

# Harnessing deep learning in the war against pests

Brent Martin

Manaaki Whenua Landcare Research

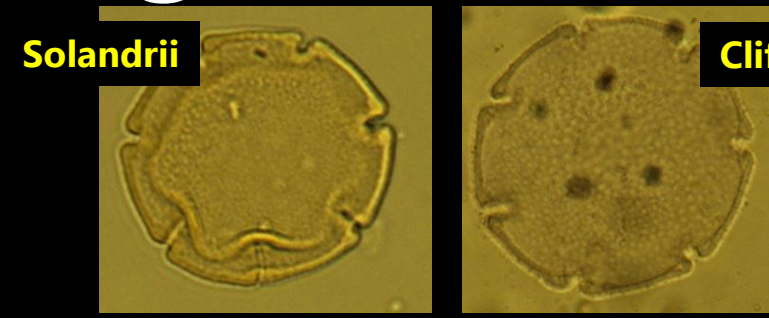
Remote Sensing: more than meets the eye

17<sup>th</sup> May 2023





# Deep learning at Manaaki whenua

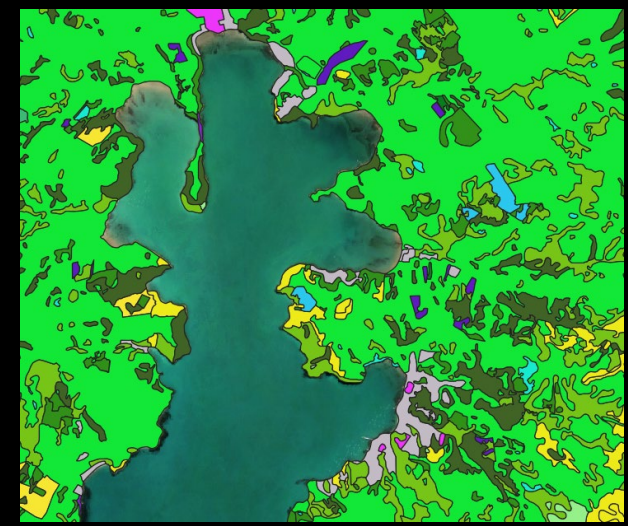


Species classification

Predator detection



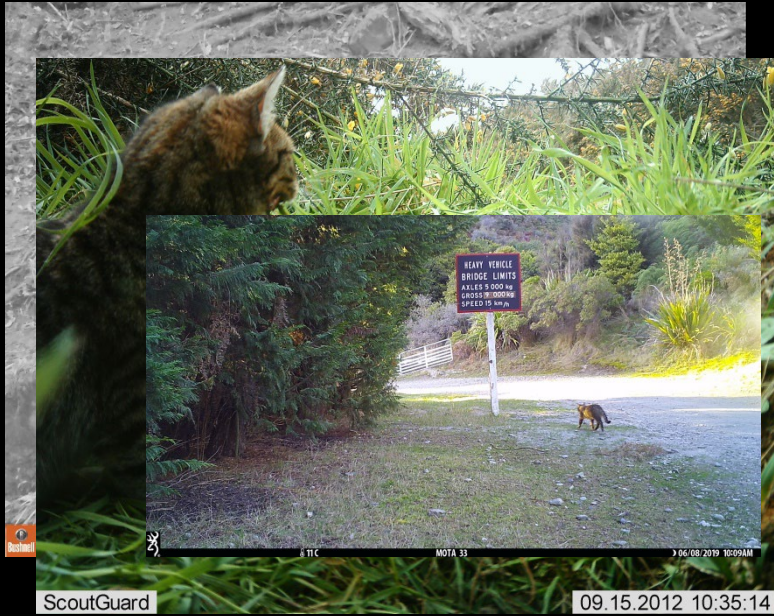
Land segmentation



Autonomy?



# Detecting predators



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- 10,000+ images from the field
- Many false triggerings
- Time-consuming to sort
- Can deep learning help?



# AI's promise



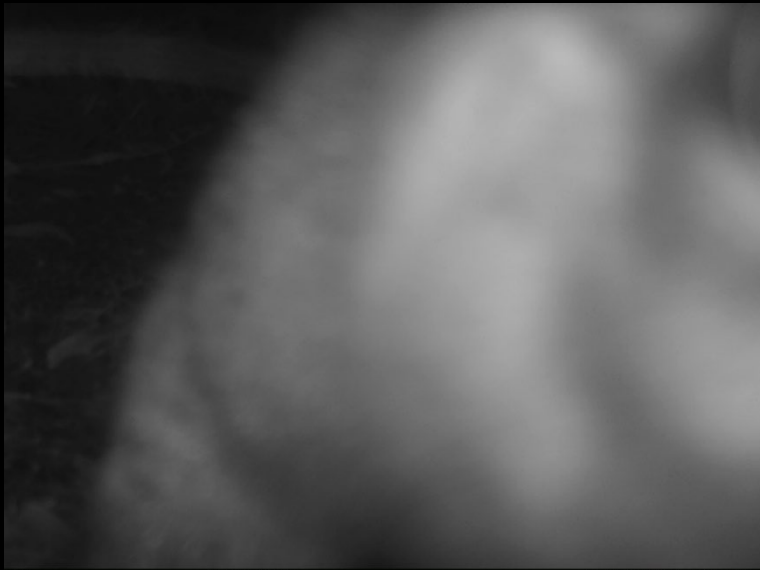
YOLO on Serengeti dataset

95% accuracy



CamerarTrapDetectR on North American Camera Trap Images (NACTI) dataset (Tabak et al, 2022)

