Modeling barrier discovery

Can satellite data be used to fill data gaps?

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AMBER
LET IT FLOW

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 689682.

Free Flow Conference 15-17 April 2024

Swansea University
Prifysgol Abertawe

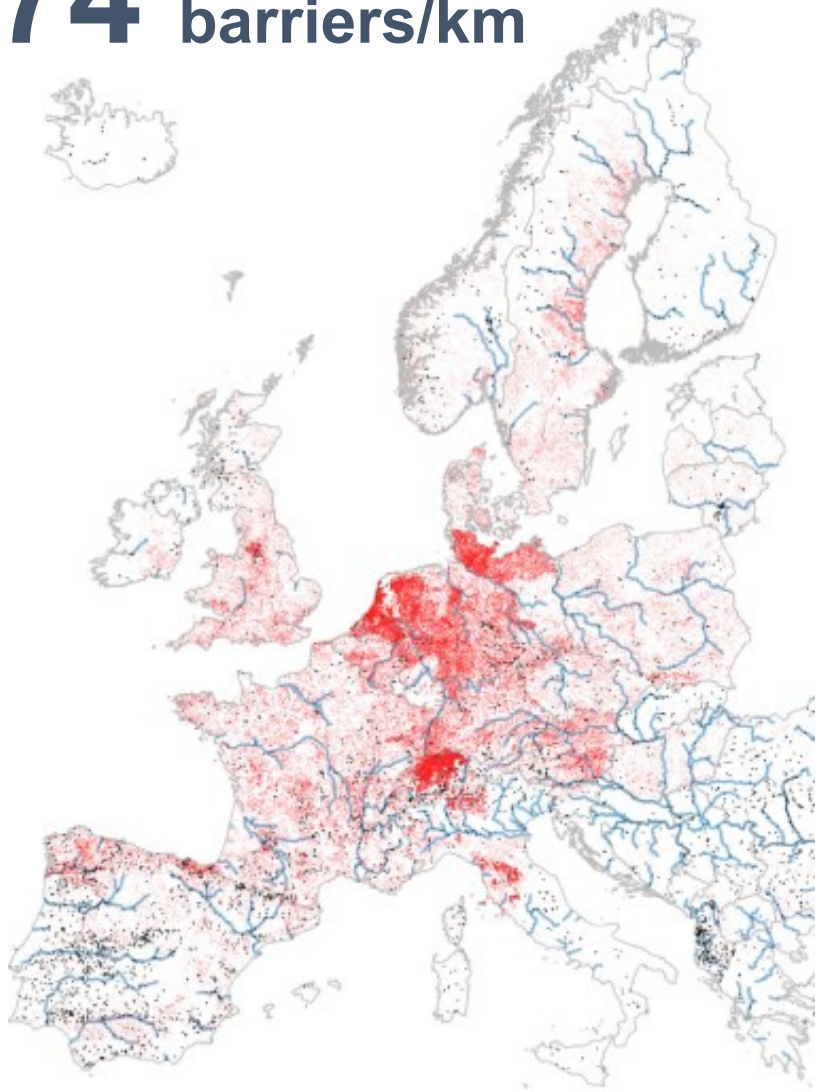
The problem

+1.2M barriers

Goal of +25K of free-flowing rivers in EU by 2030

European Barrier Density

0.74 barriers/km



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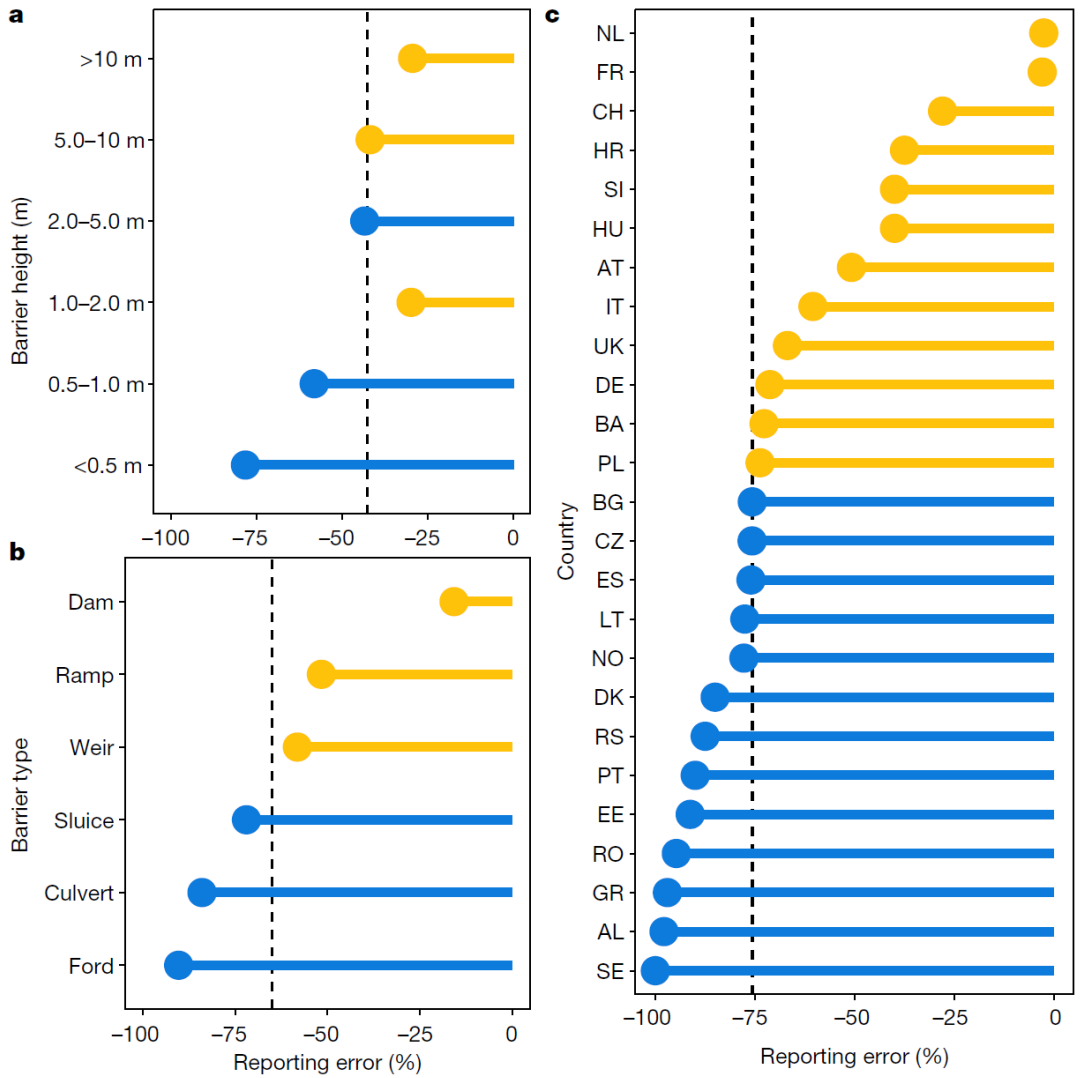
Belletti et al. (2020) *Nature*

The problem

Half of the barriers are missing....

