

# COMBINING AERIAL LIDAR AND DEEP LEARNING TO DETECT ARCHAEOLOGICAL FEATURES IN THE PIEDMONT NATIONAL WILDLIFE REFUGE, GEORGIA

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# Piedmont National Wildlife Refuge, a brief history

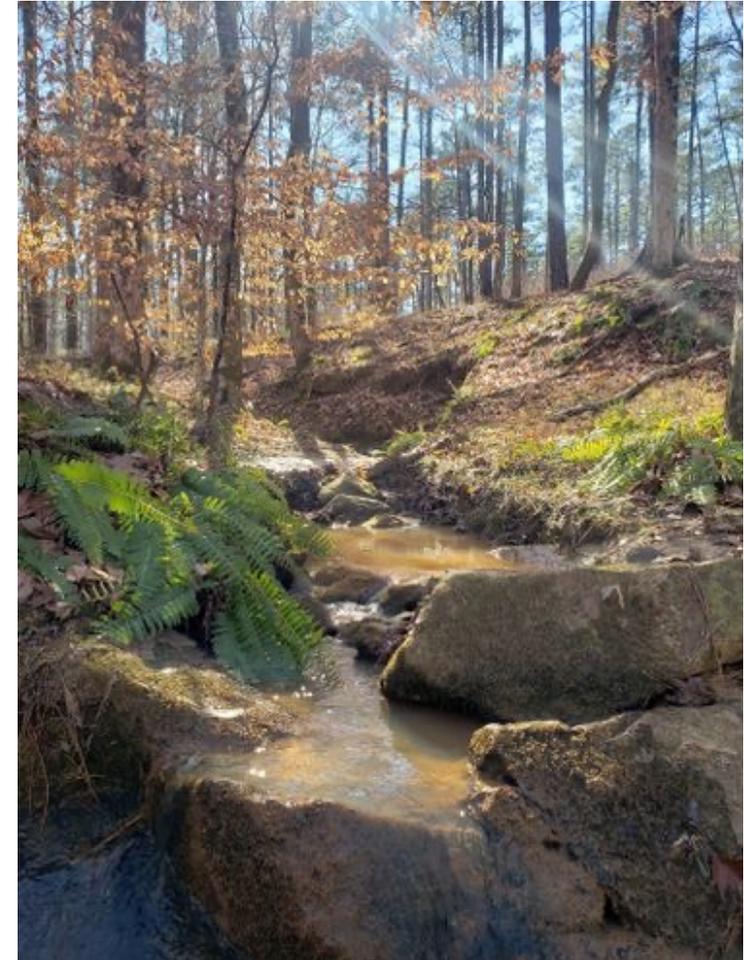
- Heart of the pre- and post-Civil War agricultural production area<sup>1</sup>
- By 1820s: cotton plantations<sup>4</sup>
- 1910-20s:
  - Over-farming on poor soil without good irrigation
  - Boll weevil ravaged the fields<sup>4</sup>
  - 3-year drought<sup>5</sup>
  - Great Depression dried up loans
- 1930s: Exodus of farmers from the region



*"Sharecroppers, Greene County"<sup>7</sup>*

# Resettlement Administration

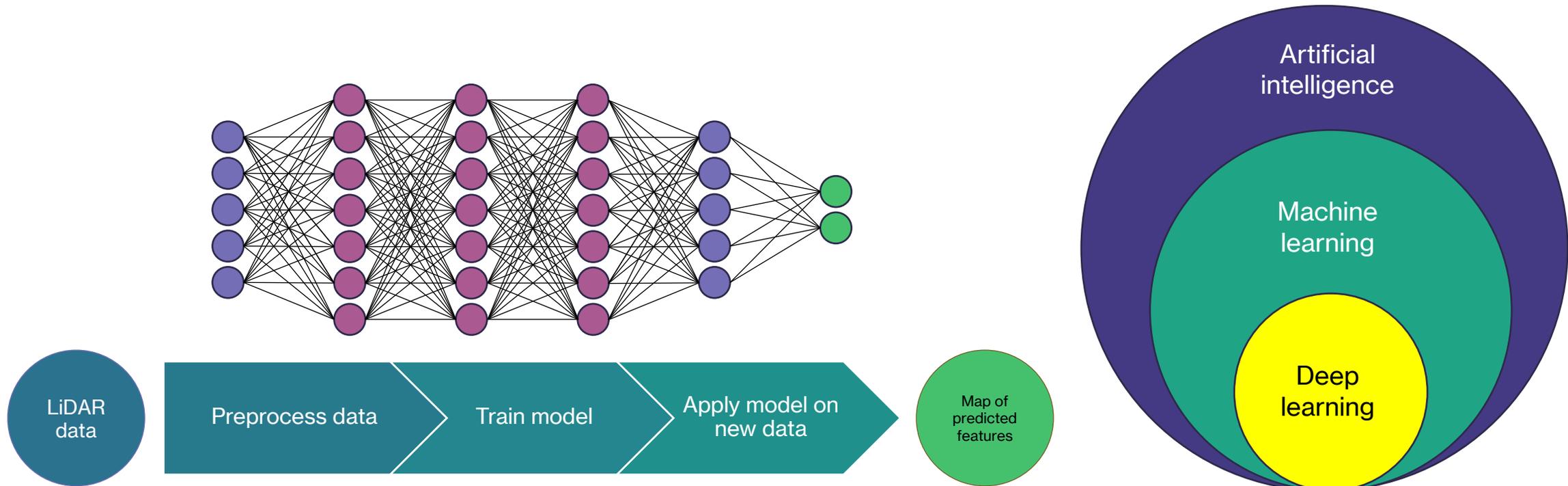
- 1933: Project initiated to purchase land from farmers<sup>4</sup>
  - **Goal:** show that poor, eroded, idle landscape could be restored<sup>6</sup>
- 1939: Piedmont National Wildlife Refuge (PNWR)
  