# Reality for trail cameras...



13 C TRAILCAM01 11/28/2018 02:20AM  
2015-06-14 4:42:53 AM M 5/5 11°C



7 C CAM398  
2015-06-13 5:53:29 AM M 1/5 12°C



HCO ScoutGuard 6.16.2012 17:51:43



PC900 PROFESSIONAL RECONYA



PC900 PROFESSIONAL RECONYA



PC900 PROFESSIONAL RECONYA

**70-75% accuracy**

# Problem: lack of training = camera bias



Solution: two-stage pipeline



# Performance



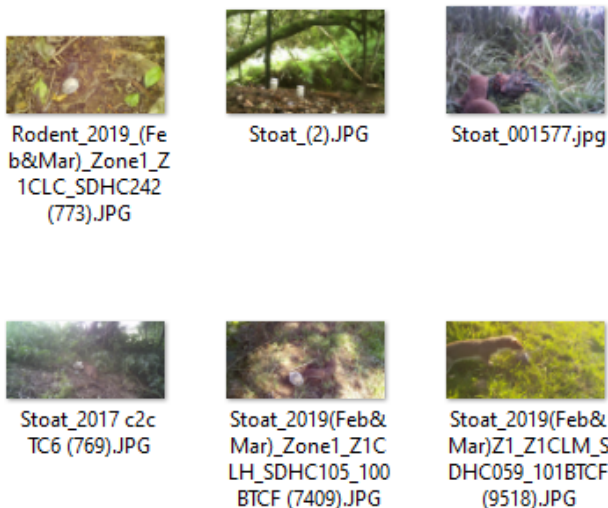
ACTUAL/PREDICTED	bird	cat	deer	empty	ferret	goat	hedgehog	kiwi	lagomorph	livestock	pig	possum	rodent	stoat	wallaby	RECALL
bird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cat	1	1971	2	28	6	1	2	2	6	1	2	39	5	3	0	95.3%
deer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
empty	13	9	0	958	2	0	3	0	6	0	0	7	18	9	0	93.5%
ferret	16	29	4	57	1111	0	7	4	7	1	0	9	2	7	0	88.6%
goat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hedgehog	1	0	0	102	3	0	1430	0	8	0	0	2	5	0	0	92.2%
kiwi	7	15	25	99	154	4	76	615	26	0	0	139	6	3	0	52.6%
lagomorph	1	4	1	24	0	0	3	0	2009	11	0	2	0	3	0	97.6%
livestock	28	5	1	239	1	0	0	0	235	1520	0	3	39	11	0	73.0%
pig	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
possum	29	1	7	46	6	0	3	0	9	0	0	830	107	11	4	78.8%
rodent	9	1	0	3	1	0	50	0	4	0	0	25	938	3	1	90.6%
stoat	43	17	6	56	22	1	8	0	29	1	0	19	287	1654	2	77.1%
wallaby	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>PRECISION</b>	<b>0.0%</b>	<b>96.1%</b>	<b>0.0%</b>	<b>59.4%</b>	<b>85.1%</b>	<b>0.0%</b>	<b>90.4%</b>	<b>99.0%</b>	<b>85.9%</b>	<b>99.1%</b>	<b>0.0%</b>	<b>77.2%</b>	<b>66.7%</b>	<b>97.1%</b>	<b>0.0%</b>	
Correct:	13,036	84.4%														
Wrong:	2,405	15.6%														

- 84% accurate overall
- Detects and removes 93% of false triggerings
- Accuracy can approach 100% for groups of images

# Putting it to work



confusion.csv	24/11/2022 3:07 pm	Microsoft Excel C...
predictions.csv	24/11/2022 3:07 pm	Microsoft Excel C...
crops	24/11/2022 2:55 pm	File folder
detections	24/11/2022 2:55 pm	File folder
images	24/11/2022 2:55 pm	File folder
Empty	24/11/2022 2:55 pm	File folder
Ferret	24/11/2022 2:55 pm	File folder
Hedgehog	24/11/2022 2:55 pm	File folder
Lagomorph	24/11/2022 2:55 pm	File folder
Livestock	24/11/2022 2:55 pm	File folder
Pig	24/11/2022 2:55 pm	File folder
Rodent	24/11/2022 2:55 pm	File folder
Stoat	24/11/2022 2:55 pm	File folder



	A	B	C	D	E	F	G	H	I	J	K
1	ACTUAL/PREDICTED	empty	ferret	hedgehog	lagomorph	livestock	pig	rodent	stoat	wallaby	RECALL
2	empty	0	0	0	0	0	0	0	0	0	
3	ferret	1	4	0	3	0	1	0	0	1	0.4
4	hedgehog	0	0	9	1	0	0	0	0	0	0.9
5	lagomorph	0	0	0	0	0	0	0	0	0	
6	livestock	0	0	0	0	0	0	0	0	0	
7	pig	0	0	0	0	0	0	0	0	0	
8	rodent	0	0	0	1	1	0	7	1	0	0.7
9	stoat	1	0	0	0	0	0	0	9	0	0.9
10	wallaby	0	0	0	0	0	0	0	0	0	
11	PRECISION	0	1	1	0	0	0	1	0.9	0	
12											
13	Correct:	29	0.725								
14	Wrong:	11	0.275								

