

AI

# ~~ai~~ AI FOR WEEDS

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WEED



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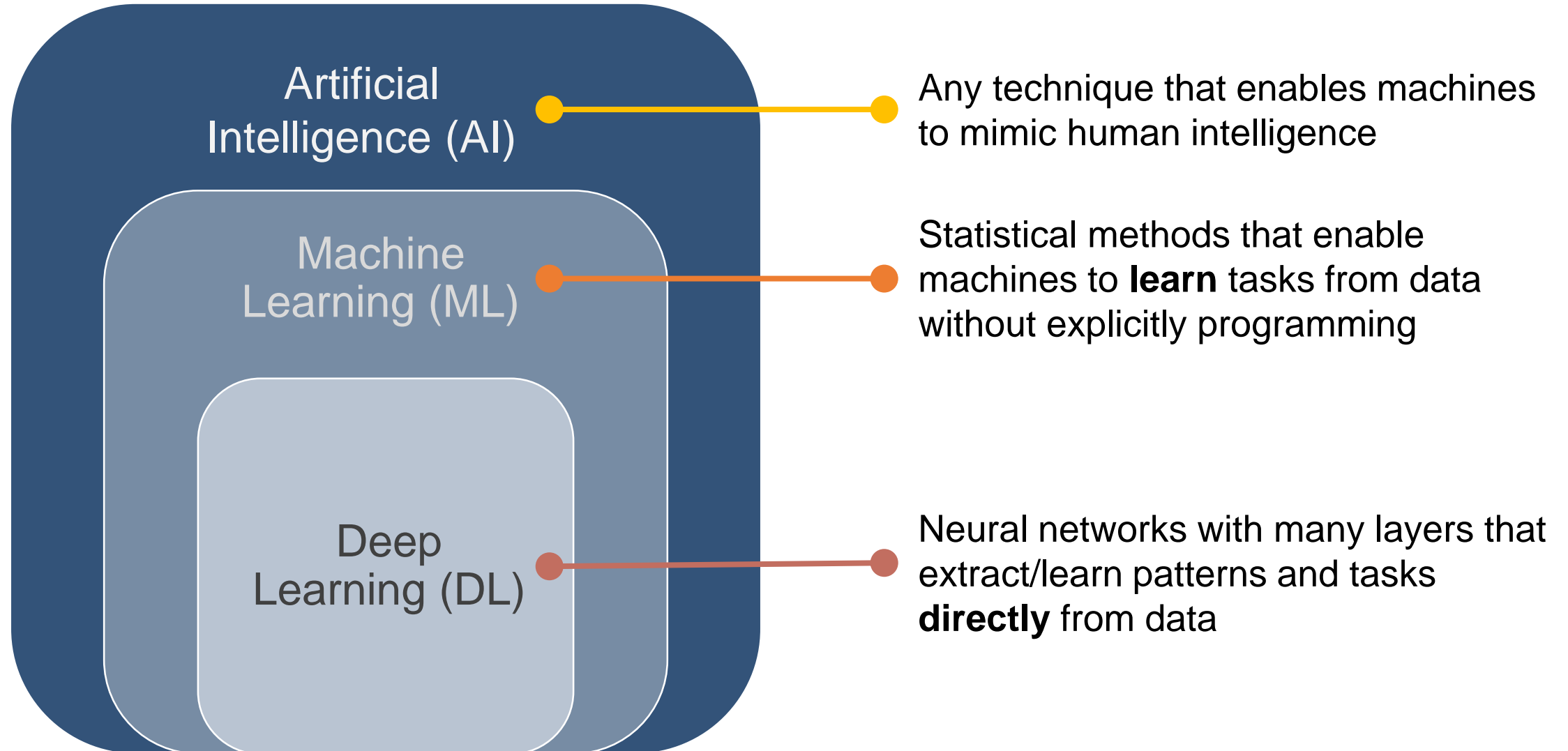
u



@MBMesgara

**UC DAVIS**  
UNIVERSITY OF CALIFORNIA

# AI vs. ML vs. DL



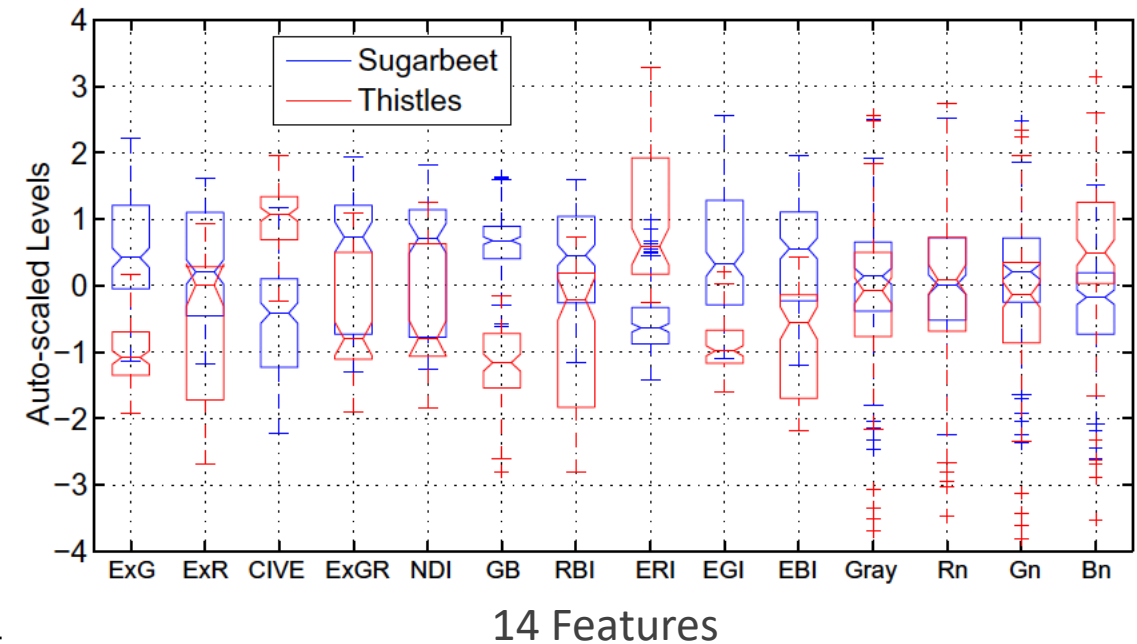
# ML vs. DL

[Canada] thistle  
(*Cirsium arvense*)



Sugar beet  
(*Beta vulgaris*)

Color index	Definition
Rn, Gn, Bn	$R/(R + G + B), G/(R + G + B), B/(R + G + B)$
Gray	$0.2898 * Rn + 0.5870 * Gn + 0.1140 * Bn$
ExG (Woebbecke et al., 1995)	$2 * Gn - Rn - Bn$
ExR (Meyer et al., 1998)	$1.4 * Rn - Gn$
CIVE (Kataoka et al., 2003)	$0.441 * Rn - 0.811 * Gn + 0.385 * Bn + 18.78$
ExGR (Meyer and Neto, 2008)	$ExG - ExR$
NDI (Woebbecke et al., 1992)	$(Gn - Bn)/(Gn + Bn)$
GB (Woebbecke et al., 1995)	$Gn - Bn$
RBI (Golzarian and Frick, 2011)	$(Rn - Bn)/(Rn + Bn)$
ERI (Golzarian and Frick, 2011)	$(Rn - Gn) * (Rn - Bn)$
EGI (Golzarian and Frick, 2011)	$(Gn - Rn) * (Gn - Bn)$
EBI (Golzarian and Frick, 2011)	$(Bn - Gn) * (Bn - Rn)$



# ML vs. DL

Feature (independent variables, predictors)						Response	
$X_1$	$X_2$	$X_3$	...	$X_p$		$Y$	
$x_{1,1}$	$x_{2,1}$	$x_{3,1}$		$x_{p,1}$		$y_1$	Sugar beet
$x_{1,2}$	$x_{2,2}$	$x_{3,2}$		$x_{p,2}$		$y_2$	Sugar beet
$x_{1,3}$	$x_{2,3}$	$x_{3,3}$		$x_{p,3}$		$y_3$	Thistle
.	.	.		.		.	Thistle
.	.	.		.		.	Sugar beet
.	.	.		.		.	Thistle
$x_{1,n}$	$x_{2,n}$	$x_{3,n}$	...	$x_{p,n}$		$y_n$	

Linear Discriminant Analysis and Multiple Regression gave 95-97% accuracy.

Kazmi et al (2015)

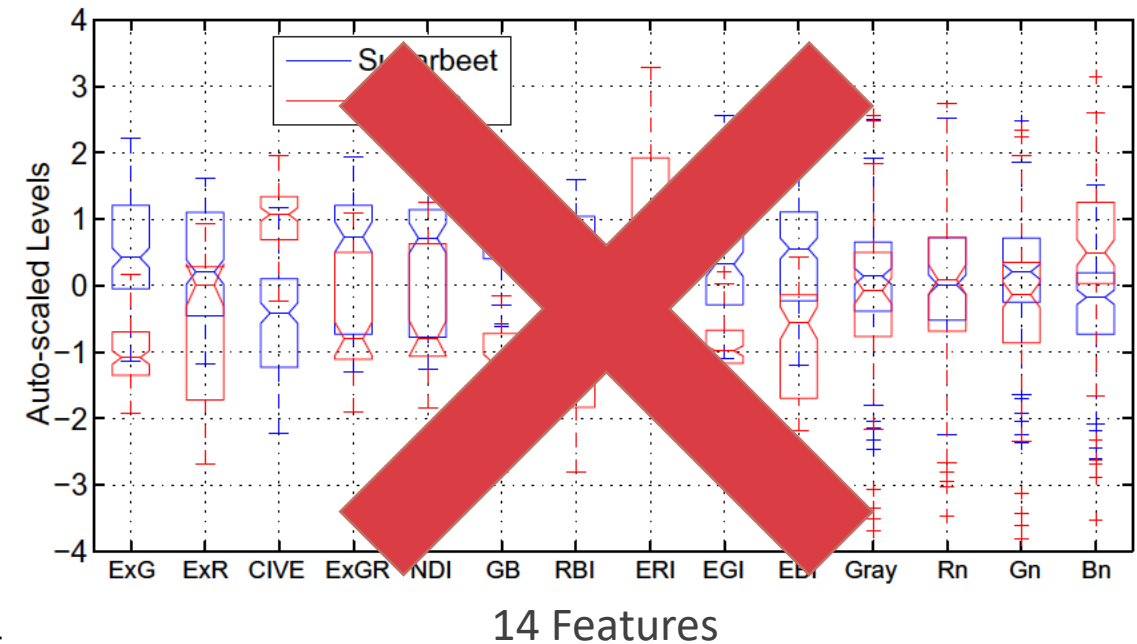
# Deep Learning

[Canada] thistle  
(*Cirsium arvense*)



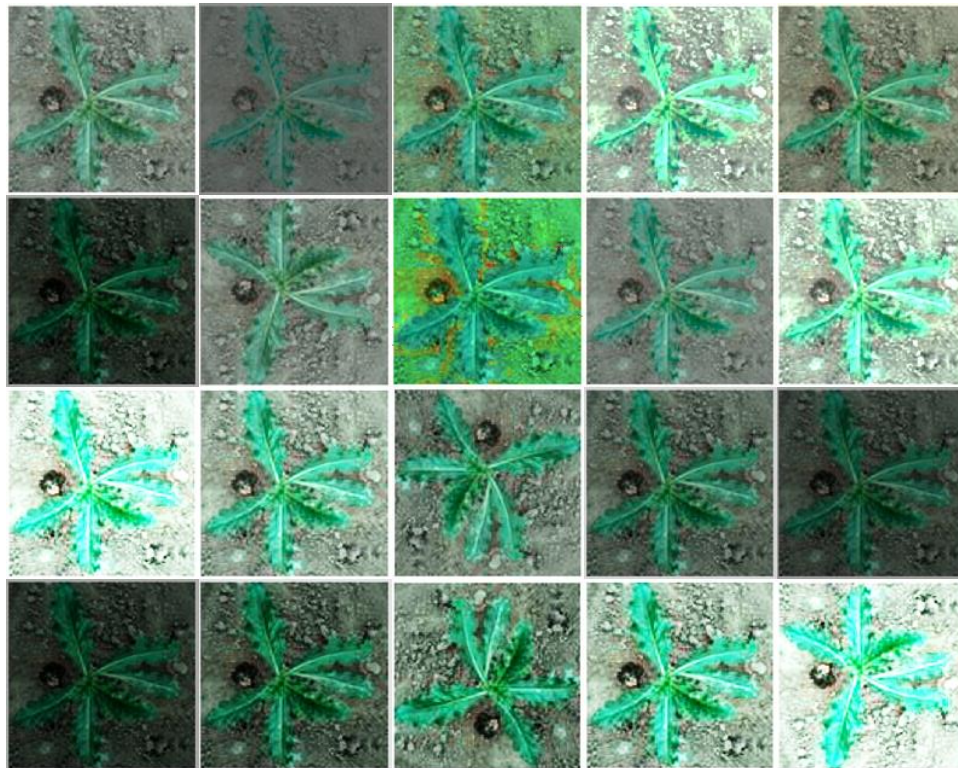
Sugar beet  
(*Beta vulgaris*)

Color index	Definition
Rn, Gn, Bn	$R/(R + G + B)$ , $G/(R + G + B)$ , $B/(R + G + B)$
Gray	$0.2898 * R + 0.5870 * Gn + 0.1140 * Bn$
ExG (Woebbecke et al., 1995)	$2 * Gn - Bn$
ExR (Meyer et al., 1990)	$1.4 * R - Bn$
CIVE (Kataoka et al., 2002)	$0.309 * Rn - 0.811 * Gn + 0.385 * Bn + 18.78$
ExGR (Meyer and Neto, 2000)	$ExR$
NDI (Woebbecke et al., 1995)	$(R - Bn)/(Gn + Bn)$
GB (Woebbecke et al., 1995)	$Bn$
RBI (Golzarian and Frick, 2011)	$(Rn - Bn)/(Rn + Bn)$
ERI (Golzarian and Frick, 2011)	$(Rn - Bn) / (Rn + Bn)$
EGI (Golzarian and Frick, 2011)	$(Gn - Rn) / (Gn + Rn)$
EBI (Golzarian and Frick, 2011)	$(Bn - Gn) * (Bn - Rn)$