Complete walkover surveys are expensive & time consuming



Belletti et al. (2020) *Nature*

It would take
two people walking

356 yrs

to locate all missing
barriers in Europe*

*or 1 year for a small battalion of 800 people to cover 1.3M km of river network @ 10km/day

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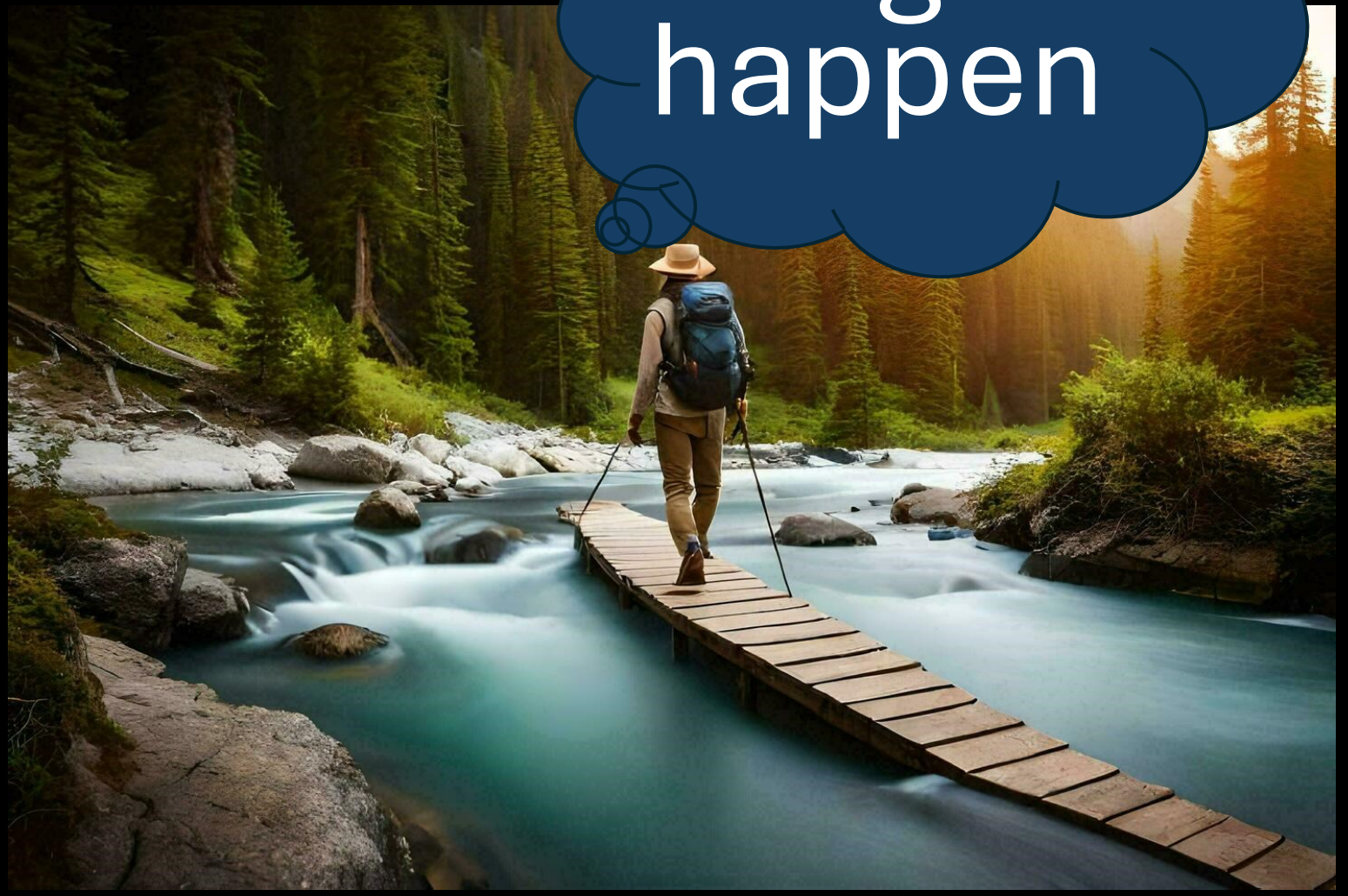


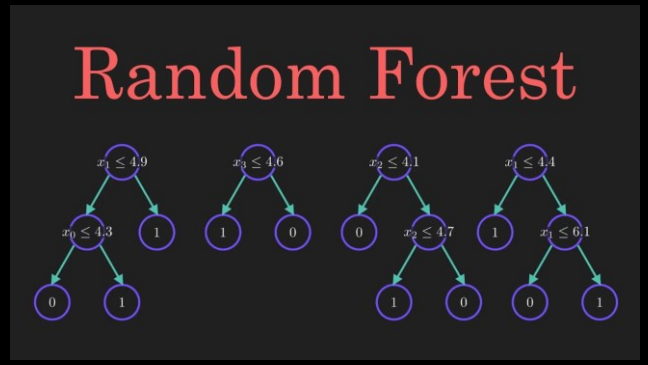
*or 1 year for a small battalion of 800 people to cover 1.3M km of river network @ 10km/day

So what are the alternatives...?