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Label	Object	Object_conf	Class	Correct?	Class_conf	Filename	Bird	Cat	Deer	Dog	Ferret	Goat	Hedgehog
2	Stoat	animal	0.79	Stoat	TRUE	1.000	Stoat\2019(Feb&Mar)Z1_Z1CLM_SDHC059_101BTCF (9518).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	Stoat	animal	0.967	Stoat	TRUE	1.000	Stoat\2019(Feb&Mar)Z2CLM_SDHC088_100BTCF (828).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	Stoat	animal	0.919	Stoat	TRUE	1.000	Stoat\2019(Feb&Mar)Z3CLB_SDHC308 BTCF100 (1723).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	Stoat	animal	0.923	Stoat	TRUE	1.000	Stoat\2019(Feb&Mar)Z2CLM_SDHC019_101BTCF (2566).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	Hedgehog	animal	0.913	Hedgehog	TRUE	1.000	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (275).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000
7	Rodent	animal	0.857	Rodent	TRUE	1.000	Rodent\2019_(Feb&Mar)_Zone1_Z1CLC_SDHC242 (530).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	Rodent	animal	0.927	Rodent	TRUE	1.000	Rodent\2019_(Feb&Mar)_Zone1_Z1CLC_SDHC242 (522).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	Hedgehog	animal	0.901	Hedgehog	TRUE	1.000	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (308).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.99900
10	Ferret	animal	0.882	Ferret	TRUE	1.000	Ferret\IM000003_4.JPG	0.00000	0.00000	0.00004	0.00000	0.99972	0.00000	0.00000
11	Hedgehog	animal	0.889	Hedgehog	TRUE	1.000	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (255).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.99900
12	Stoat	animal	0.796	Stoat	TRUE	0.999	Stoat\2017 c2c TC6 (769).JPG	0.00003	0.00003	0.00000	0.00000	0.00000	0.00001	0.00000
13	Stoat	animal	0.93	Stoat	TRUE	0.999	Stoat\001577.jpg	0.00000	0.00000	0.00006	0.00000	0.00000	0.00002	0.00000
14	Rodent	animal	0.916	Rodent	TRUE	0.999	Rodent\mouse.JPG	0.00003	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	Hedgehog	animal	0.918	Hedgehog	TRUE	0.999	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (363).JPG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00018	0.99900
16	Hedgehog	animal	0.885	Hedgehog	TRUE	0.998	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (350).JPG	0.00000	0.00000	0.00001	0.00000	0.00000	0.00003	0.99800
17	Hedgehog	animal	0.909	Hedgehog	TRUE	0.997	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (377).JPG	0.00003	0.00000	0.00000	0.00000	0.00000	0.00001	0.99600
18	Stoat	animal	0.688	Stoat	TRUE	0.996	Stoat\2).JPG	0.00014	0.00021	0.00006	0.00001	0.00004	0.00098	0.00000
19	Hedgehog	animal	0.911	Hedgehog	TRUE	0.993	Hedgehog\2019(Feb&Mar)Z3CLA_SDHC241 (355).JPG	0.00001	0.00001	0.00008	0.00000	0.00000	0.00011	0.99200