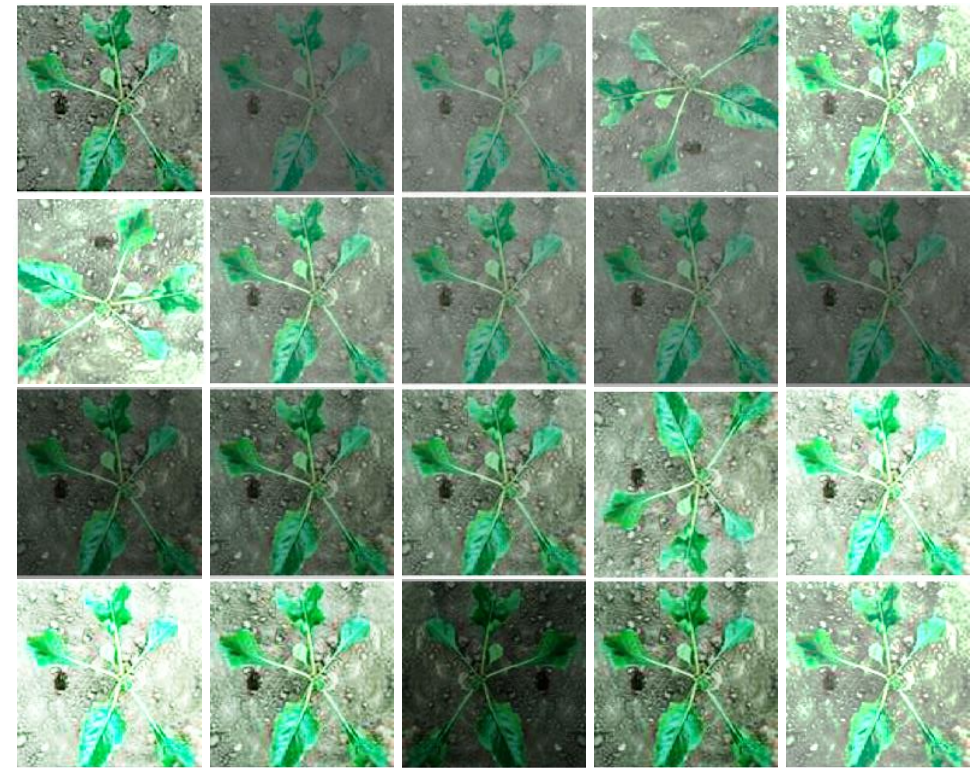


# Deep Learning

[Canada] thistle  
(*Cirsium arvense*)

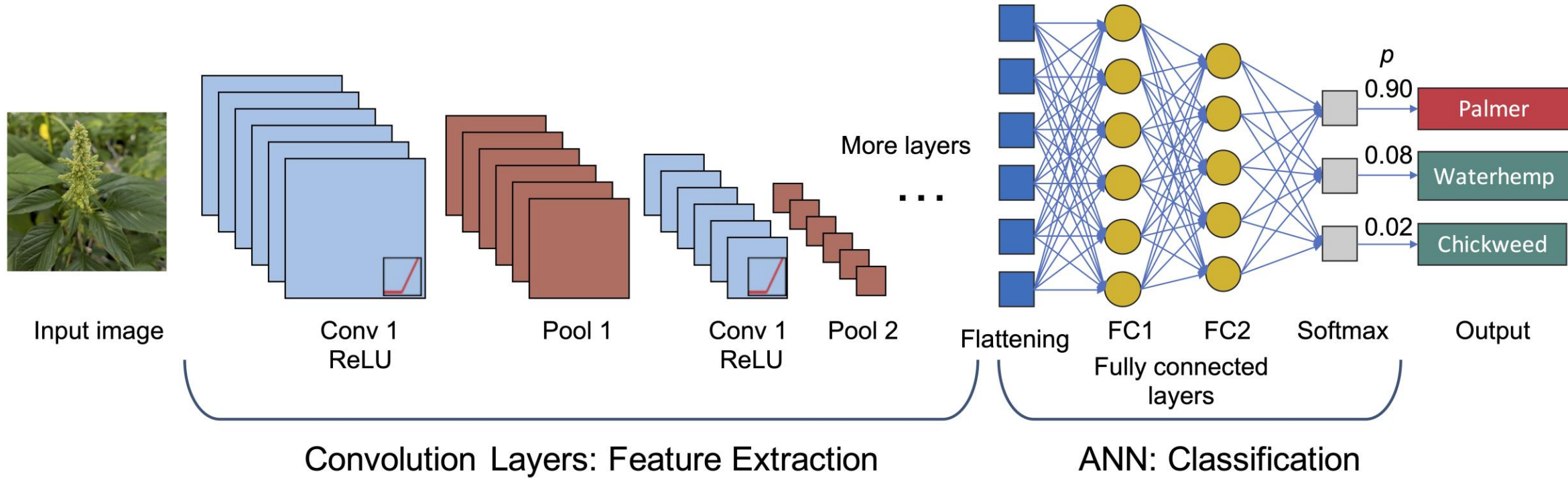


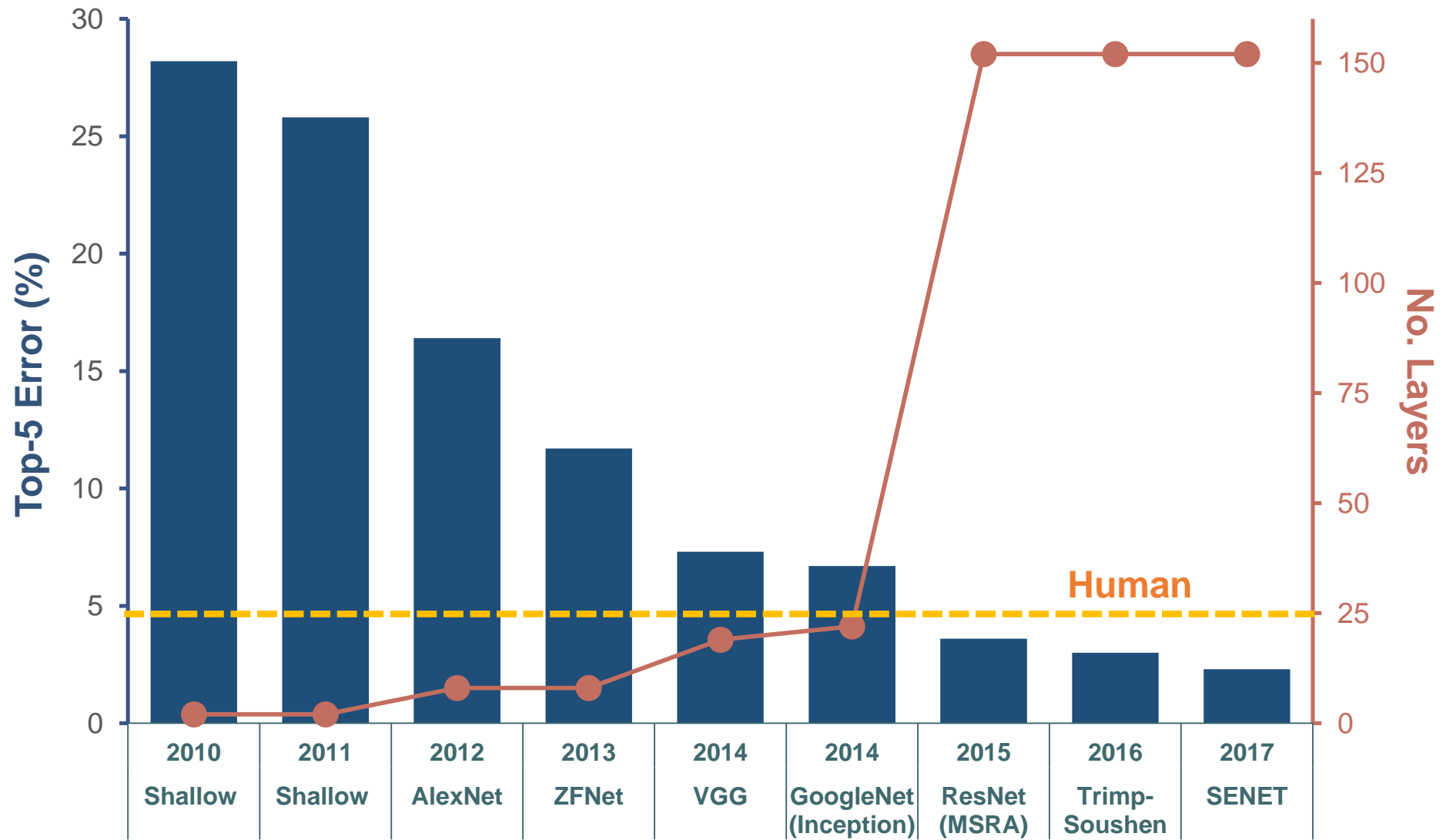
Sugar beet  
(*Beta vulgaris*)



# Deep Learning: How does it work?

## Convolutional Neural Network (CNN)

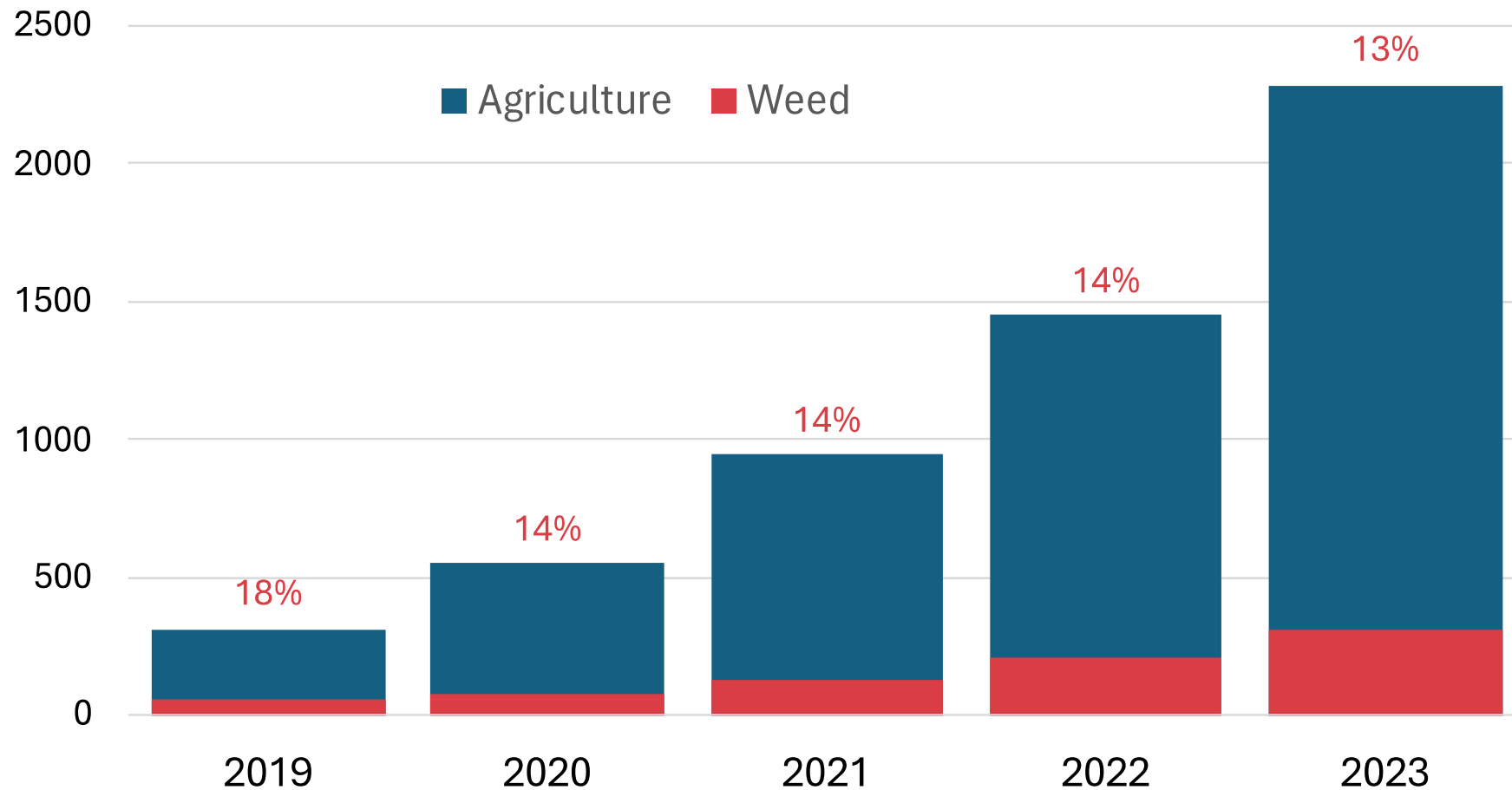






# No. documents retrieved on Scopus

TITLE-ABS-KEY("Deep learning" AND "X" )



Weed number is large (13-18%%) relative to Ag

# Weedy Examples

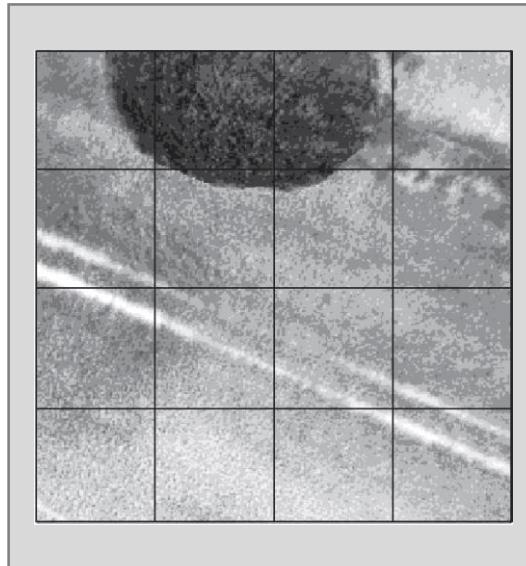
Weed/crop classification



Weed type,  
Weed vs. crop  
Most common  
(62-98% accuracy)

Olsen et al (2019)

Weed density class



Classify 5 densities  
of *Alopecurus  
myosuroides* in  
20×20 m plots

Lambert et al (2019)

Semantic segmentation



Weed, crop, and soil  
(67%-99% accuracy)

dos Santos Ferreira et al  
(2017)

