



Manaaki Whenua
Landcare Research

Reaching into the past

Deep learning and historic aerial imagery

Brent Martin, David Pairman, Stella Bellis,
Alexander Amies, Tarek Soliman and Jan Schindler

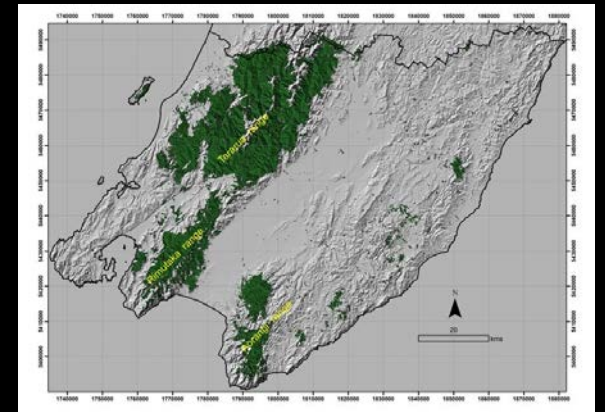
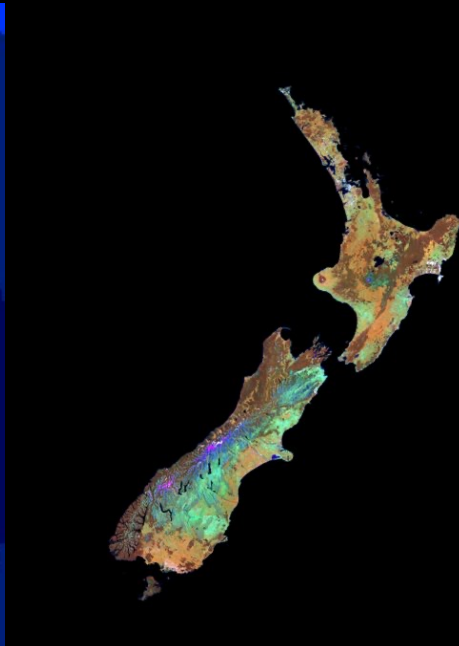
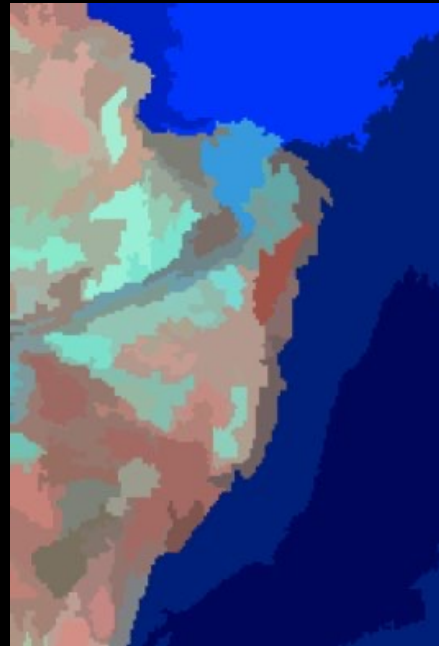
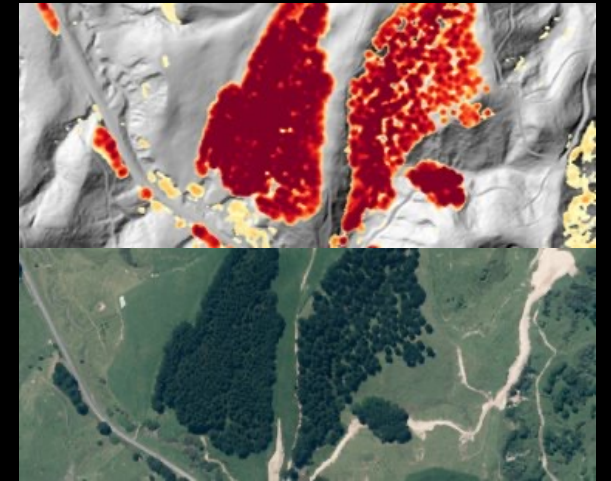
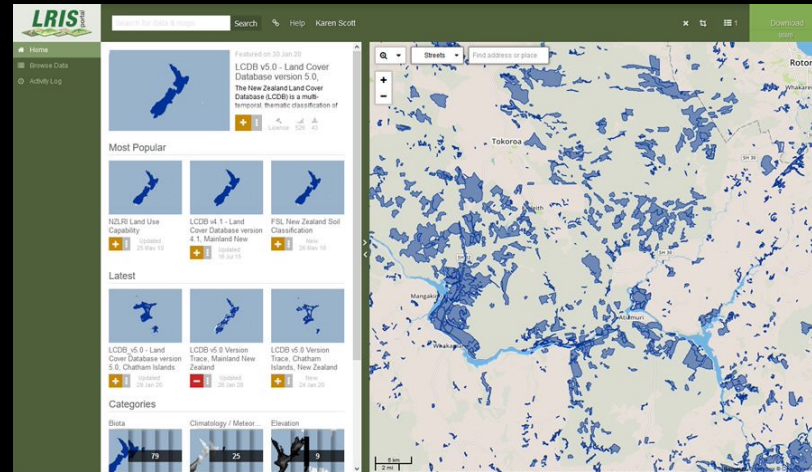
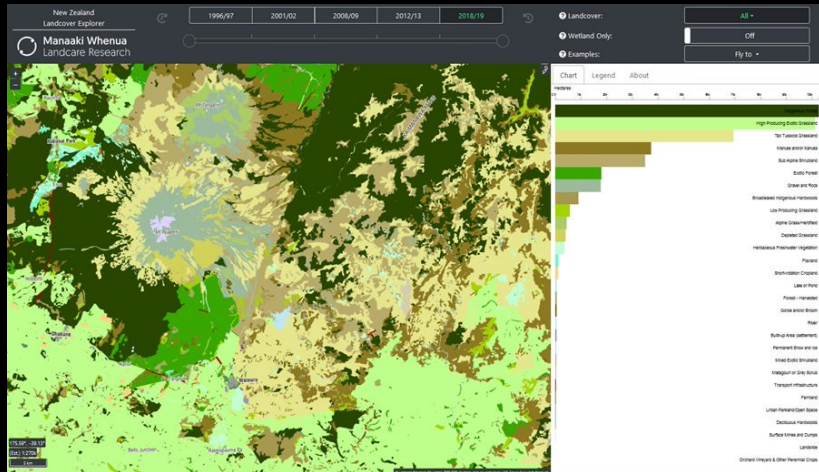
Manaaki Whenua Landcare Research