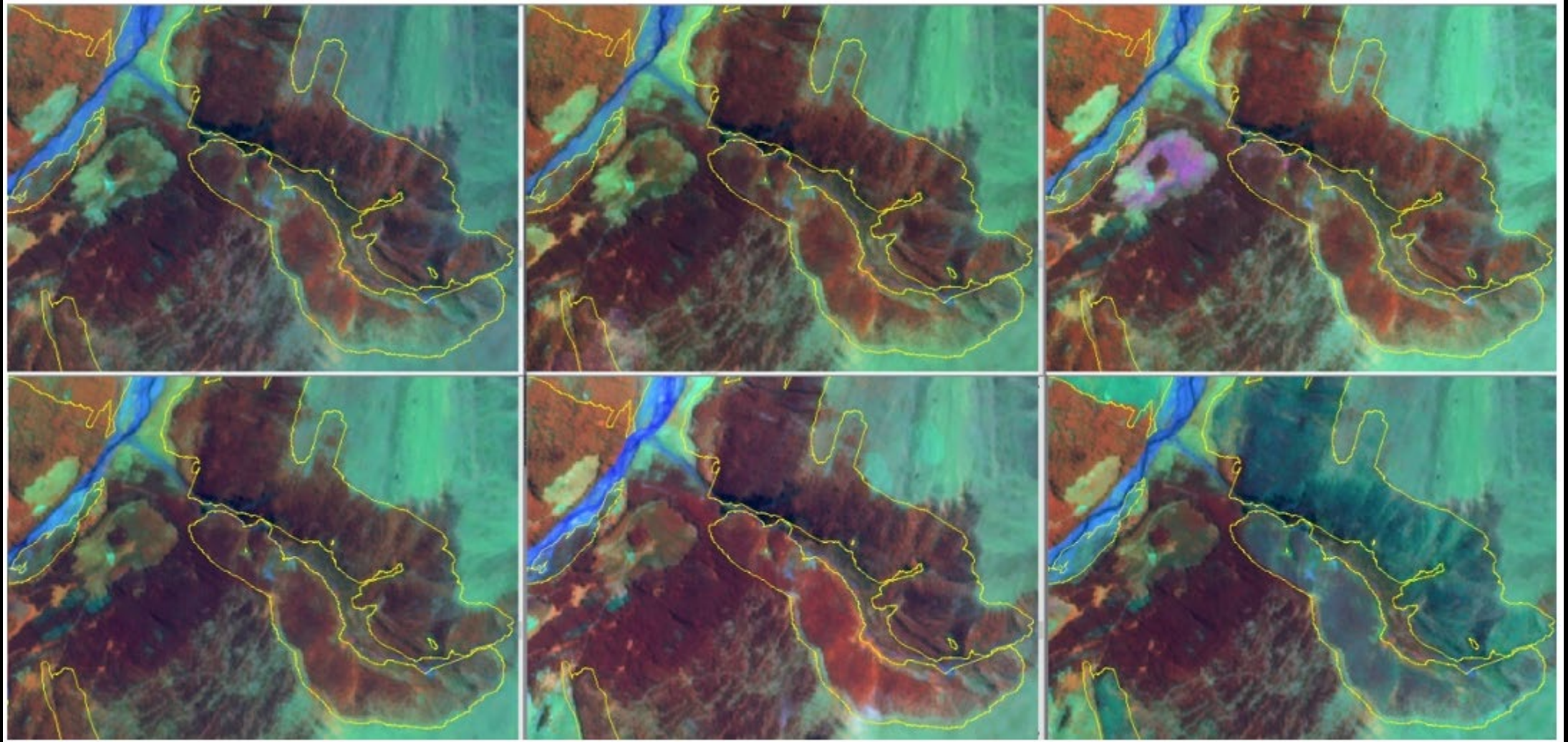


# Using the model

- Beta version integrated into 
- CamTrapNZ: a standalone Windows PC app (under development)
- Further enhancements coming soon
  - Continuous training
  - Fine-tune the AI to your imagery
  - Integration with other tools