Weed growth stage

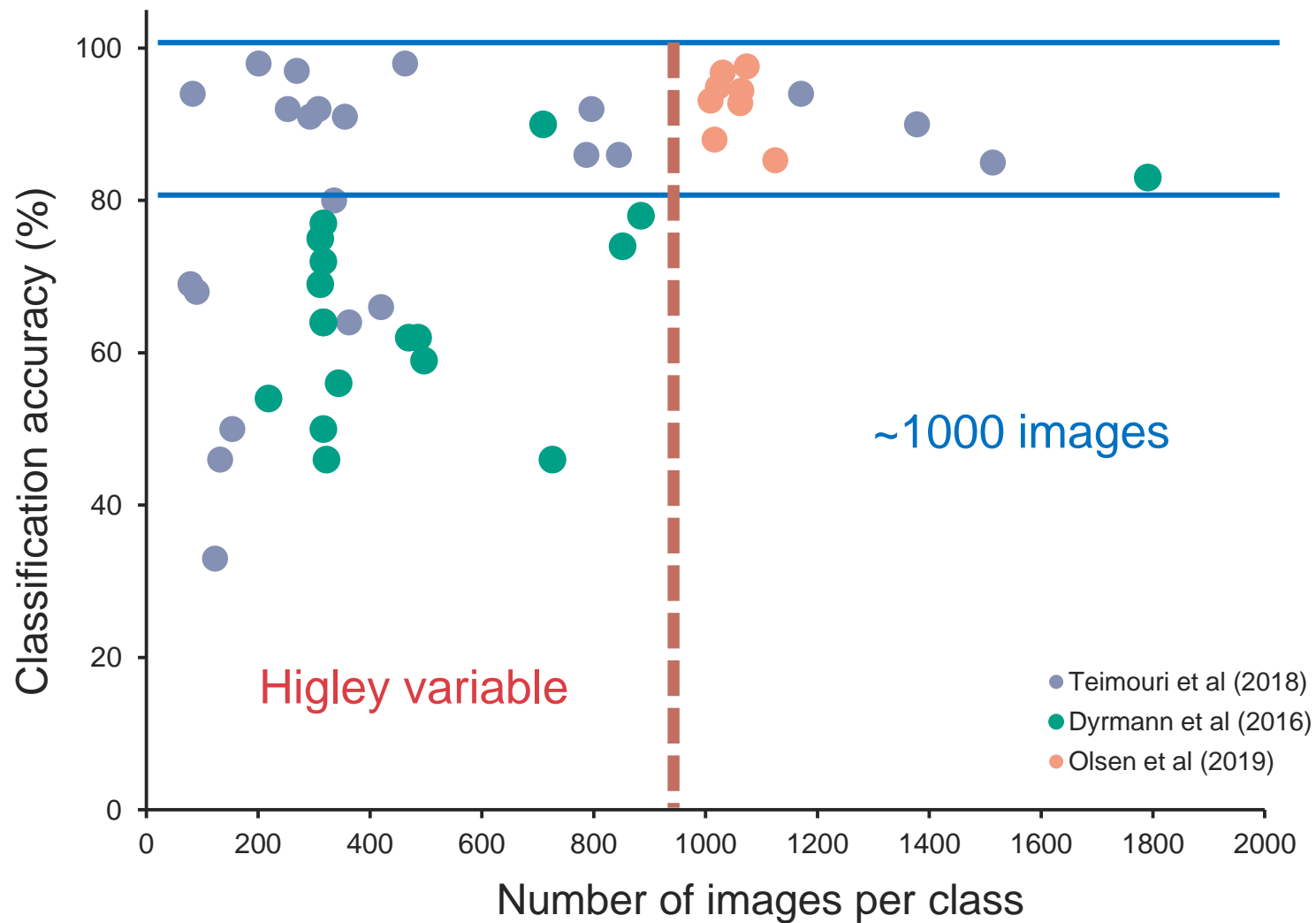


Classify 9 growth stages  
based on number of  
leaves (70% accuracy).

Teimouri et al (2018)

# “The more data, the more better” 😊

Jonathan Dorsey

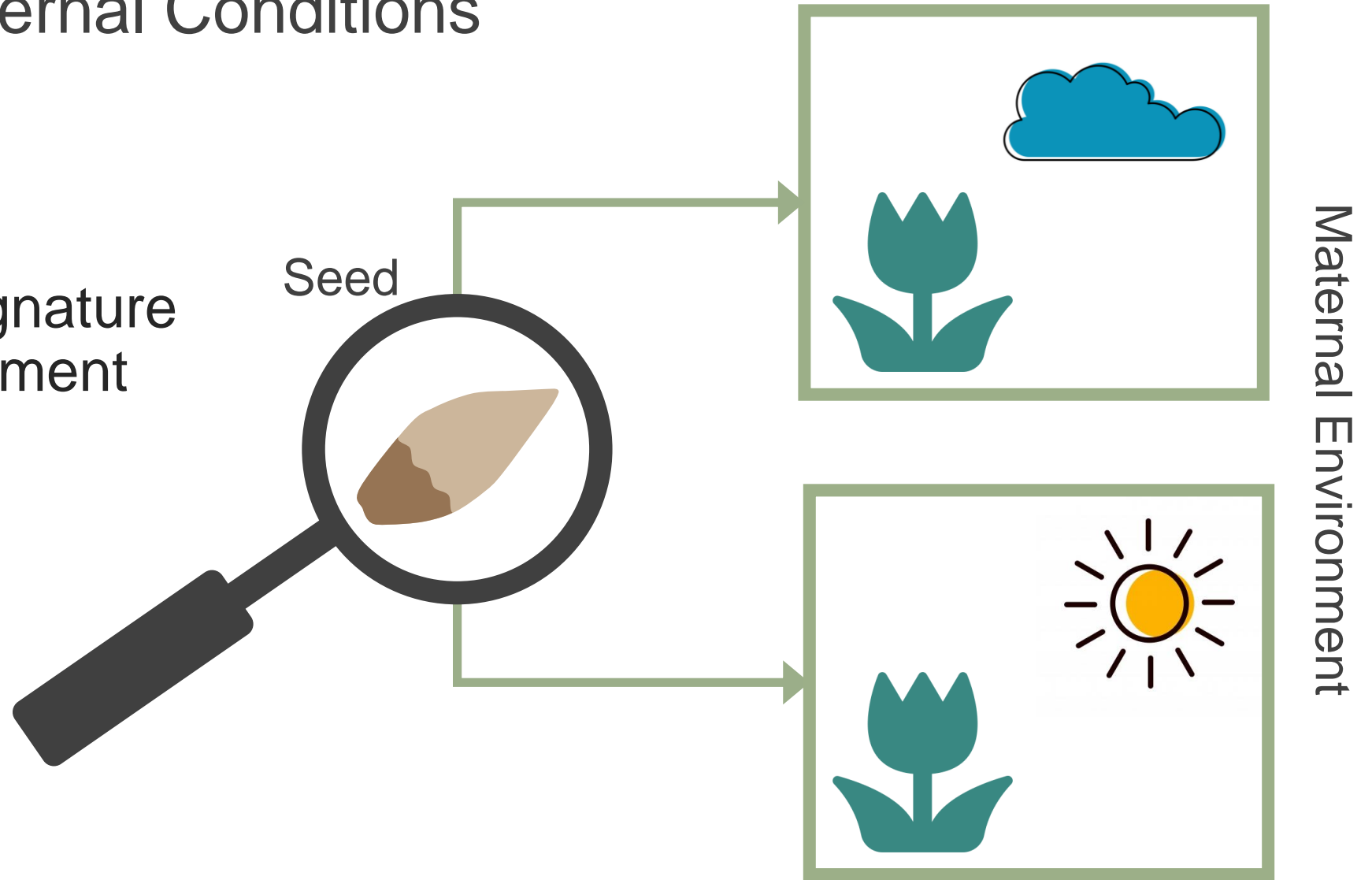


# Hindcasting: Maternal Conditions



# Inferring Maternal Conditions

Is there any signature of past environment in the seed?



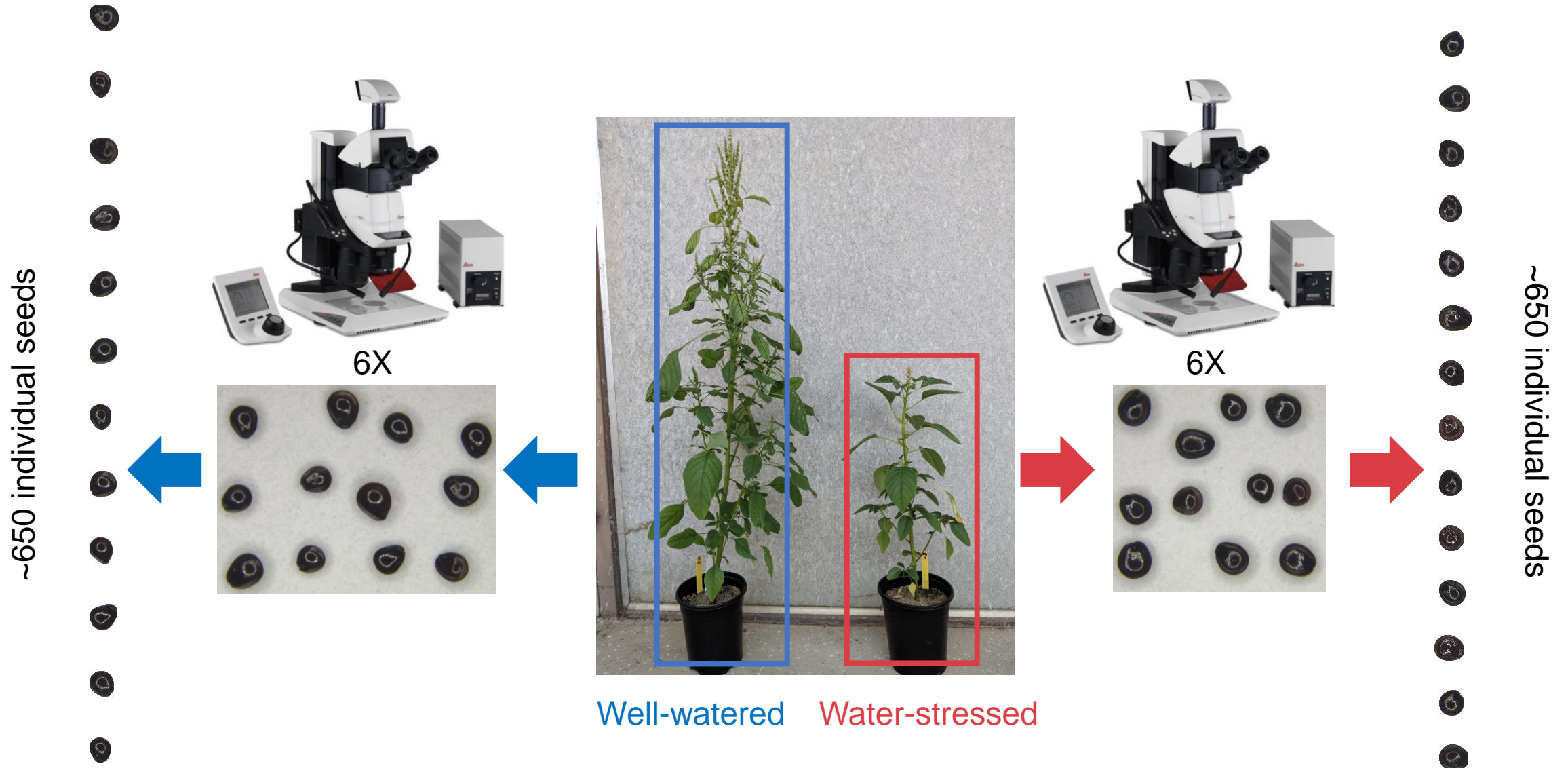
# Inferring Maternal Conditions

- **Maternal growing conditions:**
  - Normal irrigation (well watered)
  - Water stress (~30% of normal)
- **Two populations:**
  - Kansas
  - California
- **Total No. plants: 200**

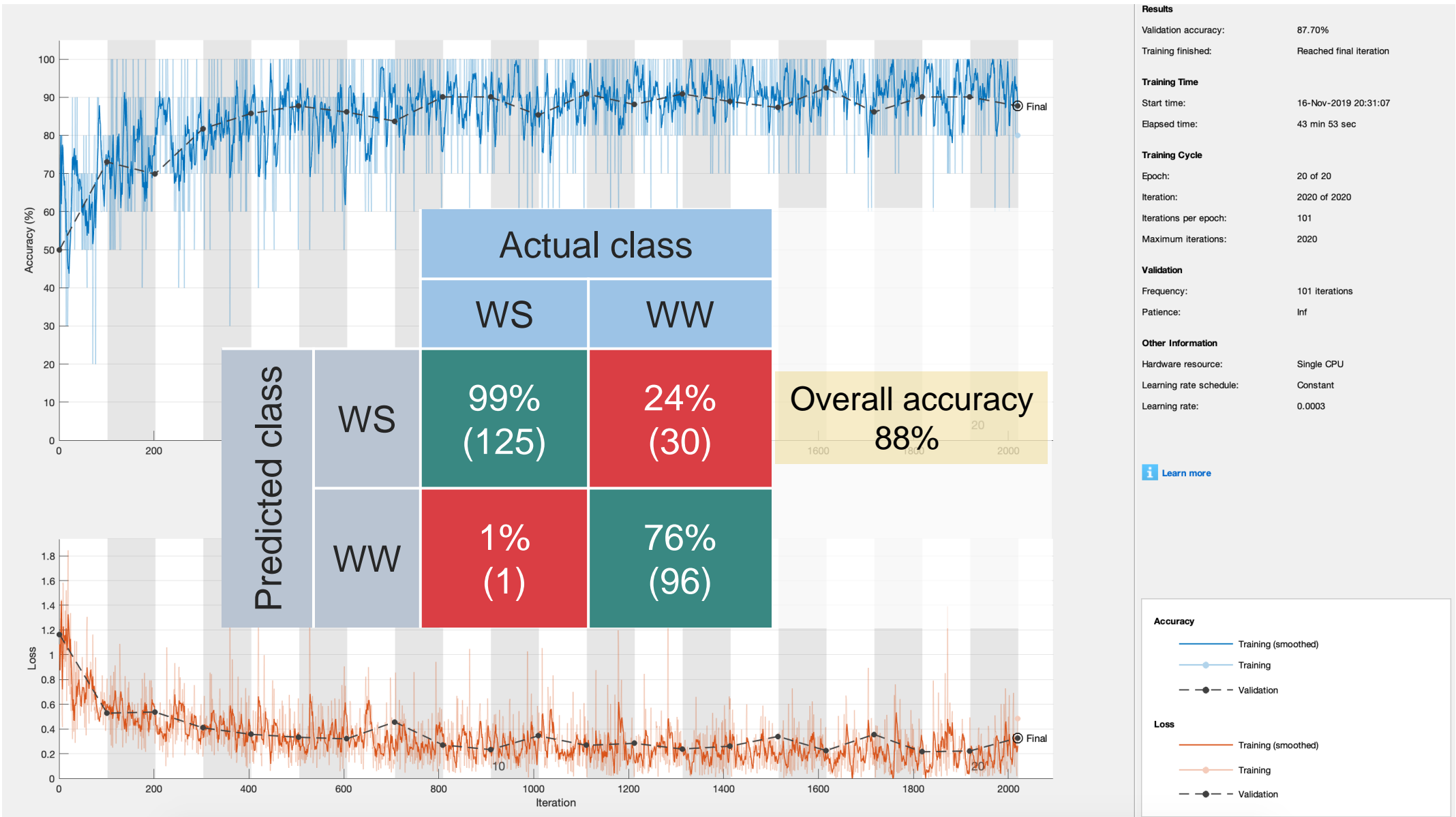
Palmer amaranth (*Amaranthus palmeri*)