Remote sensing – more than meets the eye

LINKOnline webinar

4th May 2022

The data deluge: challenge or opportunity? ☺





Computer vision at Manaaki whenua

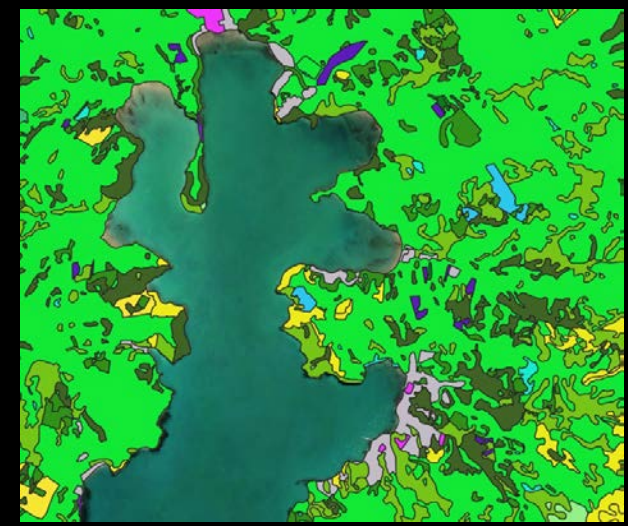


Species classification

Predator detection



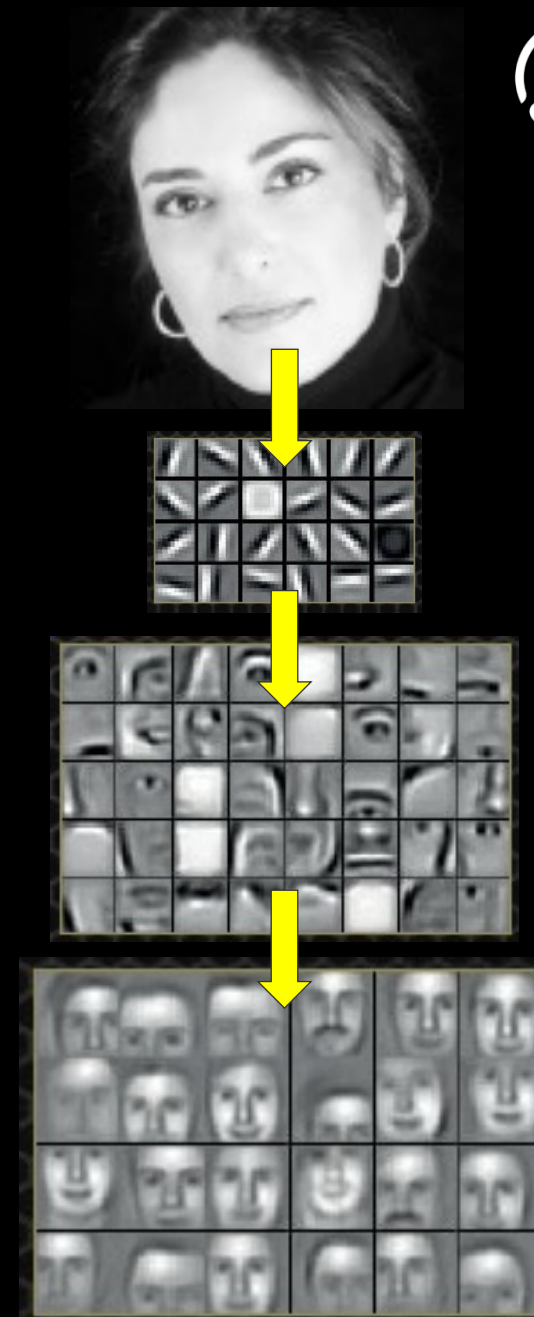
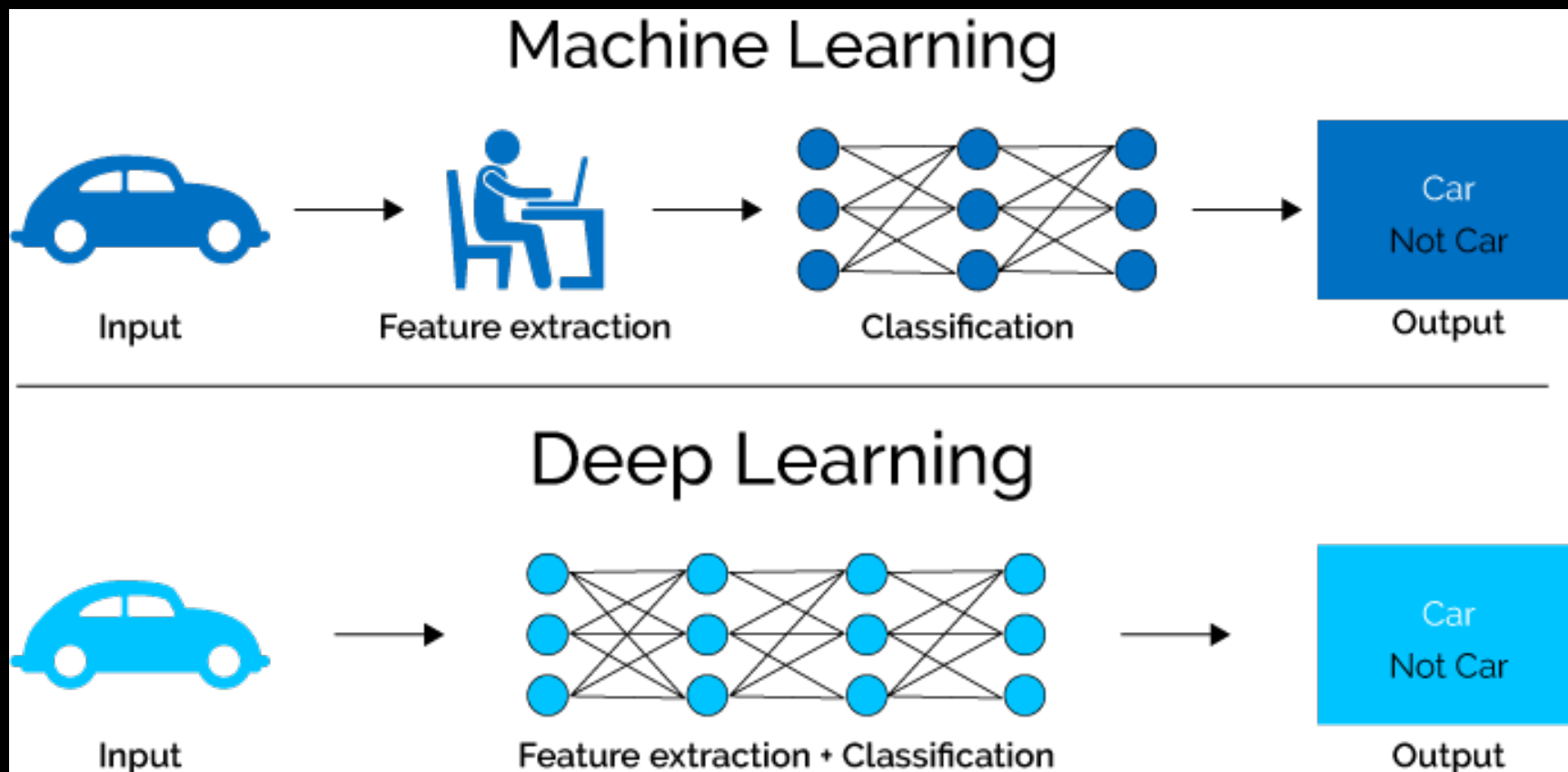
Land segmentation