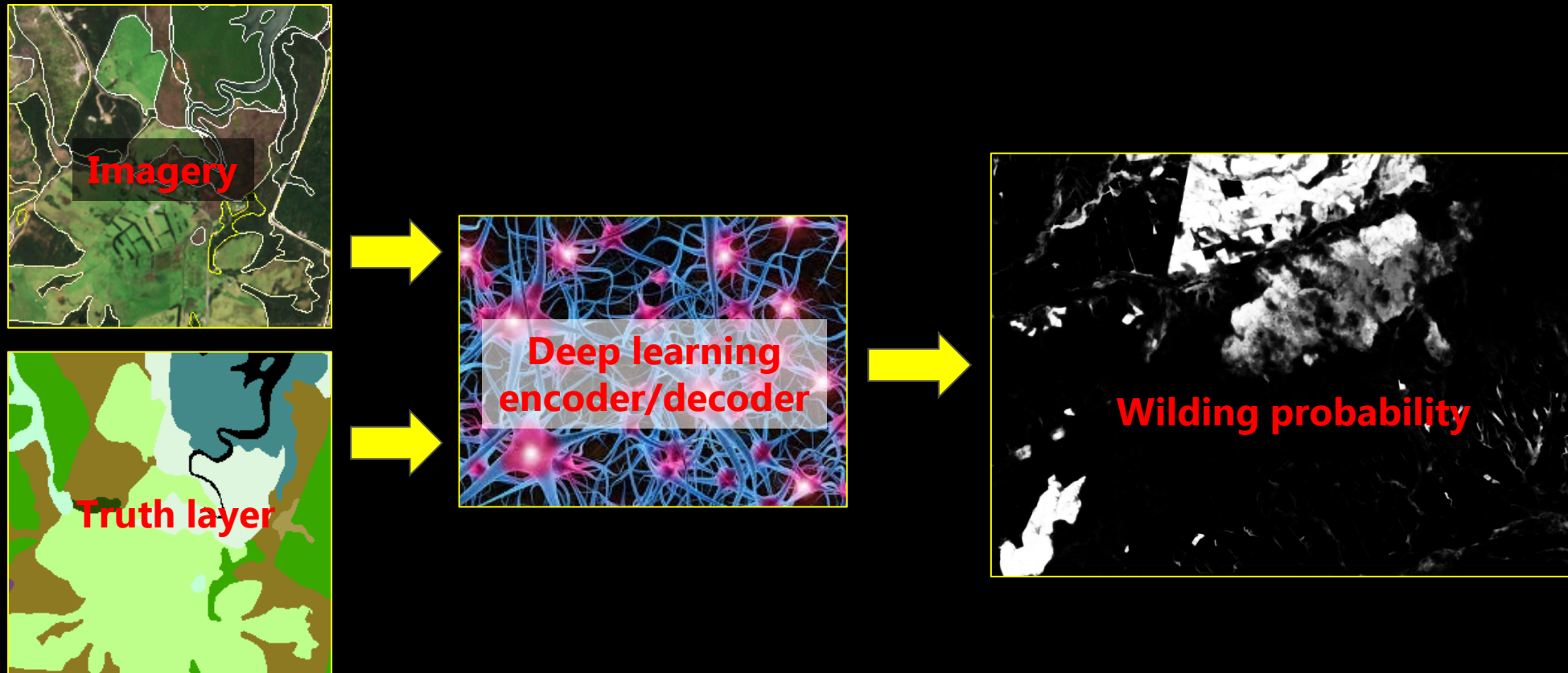


# Mapping wildings from remote imagery?

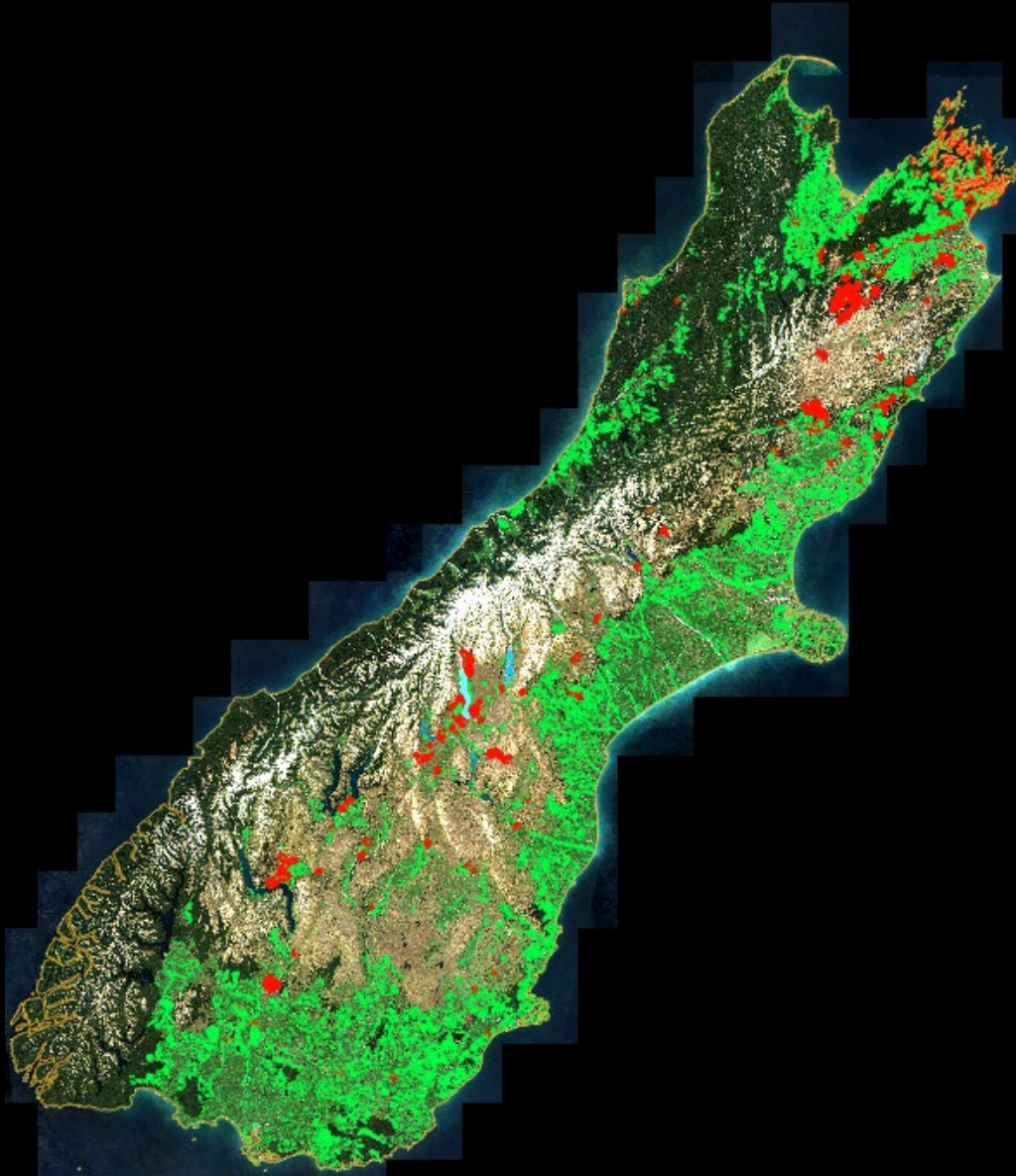


Challenge: the human eye can detect changes in wilding density: can a computer do it automatically?

# Deep learning model for detecting wildings



# Training data: Land Use Map (LUM)



- Exotic plantation data (accurate)
- Wildings (less accurate)
- Nationwide coverage means large quantity of training data
- Can it detect other wildings?

