

Scalable Information Systems for Ag in Africa and Beyond

November 17, 2016

William Wu

QED | <http://qed.ai>

OUTLINE

- **Introduction**
- **Problems: Data Scarcity**
- **Technology Solutions**

INTRODUCTION



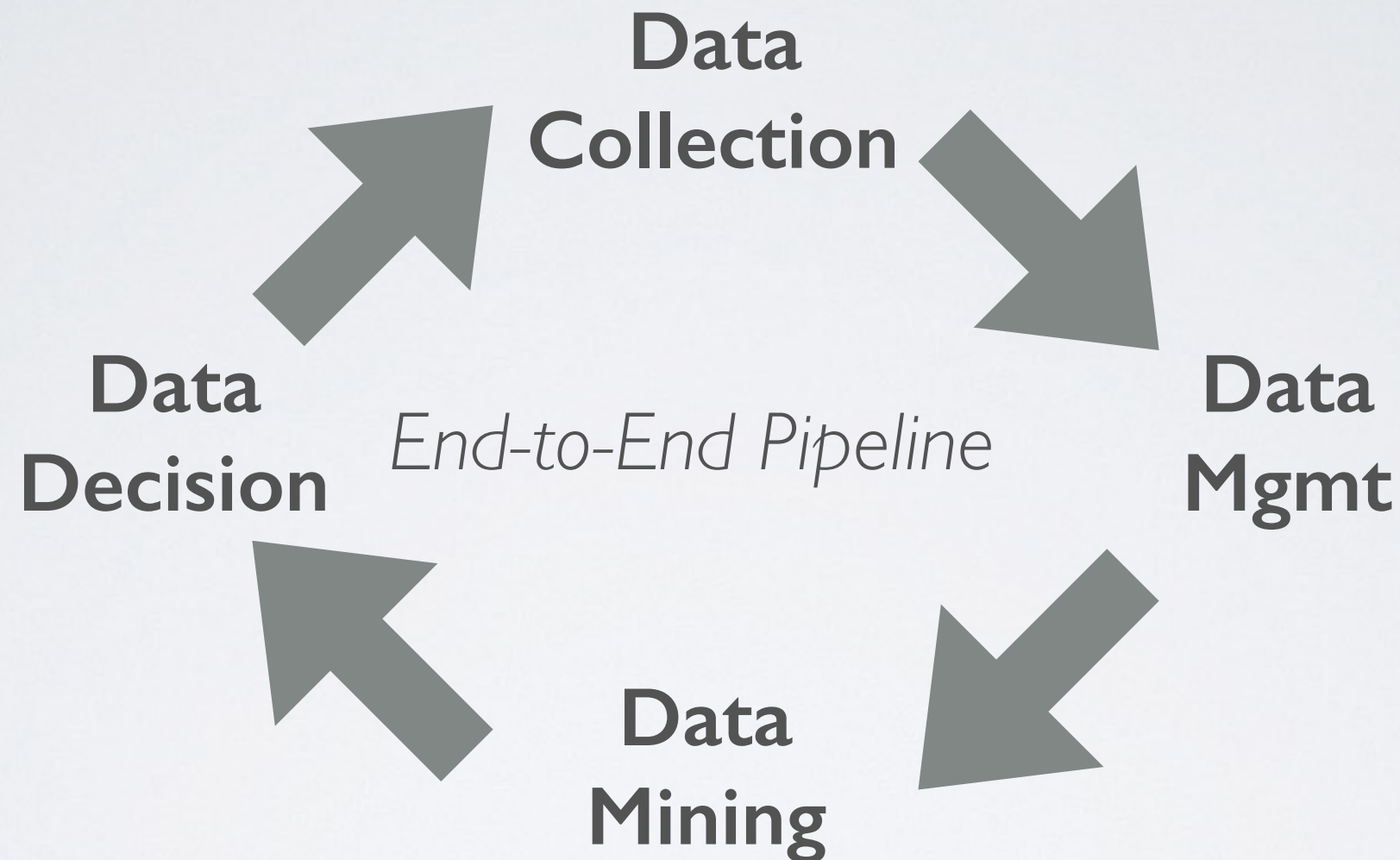
William Wu

Ph.D. EE, M.S. Math (Stanford)
B.S. EECS (Berkeley)
Ex-NASA JPL



Jiehua Chen (“JC”)

Ph.D. Statistics, M.S. Econ (Stanford)
B.Sc Math and Physics (Tsinghua)
Ex-Columbia Univ., Earth Institute



Global Development

“Help the world’s poorest people lift themselves out of poverty.”

Ag Dev

- 3/4 of world’s poorest subsist on ~0.5 ha of farmland.
- unproductive soils, plant disease and pests, drought, ill livestock, credit, market access, pricing, land reform
- malnutrition, child mortality

GLOBAL DEVELOPMENT

Agricultural Development

Emergency Response

Family Planning

Financial Services for the Poor

Global Libraries

Integrated Delivery

Maternal, Newborn & Child Health

Nutrition

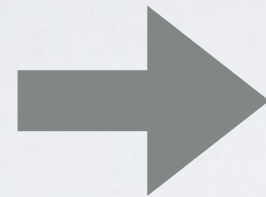
Polio

Vaccine Delivery

Water, Sanitation & Hygiene

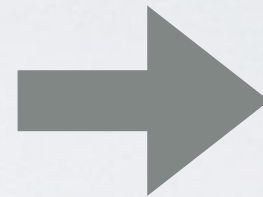


soil + landscape
info is incomplete
and outdated



**TAMASA
ACAI
CSISA**

agronomy projects
for maize, cassava,
cereals, etc.



inputs and advice
to support ~400K
SHFs in SSA

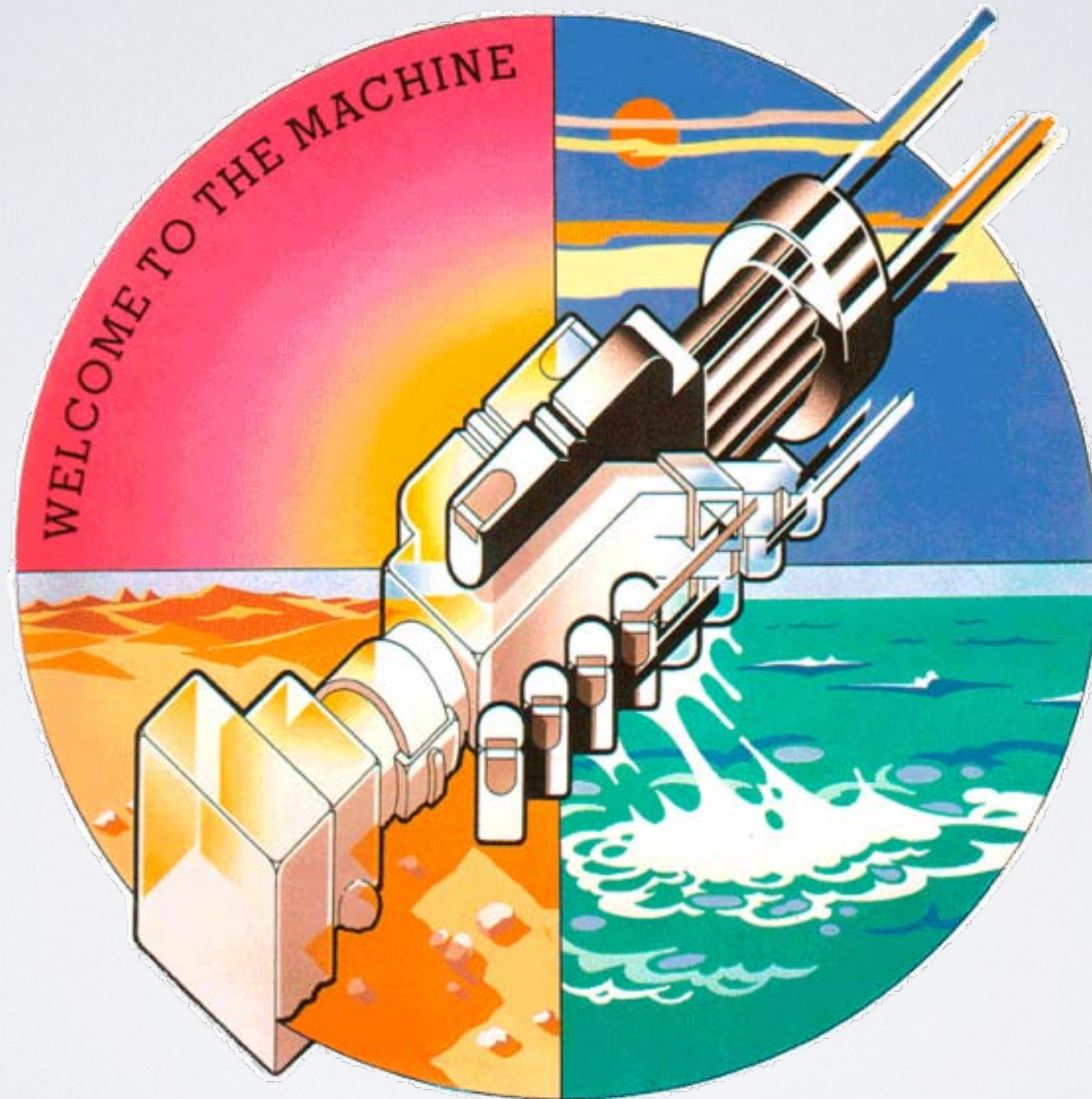
qed



tech consultant

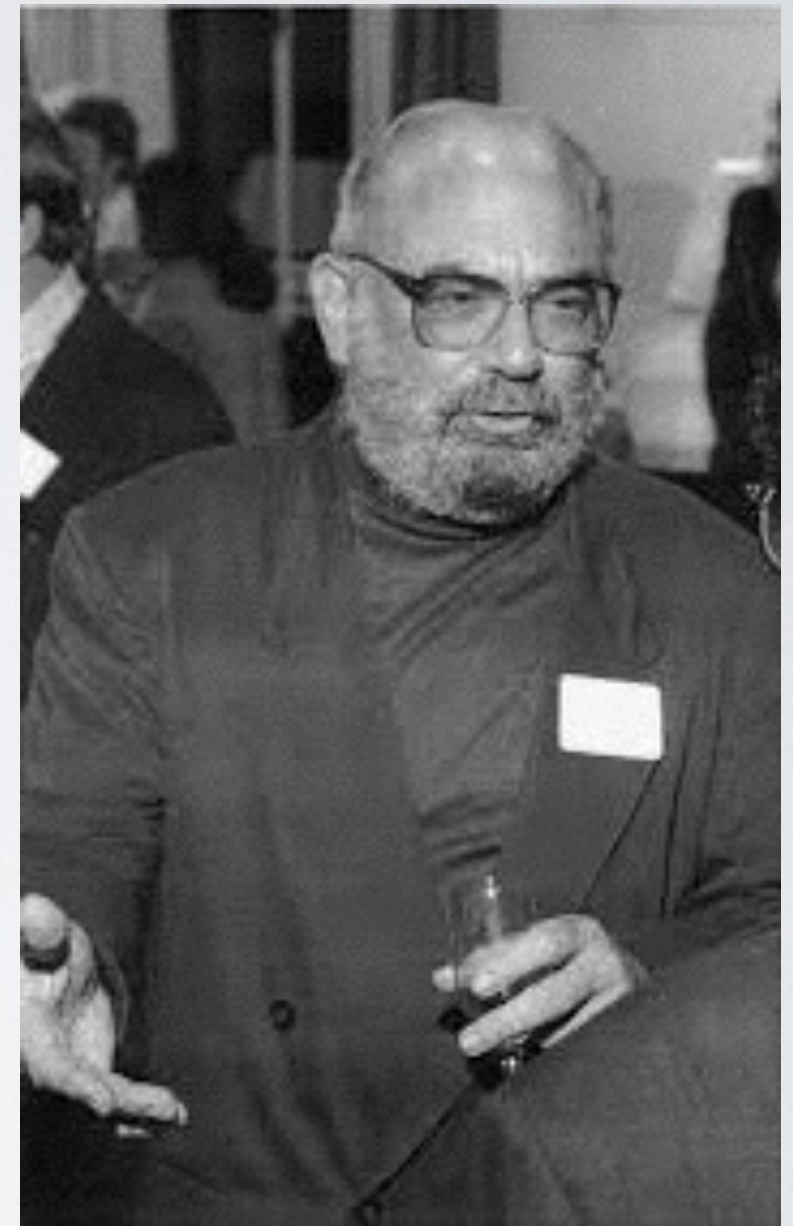
PROBLEMS: DATA SCARCITY

“WELCOME TO THE MACHINE”

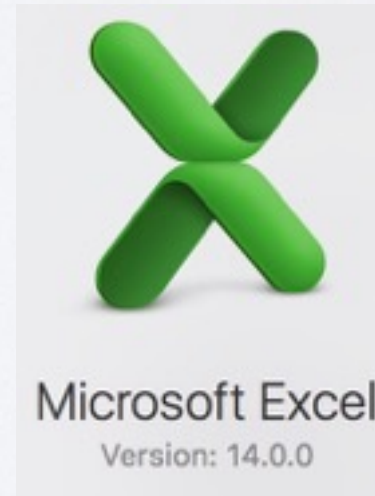
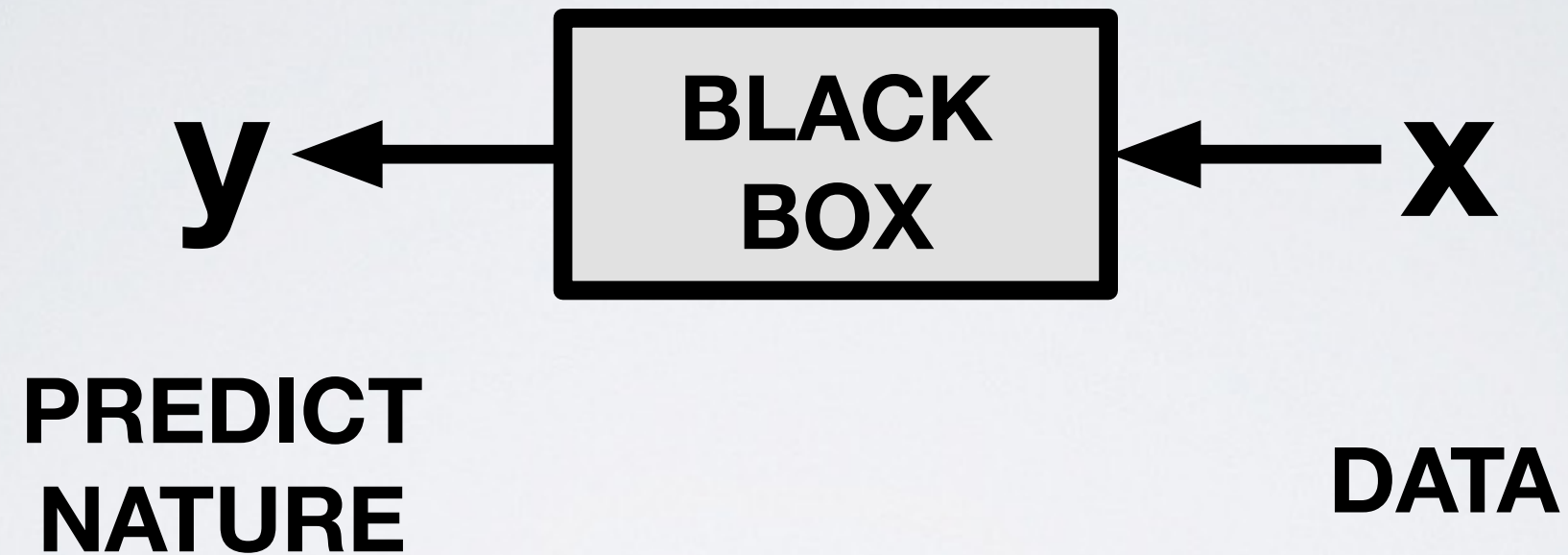


LEO BREIMAN (1928-2005)

- **Left academia to be full-time consultant in industry (13 yrs).**
- **“Statistical Modeling: The Two Cultures” (2001)**



“Goal: Use data to predict and to get information about the underlying data mechanism.”

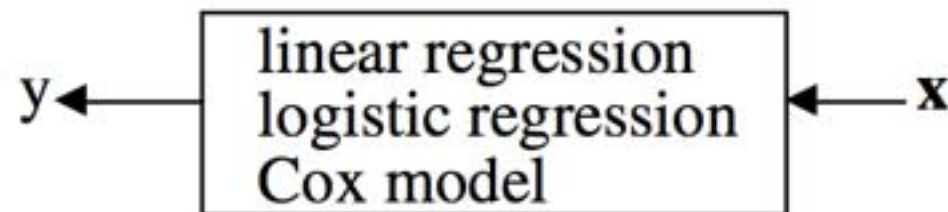


The Data Modeling Culture

The analysis in this culture starts with assuming a stochastic data model for the inside of the black box. For example, a common data model is that data are generated by independent draws from

response variables = $f(\text{predictor variables, random noise, parameters})$

The values of the parameters are estimated from the data and the model then used for information and/or prediction. Thus the black box is filled in like this:



Model validation. Yes–no using goodness-of-fit tests and residual examination.