1. Remote sensing

2. ML modeling

3....or even better BOTH



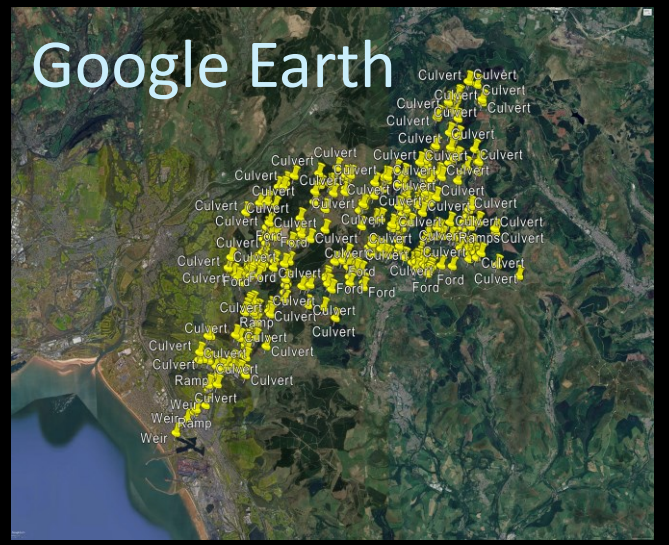
Our study

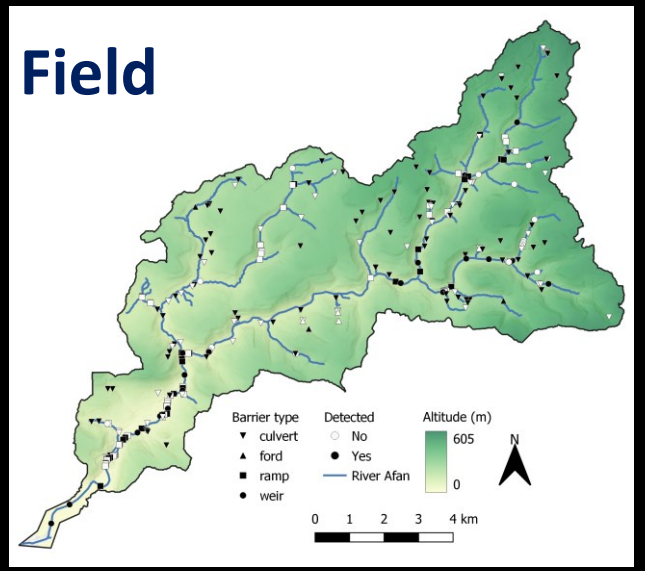
R. Afan - Complete survey

1. Cross-referenced 468 known barriers (incl a complete walkover) with Google Earth

2. Used ML to model barrier detection (LR, RF, Boosted Trees)

3. Which barriers are detected? which barries are missing?



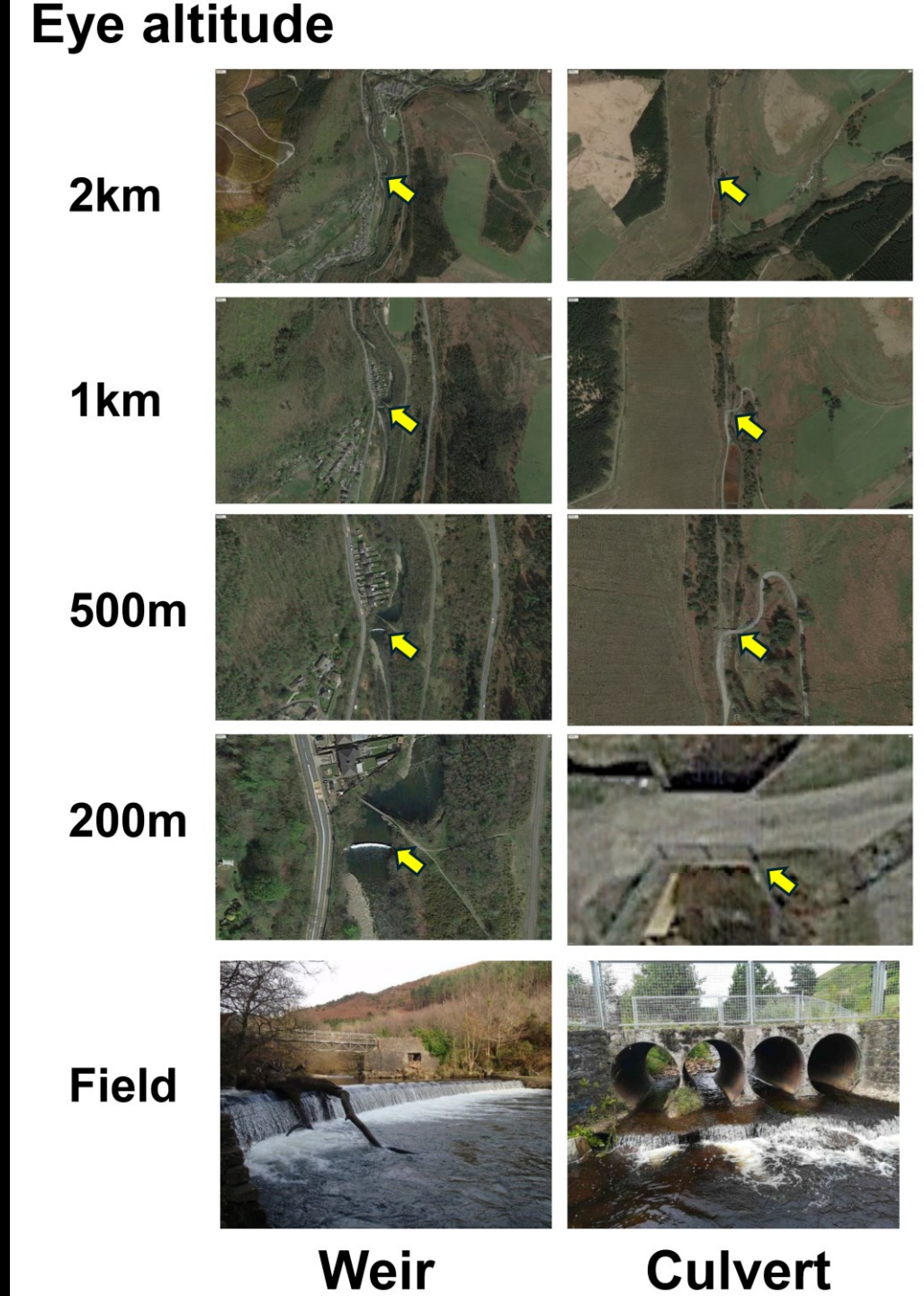


GE Detection*

No barrier could be detected from satellite images (>2Km altitude)