# Seed Collection and Imaging



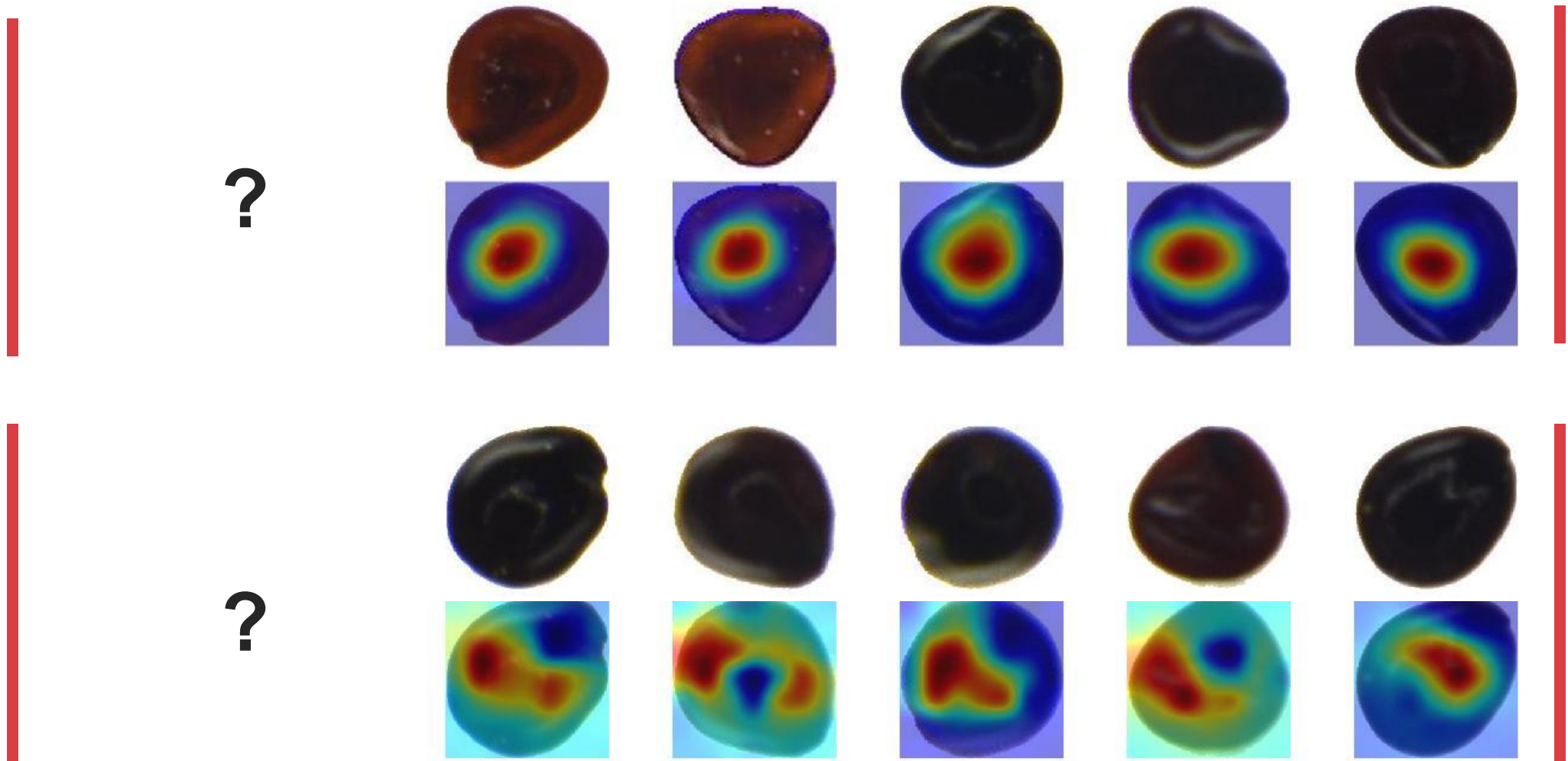
# Seed Classification with GoogleNet: California Population





# Identifying Important Regions

*Why DL predicts what it predicts?*

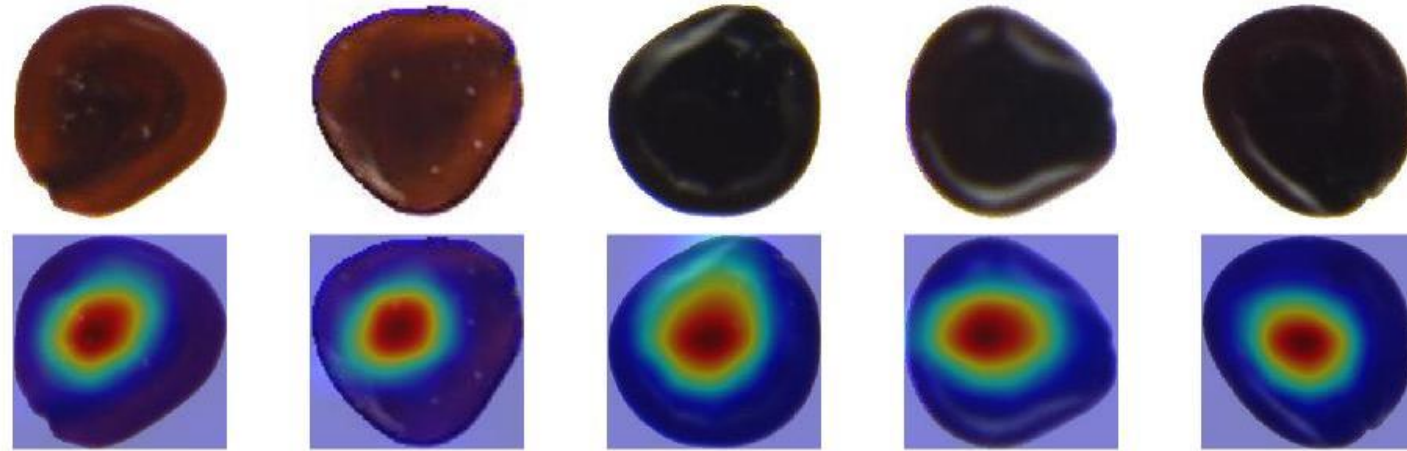


Grad-CAM: **Gradient-weighted Class Activation Mapping**  
Selvaraju et al (2017)

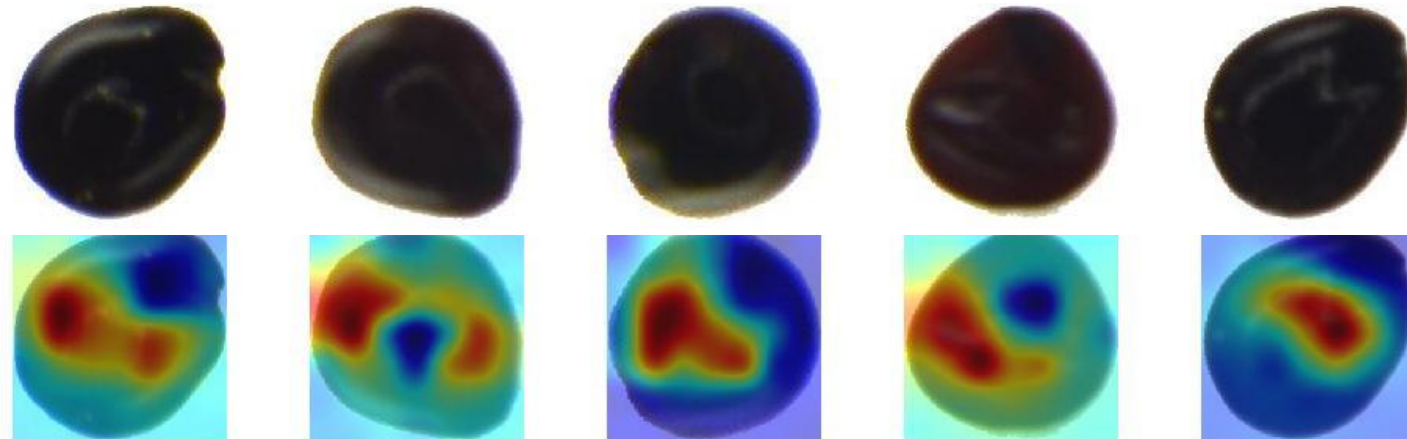
# Identifying Important Regions

*Why DL predicts what it predicts?*

Water-Stressed



Well-watered



Grad-CAM: **Gradient-weighted Class Activation Mapping**

Selvaraju et al (2017)

# Remote Sexing



# Remote Sexing

Gender determination in Palmer amaranth using DL

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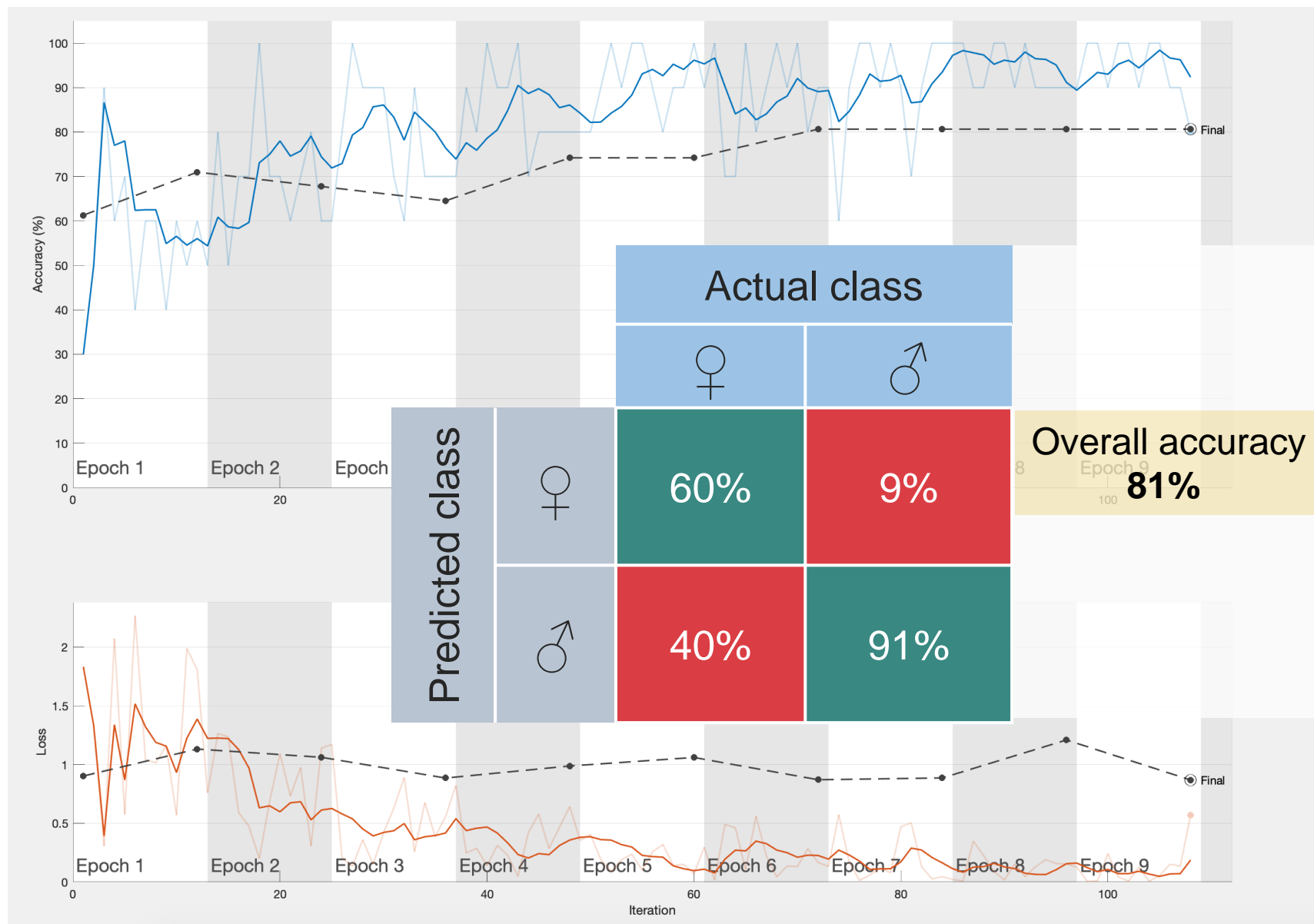


Female



Male

# Remote Sexing



Validation accuracy: 80.65%

Training finished: Output function

**Training Time**

Start time: 17-Nov-2019 15:04:04

Elapsed time: 3 min 59 sec

**Training Cycle**

Epoch: 9 of 20

Iteration: 108 of 240

Iterations per epoch: 12

Maximum iterations: 240

**Validation**

Frequency: 12 iterations

Patience: Inf

**Other Information**

Hardware resource: Single CPU

Learning rate schedule: Constant

Learning rate: 0.0003

[i Learn more](#)

**Accuracy**

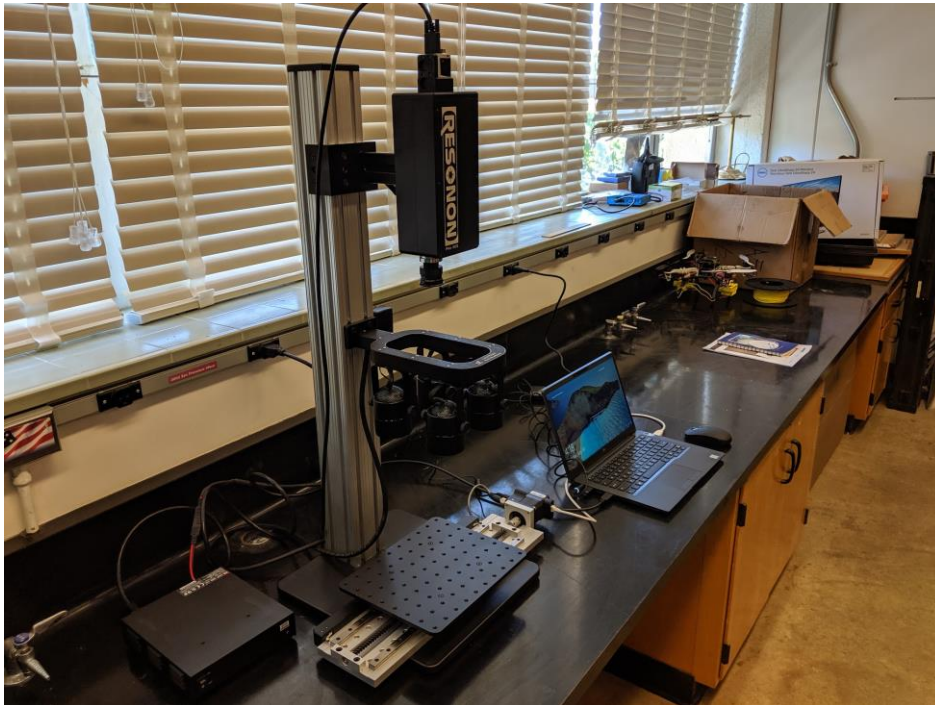
- Training (smoothed)
- Training
- - Validation

**Loss**

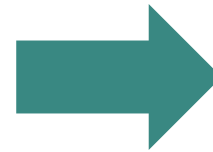
- Training (smoothed)
- Training
- - Validation

# Remote Sexing at Seed Stage

Gender determination at **seed** stage?