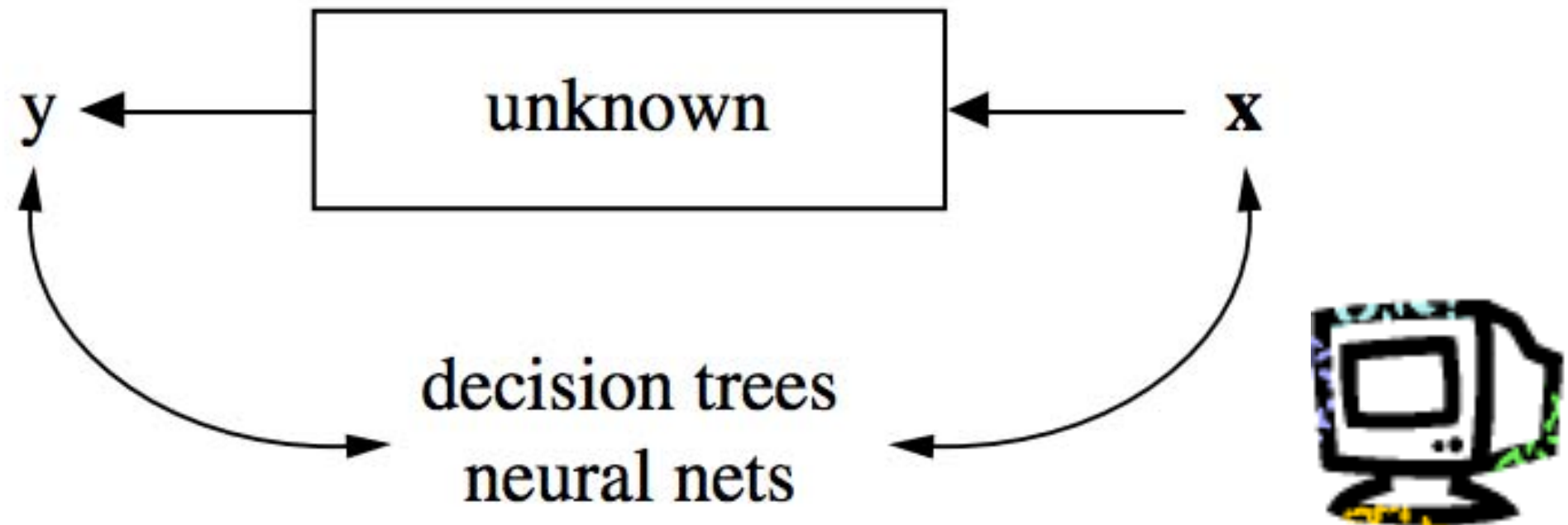
Estimated culture population. 98% of all statisticians.

$$f(X) = \beta_0 + \sum_{j=1}^p X_j \beta_j$$

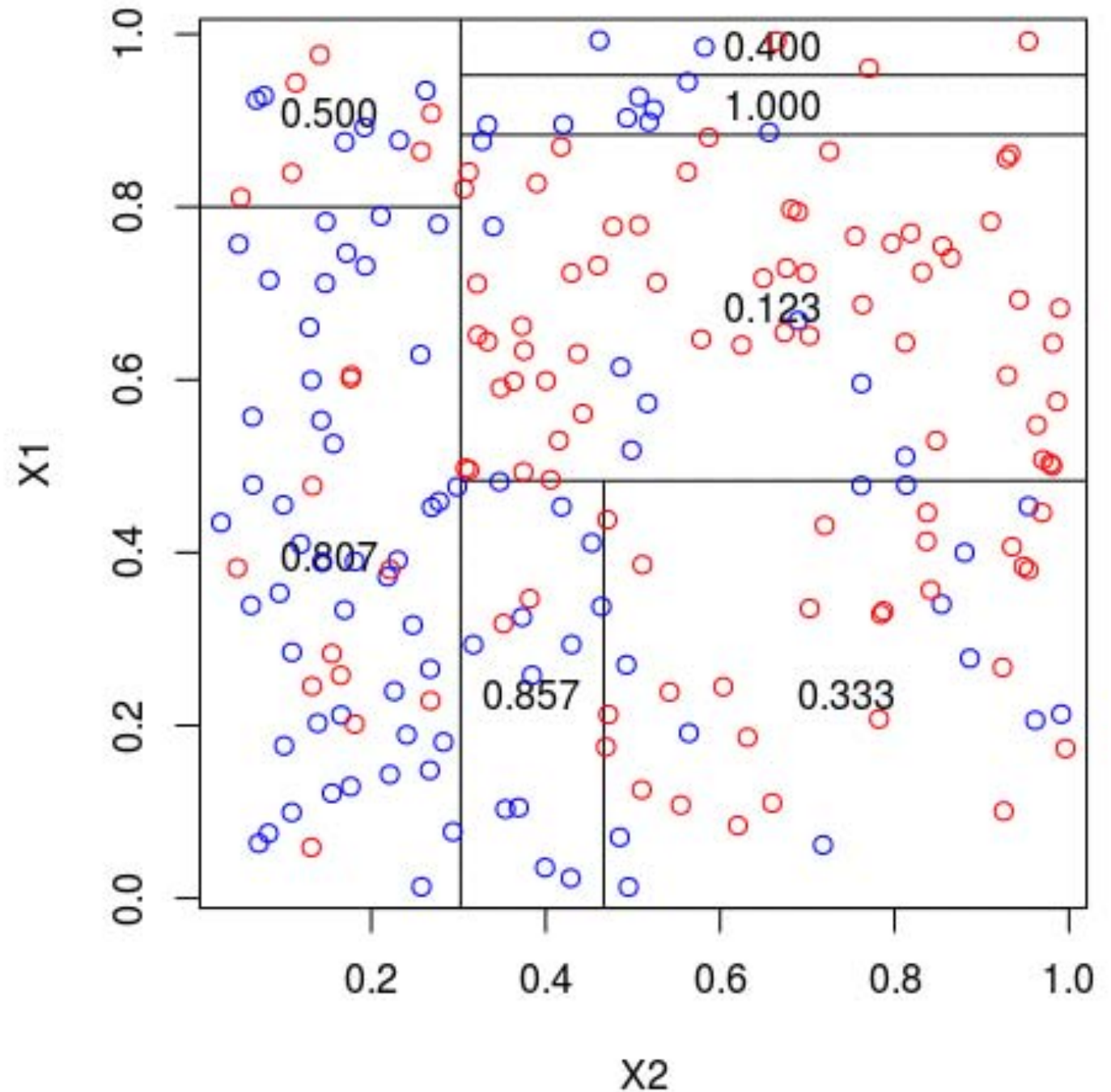
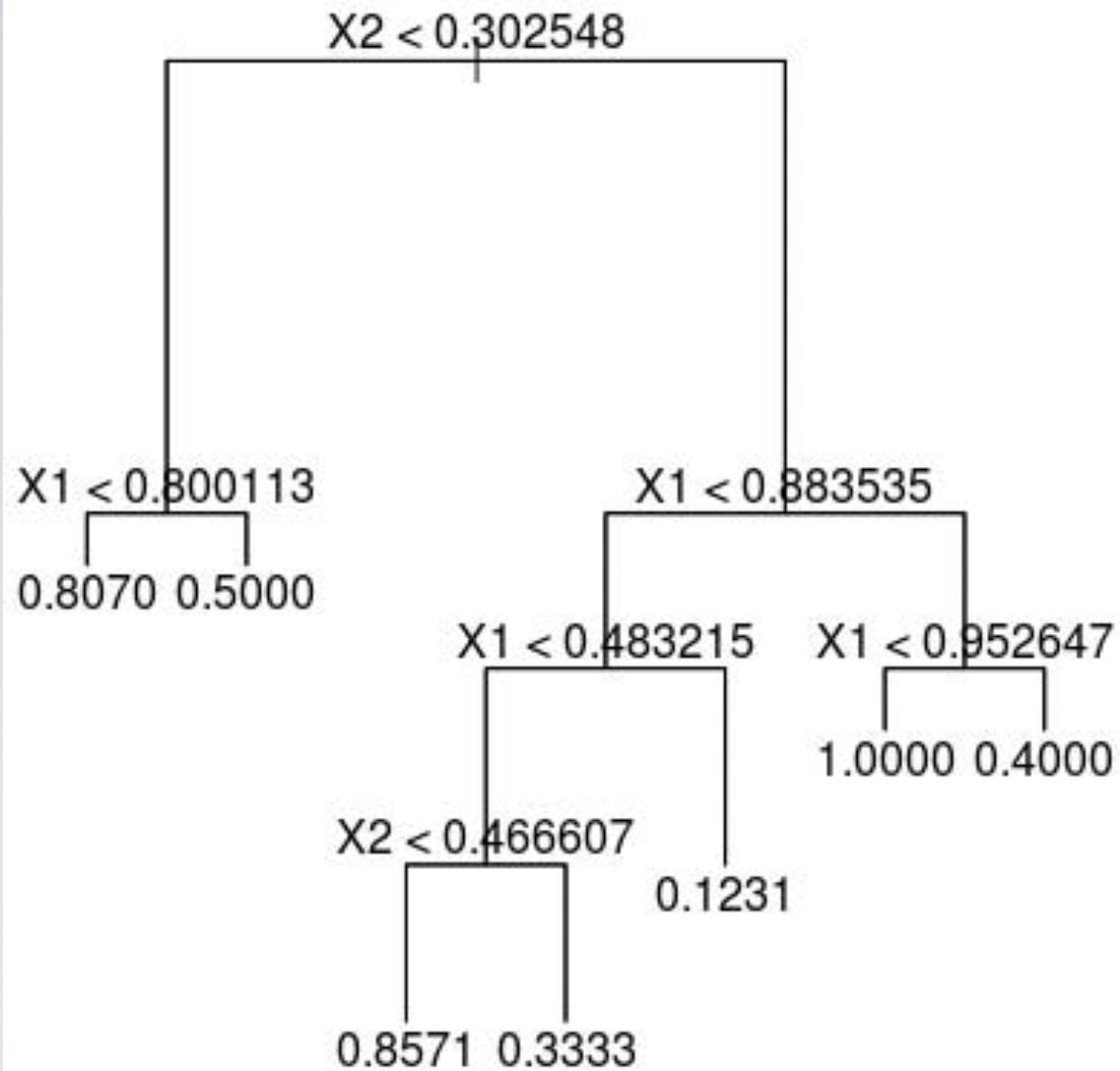
$$\log \frac{p(x)}{1 - p(x)} = \beta_0 + x \cdot \beta$$

The Algorithmic Modeling Culture

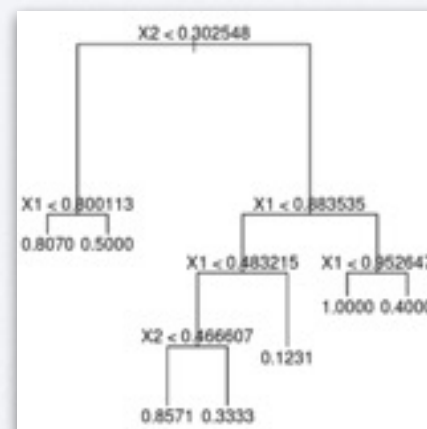
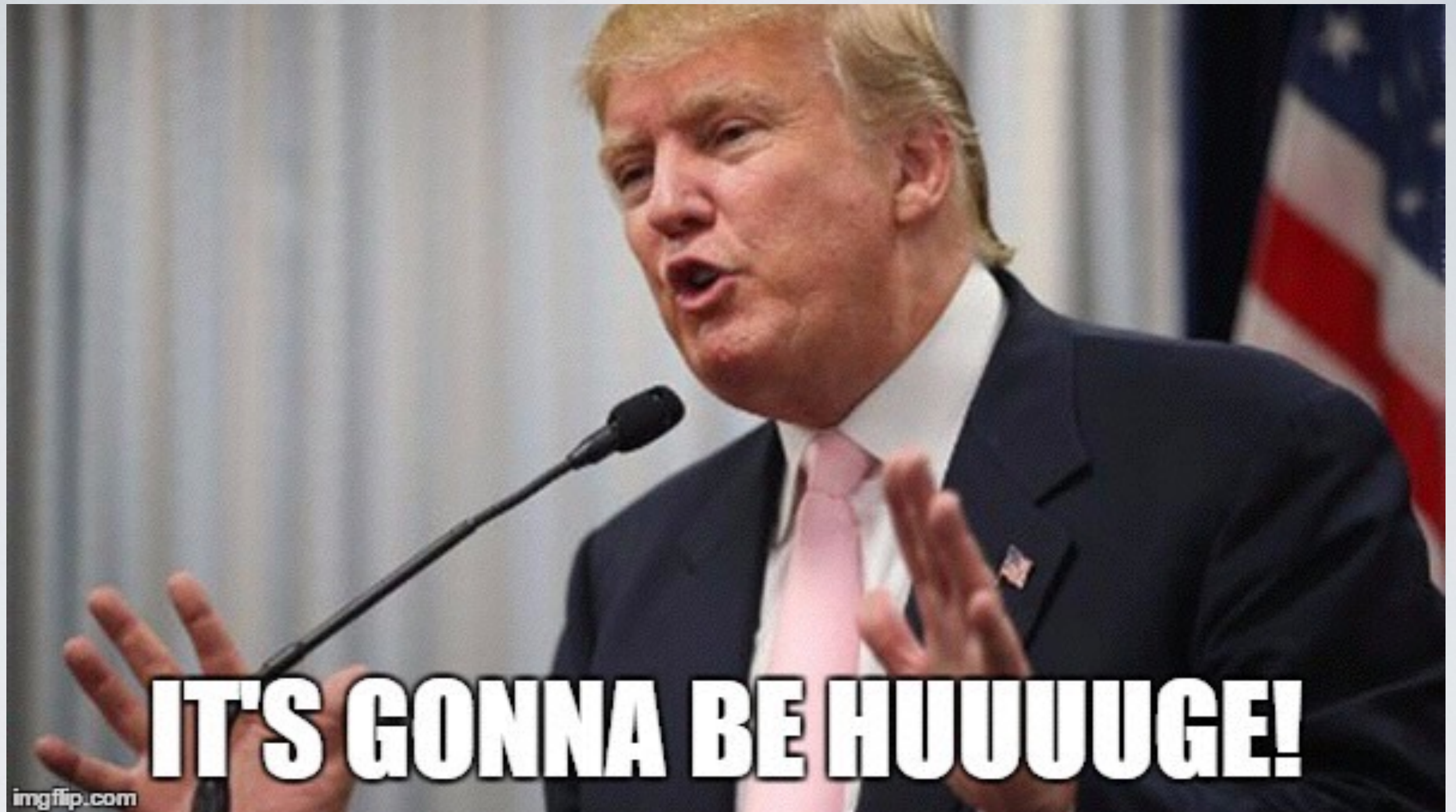
The analysis in this culture considers the inside of the box **complex and unknown**. Their approach is to find a function $f(\mathbf{x})$ —an algorithm that operates on \mathbf{x} to predict the responses \mathbf{y} . Their black box looks like this:



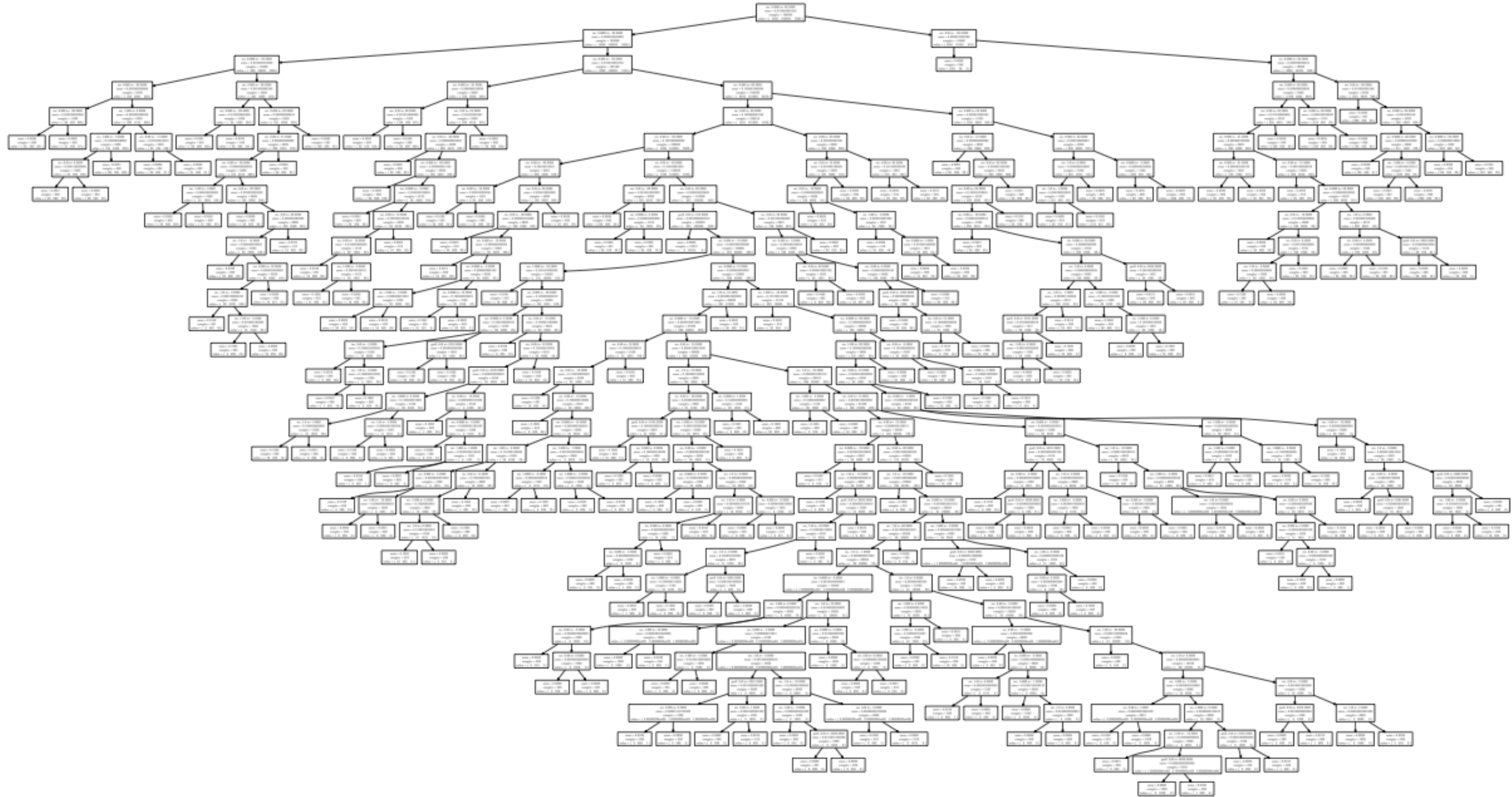
Model validation. Measured by **predictive accuracy**.
Estimated culture population. **2%** of statisticians,
many in other fields.