- **2023: CRS partners with US Fish and Wildlife Service to map archaeological sites in the PNWR.**



© Allison Lake (photo uploaded to AllTrails)

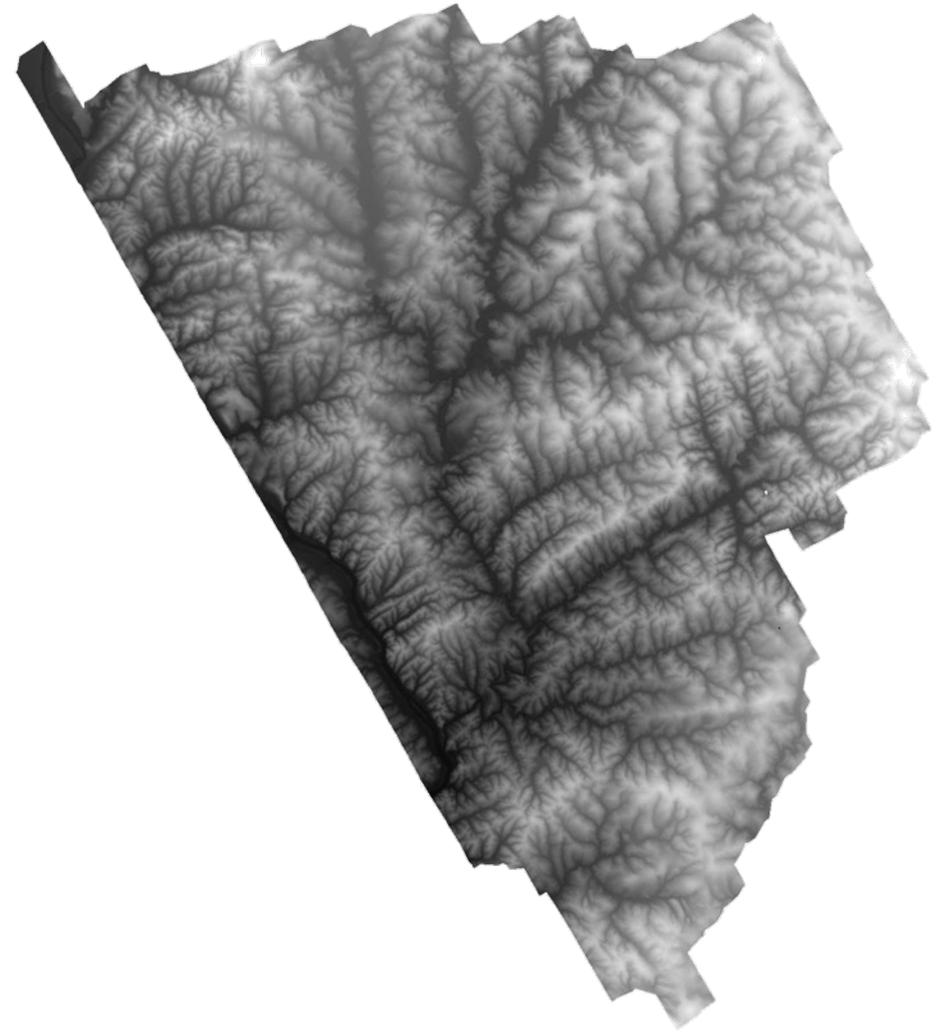
# Our methodology

- Fine tune a pre-trained **deep learning** model to detect terraces in LiDAR-derived imagery.
  - Use a Convoluted Neural Network (CNN)