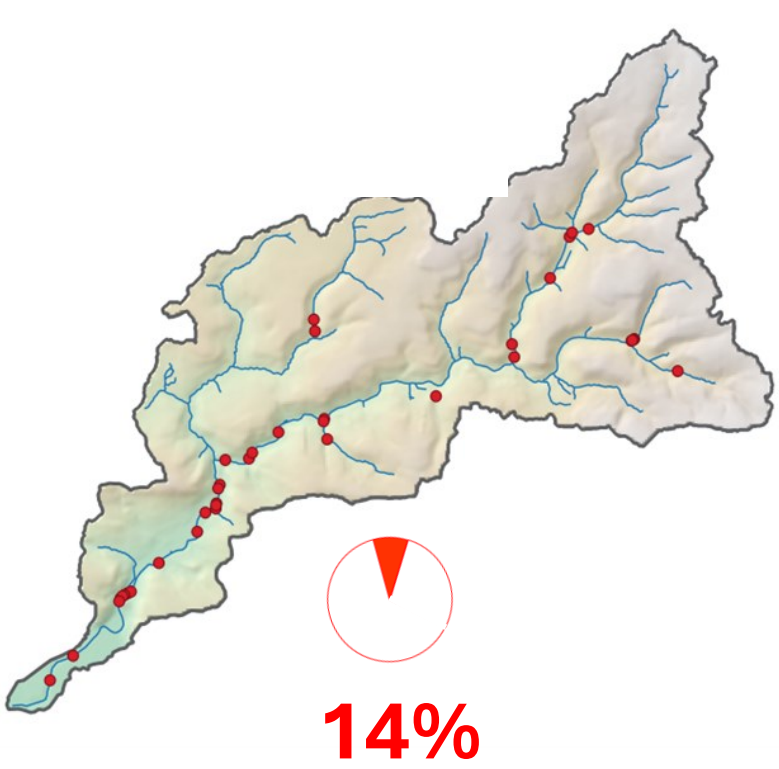
but some could be detected from aerial photos (<500m altitude)