Scanned ~600 individual seeds  
(Resonon Pika L)



Seeds planted in trays individually  
(3 populations: California, Kansas, and Texas)

Spectral range	400-1000 nm
No. channels	240
Spectral resolution	2.5 nm

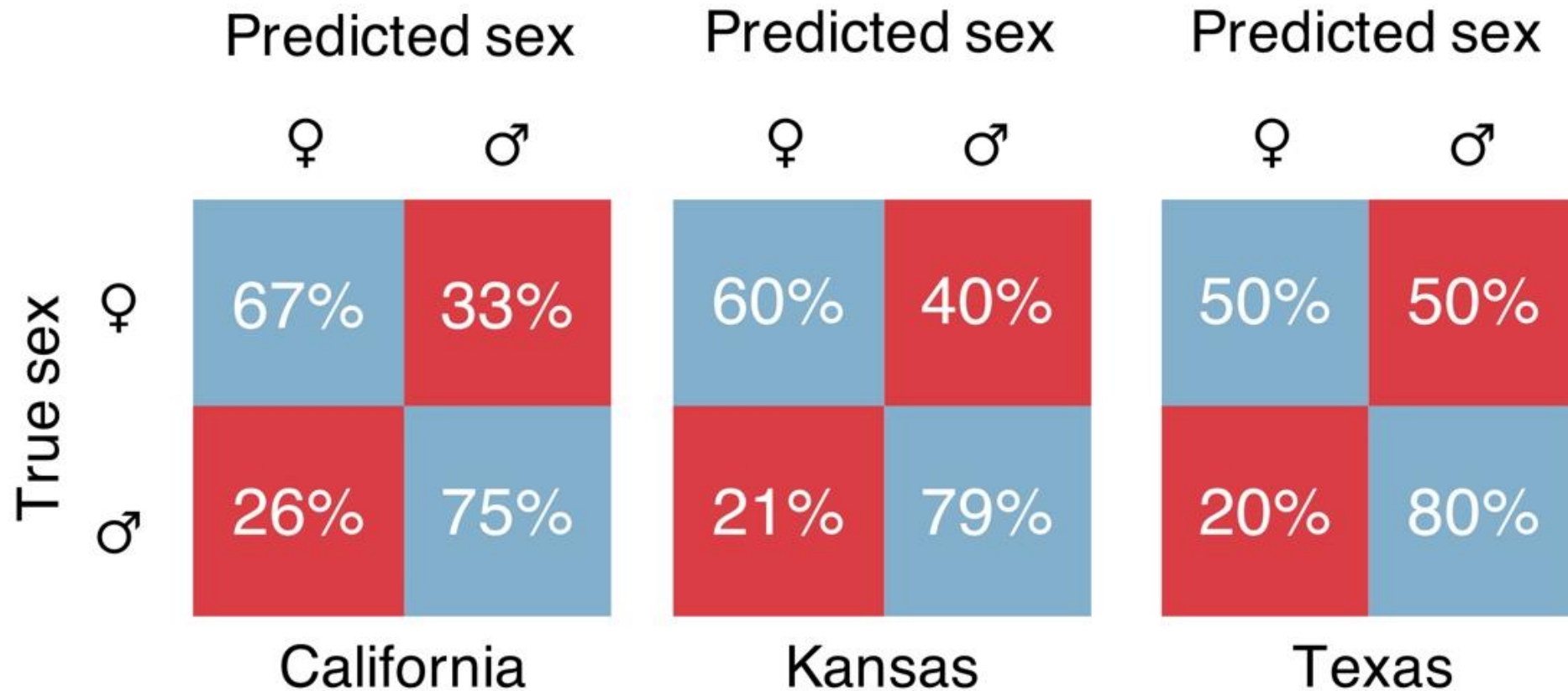
# Remote Sexing



Population	#Female	#Male	Total
California	26 (45%)	32 (55%)	58
Kansas	41 (43%)	55 (57%)	96
Texas	27 (42%)	37 (58%)	64
<b>Sum</b>	<b>94 (43%)</b>	<b>124 (57%)</b>	<b>218</b>

# Male vs. Female Seed Discrimination

Machine Learning Method: Support Vector Machine (SVM)





# Google Weed View

## A Roadside Weed Detection and Mapping Technology

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Kassim Al-Khatib



Tong Zhen

# Google Street View

- 10 million miles of Street View imagery
- Circle the globe more than 400 times



Changes in coverage since 2007

# Street View Car



<https://www.google.com/streetview/explore/#sv-headed>

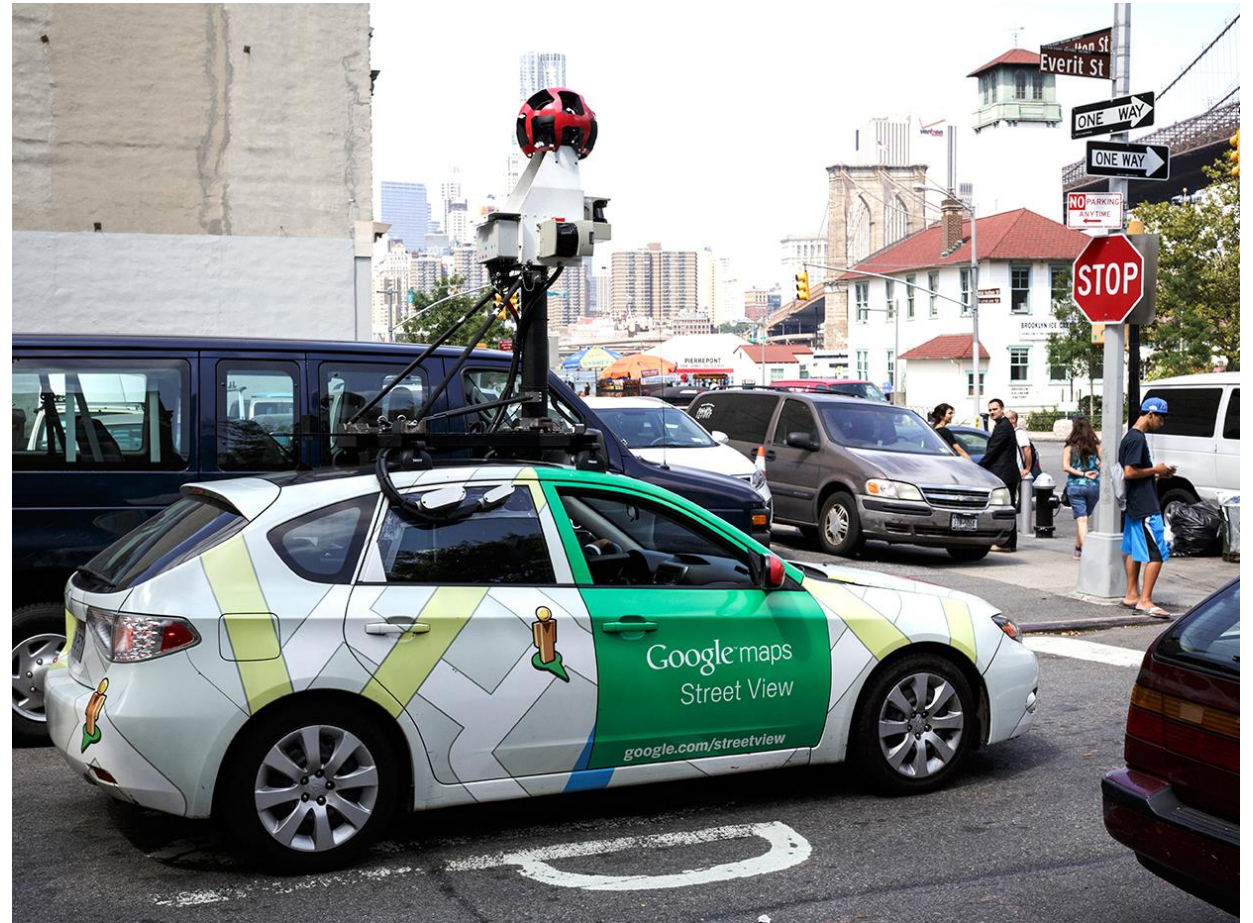


Photo: James Leynse

# Street View Three-Wheeler



<https://www.google.com/streetview/explore/#sv-headed>



<https://www.fastcompany.com/1733023/googles-trike-fleet-takes-its-street-view-peepers-road>

# Street View Trekker



<https://www.google.com/streetview/explore/#sv-headed>



<https://blog.google/products/maps/mapping-stories-new-street-view-trekker/>

# Street View Trolley



<https://www.google.com/streetview/explore/#sv-headed>



<https://kimon.hosting.nyu.edu/physical-electrical-digital/items/show/1036>

# Street View Snowmobile



<https://www.google.com/streetview/explore/#sv-headed>



Olivier Maire/European Pressphoto Agency

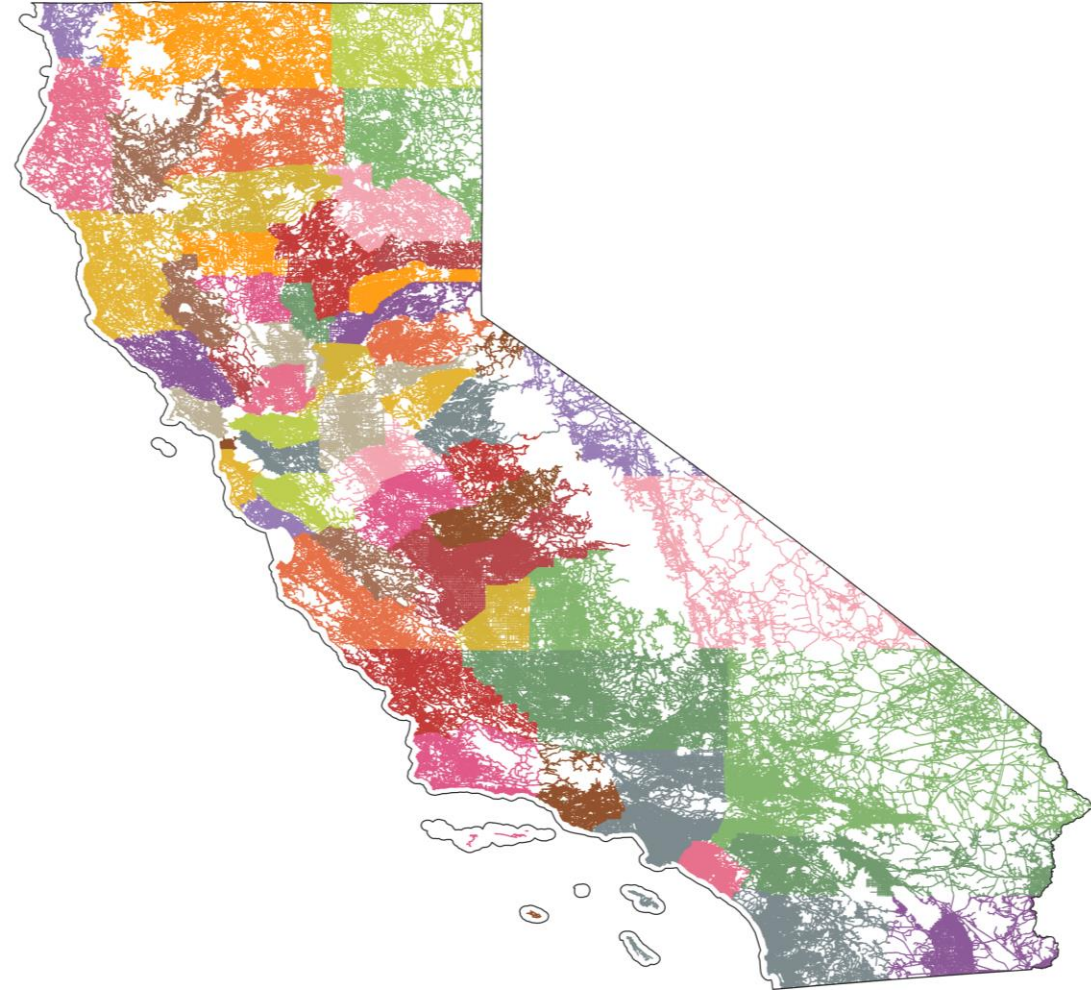
# Google Street View of Weeds





# Mapping johnsongrass

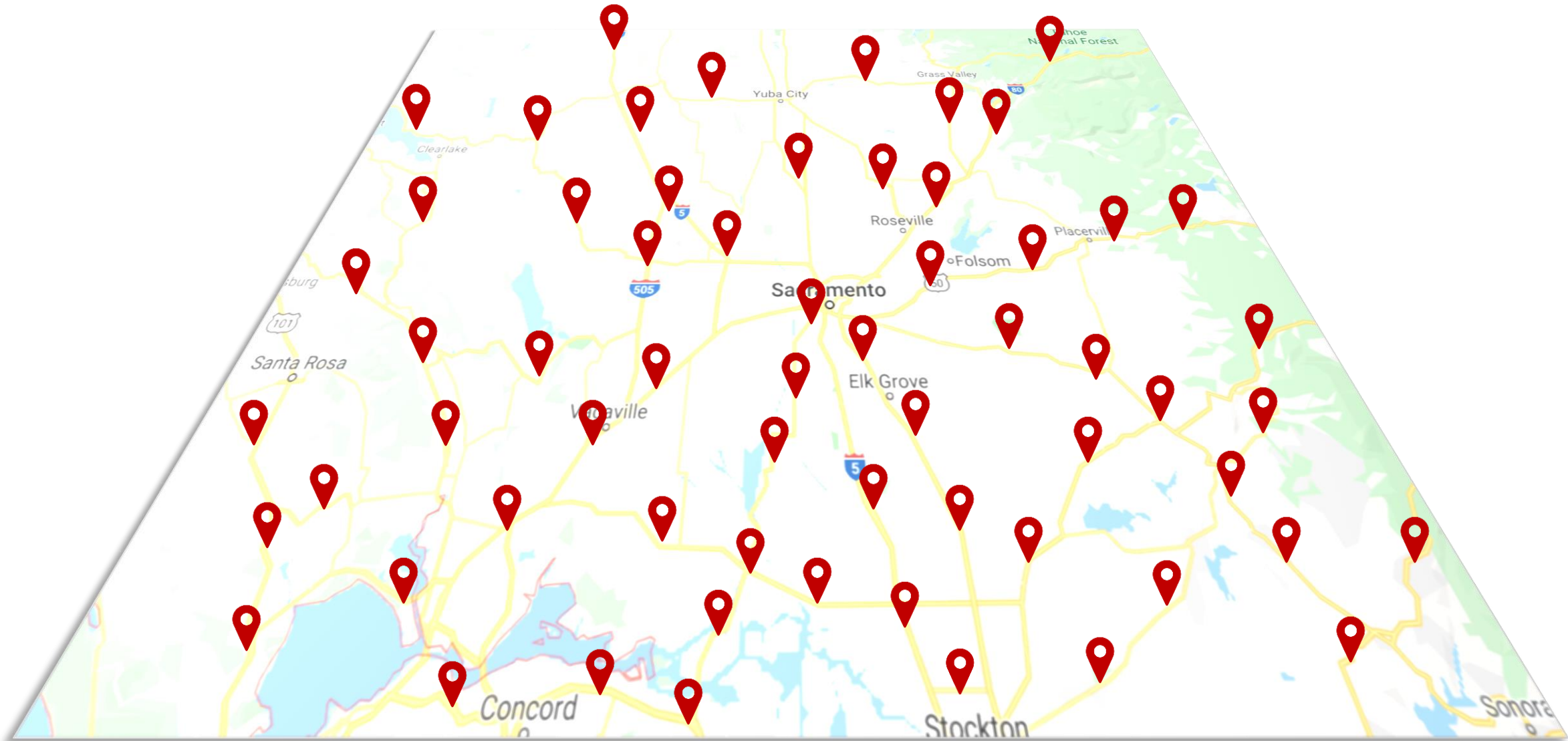
- **Primary** and **secondary** roads in CA, OR, WA, and NV
- Total length: 84,000 miles (135,000 km)
- Number of points (500 m apart): 320,000
- Number of images retrieved: ~270,000