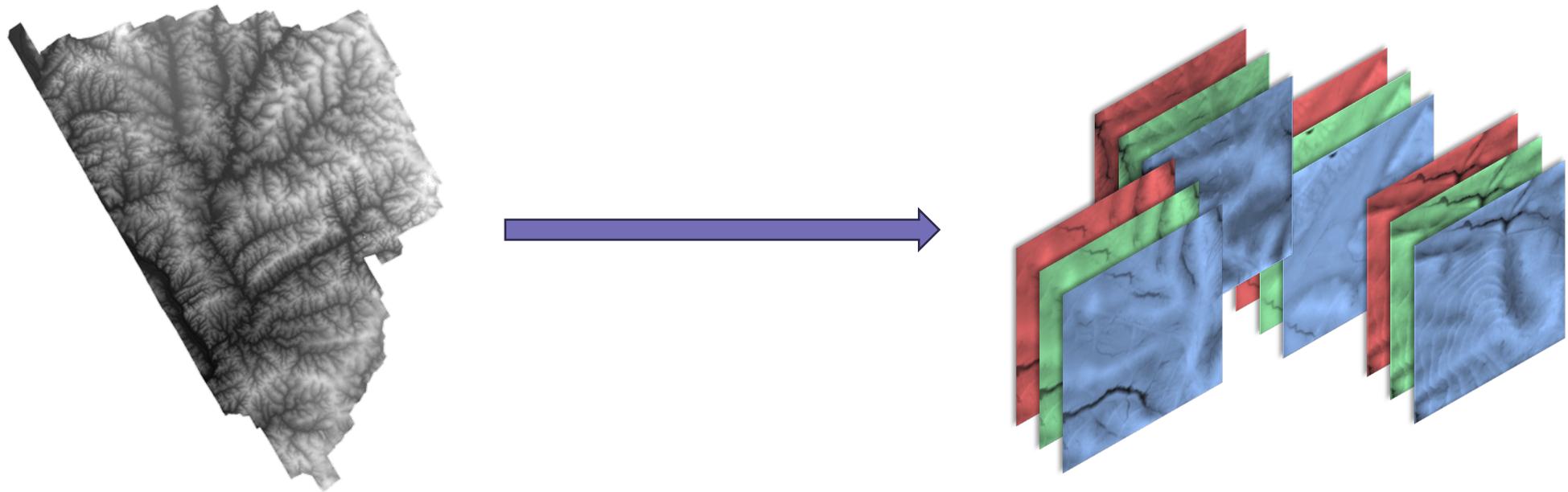
# Raw data format

- 1151 LiDAR-derived DEM tiles covering the extent of the PNWR.
  - **Resolution:** 500x500 tiles at 1m resolution
  - **Format:** geotiffs
  - **Number of bands:** 1 (grayscale)
  - **Values:** elevation in meters



# CNN requirements

- Transfer learning (using a pre-trained model):
  - Go from a grayscale DEM to 3-band tiles with enhanced feature visibility.

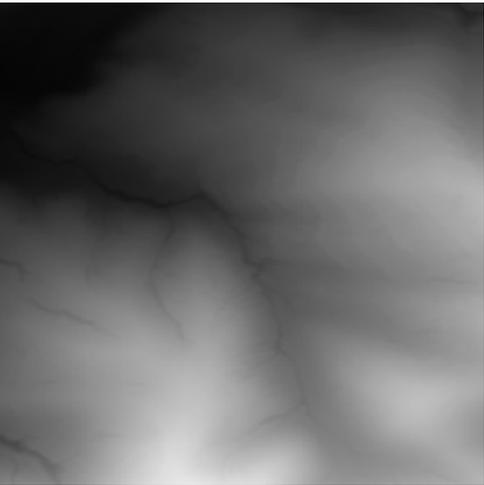




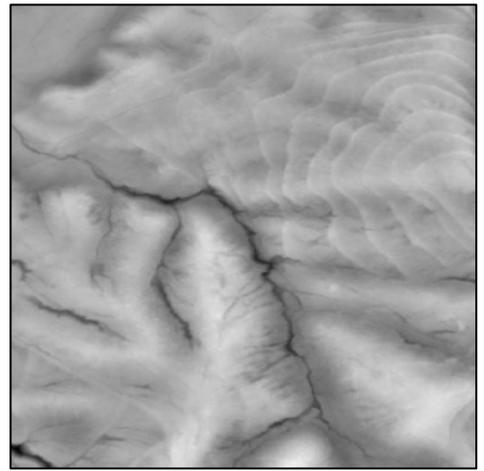
# Data formatting

- We created multiple visualizations of the DEM to enhance the visibility of small features.