*Google Earth stiches together satellite & aerial images



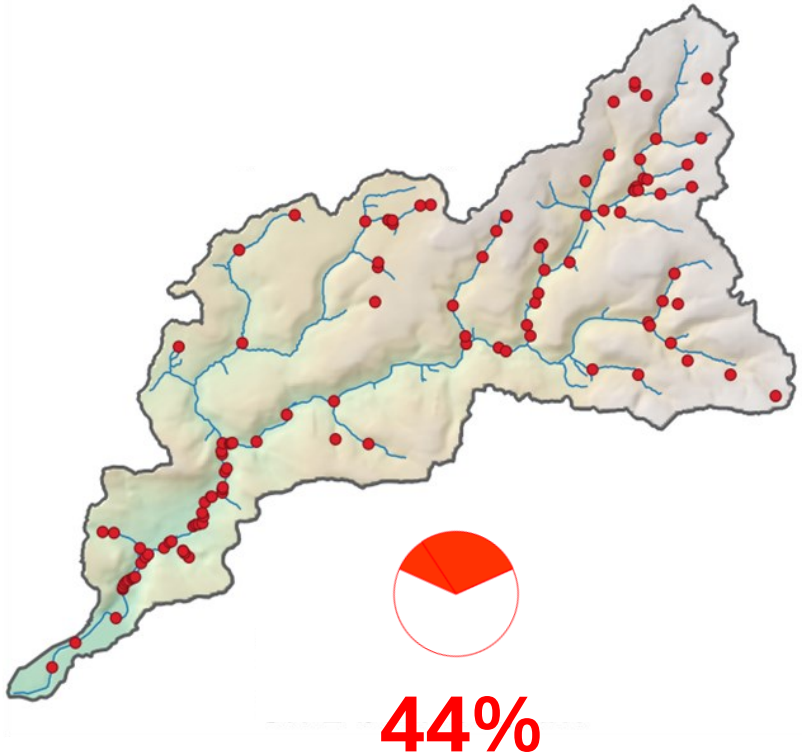
Expense

National Atlas
41 barriers



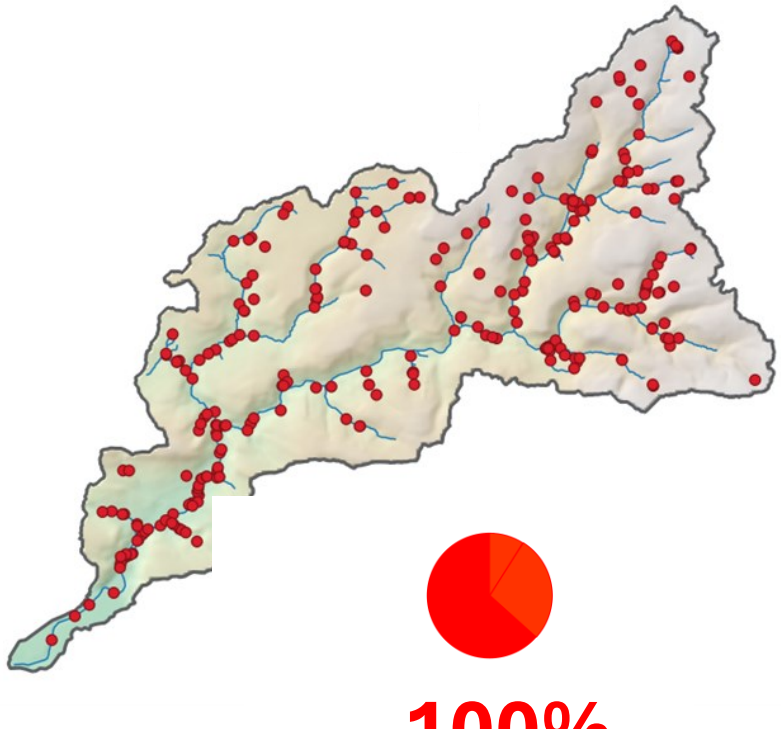
14%

Google Earth
126 barriers



44%

Walkover
289 barriers

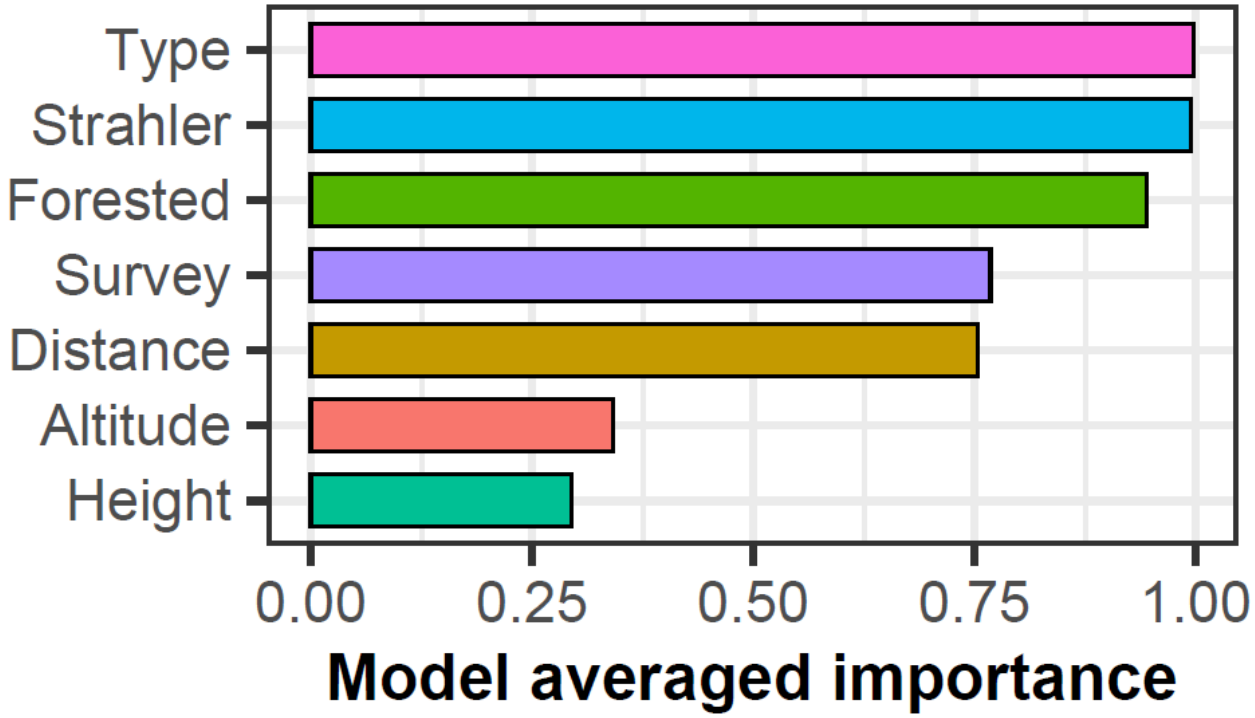