# Mapping johnsongrass



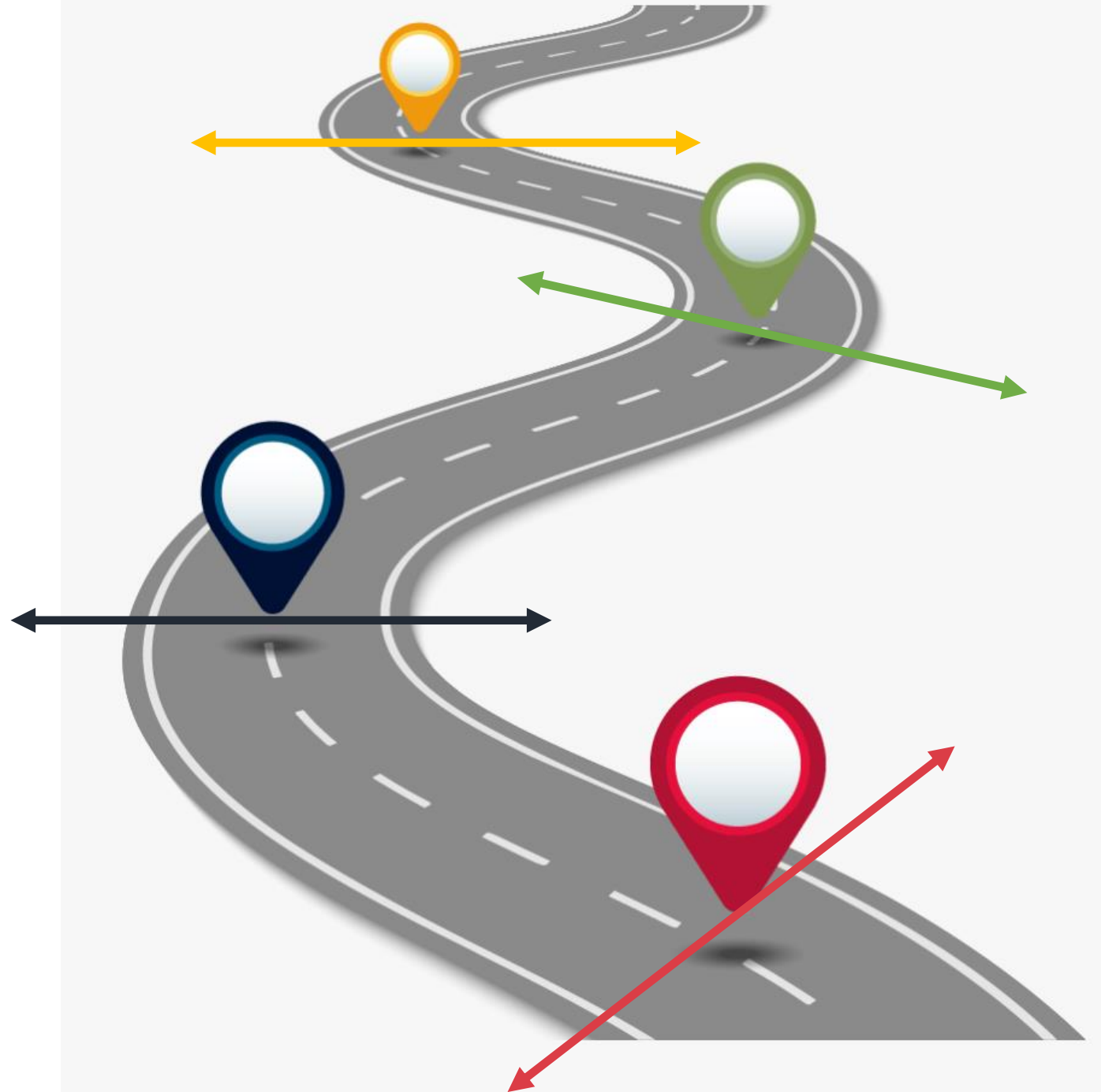
# Drop sampling points on roads



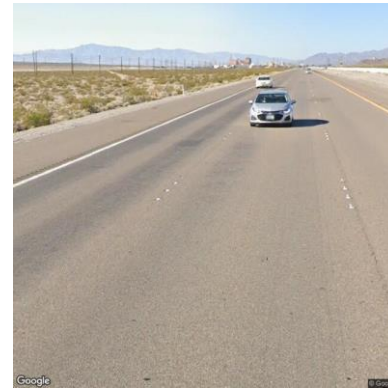
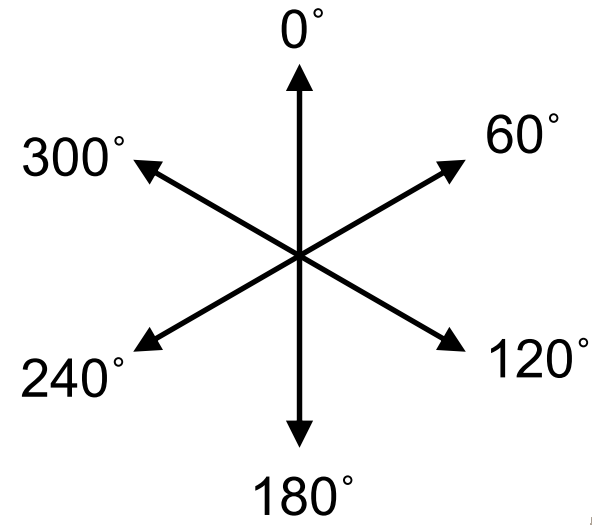
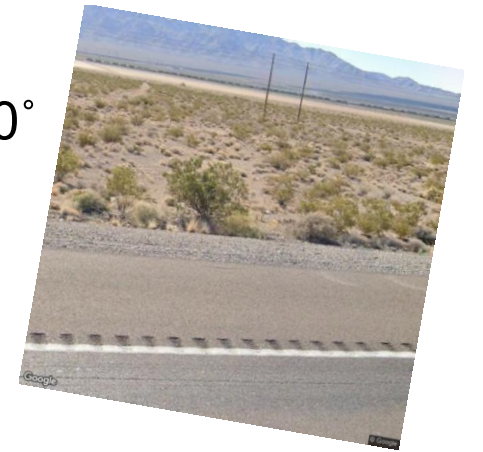
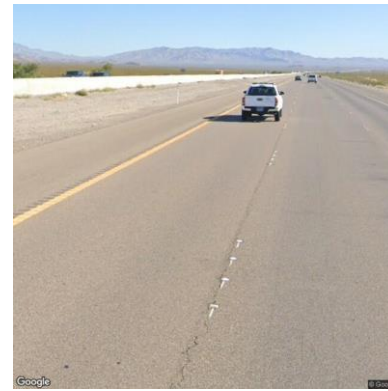
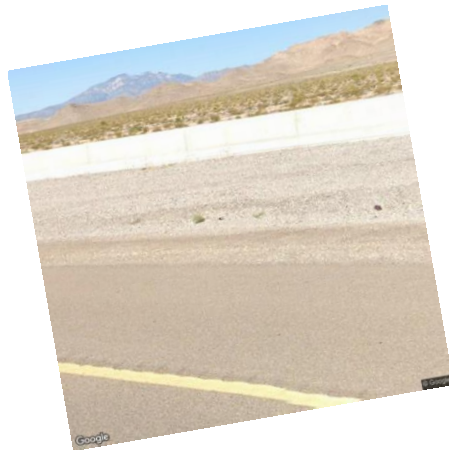
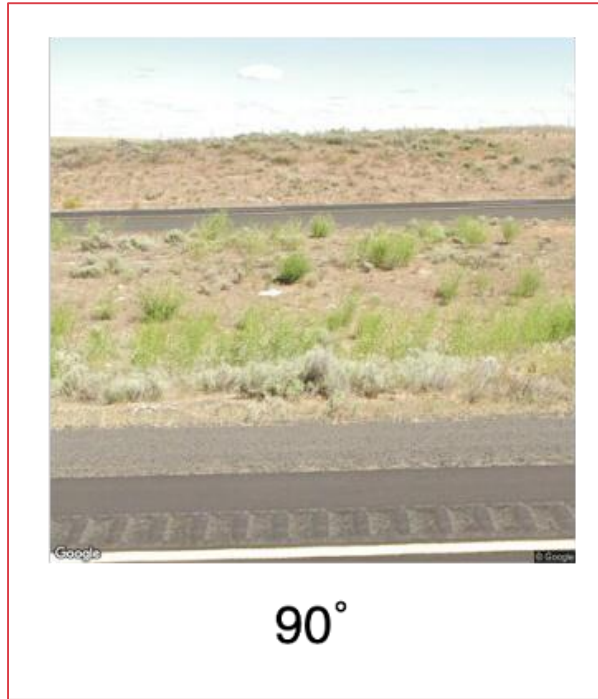
# Perpendicular view



Google's 360-degree camera



# Direction of Camera



# Retrieve images using Google Street View API

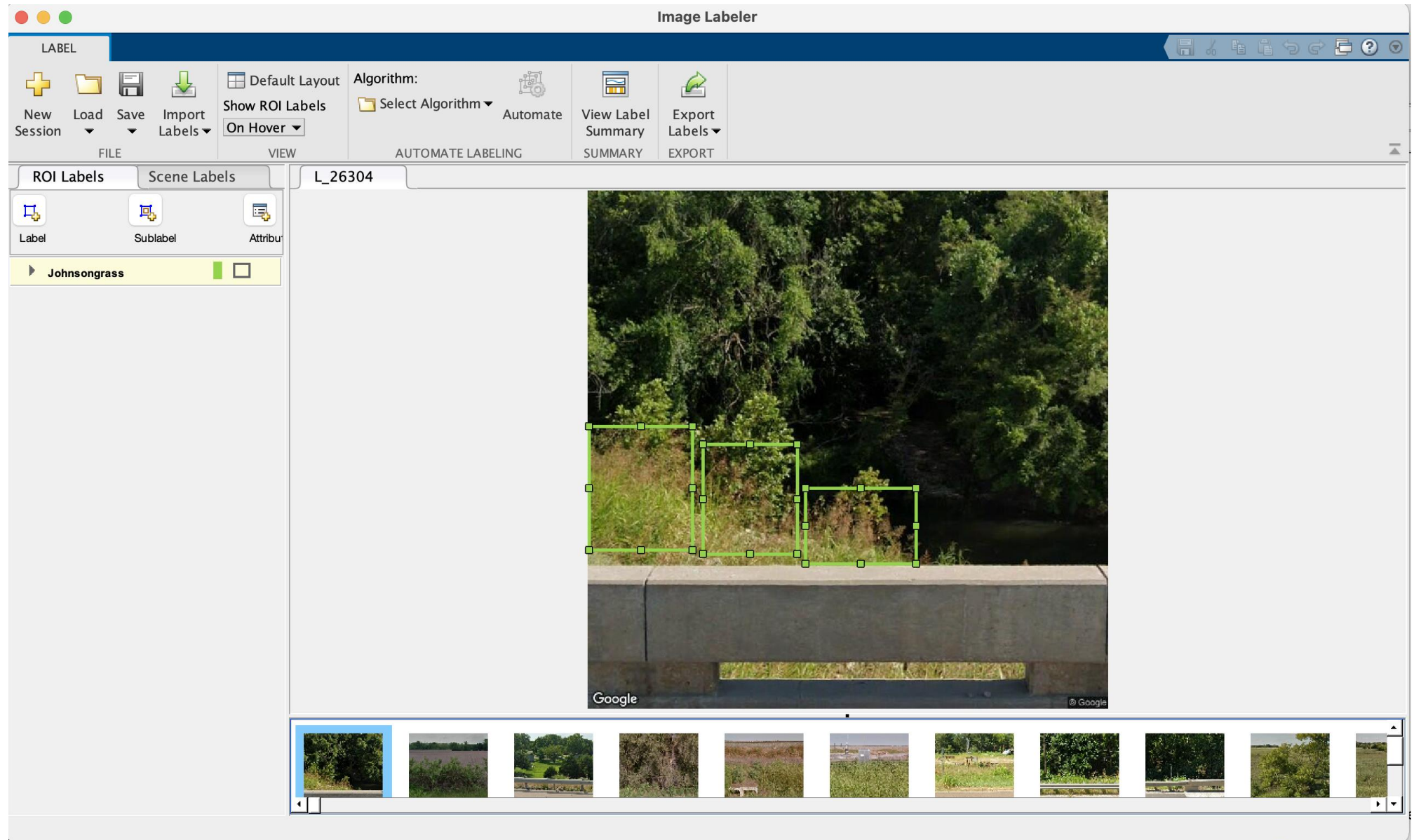
California  
Texas  
Kansas  
Yolo county