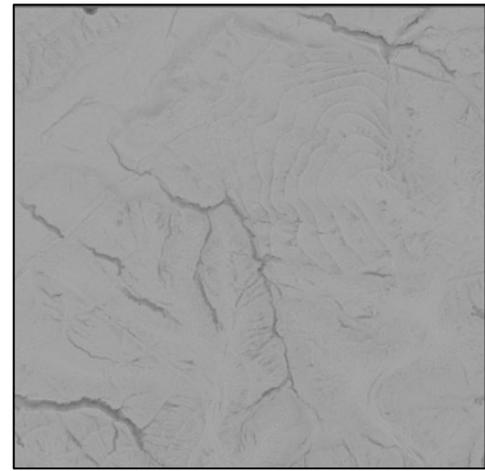
DEM



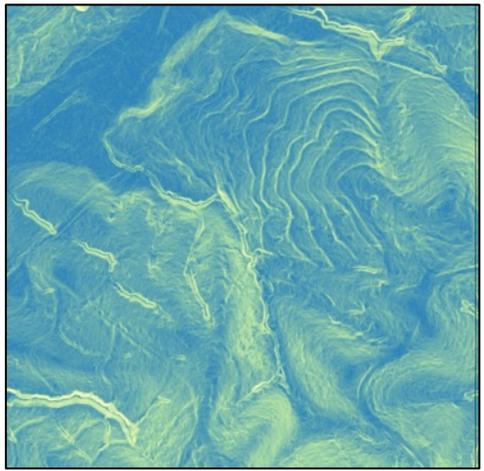
Simple Local Relief Model



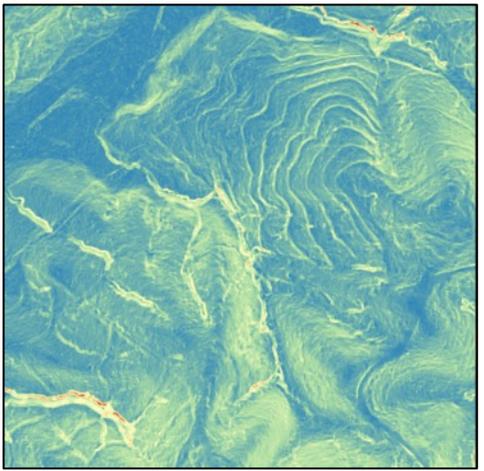
Positive openness



Slope



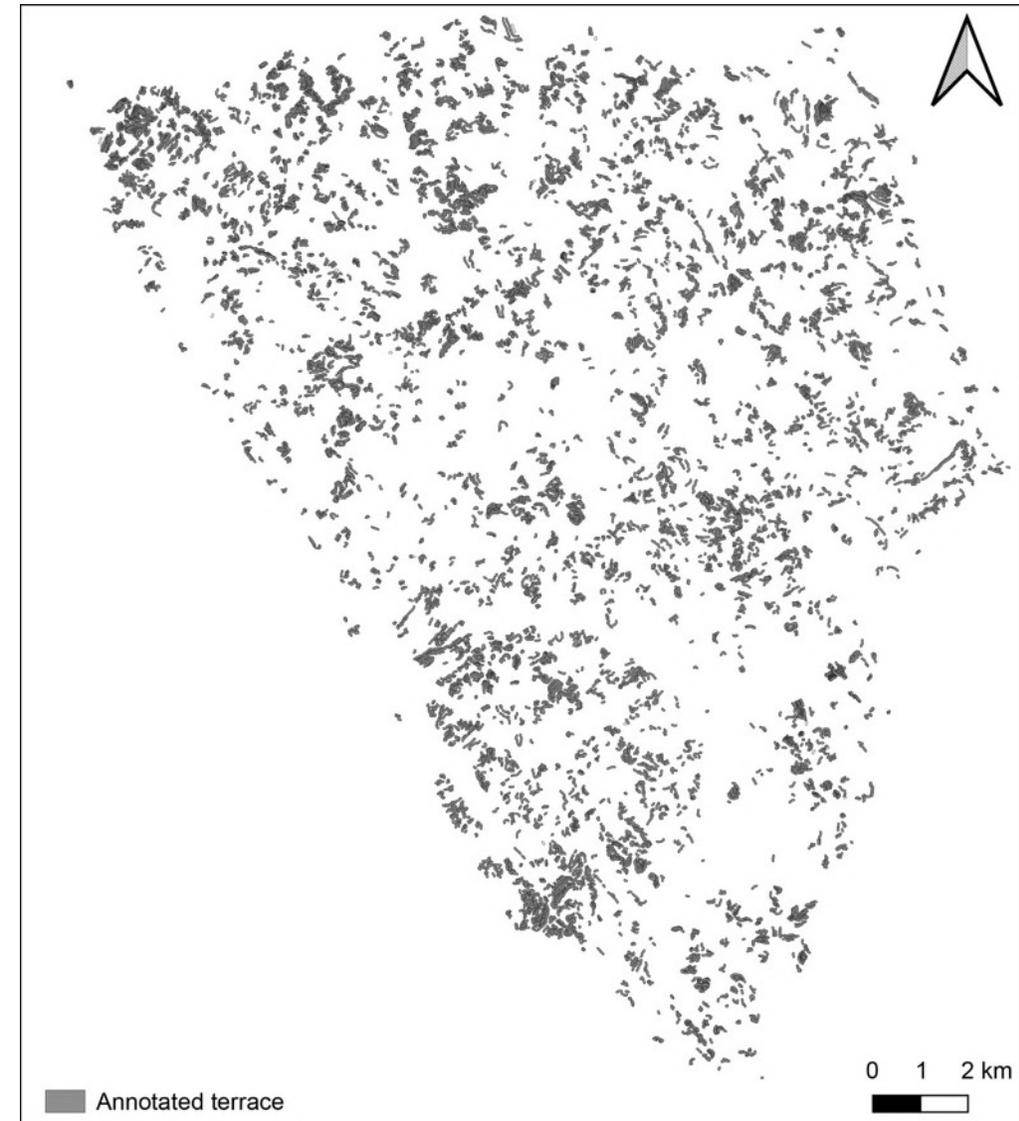
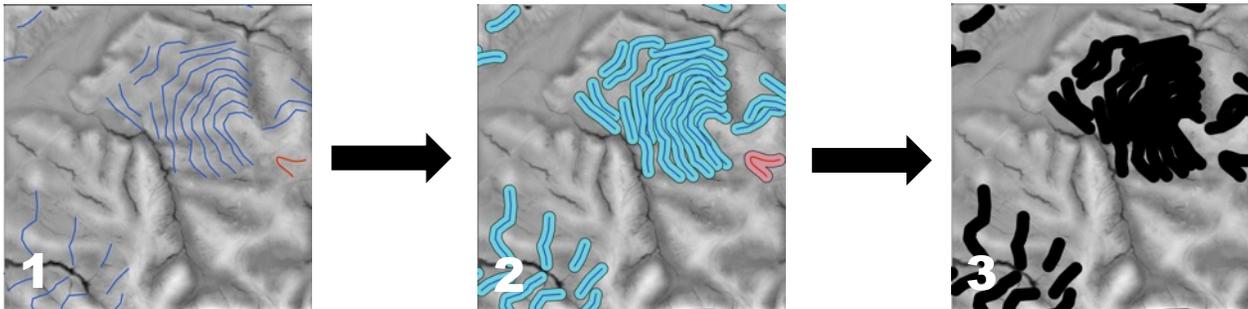
Terrain Ruggedness Index