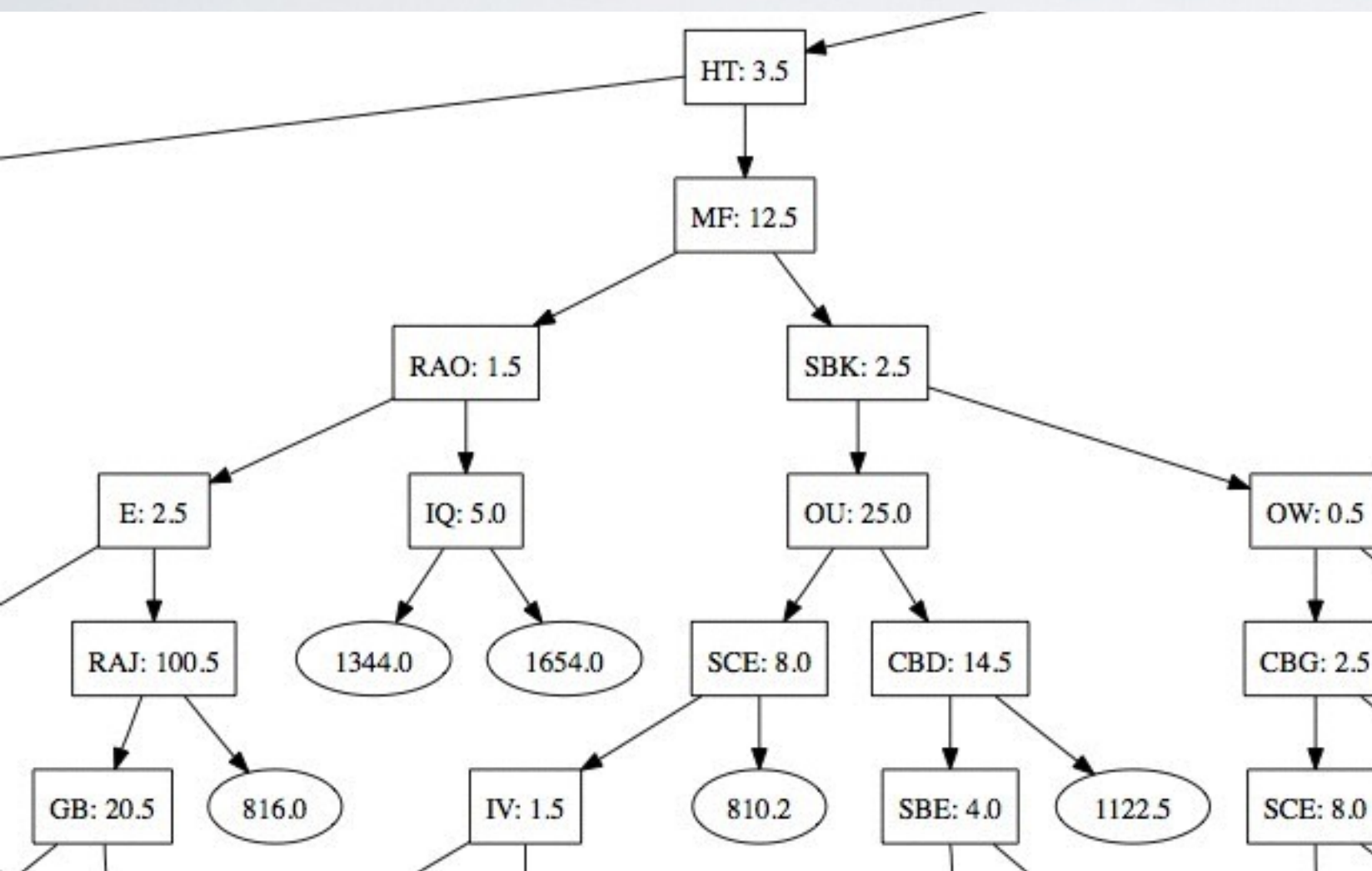
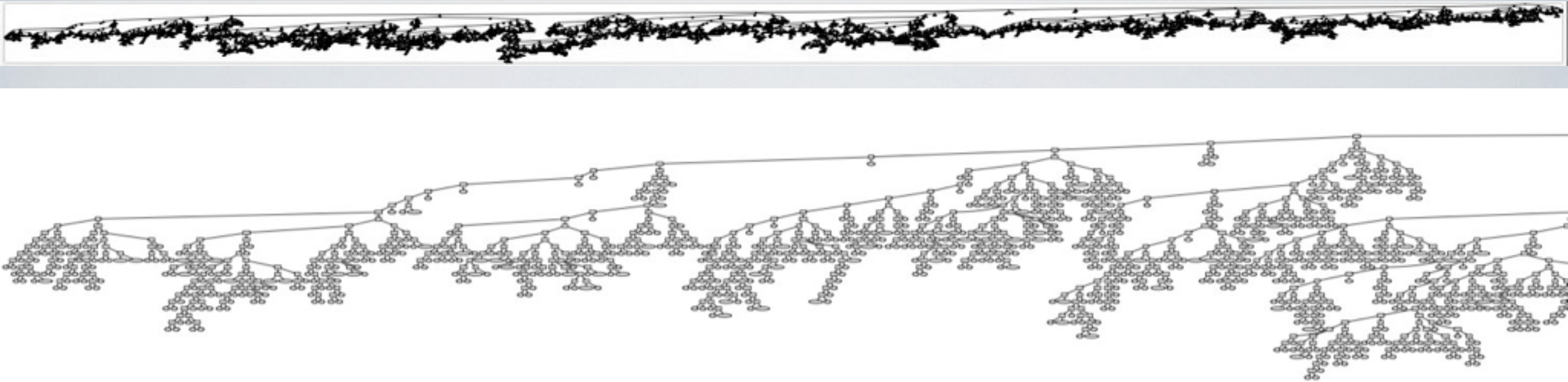
- **Decision Tree:** repeatedly partition data into nested classes
- **Random Forest:** make many decision trees from random subsets of the data, and average them



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ex: predictive image compression (W.Wu)



ex: real estate (QED)

HT: Hotels

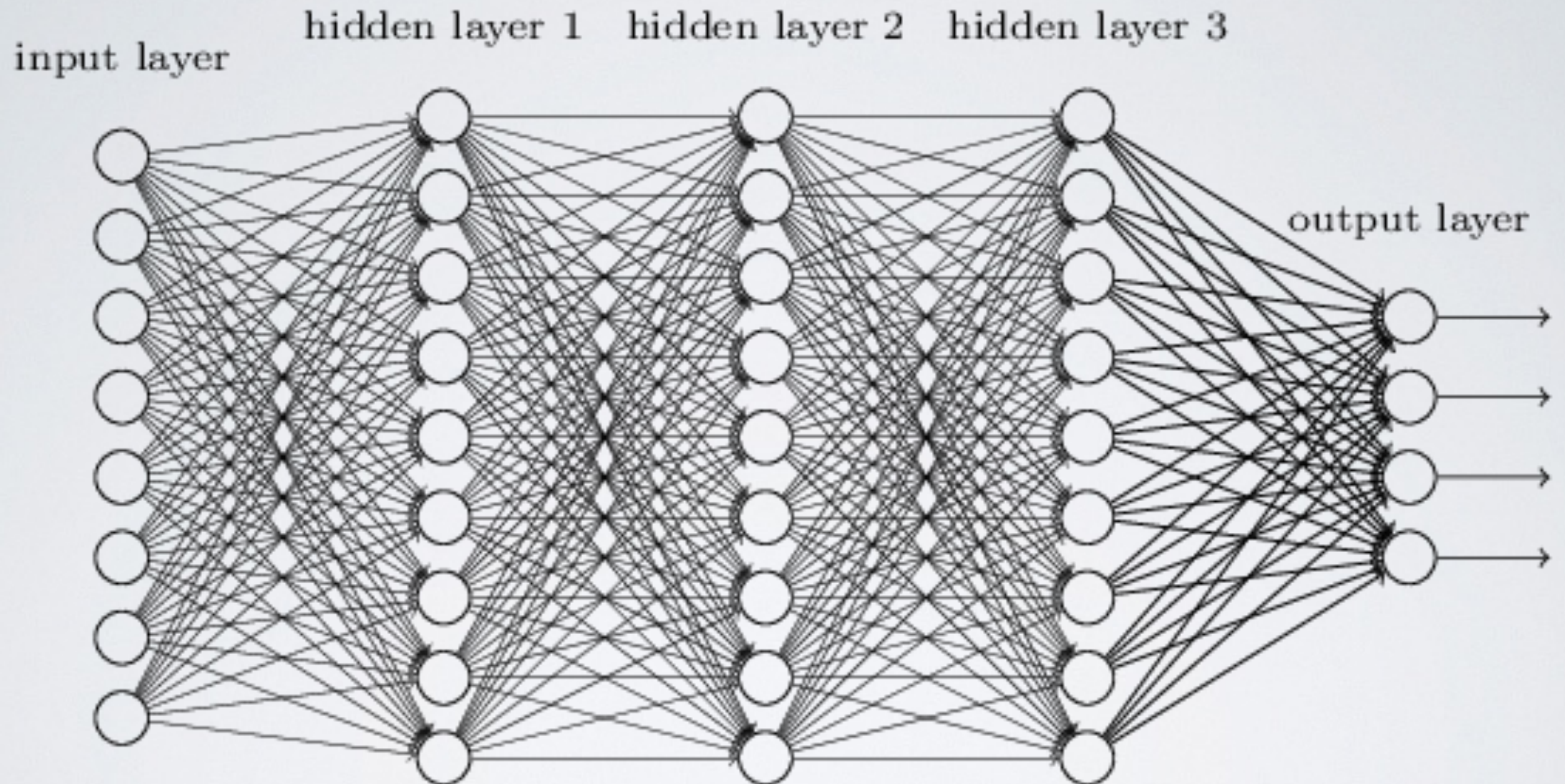
MF: Manufacturing

RAJ: Retail trade

SBK: Specialty Food Stores

...

neural networks (1953)



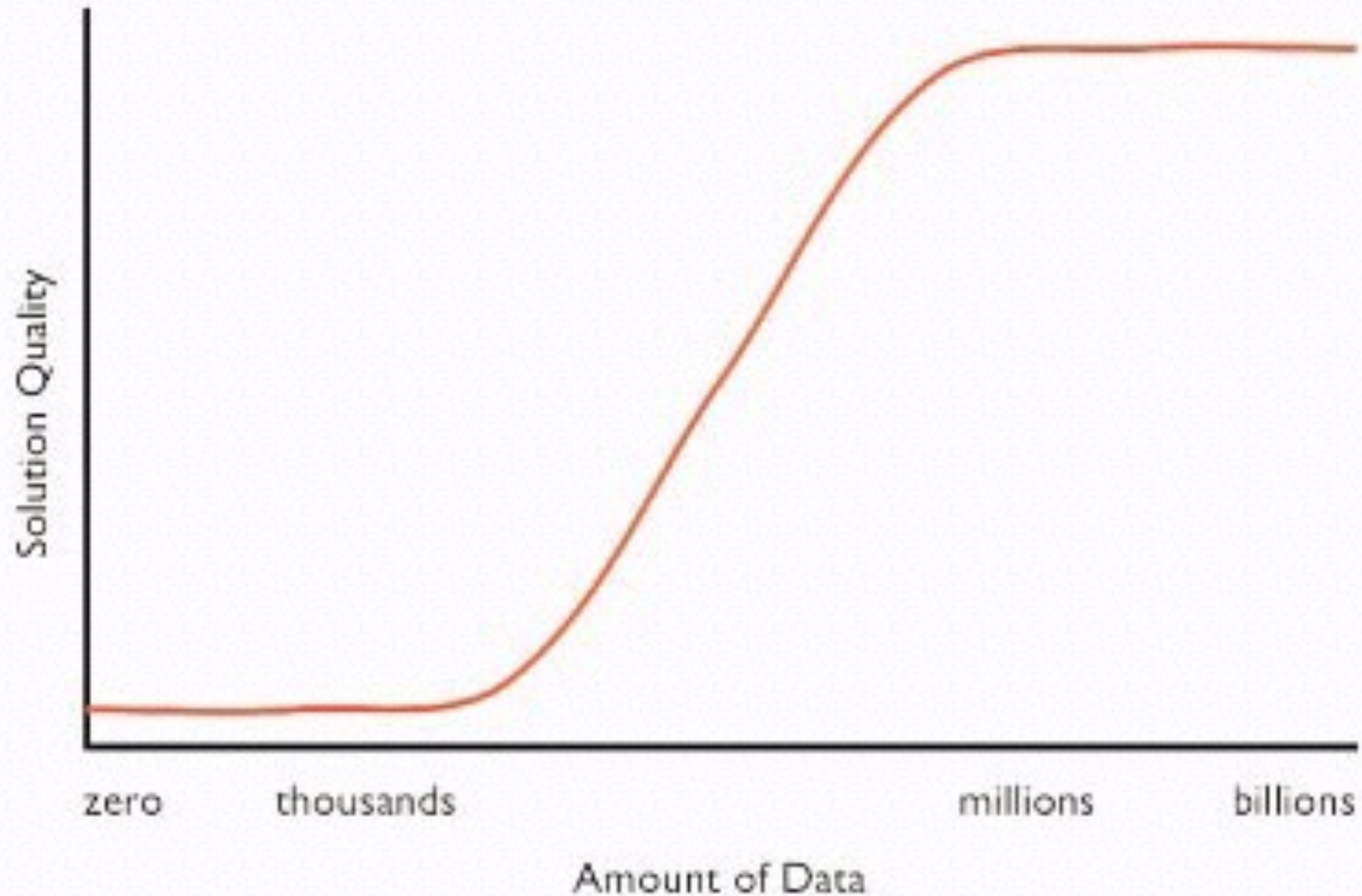
- 2016: Machines beat traditional data models and *humans*:
 - handwriting transcription
 - movie recommendation
 - spam classification
 - online advertising
 - insurance policies
 - breast cancer analysis
 - face detection
 - atari, chess, GO

ex: DeepFace (FB)



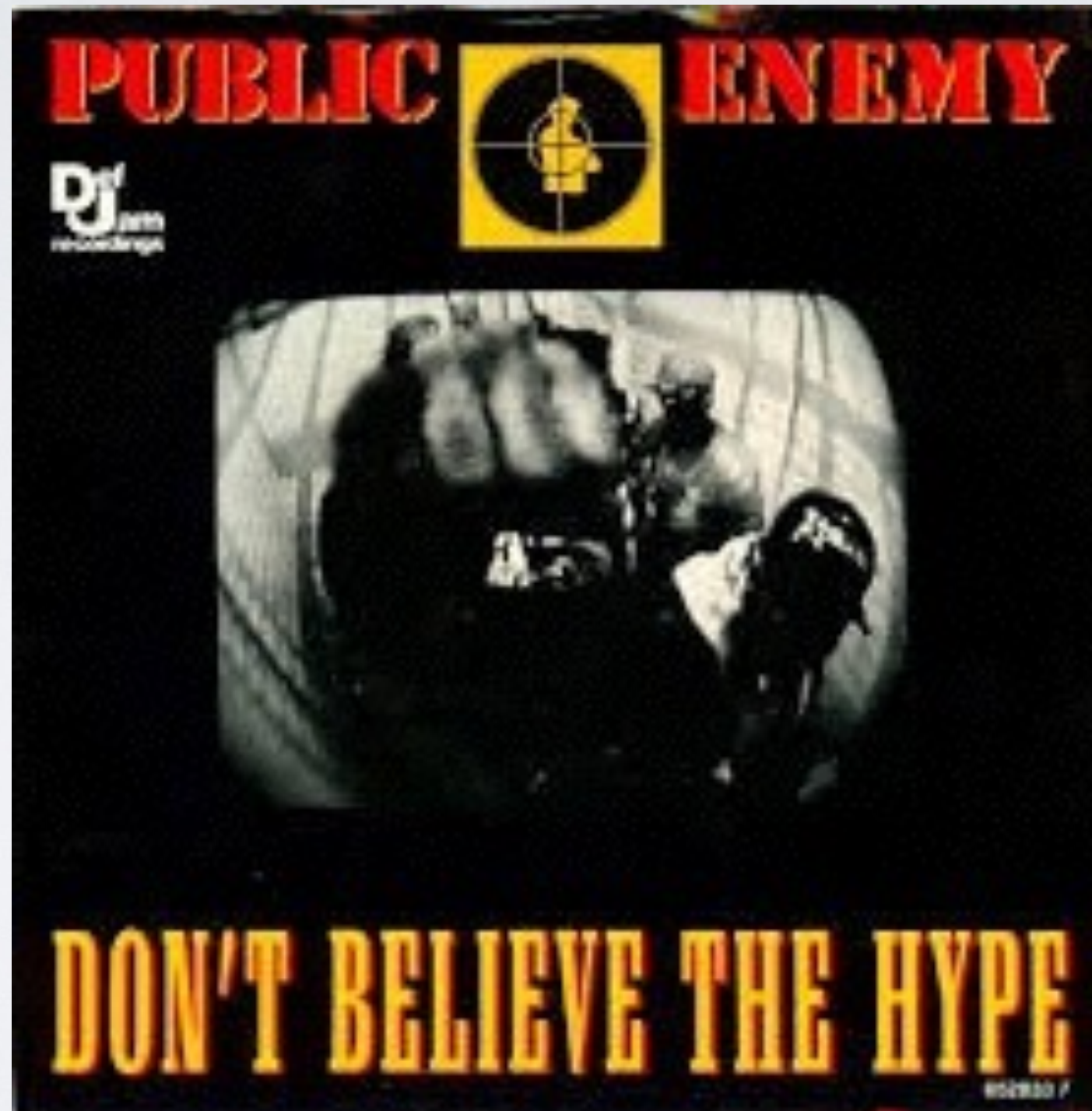
- What's the **catch**?

Peter Norvig (Google Research)



- Requires **ENORMOUS** data (TB/PB).

“DON'T BELIEVE THE HYPE”



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AG FANTASY

- food security (“9B by 2050”)
- small-holder farmers
- “big data”
- machine learning and maps



AG REALITY

- Hans Jenny:
 $s = f(\text{cl}, \text{o}, \text{r}, \text{p}, \text{t}, \dots)$
- **yield** = **G** x **E** x **M** x **F**
- SHF input = NA
- “databases” = .doc, .xls
- black box = Excel



SOLUTIONS:





SPEED

SCALABLE PIPELINE FOR ENGINEERING OF ENORMOUS DATA

End-to-end technology solutions to support systematic geospatial data collection and analysis.