# Look for images with johnsongrass (*Sorghum halepense*)



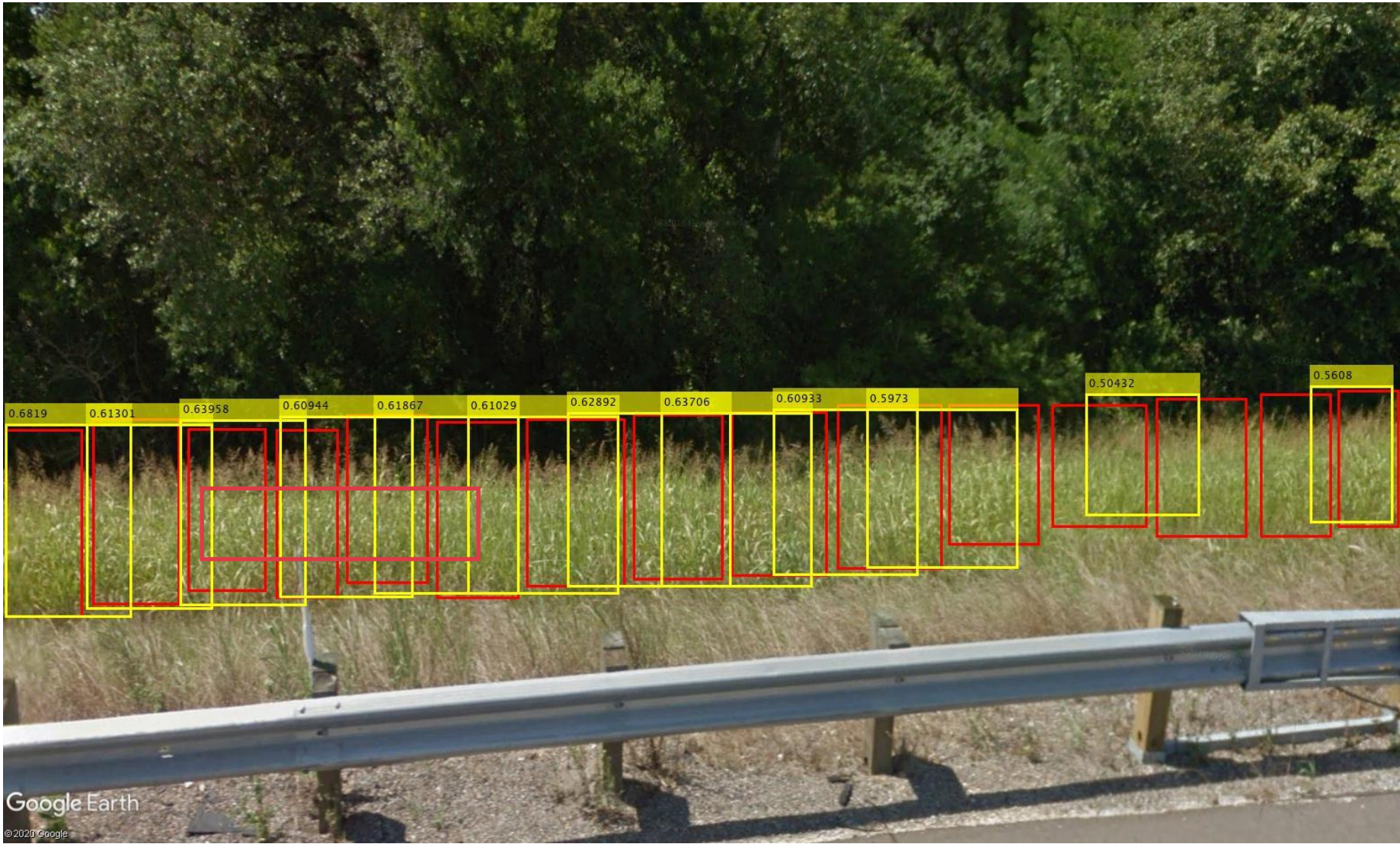
# Label image (bounding box): ~1000 images





# Train deep learning model (YOLO)

Yellow boxes: AI  
Red boxes: Human

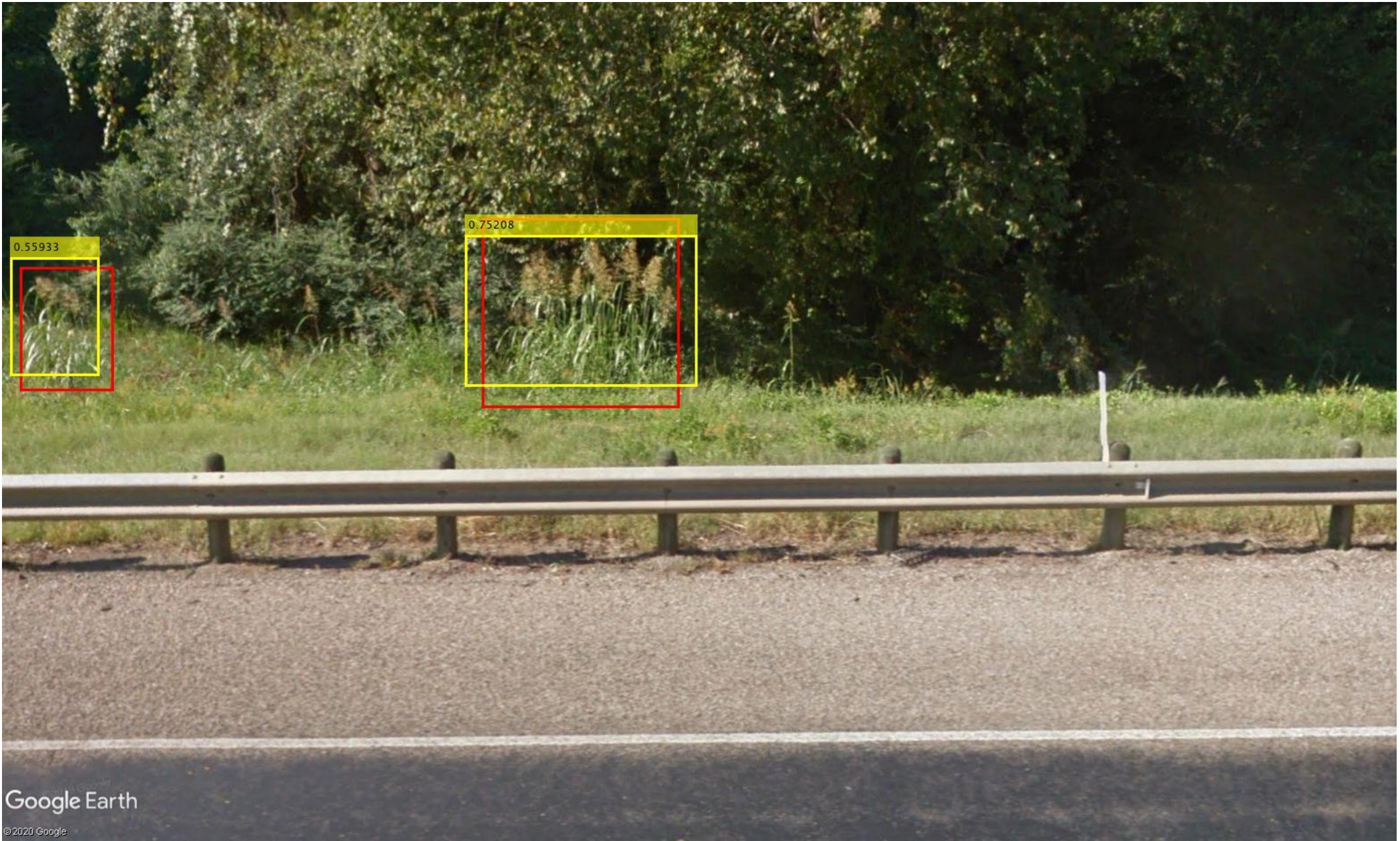




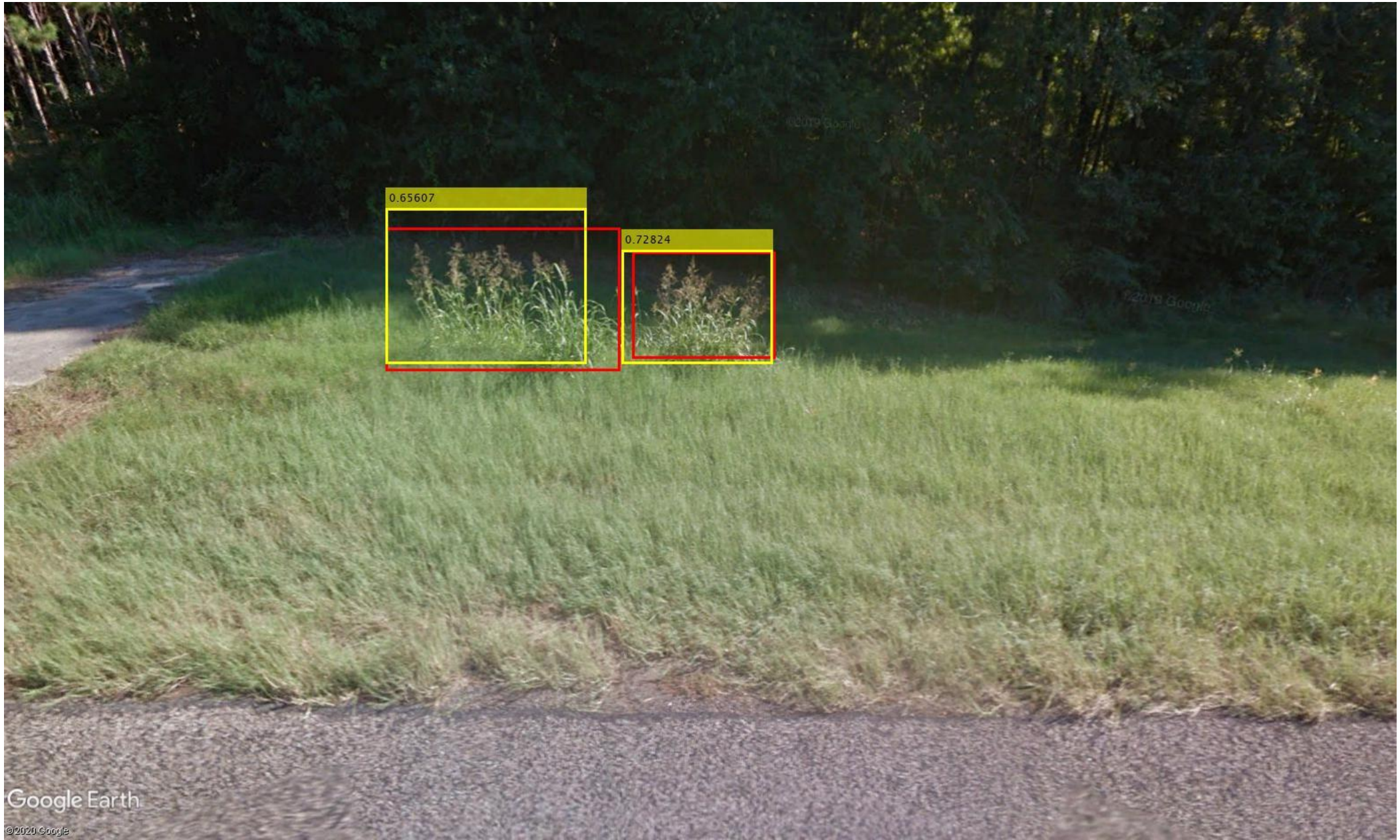
Google Earth

© 2020 Google

Yellow boxes: AI    Red boxes: Human

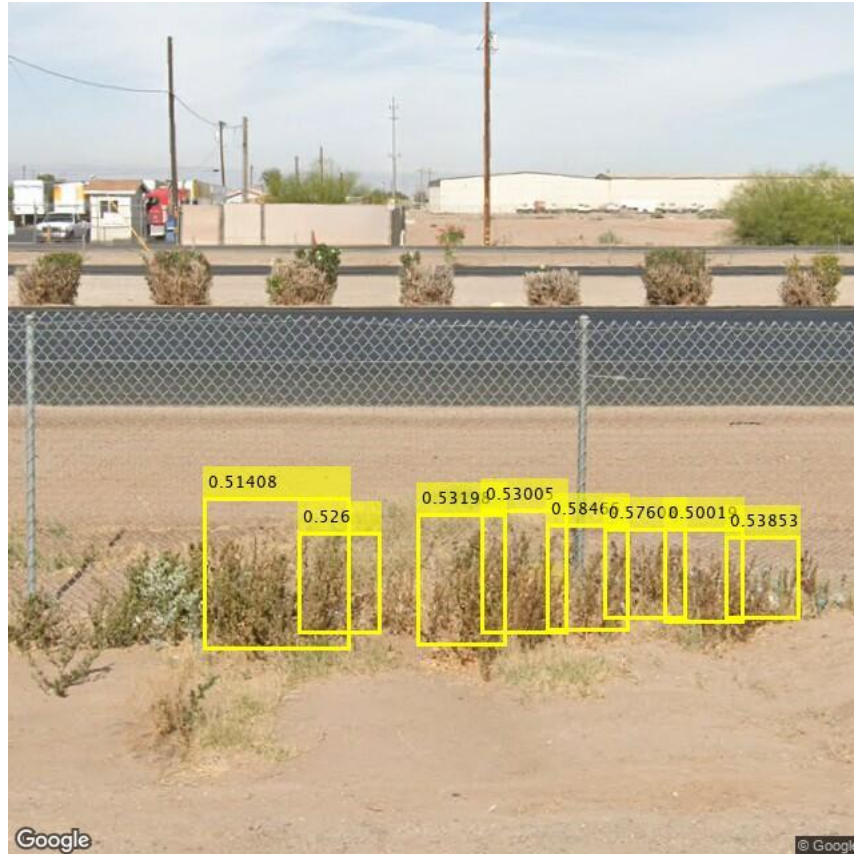


Yellow boxes: AI    Red boxes: Human



Yellow boxes: AI    Red boxes: Human

# But...not perfect yet!

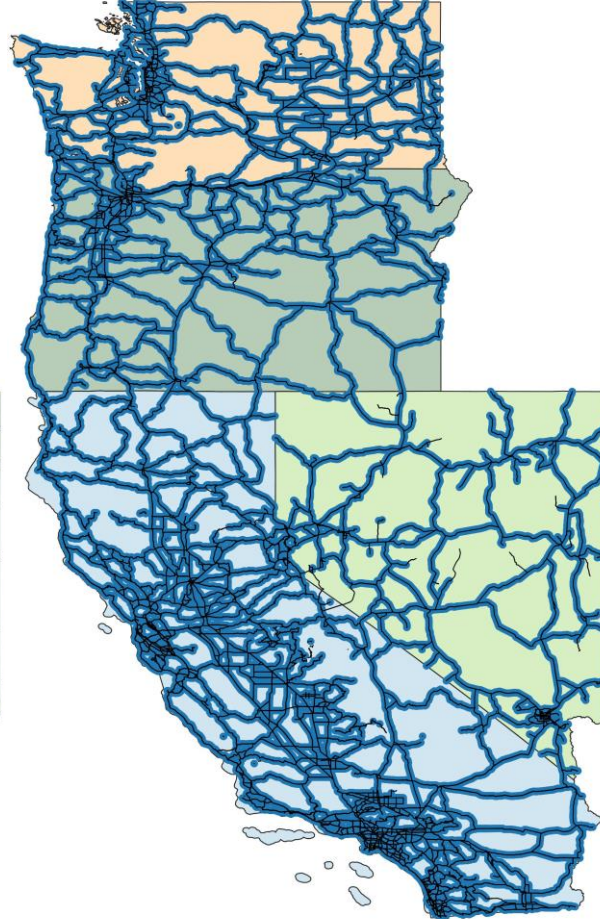


# Mapping johnsongrass

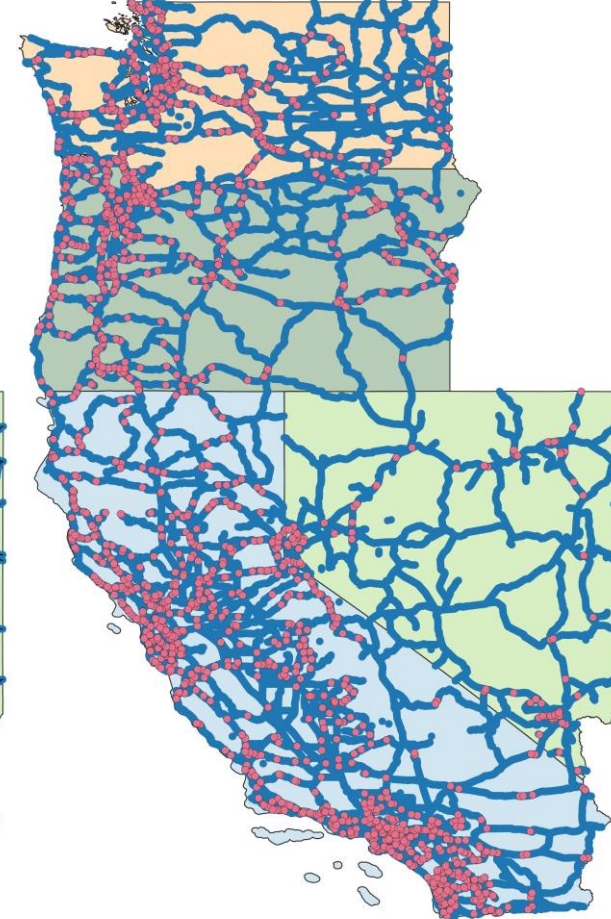
135,000 km  
(84,000 mile)