# Annotations

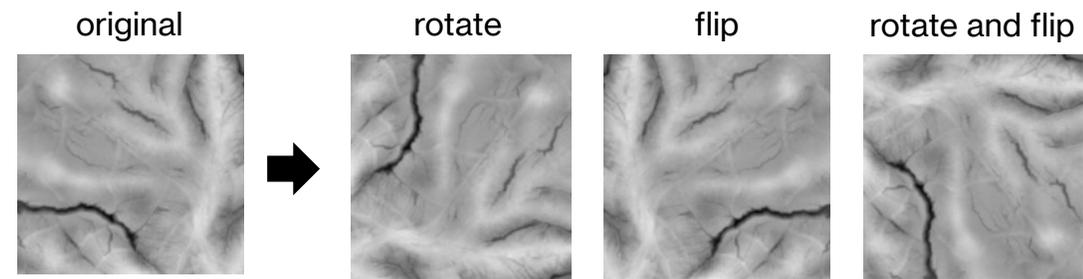
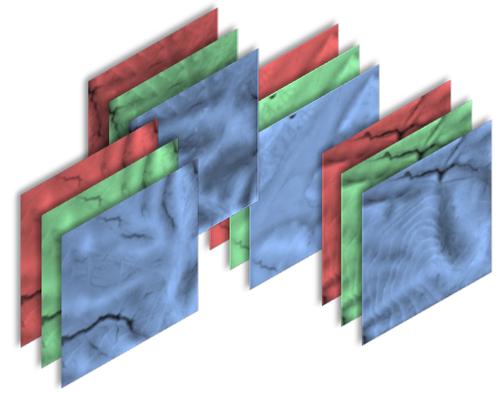
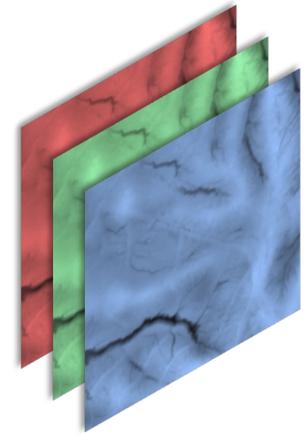
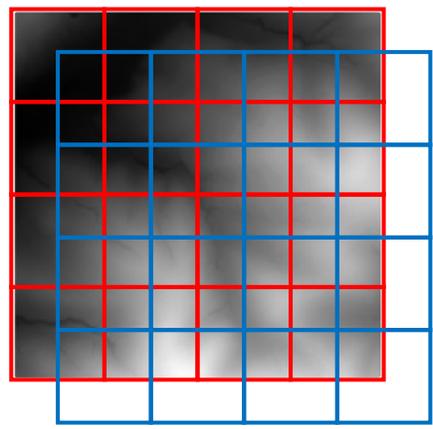
1. Manually annotated all visible terraces
2. Created buffers around each line (tried 5, 10, and 20m)
3. Rasterized the buffers to create one big raster