QED APP LEGEND

- | | | |
|----|---|-------------------|
| 1 | | geosurvey |
| 3 | | sampling |
| 4 | | tag |
| 5 | | navigation |
| 5 | | grid locator |
| 5 | | tsp |
| 7 | | uav:quadcopter |
| 7 | | uav:fixed-wing |
| 6 | 8 | mobilesurvey |
| 6 | 8 | geosurvey collect |
| 9 | | tag maker |
| 10 | | id card maker |
| 13 | | dna |
| 14 | | maps |
| 15 | | inventory |

qed.ai/speed

SUB-PROBLEMS

- **determine ROI**
- **sampling frame**
- **navigate to sampling sites**
- **georeferenced extraction**
- **lab analyses**
- **database**
- **mapping (spatial-temporal modeling)**
- **decisions**

GEOSURVEY



- **problem:**
 - **map croplands and HS for soil sampling**
 - **Govt. Statistics Division story**
- **solution: crowdsourced geospatial analysis**



Dashboard

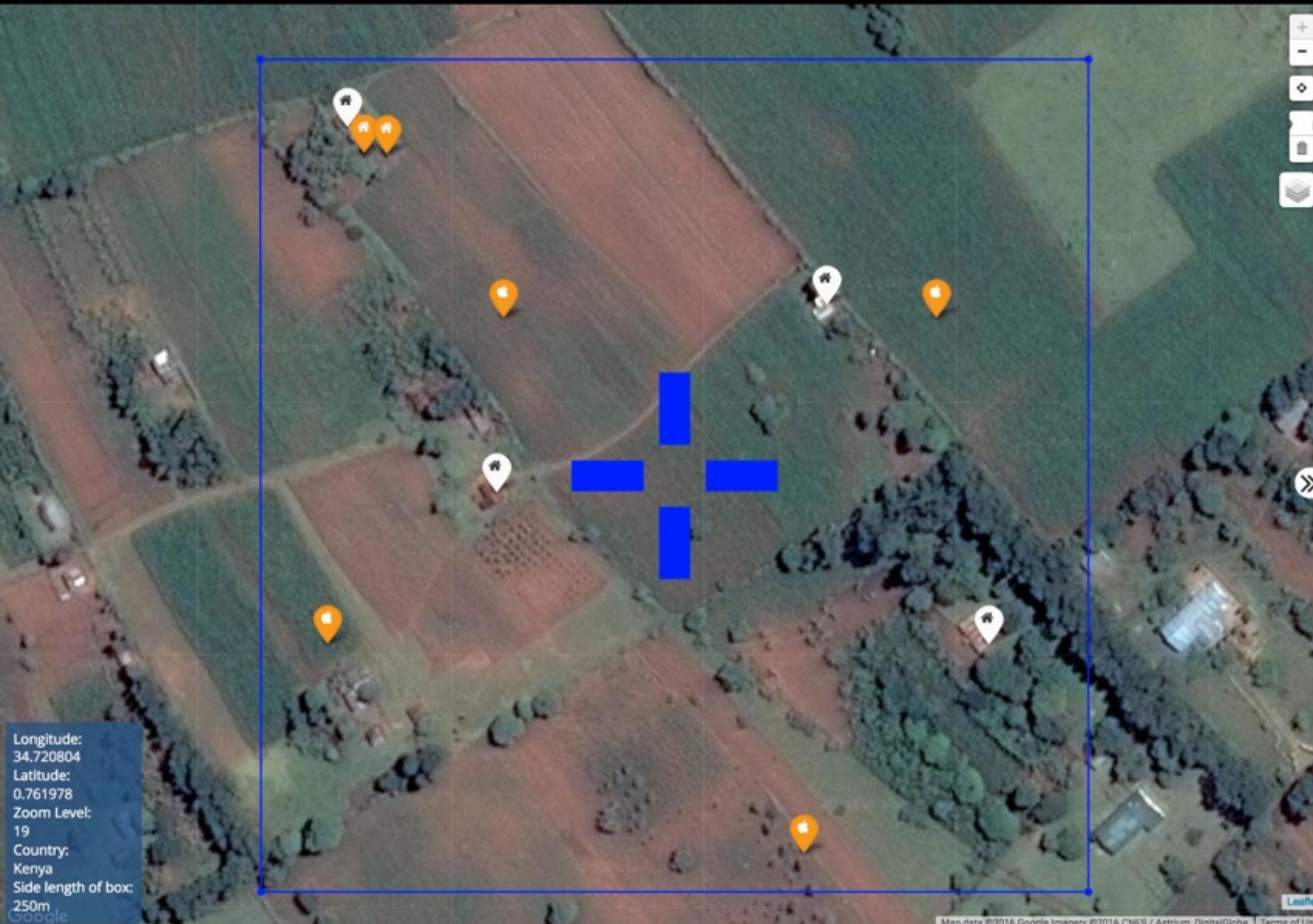
Forum

Admin

How It Works

Feedback

Log Out



Are croplands present?

☒ Yes ☐ No ☐ Don't know

What percentage of the square is cropland?

☒ 1-50% ☐ 51%-100%

☐ Don't Know

For each quadrant, if croplands exist, mark its centroid inside the quadrant.



Are houses present?

☒ Yes ☐ No ☐ Don't know

Mark every metal-roofed house.



Mark every non-metal-roofed house.



Update

Close

Grid

Color:

☒ Show markers

Markers in a row:

Submitted by

gs-gunrock-15

3 minutes 3 seconds ago



Survey



Discuss



Dashboard

Forum

Admin

How It Works

Feedback

Log Out



Buildings present?

Don't Know No Yes

Cropland Present?

Don't Know No Yes

Erosion gullies present?

Don't Know No Yes

Woody cover greater than 60 percent?

Don't Know No Yes

Update Close

Grid

Color: Orange

☒ Show markers

Markers in a row: 2

Submitted by

Chris-E

1 year, 1 month ago

Max zoom

Google: not recorded

Bing: not recorded

Coordinates

(latitude, longitude)

-3.098232, 37.63576

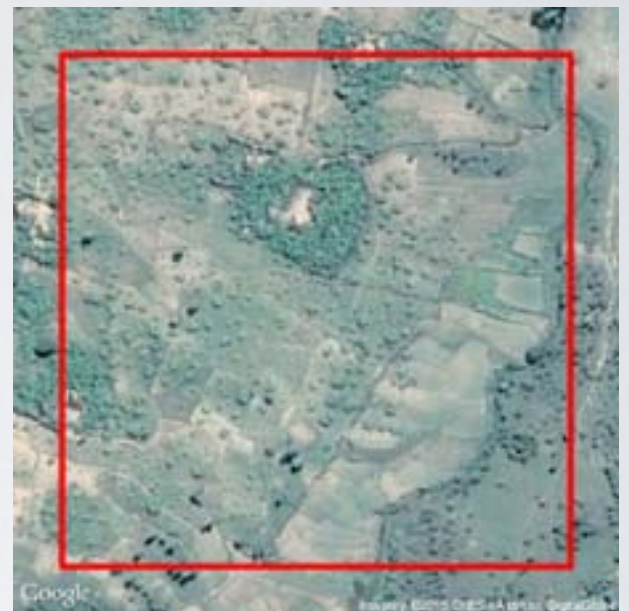
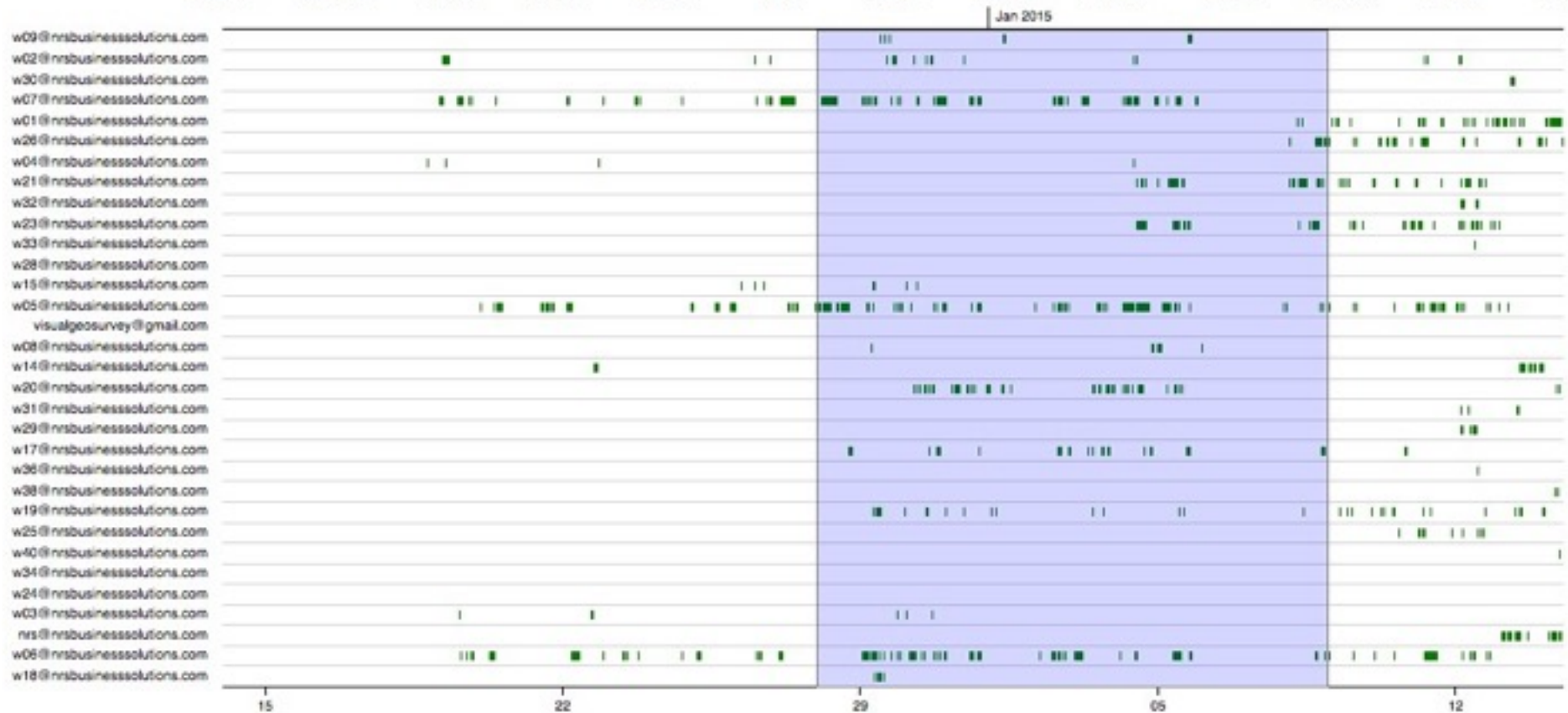
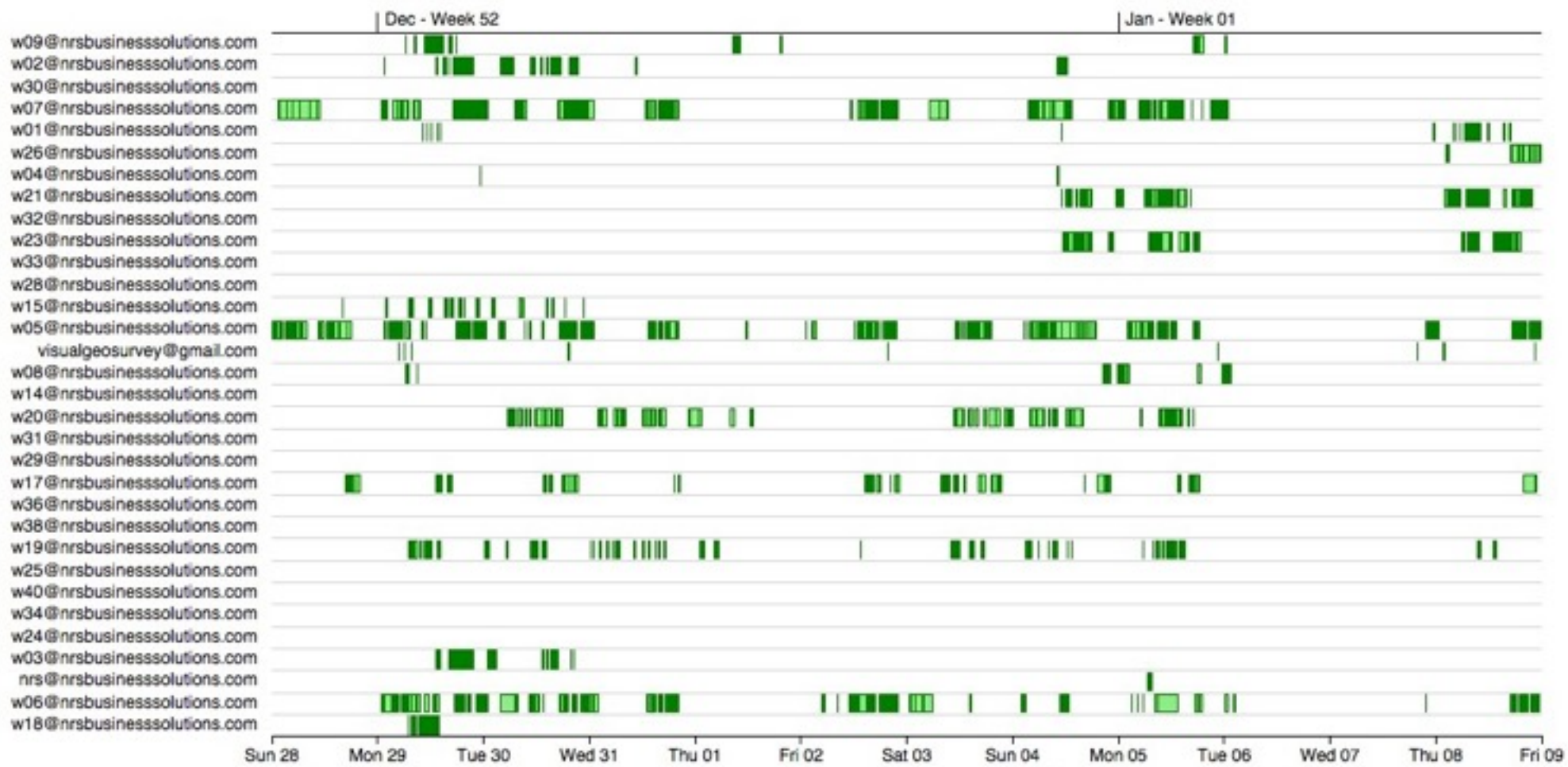
Copy

Send a message to the

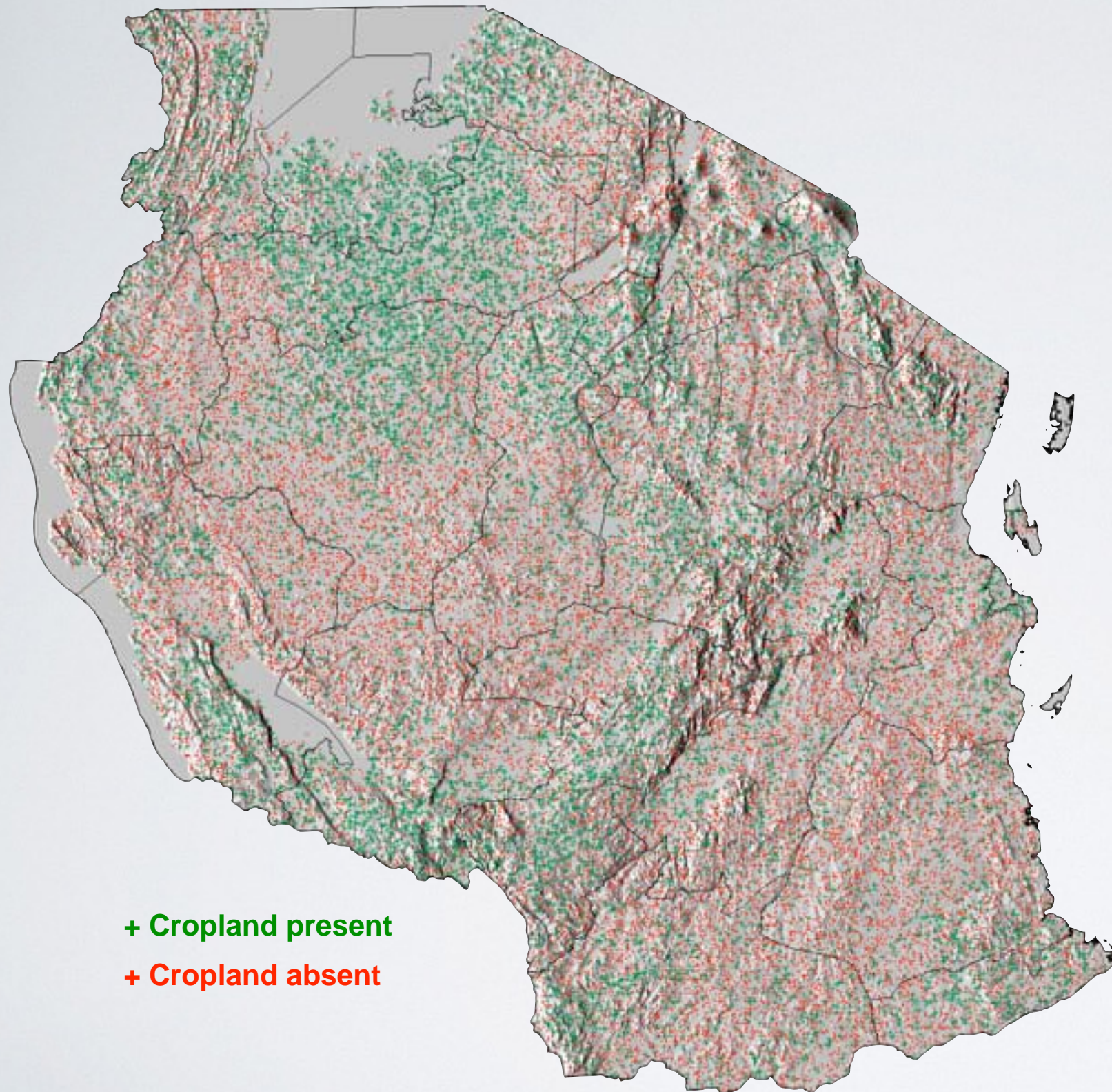
Survey

Discuss

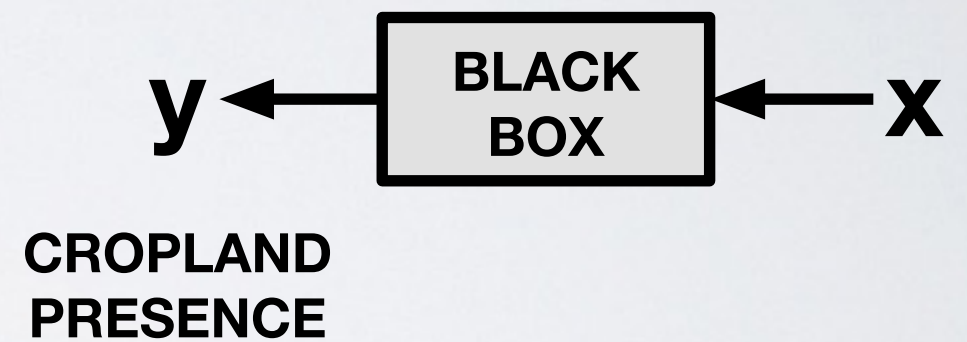




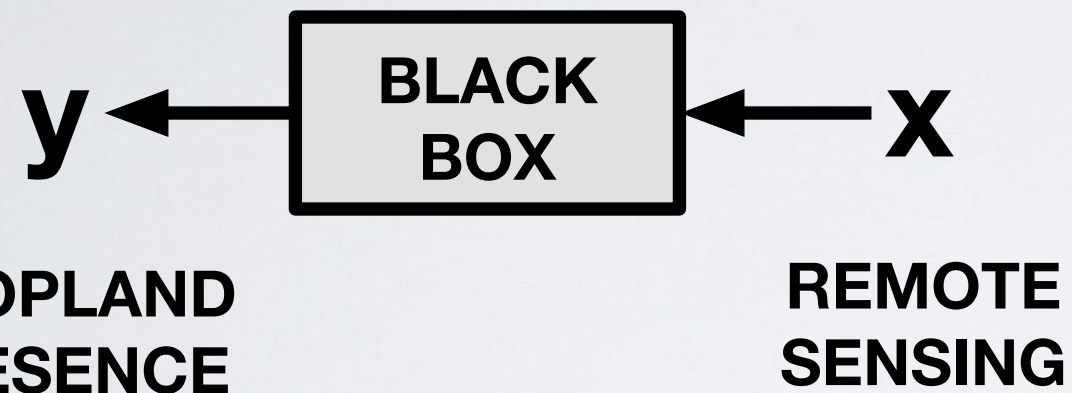
RESPONSES



+ Cropland present
+ Cropland absent



PREDICTORS



Remote sensing
is everywhere.