320,000 points  
(500 m apart)



~2000 locations  
with johnsongrass



# Cost comparison

## Car survey

- Safe drive = 500 miles
- 168 days to cover 84,000 miles of road
- Costs per day (accommodation + meal) = \$25,200 (@ \$150 per day)
- Car rental: \$9,408 (@ \$56 per day)
- Fuel (40 mpg) = \$7,350 (2100 gallon @ \$3.5)
- **Total = \$41,958**
- Risk of accident?

## Google Weed View

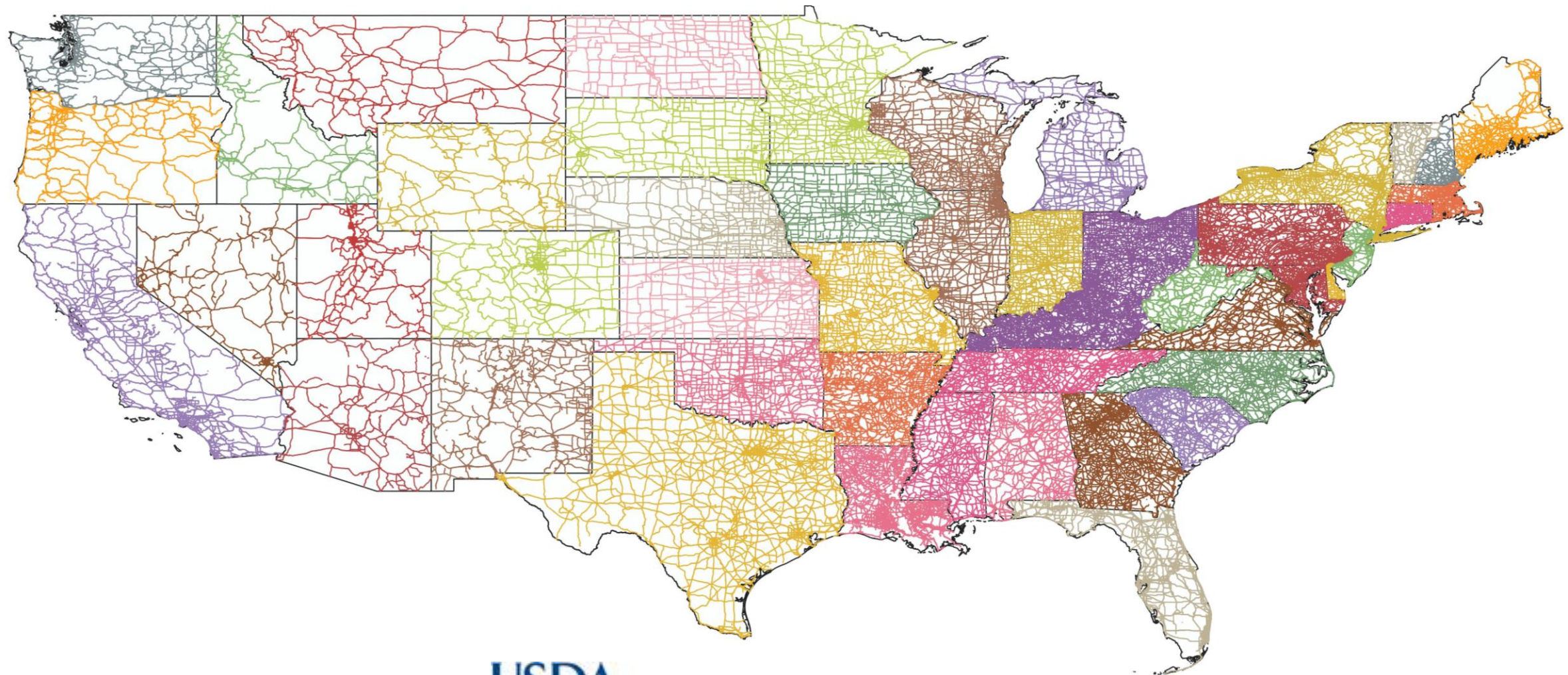
- Number of points (500 m apart): 320,000
- Number of images retrieved: ~270,000
- Estimated Google price for 1000 images:
  - \$7 ( $\geq 100,000$ )
  - \$5.6 (100,000-500,000)
- **Total : \$1,700**



- 4226 records in US since 1903
- 2000 records with lat & long over few months

# Next Scale...

# Thank You!





# WeedChat

The screenshot shows the WeedChat web application in a browser window. The browser's address bar displays "www.weedchat.com". The interface is divided into a dark green sidebar on the left and a main content area on the right.

**Sidebar (Left):**

- Logo: A dandelion seed head with a speech bubble, next to the text "WeedChat".
- Menu icon: Three horizontal lines.
- Button: "+ New chat" in a rounded rectangle.
- Section: "Recent chats" with three chat items:
  - how to control palm...
  - almond major weeds...
  - herbicides for spina...
- Button: "Show more" with a downward arrow.
- Profile: A red circle with "MM" and the name "Mohsen Mesgaran".

**Main Content Area (Right):**

- Header: "Random Weed of the Day" with a bell icon and a close button (X).
- Image: A photograph of a Common Purslane plant in a cracked soil pot.
- Text: **Common Purslane**  
Scientific name: *Portulaca oleracea*  
Common purslane, also known as little hogweed, is an annual weed in the family Portulacaceae... (+)
- Message: "Hello! Tell me about your Weed related question. Simply type in your query below or choose one of the following options to get started!"
- Options:
  - Weed Management**: Struggling with weed control in your specialty crop? Tell me about it, and I'll suggest effective control strategies, including both non-chemical and herbicide guidance specific to your needs.
  - Weed Biology**: Interested in learning more about weeds? Explore the 'Weed Biology' section to understand the life cycle, growth habits, and ecological impacts of various weeds.
  - Weed Identification**: Unsure about a plant you've come across? Upload its photo, and I'll assist in identifying it, providing details into its characteristics, biology, and more.
- Input: A text box with the placeholder "Enter your prompt here..." and a send button (green circle with a white arrow).

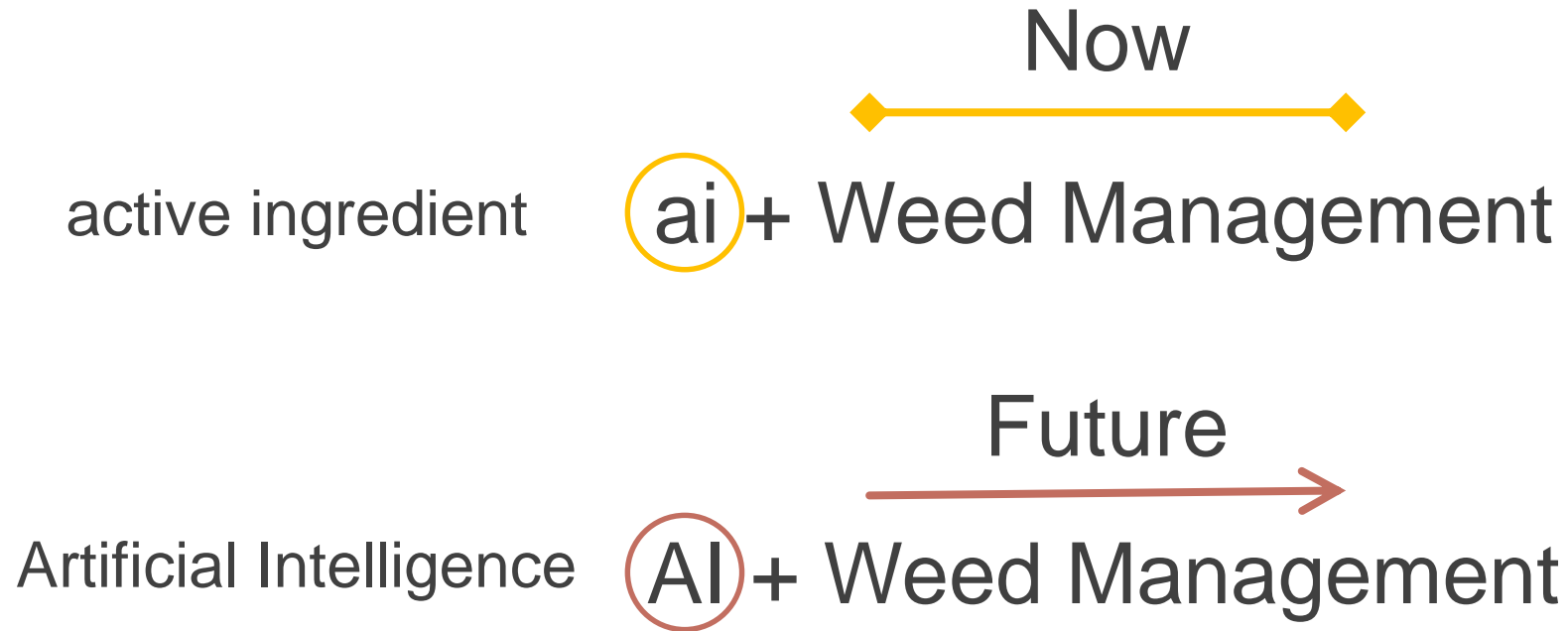
# WeedChat

Identify the weed in this photo

**WeedChat:**  
The plant in photo seems to be common purslane (*Portulaca oleracea*). Below are images of similar species; please select the correct one for more details:

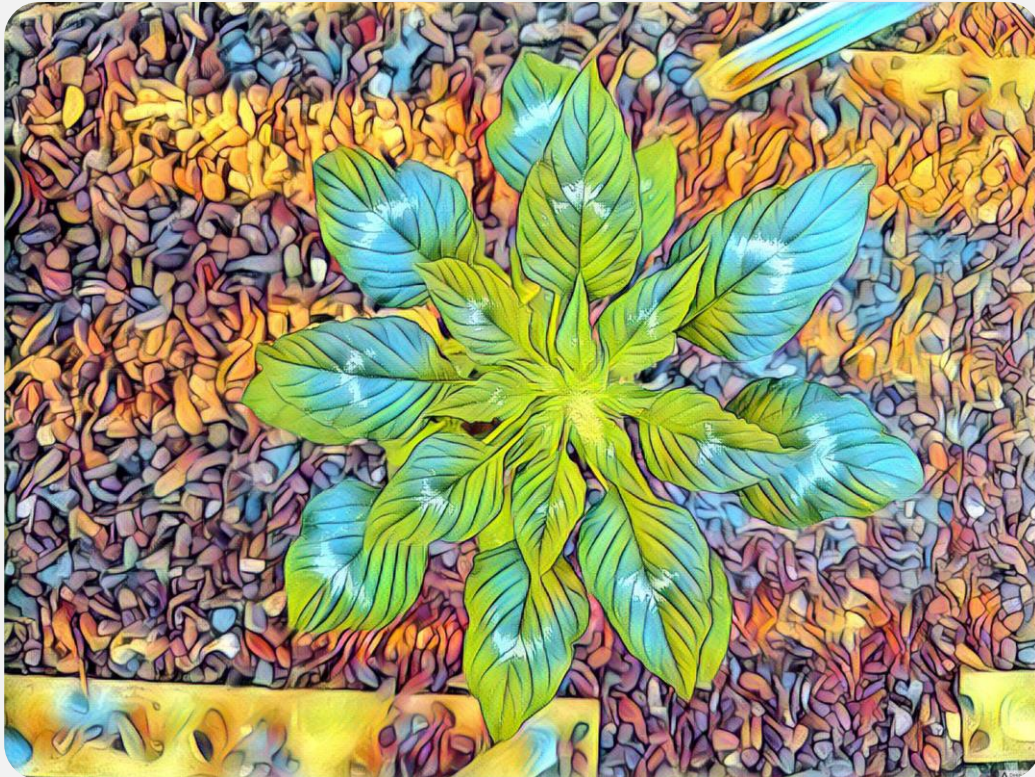
<input checked="" type="checkbox"/>	<b>Common purslane</b> ( <i>Portulaca oleracea</i> )		Portulacaceae	1
<input type="checkbox"/>	<b>Wingpod purslane</b> ( <i>Portulaca umbraticola</i> )		Portulacaceae	2
<input type="checkbox"/>	<b>Shoreline sea-purslane</b> ( <i>Sesuvium portulacastrum</i> )		Aizoaceae	3

# The Way Forward



*Weeds are smart with millions of parameters  
and many hidden layers!*

# Neural Style Transfer



# Acknowledgements

- Tong Zhen
- Wenzhou Wu
- Jia Tian
- Angie Flores Bonifacio
- Harrison Espino
- Noah Christopher Shepherd
- Dr. Maor Matzrafi
- Dr. Adewale Osipitan
- Dr. Christian Nansen
- Dr. Kassim Al-Khatib
- Dr. Pershang Hosseini
- Dr. Alireza Pourreza

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Partial Fund:  
UC Davis New Research Initiatives

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