# Evaluation data: MPI dense control areas

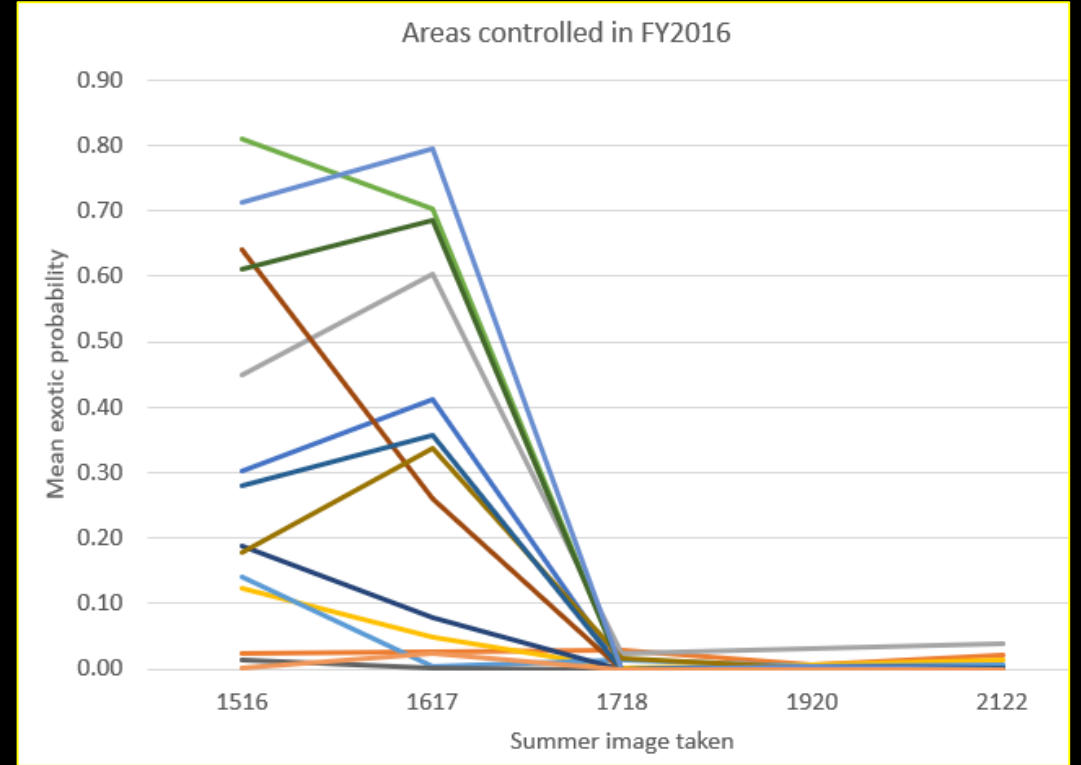
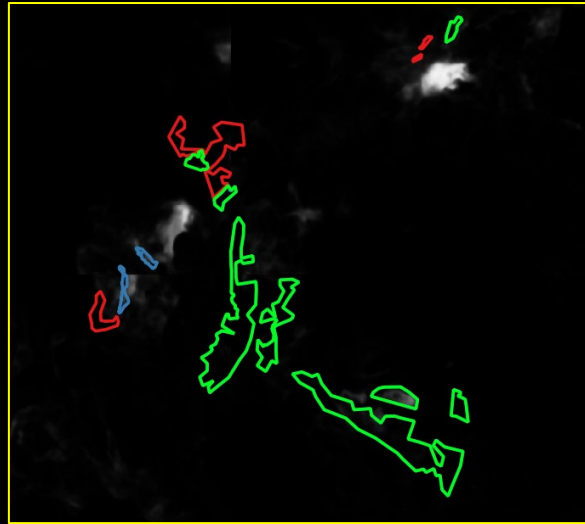
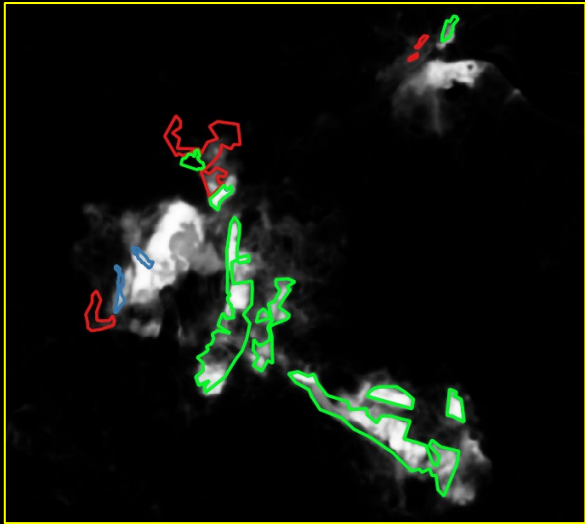
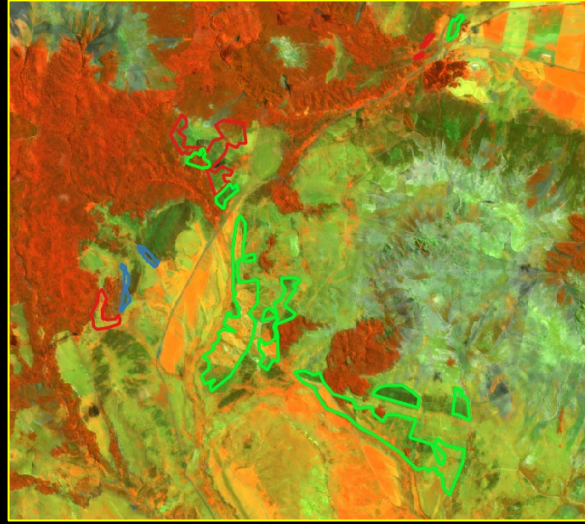
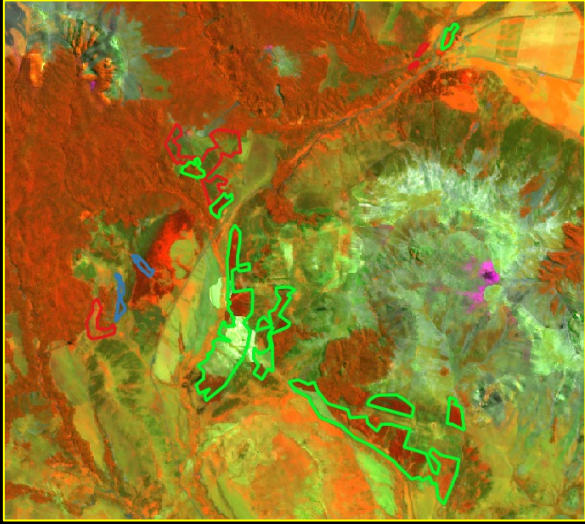


# Detecting wildings



- Use LUM model to map exotics
- Subtract known forestry to give potential wildings
- Result often more accurate than current mapping