The screenshot shows the "maps.qed.ai" website interface. At the top, there's a navigation bar with "maps qed.ai", a search bar, and links for "Home", "Maps", "Sign Up", "Log In", and "Terms of Use". The main section is titled "Browse Layers" and features a search bar with the placeholder "Type here". Below this, there are four filter categories: "YEAR", "MONTH", "SPATIAL RESOLUTION", and "REGION". Each category has a list of options with a count in a circle. For example, under "YEAR", 1978 has 4 items, 1979 has 4, 1980 has 4, 1981 has 5, and 1982 has 5. The "MONTH" category shows January (12), February (13), March (13), April (13), and May (13). "SPATIAL RESOLUTION" includes 30000m (234), 250m (131), 1000m (78), 5000m (47), and 500m (30). The "REGION" category shows Africa (544). To the right of these filters is a grid of map thumbnails, each with a title and description. The thumbnails show various satellite data layers for Africa, including reflectance bands, vegetation indices, and land surface temperature. A blue brain icon with circuitry is overlaid on the top right of the screenshot.

YEAR

- 1978 (4)
- 1979 (4)
- 1980 (4)
- 1981 (5)
- 1982 (5)
- Show more...

MONTH

- January (12)
- February (13)
- March (13)
- April (13)
- May (13)
- Show more...

SPATIAL RESOLUTION

- 30000m (234)
- 250m (131)
- 1000m (78)
- 5000m (47)
- 500m (30)
- Show more...

REGION

- Africa (544)

Long-term Average Reflectance Band 2, 2000-2014
Africa

Long-term Average Reflectance Band 1, 2000-2014
Africa

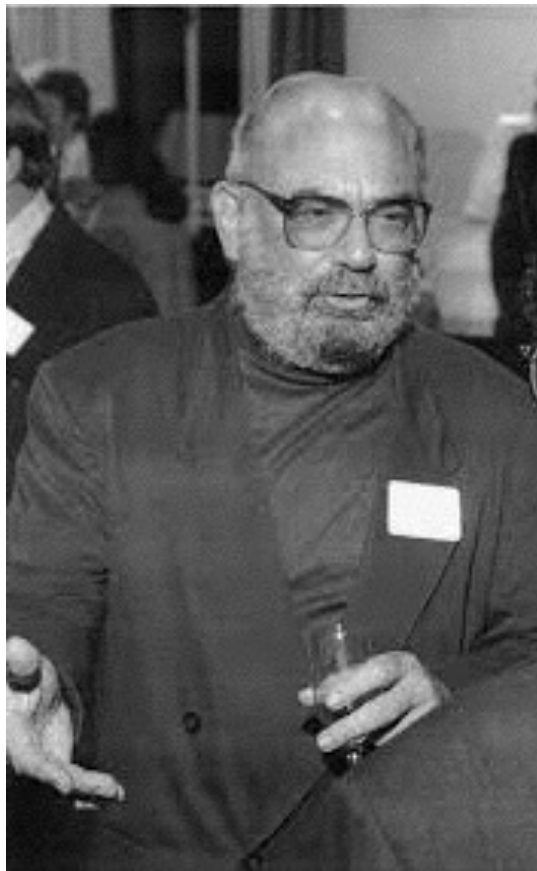
Enhanced Vegetation Index Average, 2010
The MODIS MOD13Q1 Enhanced Vegetation Index is an index measurement of greenness. Index values closer to 1 indicate an abundance of vegetation whereas values closer to 0 indicate scarce vegetation. This image contains the annual average of all EVI observations in 2010.
Africa 2010 yearly average

Land surface temperature (LST) night time series monthly average, February
The MODIS MYD11A2 Land Surface Temperature (LST) is a measure of ground temperature of the Earth's surface in degrees Celsius. This image contains the time series monthly average for February, using all available February LST Night observations from February 2003 - February 2015.
Africa February monthly average

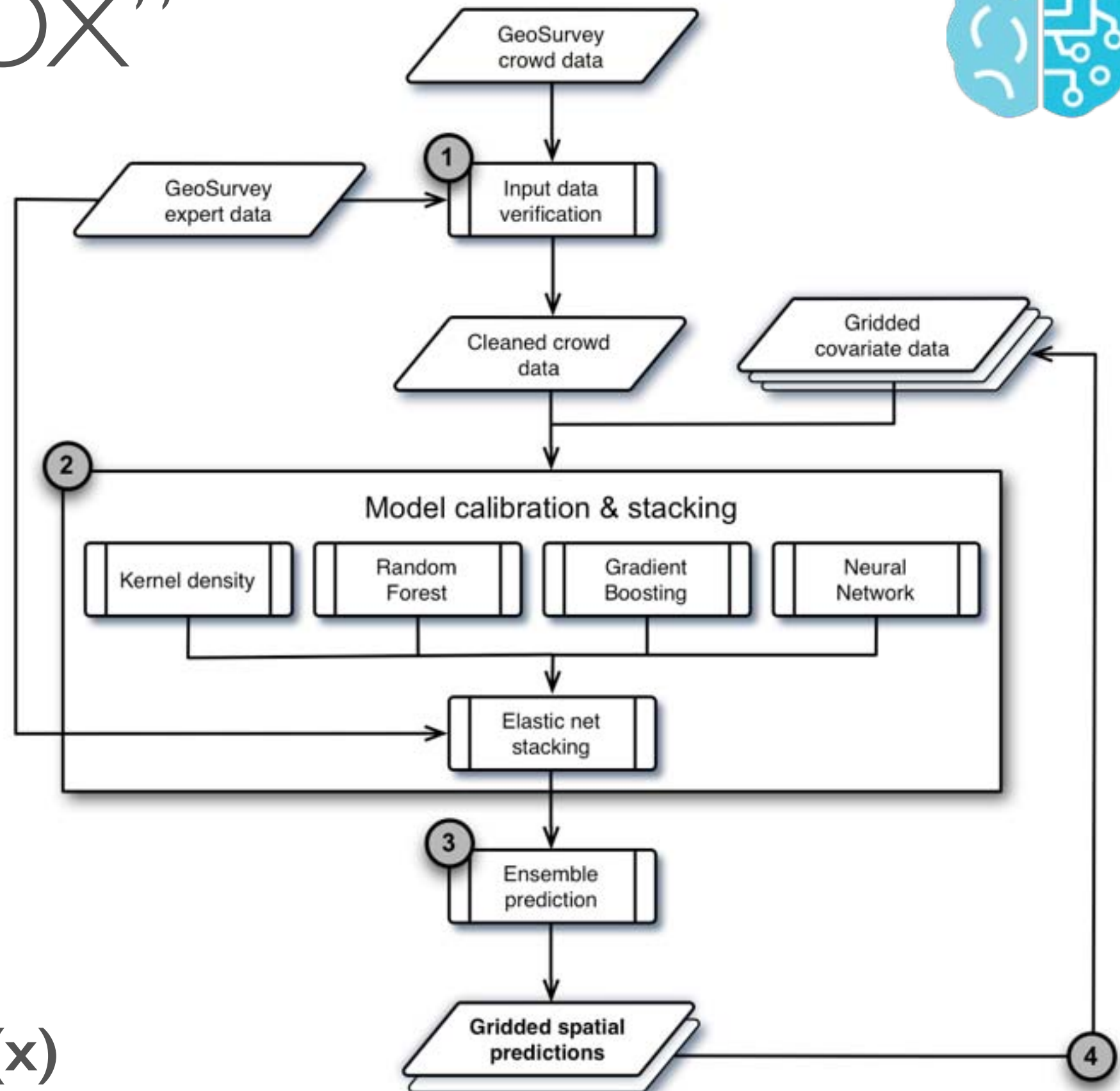
Normalized Difference Vegetation Index Time Series Average, July
The MODIS MOD13Q1 Normalized Difference Vegetation Index (NDVI) is an index measurement of greenness. Index values closer to 1 indicate an abundance of vegetation whereas values closer to 0 indicate scarce vegetation. This image contains the time series monthly average for July, using all available July NDVI observations from July 2000 - July 2015.
Africa July monthly average

Reflectance Blue Band 3 Time Series Average, October
The MODIS MOD13Q1 Reflectance Blue Band 3 data product is used in the development of the vegetation indices. Despite being the noisiest band, the blue band is particularly useful in reducing atmospheric disturbances in the vegetation indices. This image contains the time series monthly average for October, using all available October reflectance blue observations from October 2000 - October 2014.
Africa October monthly average

“BLACK BOX”

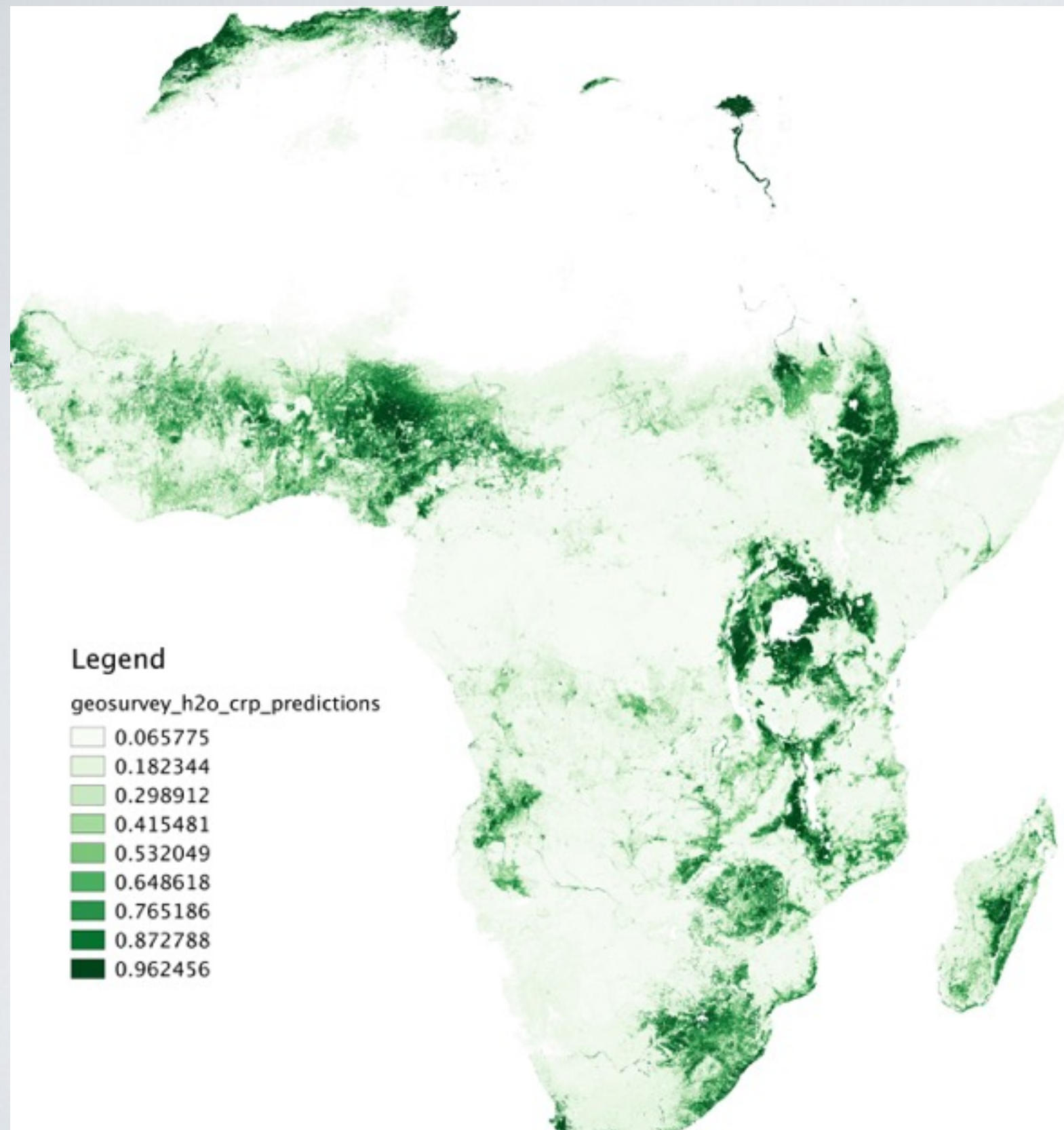


given (x,y) pairs,
find f such that $y \sim f(x)$






Predicted cropland presence; 1M points



- croplands
- houses
- roads
- phones n' drones

GLOBAL ACCESS











 Hi, ww

Home / Admin / Surveys / Edit Survey / Edit questionnaire

QUESTIONNAIRE

Delete

#	Question	Options	Actions
1	Human settlements present?	Yes/No/Don't Know	 
2	Croplands present?	0%/1-50%/51-100%/Don't Know	 
3	Woody cover > 60%?	Yes/No/Don't Know	 
4	Place a pindrop on all the farms.	—	 

Drag questions to change their order.

Add question ▾



easy to set up arbitrary surveys in arbitrary regions



geosurvey
qed.ai

Dashboard

Forum

Admin Area

How It Works

Feedback

Log Out

+

-

+

+

+

+

Longitude:
64.312506

Latitude:
31.695830

Zoom Level:
16

Country:
Afghanistan

Side length of box:
250m

Map data ©2016 Google Imagery ©2016 Cnes/Spot Image, DigitalGlobe | Terms of Use

Croplands present?

0%1-50%51-100%
Don't Know

Woody cover > 60% ?

YesNoDon't Know

Human settlements present?

YesNoDon't Know

Update

Close

Grid

Color: Orange

☒ Show markers

Markers in a row: 4

Submitted by gs-gunrock-09

1 month, 3 weeks ago
(2016-06-30 14:22:16)

Google Maps max zoom: 19

Bing Maps max zoom: 13

Coordinates

(latitude, longitude)

Survey

Discuss



geosurvey
qed.ai

DashboardForumAdmin AreaHow It WorksFeedbackLog Out

+

-

+

+

+

+

»

Longitude:
-43.870811
Latitude:
-20.429174
Zoom Level:
16
Country:
Brazil
Side length of box:
250m

Google

Map data ©2016 Google Imagery ©2016 CNES / Astrium, Cnes/Spot Image, DigitalGlobe

Terms of Use

Report a map error

In the box:

(latitude, longitude)
-20.429167, -43.870833

Copy

Croplands present?

0%1-50%51-100%
Don't Know

Woody cover > 60% ?

YesNoDon't Know

Human settlements present?

YesNoDon't Know

Submitting answers is disabled.
The survey has ended.

Grid

Color: Blue

Show markers

Markers in a row: 4

Survey

Discuss

[geosurvey.qed.ai]

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INC



geosurvey
qed.ai

Dashboard

Forum

Admin Area

How It Works

Feedback

Log Out

+

-

Longitude:
-47.045817

Latitude:
-20.954156

Zoom Level:
16

Country:
Brazil

Side length of box:
250m

Leaflet

Bing, © 2010 DigitalGlobe, © 2010 GeoEye, Earthstar Geographics SIO, © 2016 Microsoft Corporation

In the box:

(latitude, longitude)
-20.954167, -47.045833

Copy

Croplands present?

0%

1-50%

51-100%

Don't Know

Woody cover > 60% ?

Yes

No

Don't Know

Human settlements present?

Yes

No

Don't Know

Submitting answers is disabled.

The survey has ended.

Grid

Color: Blue

Show markers

Markers in a row: 4

Survey

Discuss

Indonesia: 2012-10-15





geosurvey
qed.ai

Dashboard Forum Admin How It Works Feedback Log Out

In the box:

(latitude, longitude)
0.679167, 109.1375
[Copy](#)

Croplands present?

0%	1-50%	51-100%
Don't Know		

Woody cover > 60% ?

Yes	No	Don't Know
-----	----	------------

Human settlements present?

Yes	No	Don't Know
-----	----	------------

Submitting answers is disabled.
The survey has ended.

Grid

Color: Blue

☐ Show markers

Markers in a row: 4

Permalink:

<https://geosurv> [Copy](#)

Longitude: 109.137701
Latitude: 0.679136
Zoom Level: 17
Country: Indonesia
Side length of box: 250m

Leaflet | Bing, © 2016 DigitalGlobe, © 2016 GeoEye, Earthstar Geographics SIO, © 2016 Microsoft Corporation

Survey Discuss

Indonesia: 2015-12-02



geosurvey
qed.ai

Dashboard Forum Admin How It Works Feedback Log Out

In the box:

(latitude, longitude)
0.679167, 109.1375
[Copy](#)

Croplands present?
0% 1-50% 51-100%
Don't Know

Woody cover > 60%?
Yes No Don't Know

Human settlements present?
Yes No Don't Know

Submitting answers is disabled.
The survey has ended.

