control + Shift + Enter** (*Control-Plus-Shift-Plus-Enter*) [3].
 - 3.7.1. SCREEN: JOVE_SCREEN_70523_3.7.mp4: 00:03-00:11
 - 3.7.2. SCREEN: JOVE_SCREEN_70523_3.7.mp4: 00:11-00:21
 - 3.7.3. SCREEN: JOVE_SCREEN_70523_3.7.mp4: 00:21-00:37

Results

4. Results

4.1. The evaluation of two random forest algorithm models to classify four plant communities [1] revealed that the multispectral VI model achieved 92.34% validation accuracy with the class-level F1 scores ranging from 0.845 in TG [2] to 0.984 in OP plant communities, indicating moderate variability in performance across communities [3].

4.1.1. LAB MEDIA: 70523 Results: Table 1. *Video Editor: Please emphasize the four rows under "Plant community code" sequentially.*

4.1.2. LAB MEDIA: 70523 Results: Table 1. *Video Editor: Please emphasize the text "TG" and the value "0.845" in the last row simultaneously.*

4.1.3. LAB MEDIA: 70523 Results: Table 1. *Video Editor: Please emphasize the text "OP" and the value "0.984" in the first row simultaneously.*

4.2. In contrast, the RGB VI plus DSM RF model delivered highly reliable results, achieving 98.89% accuracy with class-level F1 scores ranging between 0.986 [1] and 0.993, indicating robust classification for all communities [2].

4.2.1. LAB MEDIA: 70523 Results: Table 2. *Video Editor: Please emphasize the text "TG" and the value "0.986" in the last row simultaneously.*

4.2.2. LAB MEDIA: 70523 Results: Table 2. *Video Editor: Please emphasize the text "OP" and the value "0.993" in the first row simultaneously.*

1. Stratified

Pronunciation link: <https://www.merriam-webster.com/dictionary/stratified>

IPA: /'stræt.əˌfaɪd/

Phonetic Spelling: strat·uh·fyd

2. Quadrat

Pronunciation link: <https://www.merriam-webster.com/dictionary/quadrat>

IPA: /'kwɑː.dræt/

Phonetic Spelling: kwah·druht

3. Baltic

Pronunciation link: <https://www.merriam-webster.com/dictionary/Baltic>

- IPA: /'bɔ:l.tɪk/
Phonetic Spelling: bawl·tik
4. Boreal
Pronunciation link: <https://www.merriam-webster.com/dictionary/boreal>
IPA: /'bɔ:r.i.əl/
Phonetic Spelling: bor·ee·uhl
 5. Biophysical
Pronunciation link: <https://www.merriam-webster.com/dictionary/biophysical>
IPA: /,baɪ.oo'fɪz.i.kəl/
Phonetic Spelling: bye·oh·fiz·ih·kuhl
 6. Geospatial
Pronunciation link: <https://www.merriam-webster.com/dictionary/geospatial>
IPA: /,dʒi:.oo'speɪ.ʃəl/
Phonetic Spelling: jee·oh·spay·shuhl
 7. Global Navigation Satellite System
Pronunciation link: No confirmed link found
IPA: /'gloʊ.bəl ,næv.ə'geɪ.ʃən 'sæt.əl aɪt 'sɪs.təm/
Phonetic Spelling: gloh·buhl nav·uh·gay·shuhn sat·uh·lite sis·tuhm
 8. Phytosociological
Pronunciation link: <https://www.merriam-webster.com/dictionary/phytosociological>
IPA: /,faɪ.toʊ ,soʊ.si.ə'lɑ:.dʒi.kəl/ ; /,faɪ.toʊ ,soʊ.ʃi.ə'lɑ:.dʒi.kəl/
Phonetic Spelling: fy·toh·soh·see·uh·loj·ih·kuhl; fy·toh·soh·shee·uh·loj·ih·kuhl
 9. Biomass
Pronunciation link: <https://www.merriam-webster.com/dictionary/biomass>
IPA: /'baɪ.oo ,mæs/
Phonetic Spelling: bye·oh·mass
 10. Digitize
Pronunciation link: <https://www.merriam-webster.com/dictionary/digitize>
IPA: /'dɪdʒ.ə ,taɪz/
Phonetic Spelling: dij·uh·tyze
 11. Geographic Information System
Pronunciation link: No confirmed link found
IPA: /,dʒi:.ə'græf.ɪk ,ɪn.fə'meɪ.ʃən 'sɪs.təm/
Phonetic Spelling: jee·uh·graf·ɪk in·fer·may·shuhn sis·tuhm
 12. Polygon
Pronunciation link: <https://www.merriam-webster.com/dictionary/polygon>
IPA: /'pɑ:.li ,ɡɑ:n/
Phonetic Spelling: pol·ee·gon
 13. Shapefile
Pronunciation link: No confirmed link found
IPA: /'ʃeɪp ,faɪl/
Phonetic Spelling: shayp·fyle
 14. GeoPackage
Pronunciation link: No confirmed link found
IPA: /,dʒi:.oo'pæk.ɪdʒ/
Phonetic Spelling: jee·oh·pak·ij
 15. Unmanned aerial vehicle
Pronunciation link: No confirmed link found

- IPA: /ˌʌnˈmænd ˈer.i.əl ˈvi:.ə.kəl/
Phonetic Spelling: un·mand air·ee·uhl vee·uh·kuhl
16. Reflectance
Pronunciation link: <https://www.merriam-webster.com/dictionary/reflectance>
IPA: /rɪˈflek.təns/
Phonetic Spelling: rih·flek·tuhns
17. Multispectral
Pronunciation link: <https://www.merriam-webster.com/dictionary/multispectral>
IPA: /ˌmʌl.tiˈspek.trəl/
Phonetic Spelling: mul·tee·spek·truhl
18. Near-infrared
Pronunciation link: <https://www.merriam-webster.com/dictionary/infrared>
IPA: /ˌnɪrˌɪn.frəˈred/
Phonetic Spelling: neer·in·fruh·red
19. GeoTIFF
Pronunciation link: No confirmed link found
IPA: /ˈdʒi:.oʊ.tɪf/
Phonetic Spelling: jee·oh·tif
20. Raster
Pronunciation link: <https://www.merriam-webster.com/dictionary/raster>
IPA: /ˈræs.tər/
Phonetic Spelling: ras·ter
21. Grayscale
Pronunciation link: <https://www.merriam-webster.com/dictionary/grayscale>
IPA: /ˈɡreɪˌskeɪl/
Phonetic Spelling: gray·skayl
22. Supervised classification
Pronunciation link: No confirmed link found
IPA: /ˈsu:.pəˌvaɪzd ˌklæs.ə.fəˈkeɪ.fən/
Phonetic Spelling: soo·per·vyzd klas·uh·fuh·kay·shuhn
23. Random forest algorithm
Pronunciation link: No confirmed link found
IPA: /ˈræn.dəm ˈfɔ:r.ɪst ˈæl.gəˌrɪð.əm/
Phonetic Spelling: ran·duhm for·ist al·guh·rith·uhm
24. RStudio
Pronunciation link: No confirmed link found
IPA: /ˈɑ:rˌstu:.di.oʊ/
Phonetic Spelling: ar·stoo·dee·oh
25. Validation
Pronunciation link: <https://www.merriam-webster.com/dictionary/validation>
IPA: /ˌvæl.əˈdeɪ.fən/
Phonetic Spelling: val·uh·day·shuhn