# Cut and format tiles

1. Cut the rasters (input visualizations and mask) into overlapping square geotiff tiles
2. Combined 3 visualizations to create 3-band images
3. Separated dataset into 80% training and 20% validation
4. Arranged images in batches
5. Used augmentations to increase the number of different images seen by the model



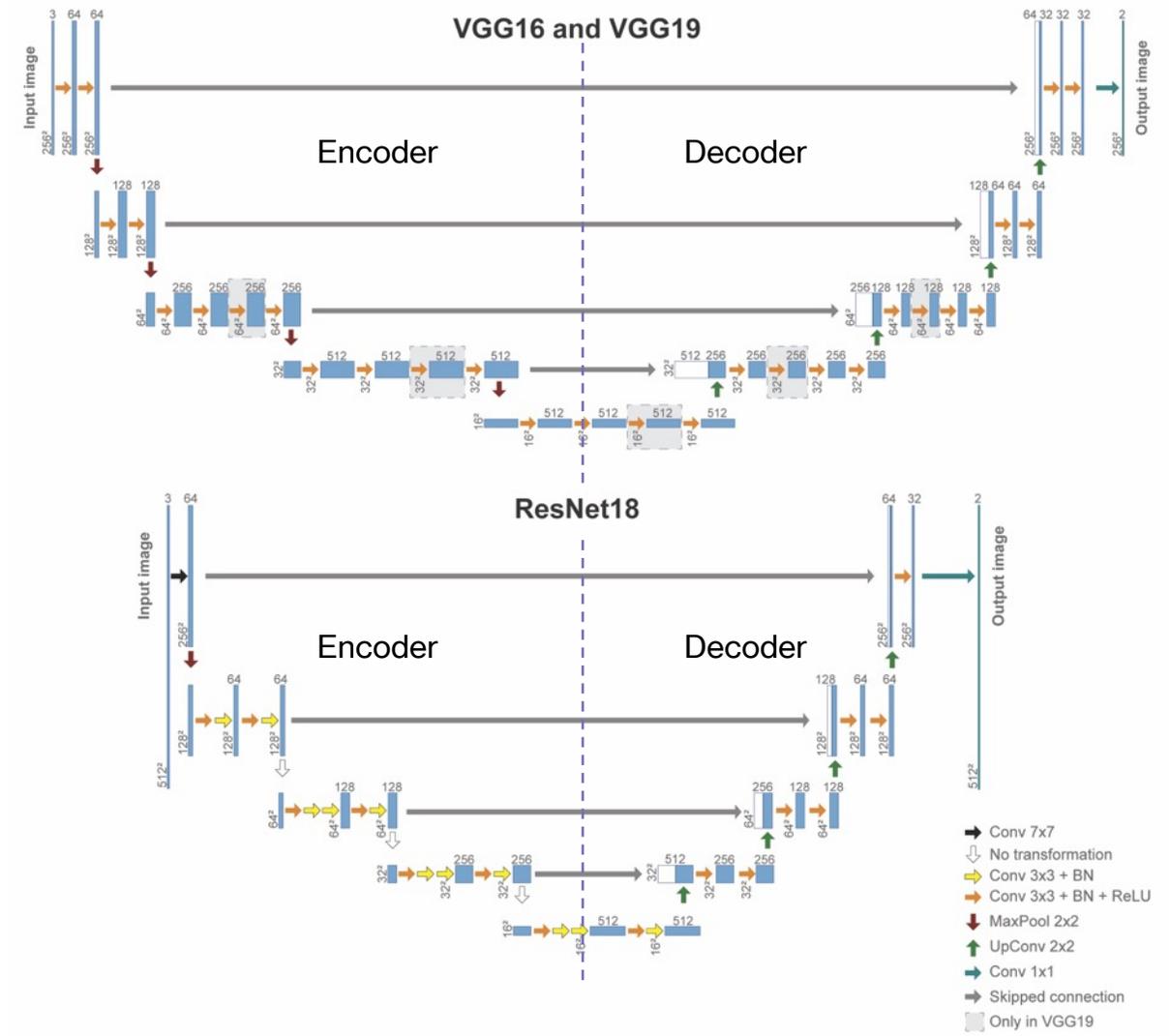


# U-NET

- U-Nets are **segmentation** CNNs
- To use pre-trained weights, we set different backbones for the encoder.