Grid
Color: Blue
☐ Show markers
Markers in a row: 4

Permalink:
<https://geosurv> [Copy](#)

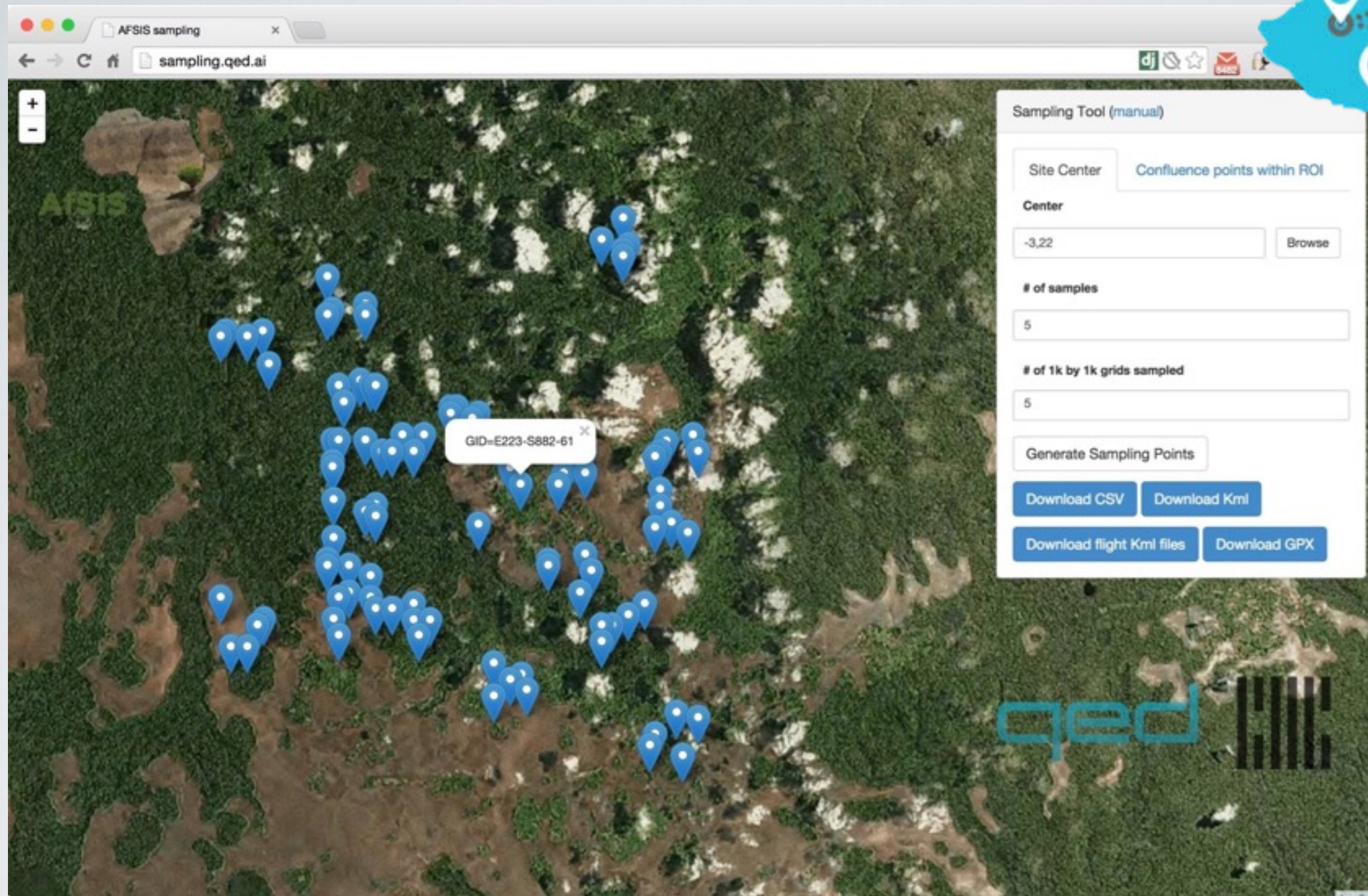
Longitude: 109.137701
Latitude: 0.679136
Zoom Level: 17
Country: Indonesia
Side length of box: 250m

Map data ©2016 Google Imagery ©2016 CNES / Astrium, DigitalGlobe | Terms of Use | Report a map error

Survey Discuss

SUB-PROBLEMS

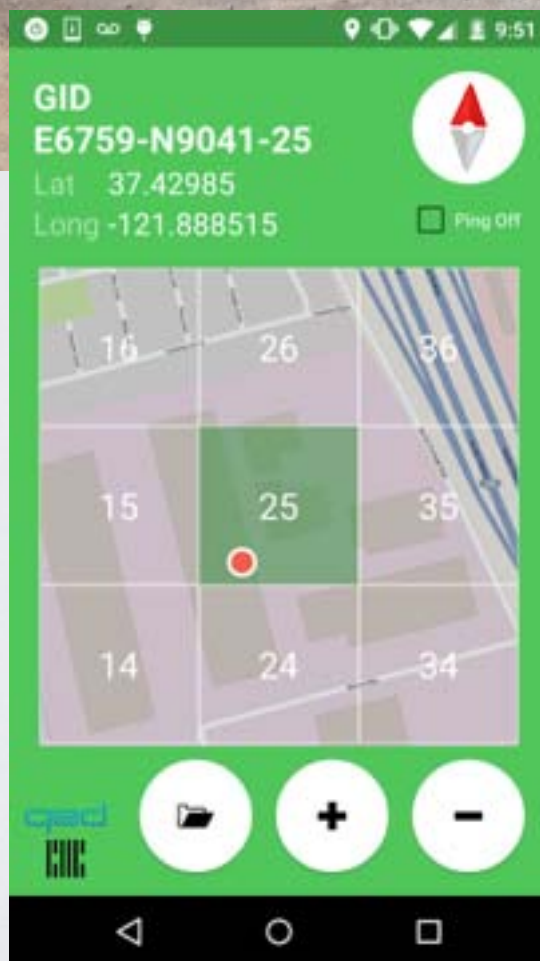
- determine ROI
- **sampling frame**
- navigate to sampling sites
- georeferenced extraction
- lab analyses
- database
- mapping (spatial-temporal modeling)
- decisions



Generate randomized sampling locations that are hierarchically clustered to minimize transportation costs.

SUB-PROBLEMS

- determine ROI
- sampling frame
- **navigate to sampling sites**
- georeferenced extraction
- lab analyses
- database
- mapping (spatial-temporal modeling)
- decisions



SUB-PROBLEMS

- determine ROI
- sampling frame
- navigate to sampling sites
- **georeferenced extraction**
- lab analyses
- database
- mapping (spatial-temporal modeling)
- decisions

tag.kutabiri.com/sheet/ William

Code sheet generator

Units: mm

Page Dimensions

Width: 210 mm Height: 297 mm

Margins

Top: 0 mm Left: 0 mm Right: 0 mm Bottom: 0 mm

Codes

Image type: QRCode

Code type: Random String Length: 8

Prefix (e.g. country code): max 10 chars

Hidden prefix:

Layout

No. of codes: 1 No. of copies: 2

Columns: 3 Rows: 4

Code padding: 0 Label: ☒ Show Number: ☒ Show

Rulers

Horizontal: ☒ Show Vertical: ☒ Show Font size: 14

Generate

Preview



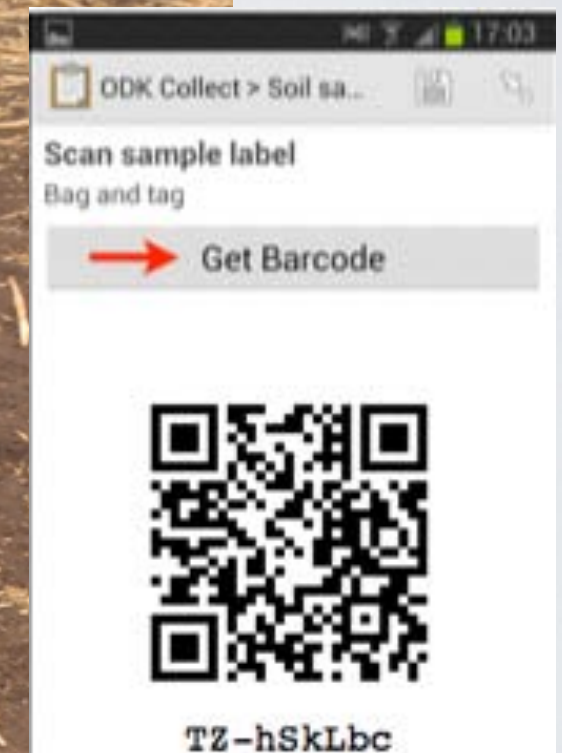
Pre-generate customizable QR codes for labeling samples.

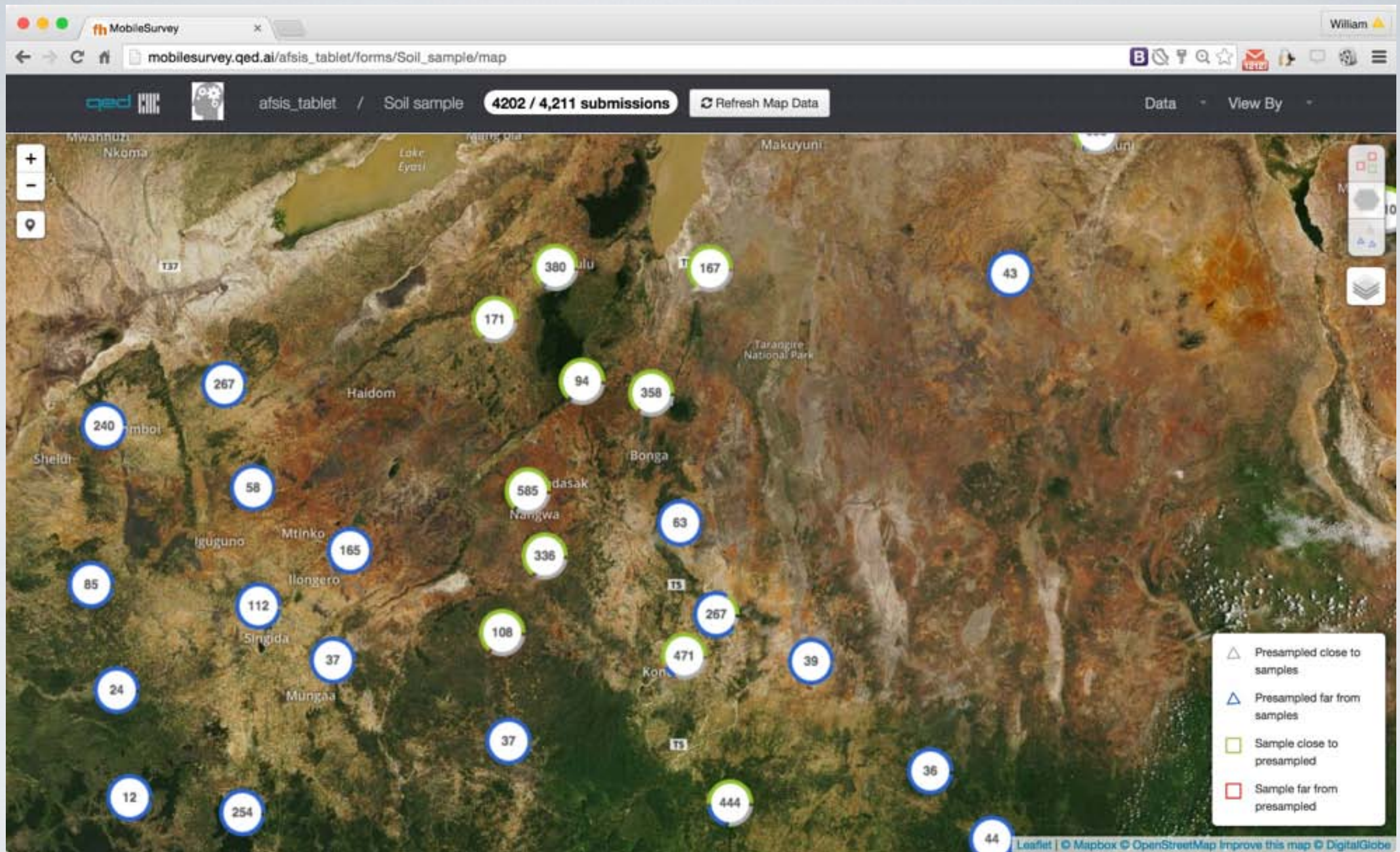


MobileSurvey

- Easily deploy surveys onto Android phones, using Excel spreadsheets.
- Record georeferences, timestamps, pictures, and barcodes.
- Work in zero-wifi areas, caching data until network returns.
- Regular maintenance coupled with scalable geospatial visualizations and fraud detection.

[Sign Up!](#)



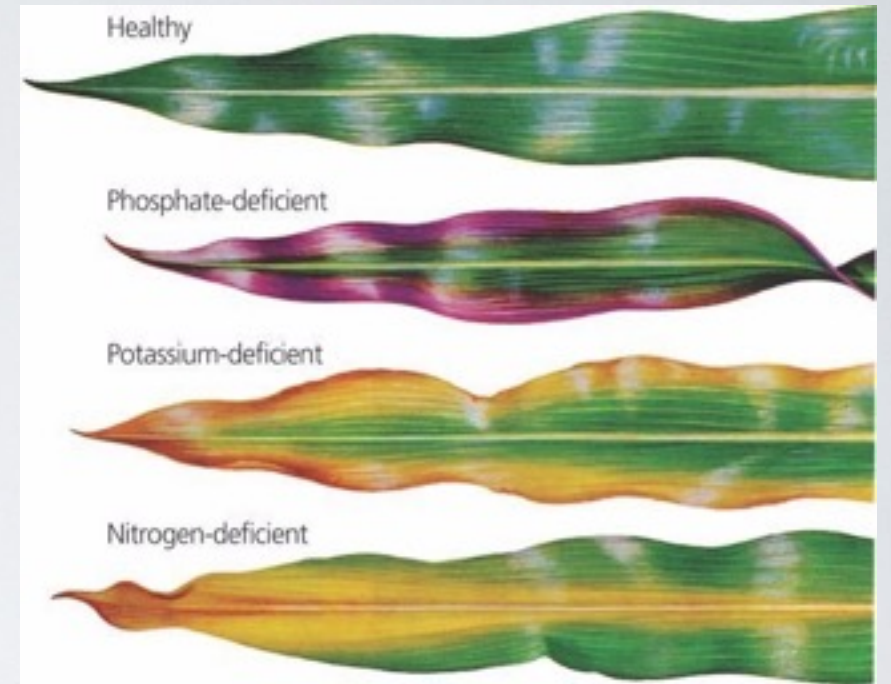


Build surveys with Excel and deploy to Android. Cache data until internet returns. Fraud detection and geospatial visualization.

[mobilesurvey.qed.ai]

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CROP ANALYSIS

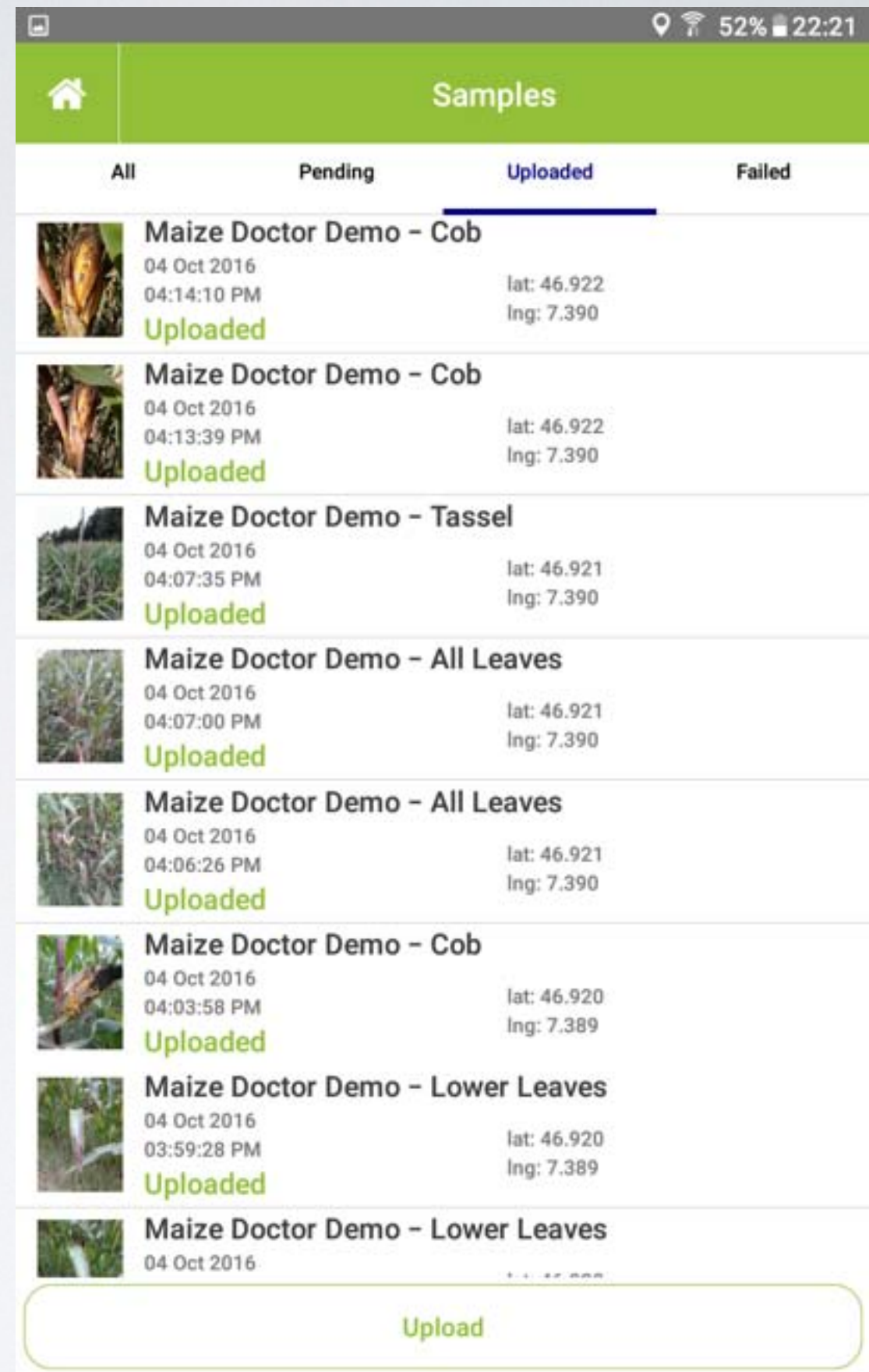
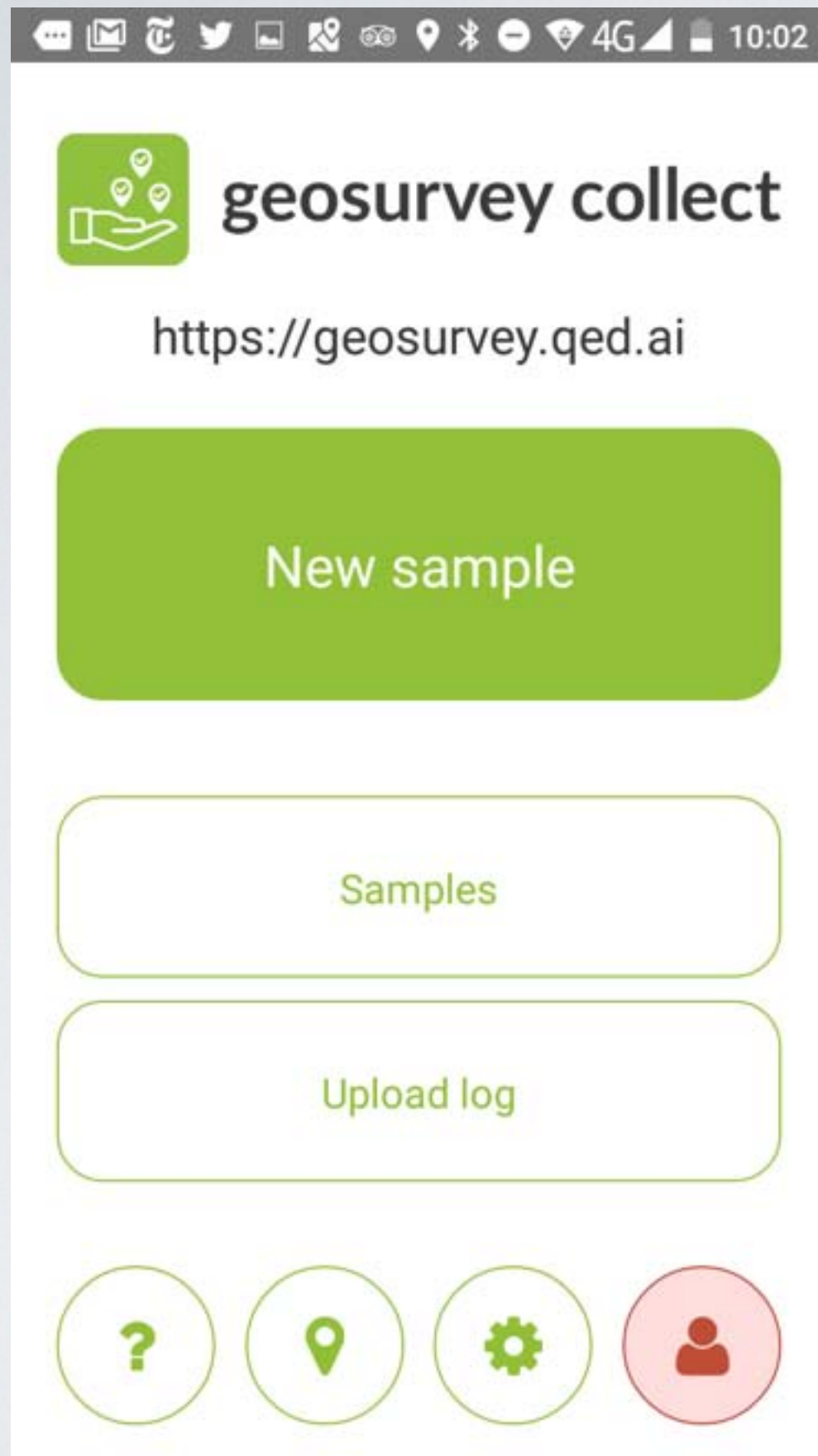