Autonomy

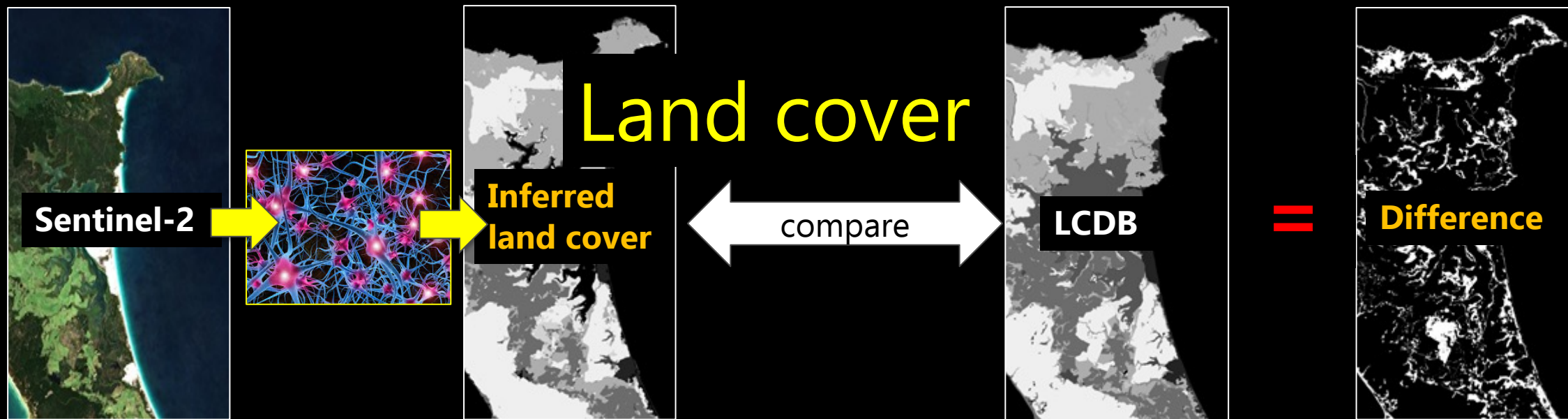


The deep learning revolution





Deep learning for remote sensing





Map Layers ×

Tree Crowns —

Tree Crowns

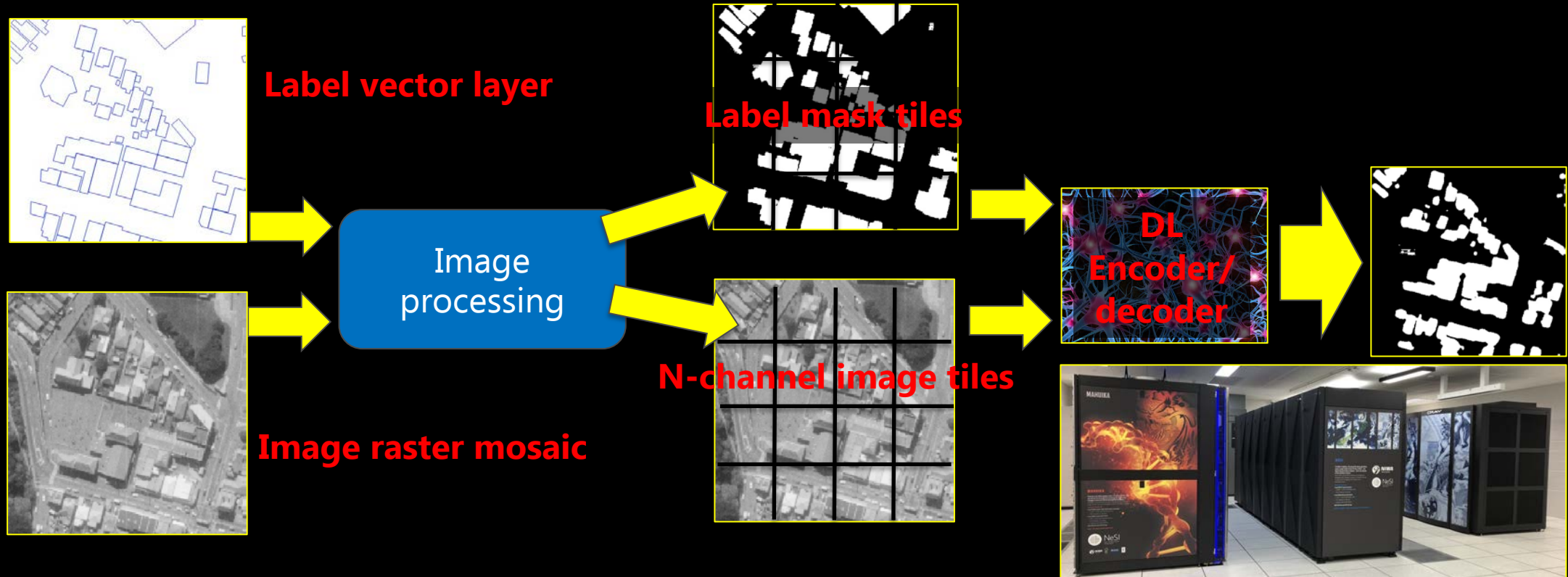
Aerial Photography —



Goal: map urban built form change over time



Approach: deep learning segmentation



- MWLR pipeline processes input data into image/label mask tile pairs for training/prediction
- Deep learning encoder-decoder network (Unet64) learns to generate mask tiles (512x512 pixels)
- Masks stitched back together (50% overlap)

Training data: LINZ 2016



The screenshot displays the LINZ DATA SERVICE interface. The search bar at the top contains the term 'buildings', resulting in 71 items. The left sidebar shows a navigation menu with categories like 'DATA TYPE', 'CATEGORY', and 'REGION'. The main content area lists several data layers, including 'NZ Building Outlines (All Sources)' and 'NZ Building Polygons (Topo, 1:50k)'. The map view on the right shows an aerial photograph of a coastal town with blue outlines representing building footprints. A legend in the top right corner of the map area indicates that the blue outlines correspond to 'NZ Building Outlines (All Sources)' and the background is 'Wellington 0.3m Rural Aerial Photos (2016-2017)'. The interface also shows a search bar for streets and a 'Download or Order' button for the selected layers.

Imagery: 2016 0.3m aerial photos

Labels: NZ building outlines

Historic imagery: Retrolens/LINZ



retrolens.co.nz/map/#/1595774.3358734446/5148637.423989935/1598795.9871479226/5150603.288811196/2193/11

RETROLENS
Historical Image Resource

ableby ? i f t

Akaroa, Canterbury

1926 2022

Auto refresh photos from map.

Place point on the map.

106 images found [add all](#) | [remove all](#) | [download\(0\)](#)

17/01/1941 <input type="checkbox"/> add	17/01/1941 <input type="checkbox"/> add
17/01/1941 <input type="checkbox"/> add	17/01/1941 <input type="checkbox"/> add

ableby

Eagle Technology, Land Information New Zealand

POWERED BY esri

Developer Disclaimer

The challenge: training the model



How to train the network for all time periods and cities?

- Can a model trained on 2016 be used for historic B&W imagery?
- Can training transfer between cities?