Segment anything demo



Two backbones used



# Parameters tested

Parameter	Values tested
Backbone	VGG16, VGG19, ResNet18
Visualizations	SLRM 10m, SLRM 20m, slope, TR, Positive Openness
Pretrained weights	None, default
Learning rate	0.001, 0.0001, 0.00001
Loss function	Focal, Dice, IoU
Batch size	4, 8, 16
Buffer size around terrace	1m, 2m, 3m, 4m
Tile size	256x256, 512x512
Train %	80%, 90%, geographical or random
Number of epochs	20, 50, 100, 200

**A LOT OF PARAMETERS**



# Metrics considered

**RECALL**  
(SENSITIVITY)

**PRECISION**  
(SPECIFICITY)

**F1 SCORE**  
(HARMONIC MEAN)

$$\frac{TP}{TP + FN}$$

$$\frac{TP}{TP + FP}$$

$$\frac{2 * recall * precision}{recall + precision}$$

$$\frac{24}{24 + 10}$$

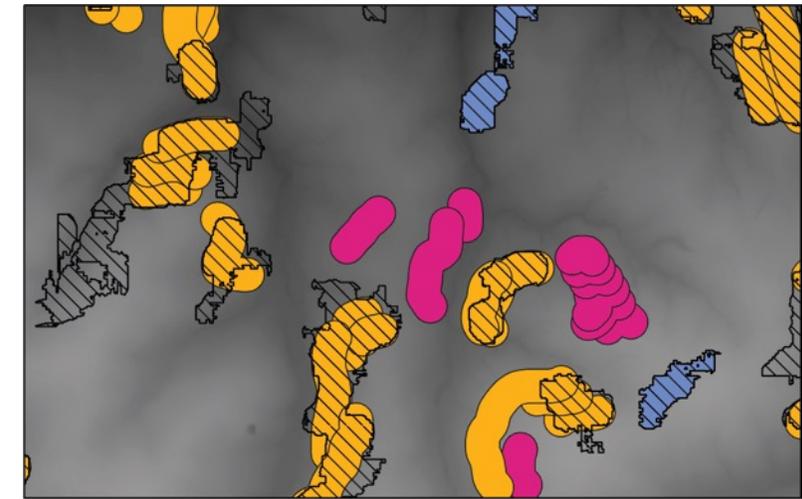
$$\frac{24}{24 + 3}$$

$$\frac{2 * .71 * .89}{.71 + .89}$$

**71%**

**89%**

**79%**





# 4 best models

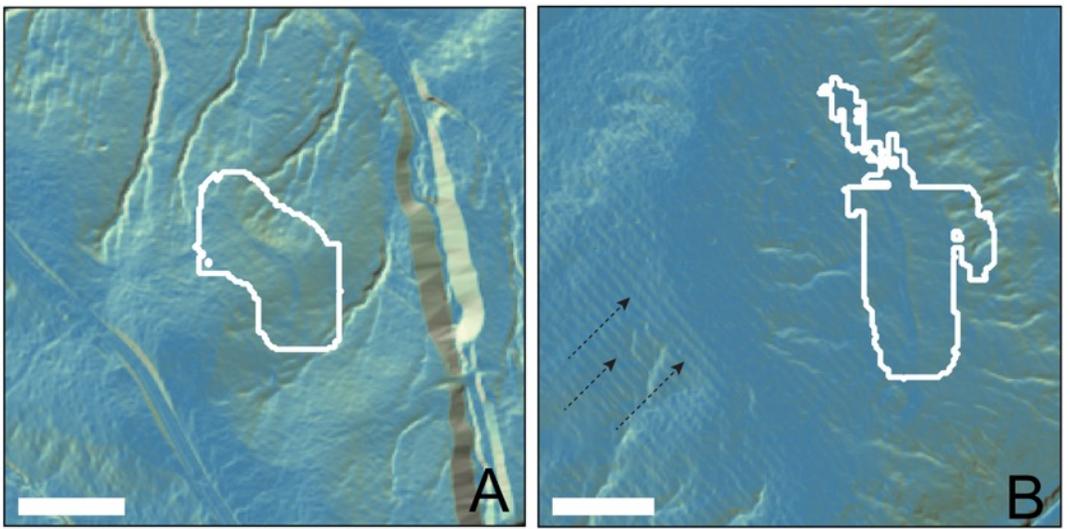
- All used **VGG16**, **IoU**, with **PosOp**, **SLRM 20m**, and **Slope** visualizations