- **Huge yield losses annually from disease and nutrient deficiency. Needs fast intervention.**

GEOSURVEY COLLECT



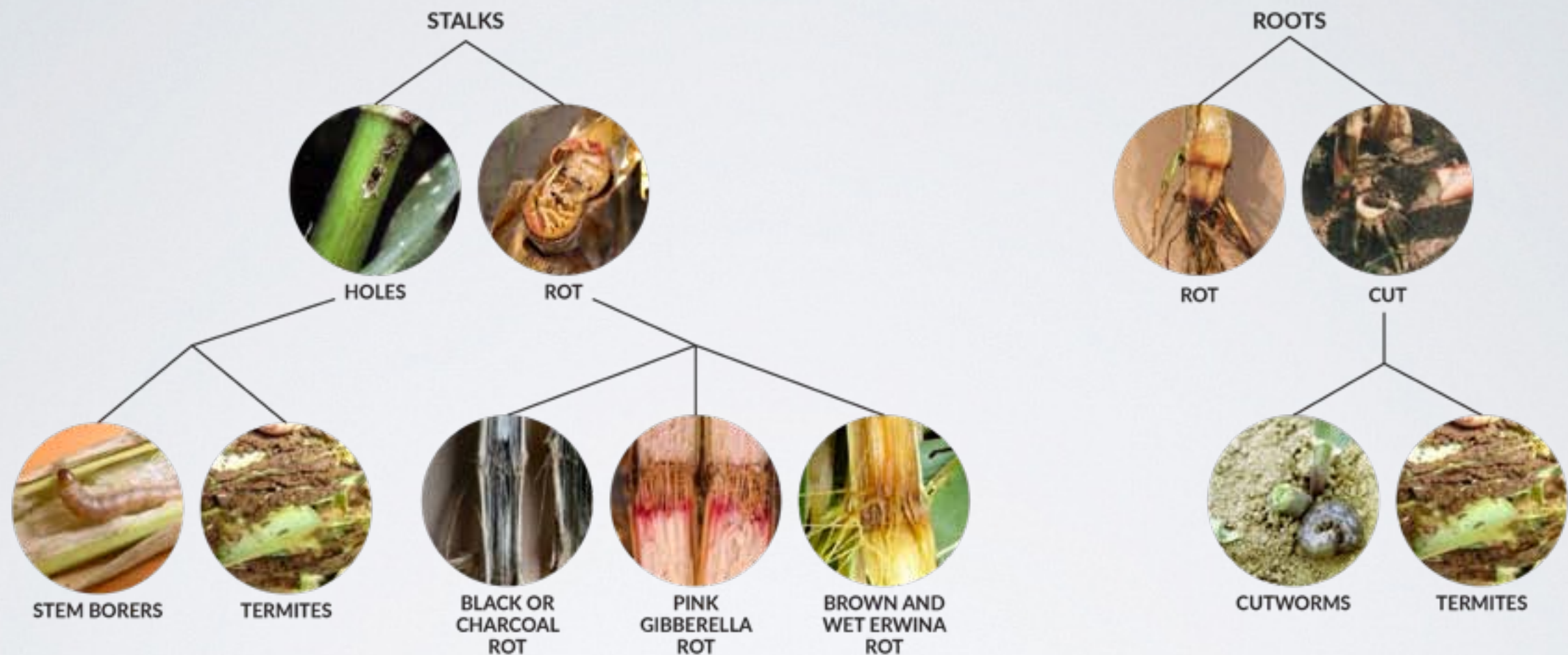
- **Field operators take pics.**
- **Diagnoses remotely provided on Geosurvey w/ interactive questionnaires.**



Maize Health Decision Tree v.1.0

Scientific Direction: Dr. David Guerena (1AF)

QED | <http://qed.ai>





Any stripes on the leaves?

☒ Yes ☐ No

Update

Close

View full-size image

Grid

Color:

☒ Show markers

Markers in a row:

Submitted by

david.guerena

2 months, 1 week ago

Max zoom

Google: 19

Bing: 19

Coordinates

(latitude, longitude)

-0.764838, 34.678611

Send a message to the
submitter

Save

Delete



Longitude:
34.678508
Latitude:
-0.764929
Zoom Level:
19
Country:
Kenya
Side length of box:
10000m



<https://youtu.be/SP0HTqlmv-Q>



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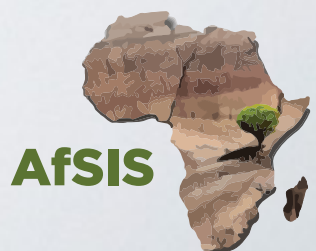


[weblink: uav-orthomosaic](#)



[[uav.qed.ai](#)]

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AutoDrone

Design flight plans for your drone
to fly autonomously offline.



AutoDrone

QED Tools

Everyone

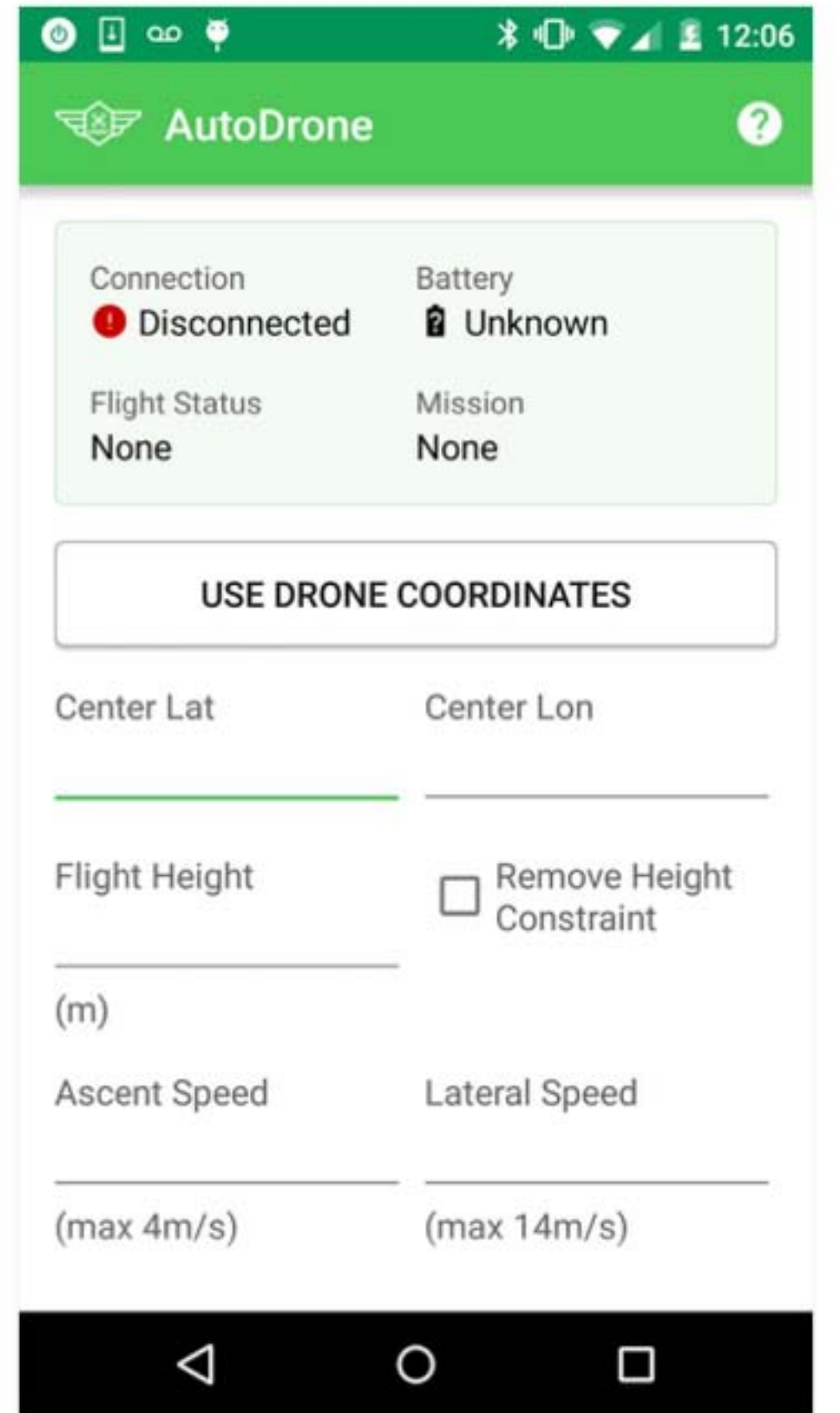
✕ This app is incompatible with your device.

Add to Wishlist

\$0.99 Buy

Automated orthomosaic flight
control. Works offline.
99 cents.

[uav:auto-drone]



AutoDrone

Connection **Disconnected** Battery **Unknown**

Flight Status **None** Mission **None**

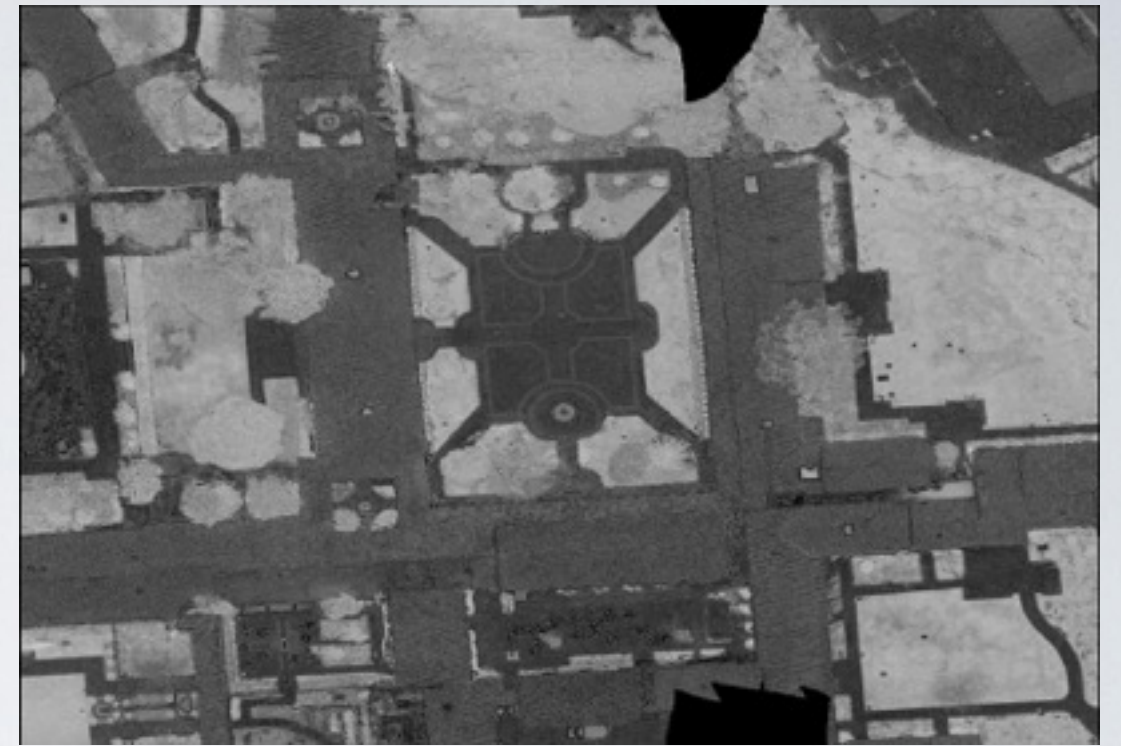
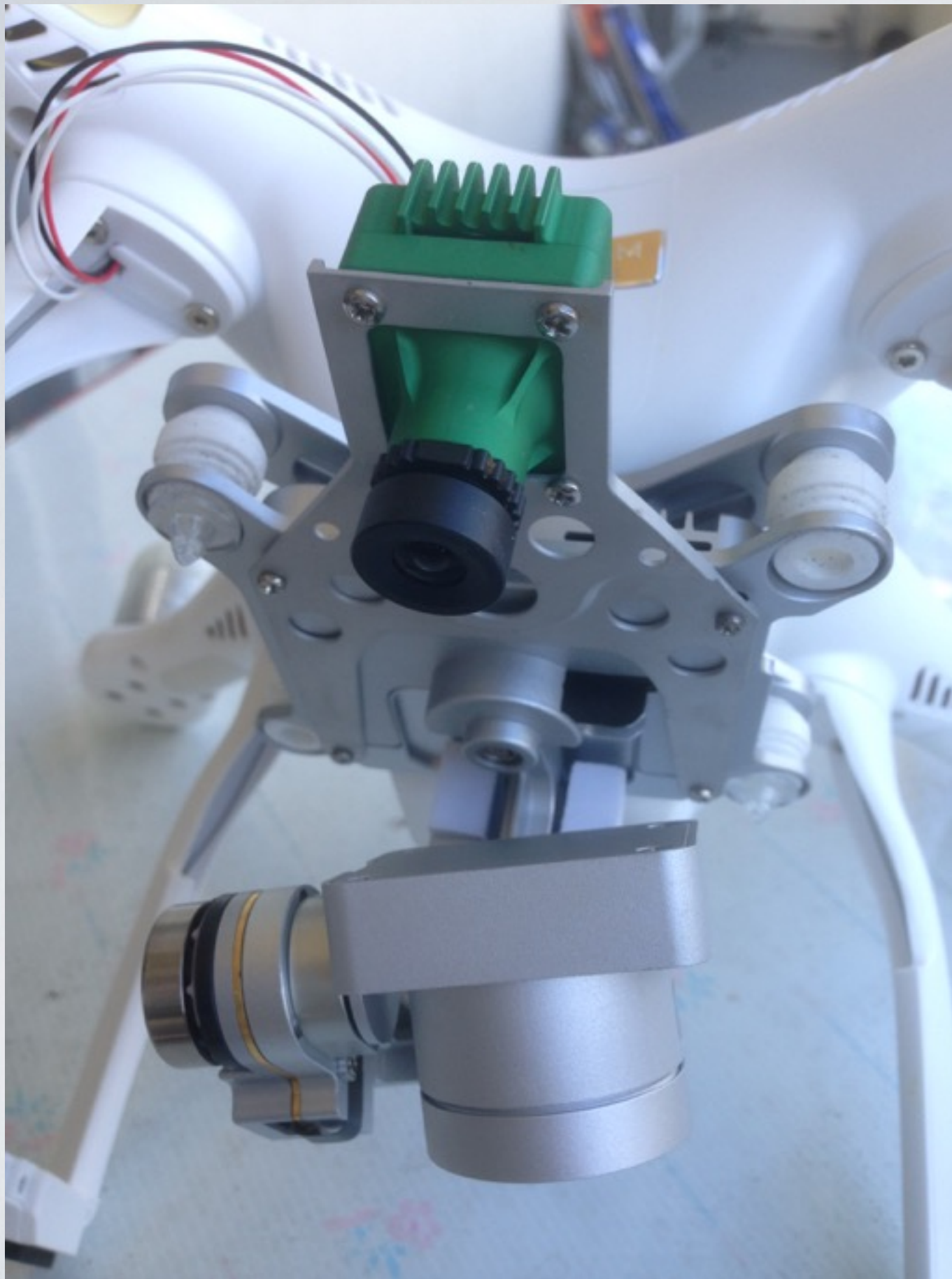
USE DRONE COORDINATES

Center Lat Center Lon

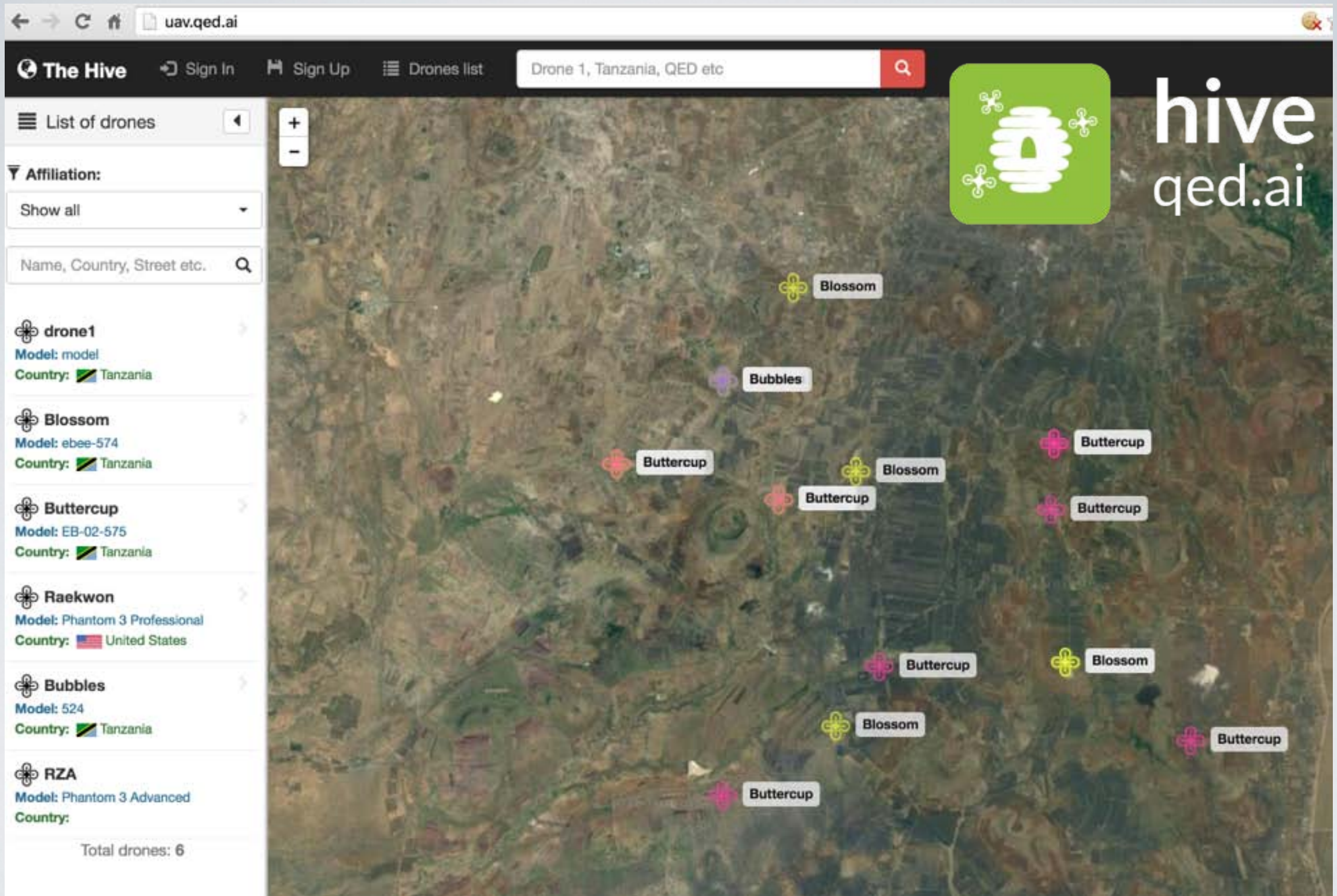
Flight Height (m)

Remove Height Constraint

Ascent Speed (max 4m/s) Lateral Speed (max 14m/s)



[uav:auto-drone]



Application: Store and visualize orthomosaics of UAVs in the cloud.