100%

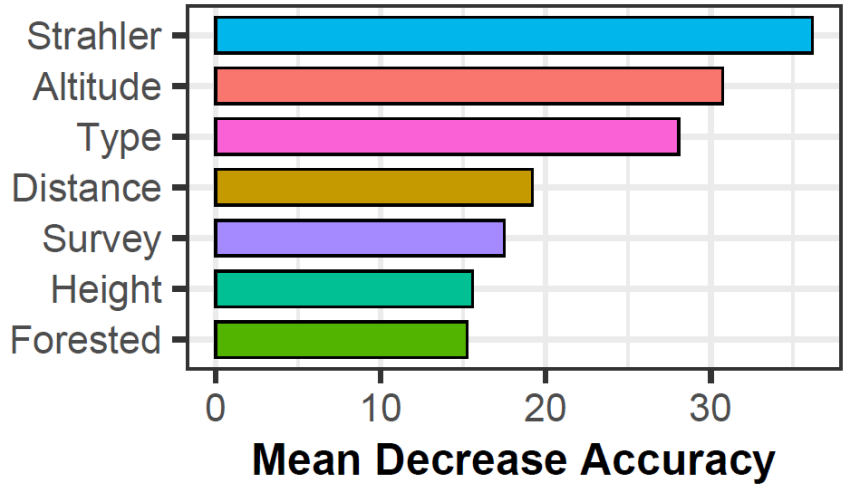
Accuracy

What determines detection?

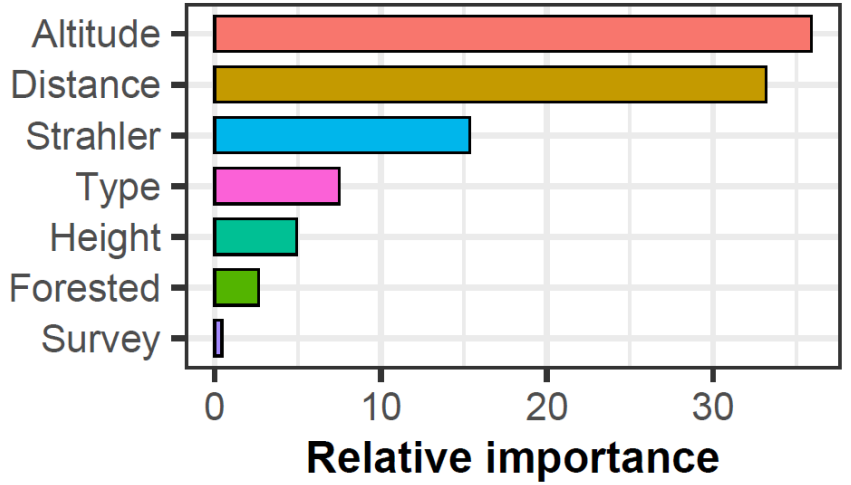
Logistic Regression (AUC = 0.62)



Random Forest (AUC = 0. 57)



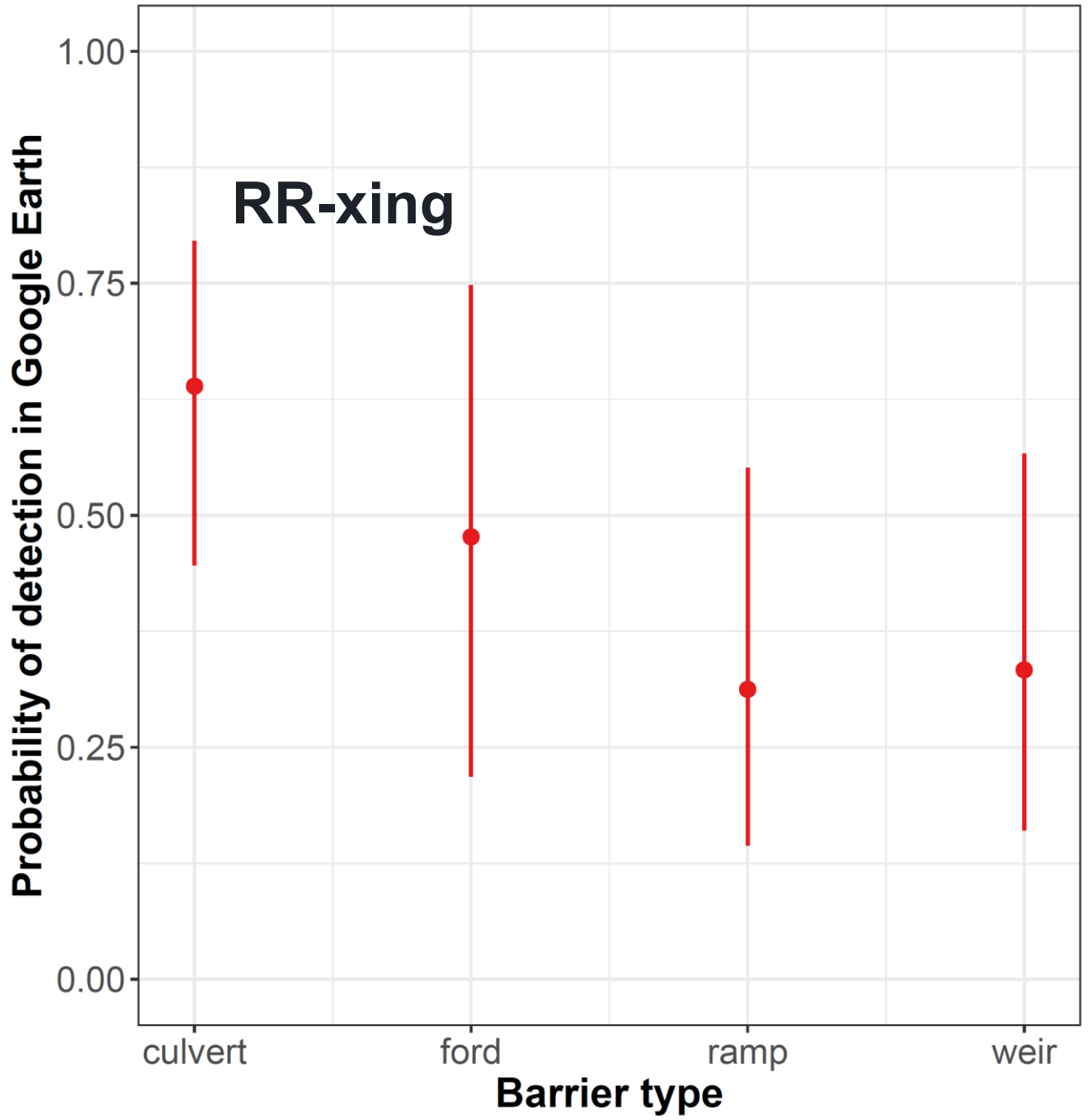
Boosted Trees (AUC = 0.86)