# Monitoring wilding control



Average probability for controlled areas

2016/17 Pre-/during control

2017/18 Post-control



# Estimating wilding density

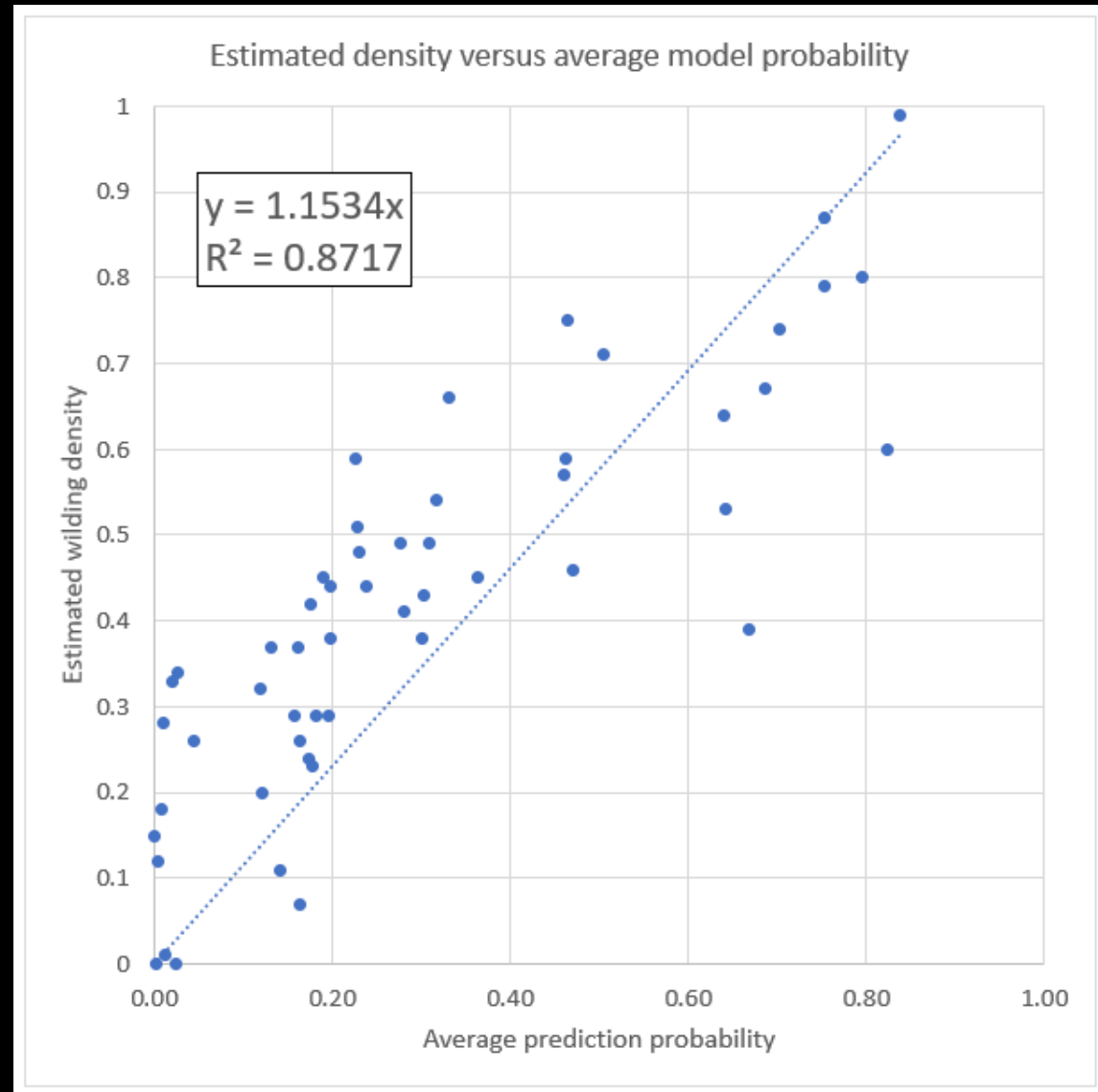
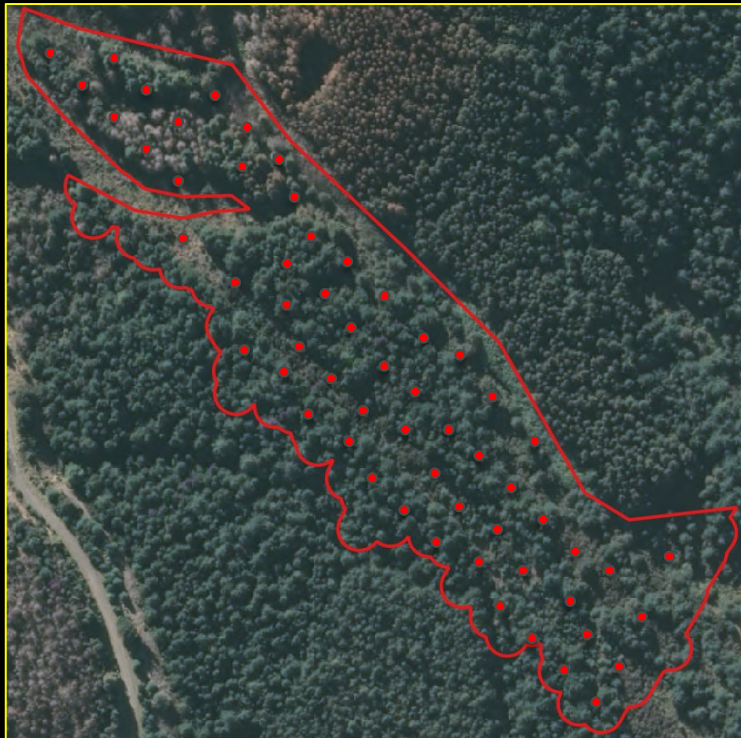
2016 image	2016 exotic	2016 mean	2020 image	2020 exotic	2020 mean
		0.851			0.017
		0.698			0.118
		0.465			0.115
		0.496			0.007

- Mean probability related to density/coverage
- Use aerial imagery to estimate density
- Fit a model to convert probability to density