[\[hive.qed.ai\]](https://hive.qed.ai)

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<https://youtu.be/3wj6pvXsgOA>

[uav:methodman]

SUB-PROBLEMS

- determine ROI
- sampling frame
- navigate to sampling sites
- georeferenced extraction
- **lab analyses**
- database
- mapping (spatial-temporal modeling)
- decisions



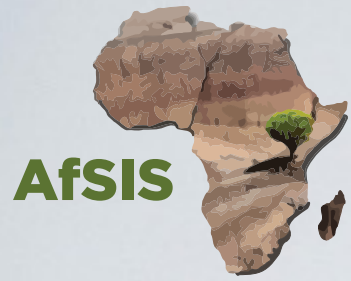
SOIL PROCESSING



[soil:preparation]

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SPECTROSCOPY

y = wet chemistry (\$\$\$) x = spectroscopy (\$)



given lots of (x,y) pairs, find f such that $y = f(x)$



spectpred
qed.ai

<https://www.kaggle.com/c/afsis-soil-properties>

SUB-PROBLEMS

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- **mapping (spatial-temporal modeling)**
- **decisions**

Change Wet Chemistry | AfsIS x William

afsisdb.qed.ai/cabinet/wetchemistry/1933/change/

AfsIS DB qed.ai Friday, 7th October 2016 14:44 Welcome, AfsIS DB. Change password | Log out

Home Search Authentication and Authorization

Cabinet

Carbon and Nitrogen
Georeferences
Laser Diffraction Particle Size Analyses
PXRF
Soil Moisture
Spectroscopy OPUS records
Wet Chemistry

CSV Imports and Exports
Info
Invites
Log of Permission Changes
Spectroscopy OPUS records downloads
Metrics

Home » Cabinet » Wet Chemistry » icr076582

Group: *	AfsIS
SSN: *	icr076582 ?
Public:	Yes
	A public sample is accessible to all users.
EC:	0.193 ? dS m ⁻¹
	Soil electrical conductivity (soil: water ratio of 1:2 weight to volume basis)
ExAc:	0.43 ? cmolc kg ⁻¹
	Exchangeable Acidity
ExBas:	9.973306631 ? cmolc kg ⁻¹
	Sum of Mehlich-3 bases (Ca, Mg, K, Na)
M3 Al:	1670.0 ? mg kg ⁻¹
	Extractable Aluminum concentration by Mehlich 3 extraction
M3 B:	0.041 ? mg kg ⁻¹
	Extractable Boron concentration by Mehlich 3 extraction
M3 Ca:	1590.0 ? mg kg ⁻¹
	Extractable Calcium concentration by Mehlich 3 extraction
M3 Cu:	0.77 ? mg kg ⁻¹
	Extractable Copper concentration by Mehlich 3 extraction
M3 Fe:	94.9 ? mg kg ⁻¹
M3 K:	169.0 ? mg kg ⁻¹
M3 Mg:	180.0 ? mg kg ⁻¹

Save

Save and continue editing

Save and add another

Delete

Tools

History

Add Wet Chemistry



AfsIS DATABASE

Application: Cloud DB of soil information. RDBMS performance, off-site backup, batch upload, input validation, geospatial search, API support.

[afsisdb.qed.ai]

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- **mapping (spatial-temporal modeling)**
- **decisions**

The screenshot shows the 'maps.qed.ai' web application. The browser address bar displays 'maps.qed.ai/map/browse/'. The page has a dark navigation bar with the 'maps qed.ai' logo, a search bar, and links for 'Home', 'Maps', 'Sign Up', 'Log In', 'Terms of Use', and 'Privacy Policy'.

Browse Layers

Type here

YEAR

- 1978 (4)
- 1979 (4)
- 1980 (4)
- 1981 (6)
- 1982 (6)
- Show more...

MONTH

- January (12)
- February (13)
- March (13)
- April (13)
- May (13)
- Show more...

SPATIAL RESOLUTION

- 30000m (34)
- 250m (131)
- 1000m (78)
- 5000m (47)
- 100m (31)
- Show more...

REGION

- Africa

Long-term Average Reflectance Band 2, 2000-2014
Q Africa

Long-term Average Reflectance Band 1, 2000-2014
Q Africa

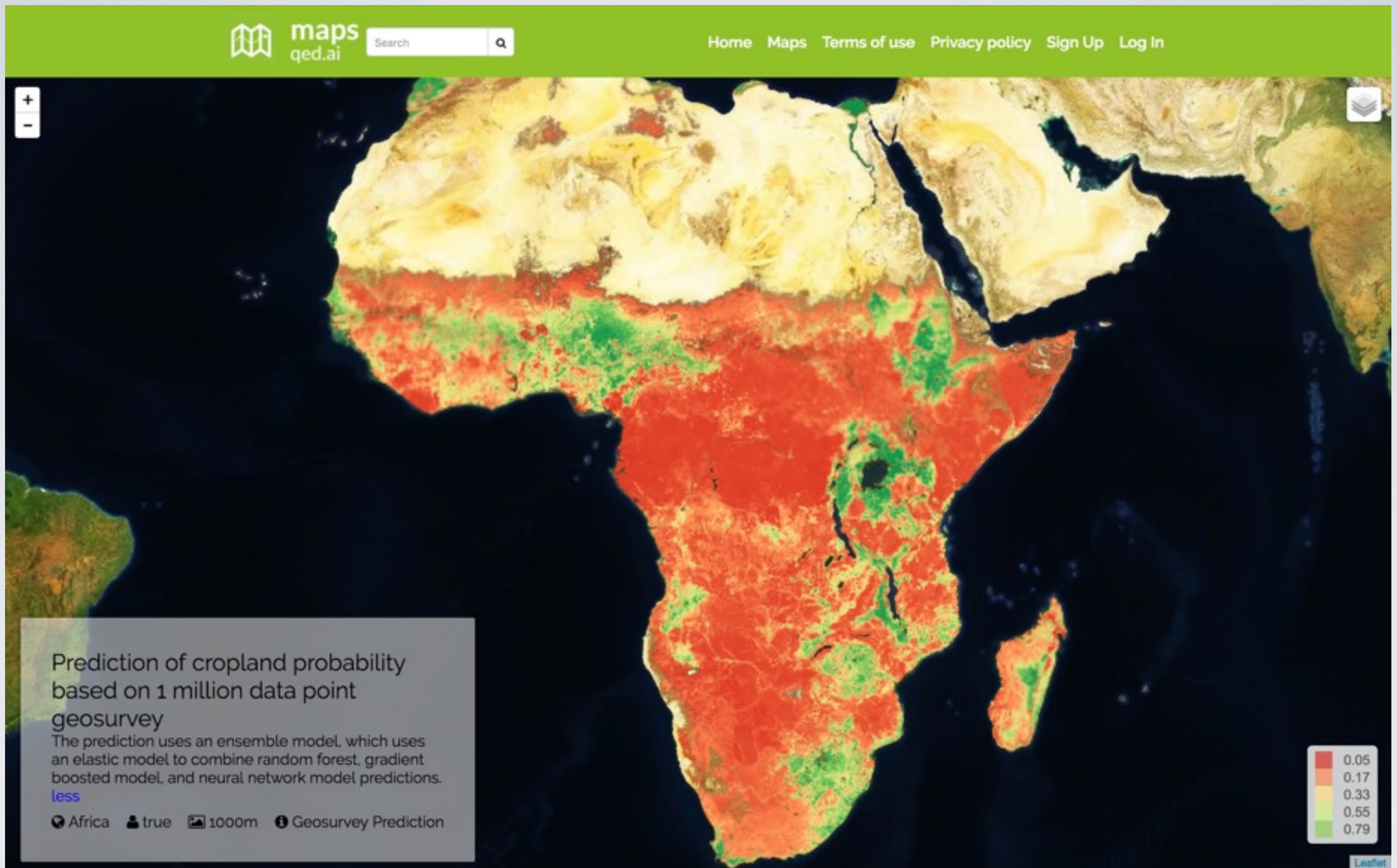
Enhanced Vegetation Index Average, 2010
 The MODIS MOD13Q1 Enhanced Vegetation Index is an index measurement of greenness. Index values closer to 1 indicate an abundance of vegetation whereas values closer to 0 indicate scarce vegetation. This image contains the annual average of all EVI observations in 2010.
Q Africa 2010 Q yearly average

Land surface temperature (LST) night time series monthly average, February
 The MODIS MYD11A2 Land Surface Temperature (LST) is a measure of ground temperature of the Earth's surface in degrees Celsius. This image contains the time series monthly average for February, using all available February LST Night observations from February 2003 - February 2015.
Q Africa February Q monthly average

Normalized Difference Vegetation Index Time Series Average, July
 The MODIS MOD13Q1 Normalized Difference Vegetation Index (NDVI) is an index measurement of greenness. Index values closer to 1 indicate an abundance of vegetation whereas values closer to 0 indicate scarce vegetation. This image contains the time series monthly average for July, using all available July NDVI observations from July 2000 - July 2015.
Q Africa July Q monthly average



Scalable viz. and mgmt. of remote sensing layers and geospatial predictions.



Scalable viz. and mgmt. of remote sensing layers and geospatial predictions.

SUB-PROBLEMS

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- **database**
- **mapping (spatial-temporal modeling)**
- **decisions ...**

CONCLUSION



Soil Erosion

Nutrient Imbalance

Plant Disease

Financial Services

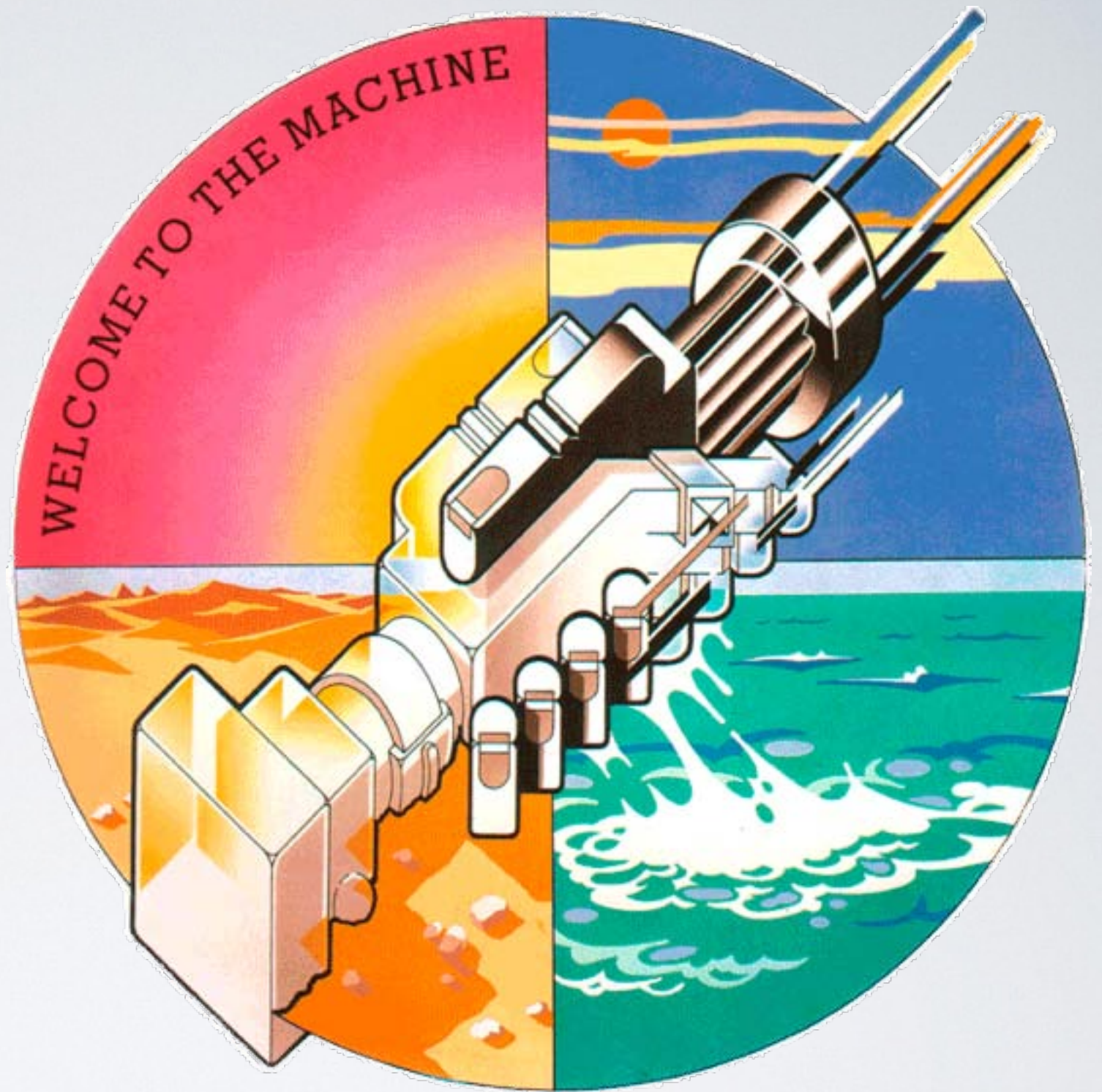
Market Access

Yield Gaps

Child Mortality

Malnutrition

Climate Change





SPEED

SCALABLE PIPELINE FOR ENGINEERING OF ENORMOUS DATA

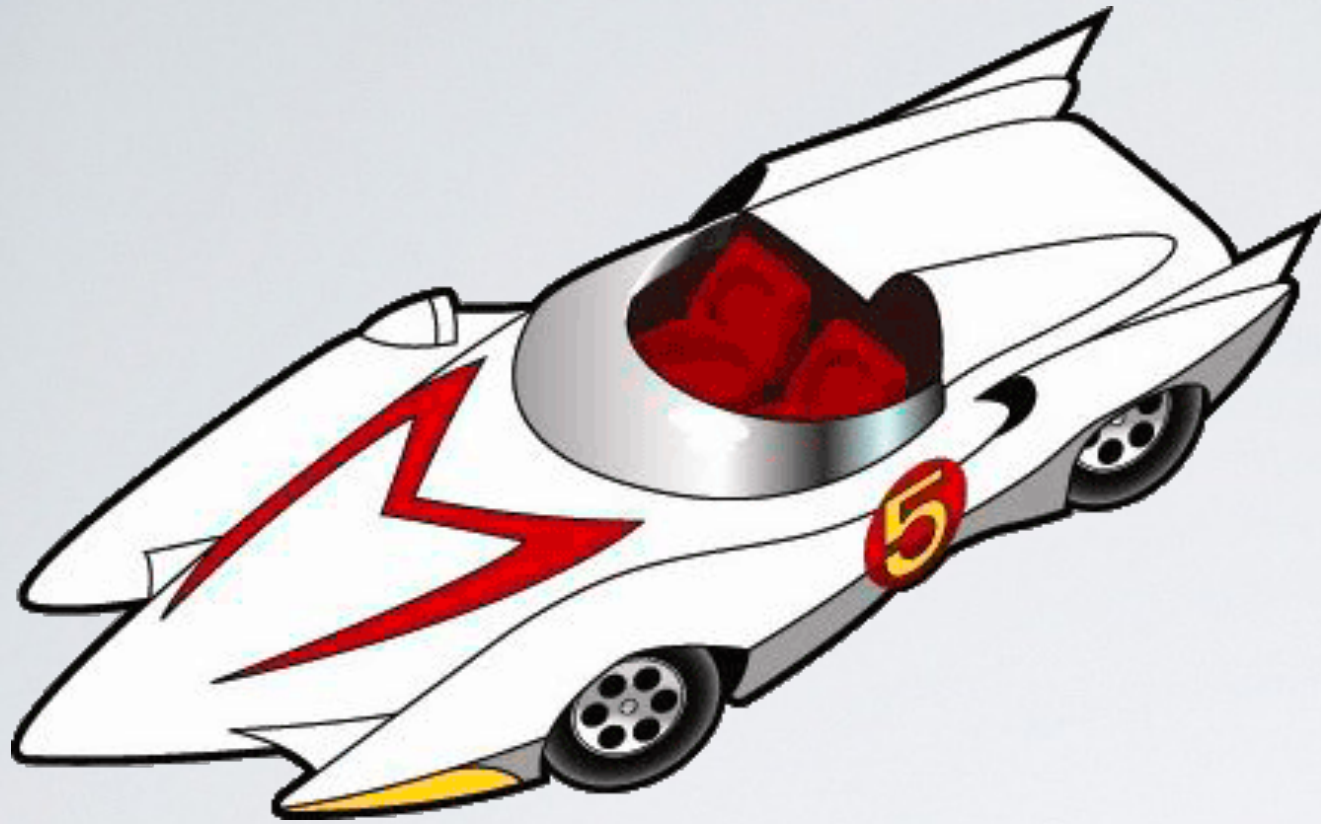
End-to-end technology solutions to support systematic geospatial data collection and analysis.



QED APP LEGEND

- 1** geosurvey
- 3** sampling
- 4** tag
- 5** navigation
- 5** grid locator
- 5** tsp
- 7** uav:quadcopter
- 7** uav:fixed-wing
- 6** **8** mobilesurvey
- 6** **8** geosurvey collect
- 9** tag maker
- 10** id card maker
- 13** dna
- 14** maps
- 15** inventory

qed.ai/speed



+



Technology

Driver = ?

“War is ninety percent information.”
- Napoleon Bonaparte

“In God we trust; all others must bring data!”
- William Edwards Deming



THANKS FOR LISTENING!



To get in touch:

info@qed.ai

<http://qed.ai>

#TweetQED