Learning rate	Batch size	N training dataset	Buffer size	N epochs	Recall feature	F1 score
0.001	8	2356	10m	124	<b>0.949</b>	0.528
variable	8	2356	10m	81	0.872	0.635
0.001	16	2356	10m	127	0.885	0.626
0.001	16	2547	20m	164	0.947	<b>0.662</b>

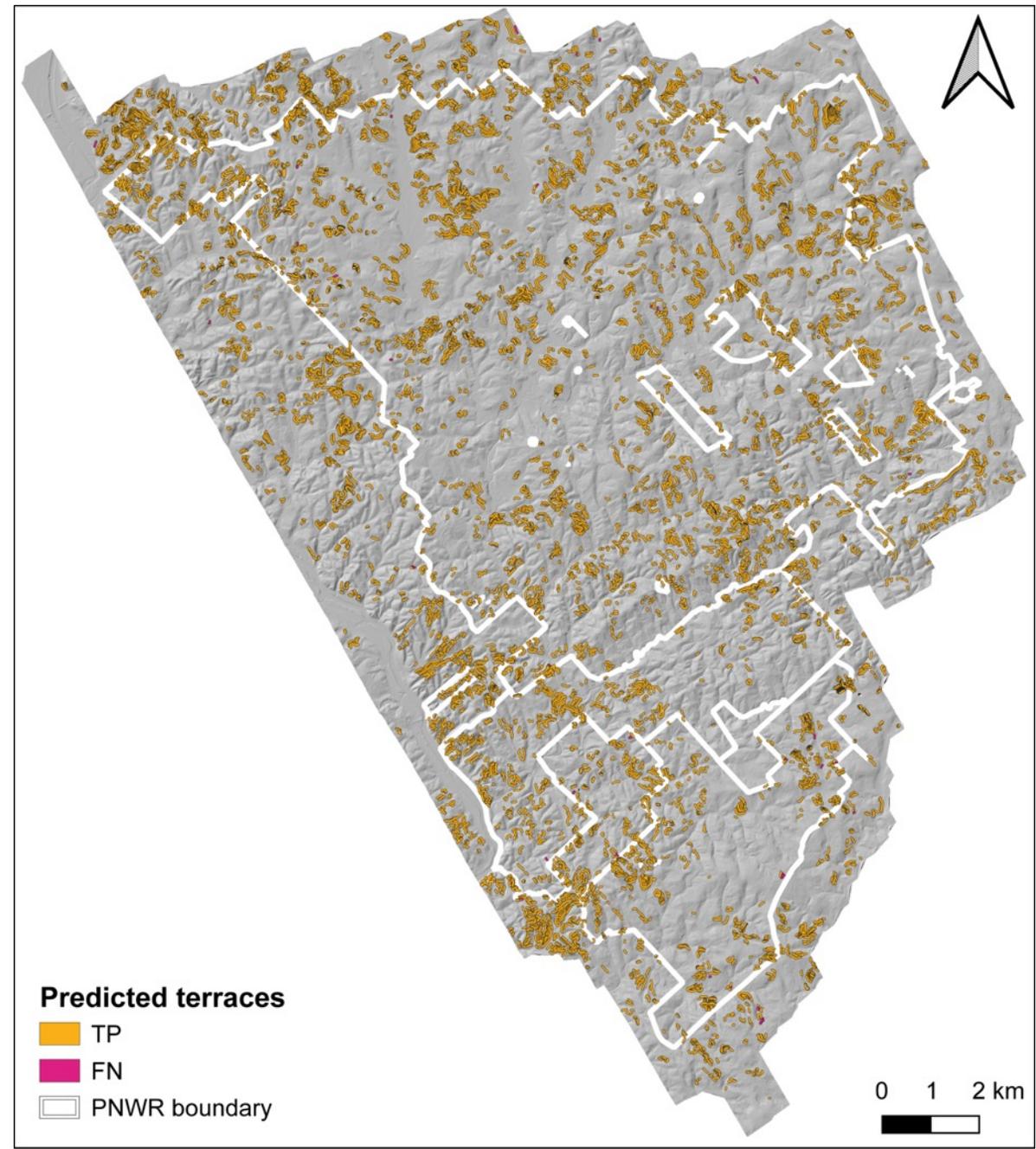
- **The best model correctly identified 95% of annotated terraces!**

# Going beyond!

- The model found terraces we had missed!



FP that were actually TP



TP and FN predictions of best model on PNWR

# Best practices



=!



- **Understand and annotate your data well**
  - If you can't recognize the feature, the model won't either
  - Consider testing different visualizations and different resolutions
- **Understand your model's requirements**
  - Pre-trained or not?
  - Format the data accordingly
- **MOST IMPORTANT: Communicate with your stakeholders**
  - Consider the ethics of revealing the location of new archaeological sites

# References and acknowledgments

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**QUESTIONS?**

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