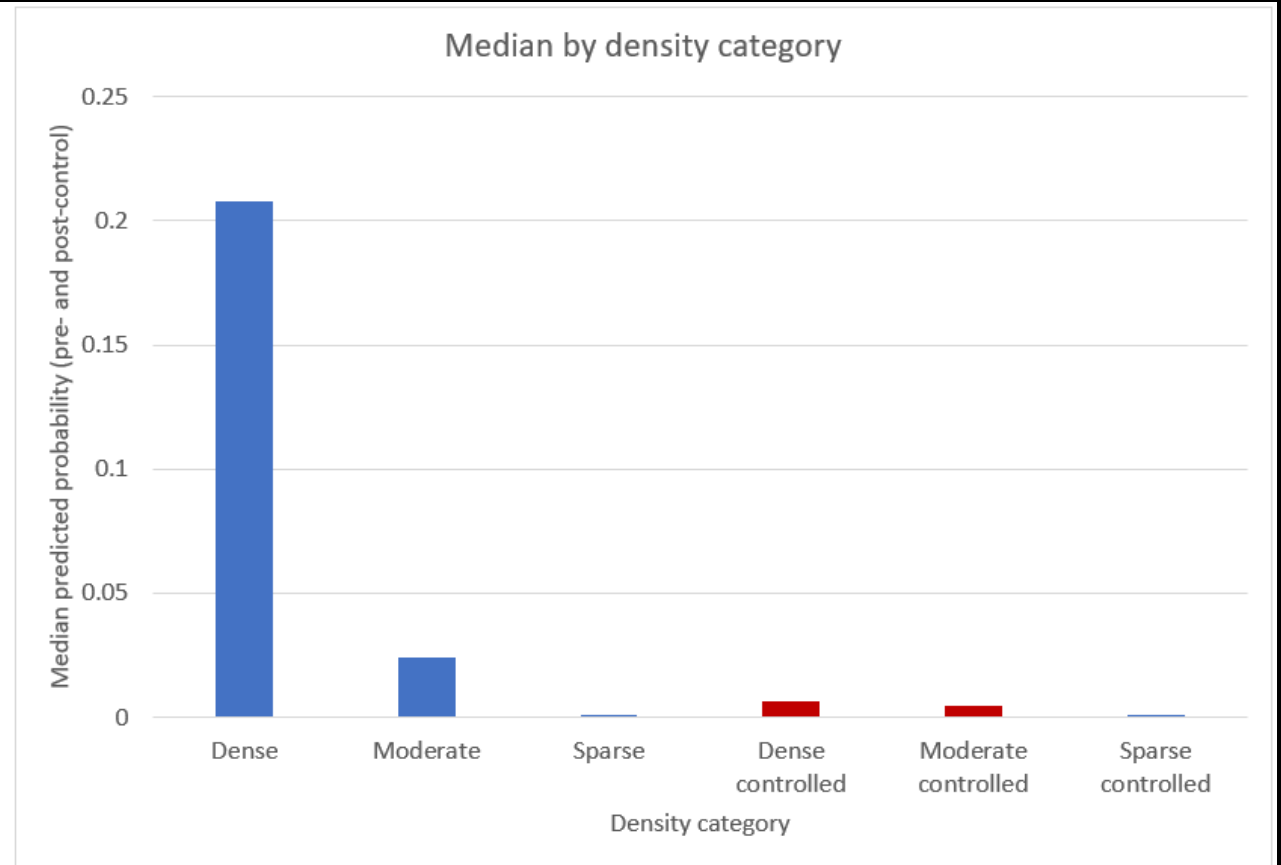
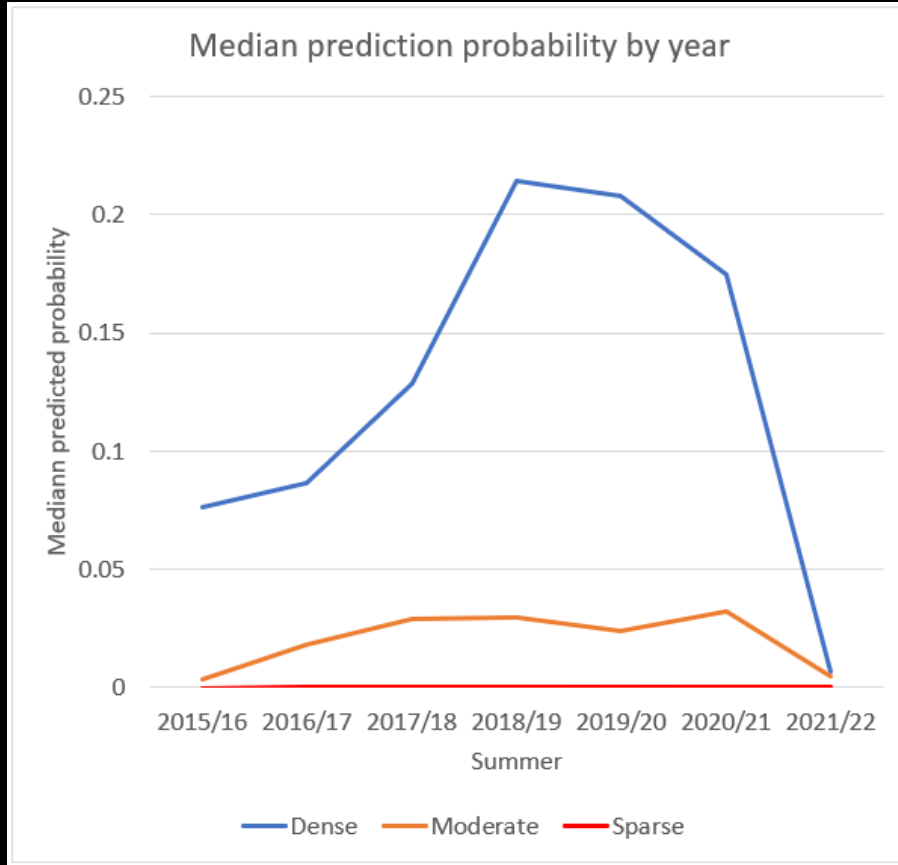




# Model versus estimated density



# Estimating low densities



- Dense and moderately dense infestations detectable
- Sparse infestations less clear – may require aerial imagery

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## Questions?