Barrier type

$P < 0.001$

Barriers are easier to detect at river-road crossings



Culvert

pd = 0.63

	Field	Google Earth
Undetected		
Detected		

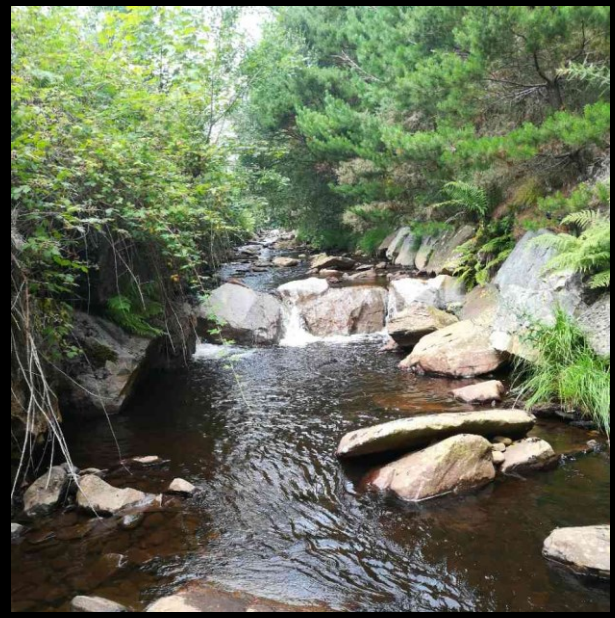
Ford

pd = 0.48

	Field	Google Earth
Undetected		
Detected		

Ramp

pd = 0.33

	Field	Google Earth
Undetected		
Detected		

Weir

pd = 0.34

Field

Google Earth

Undetected

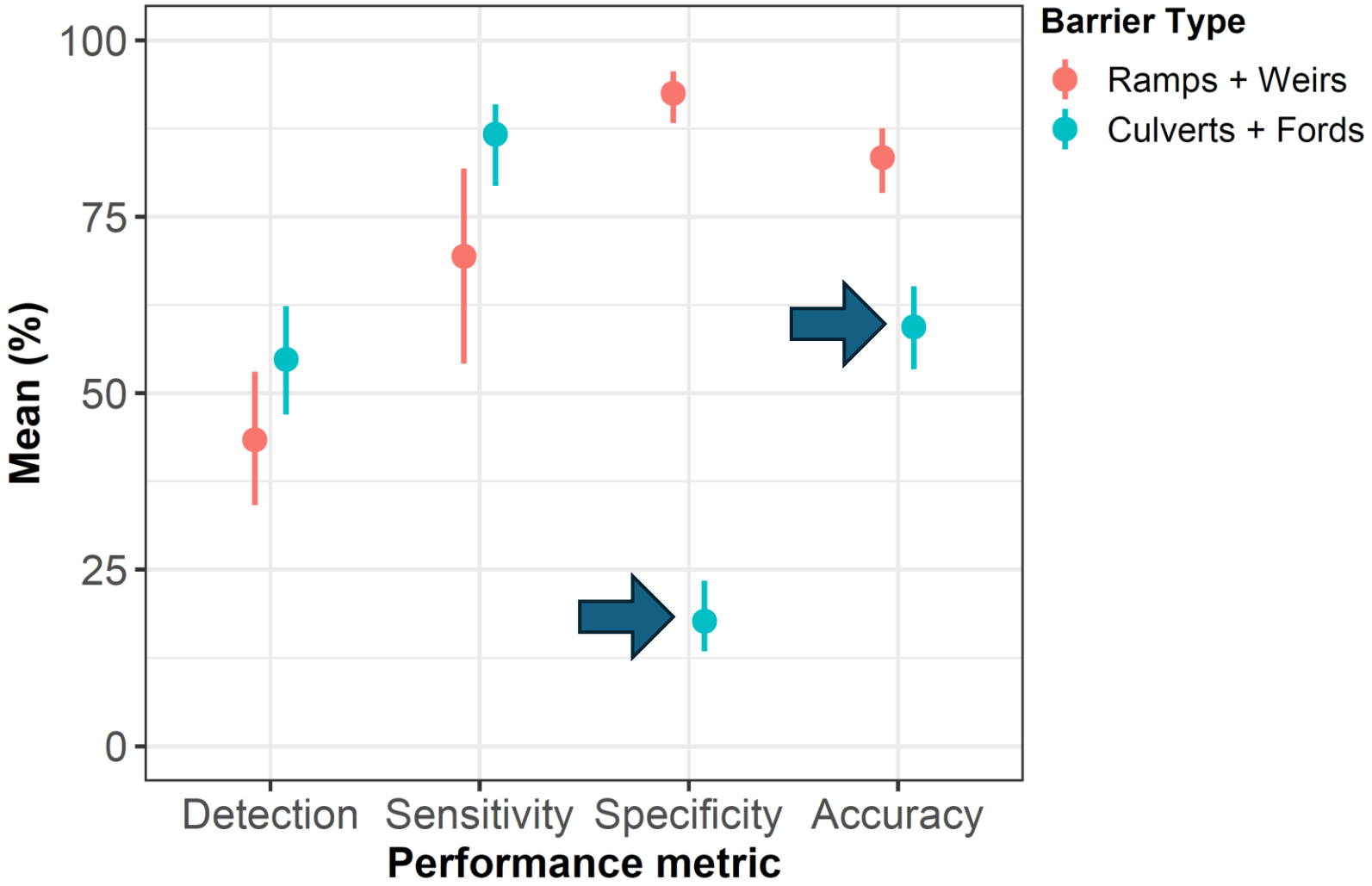
Detected

Remote detection metrics

Barriers at RR Xings are easier to detect remotely but....

1. Low specificity

2. Poor accuracy

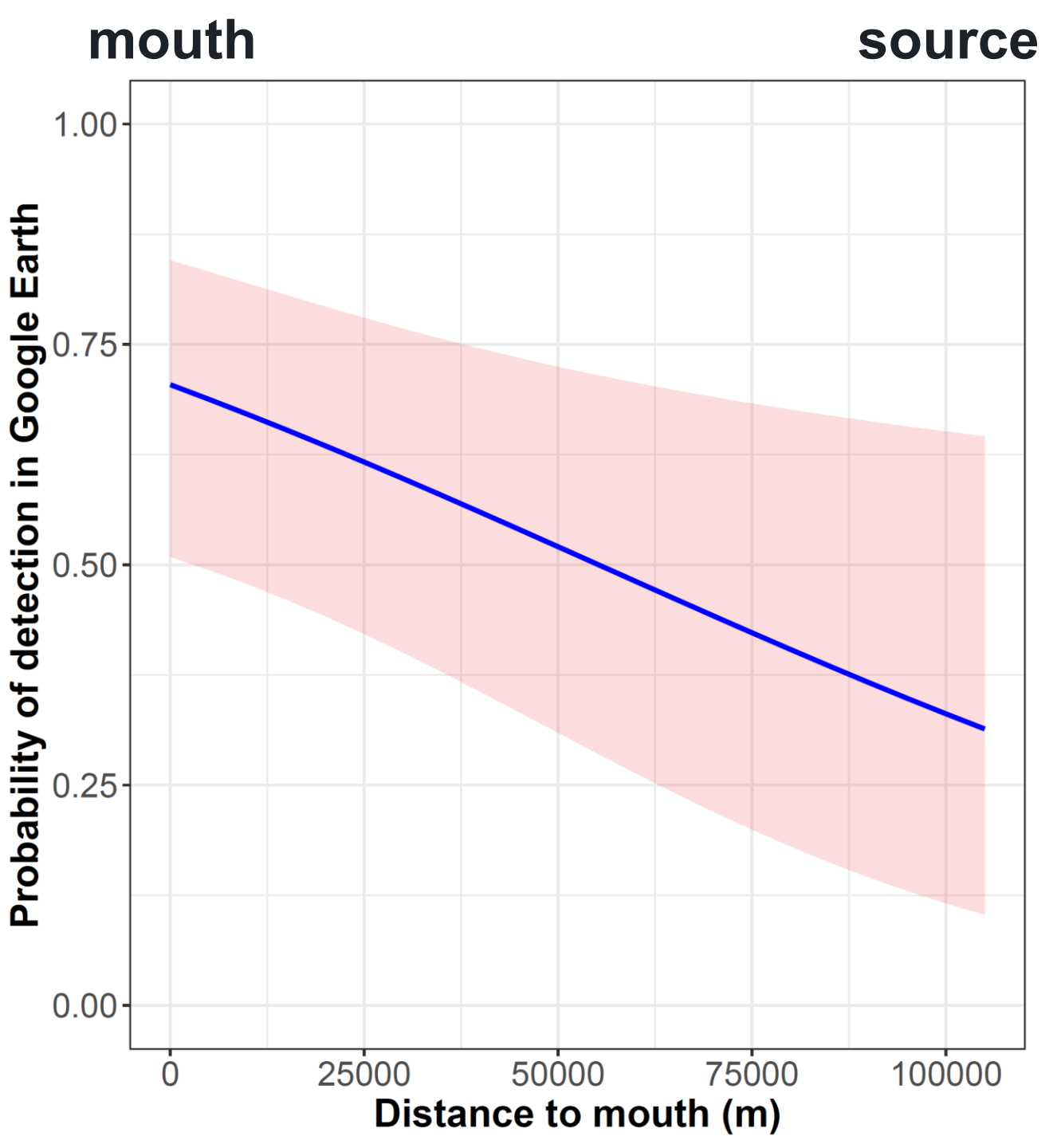


Distance to river mouth

P = 0.02

Barriers are harder to detect in the head waters

Every 10 km one moves upstream reduces *p* detection by ~3%

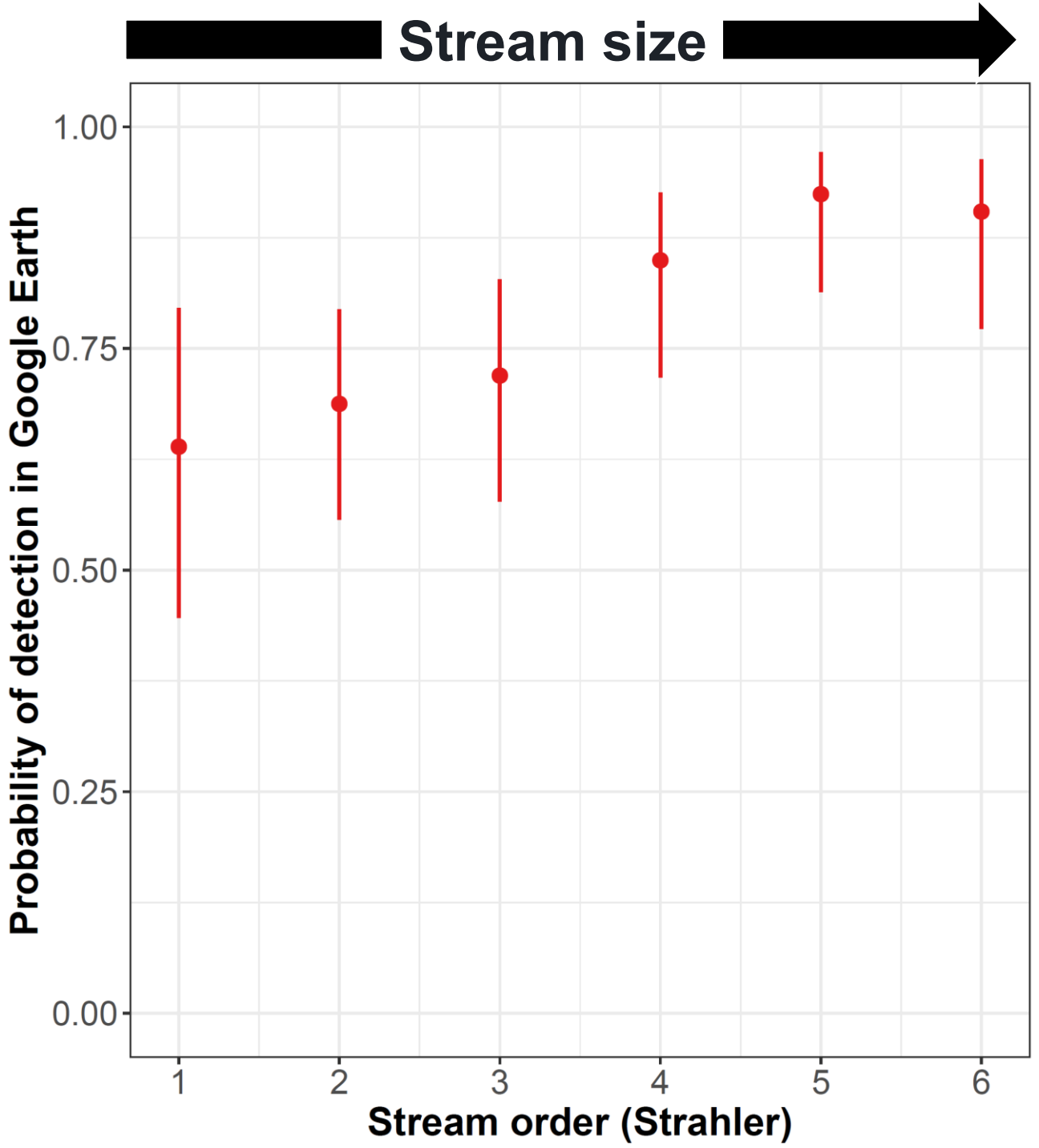


Stream order

P<0.001

Barriers are harder to detect in small rivers

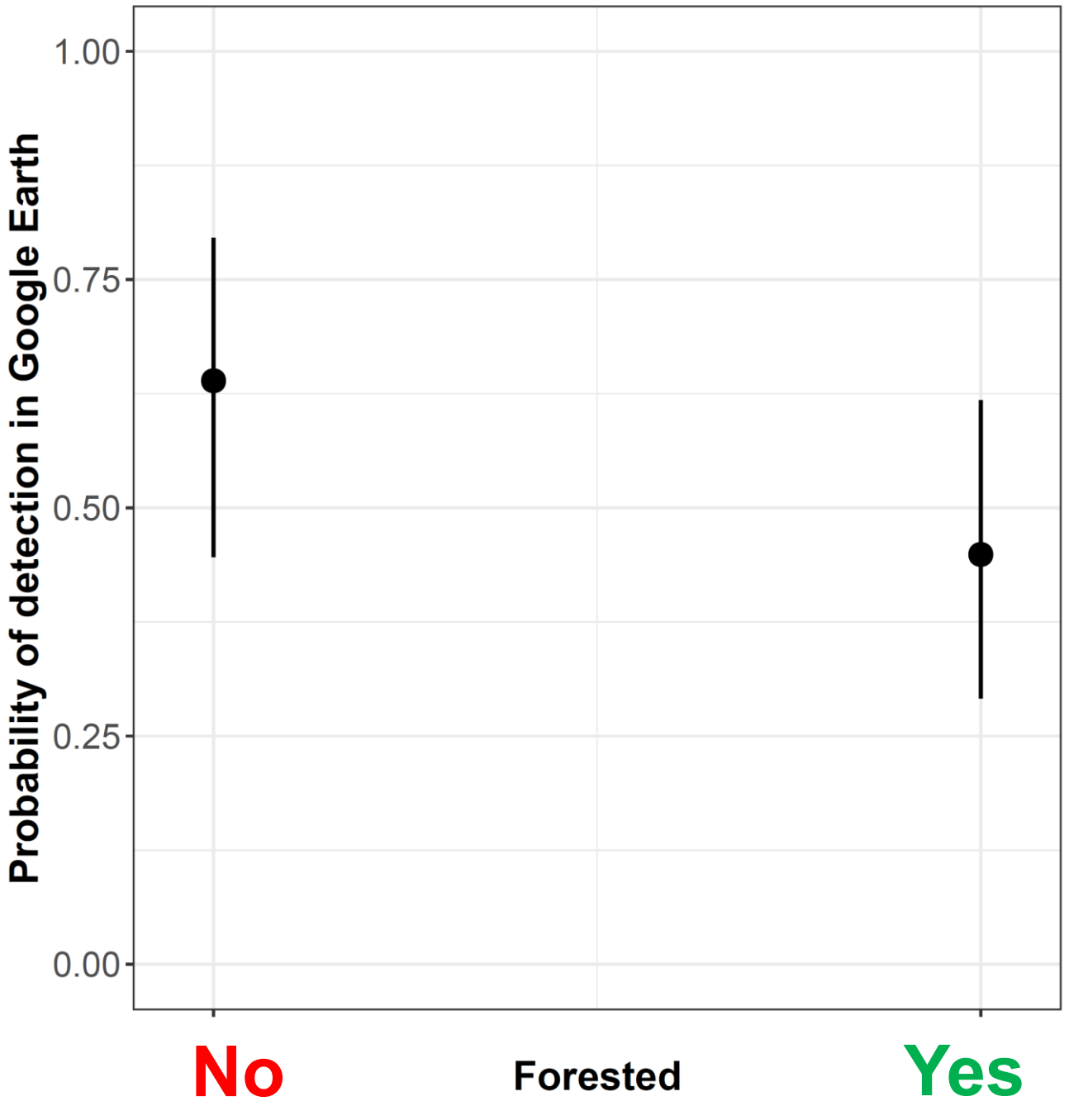
Every unit decrease in stream order reduces *p* detection by ~4%



Forest cover

P = 0.004

Barriers are 54% harder to detect in forested reaches



Conclusions

1. Remote sensing detected
   48% of known barriers

2. ML can predict barrier numbers
   and most likely locations

3. …but boots on the ground are
   needed for efficient barrier prioritization

Thank you