Transfer between time periods



2016: excellent



1940: poor

2016 model fails to transfer to historic imagery

The issue: inconsistent image quality



2016: digital
Standardised brightness/contrast
Minimal noise
Sharp focus
High spatial accuracy
Shadows

1980: film
Flat contrast
Grainy
Moderate focus
Moderate spatial accuracy
Short shadows

1940: film
Variable brightness/contrast
Grainy
Variable/poor focus
Spatial distortion/displacement
Long shadows

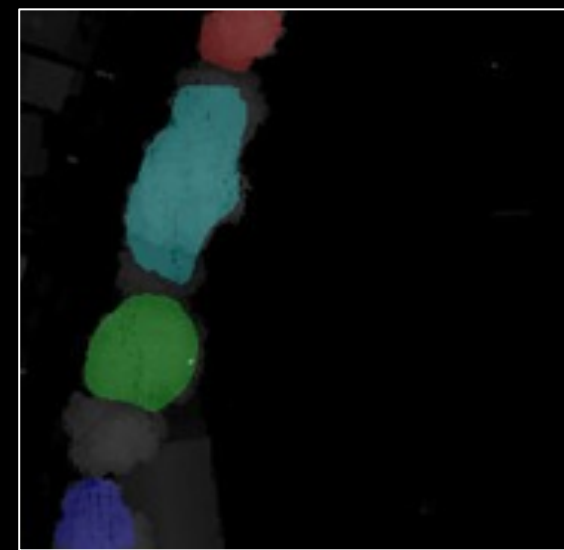
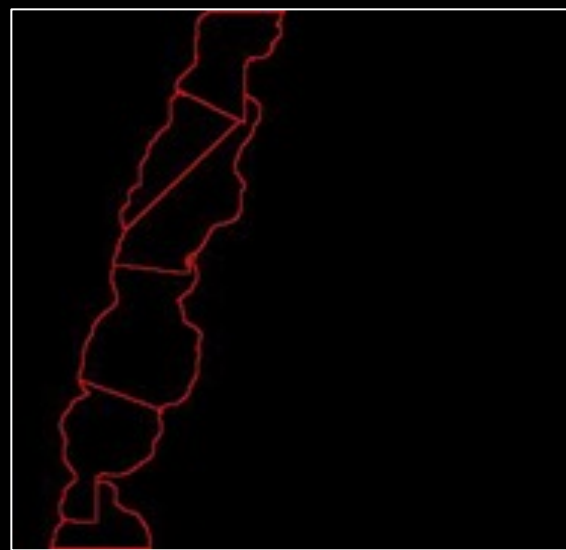
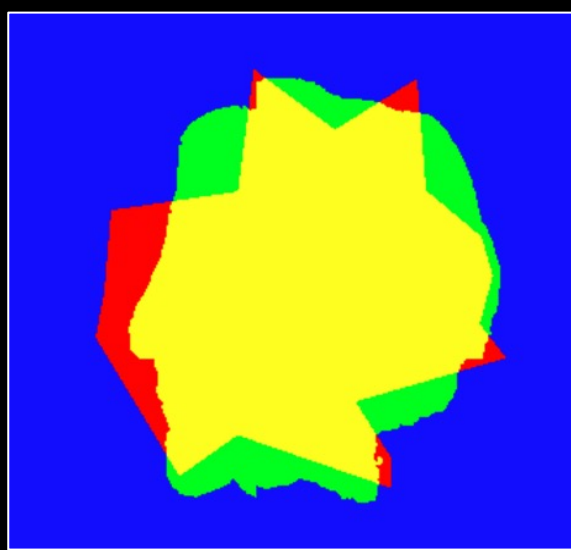
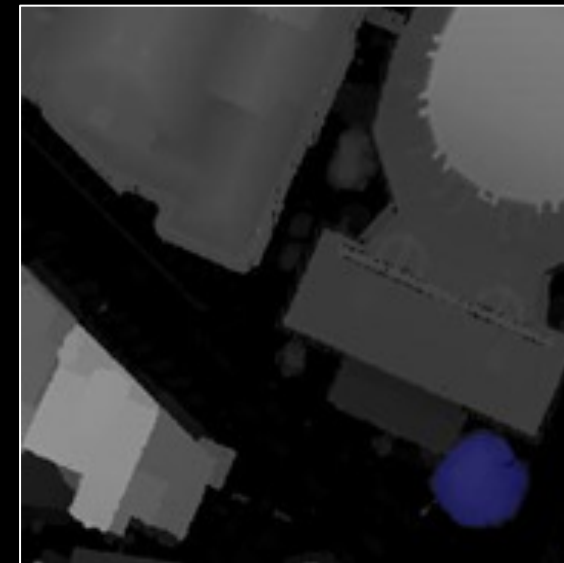
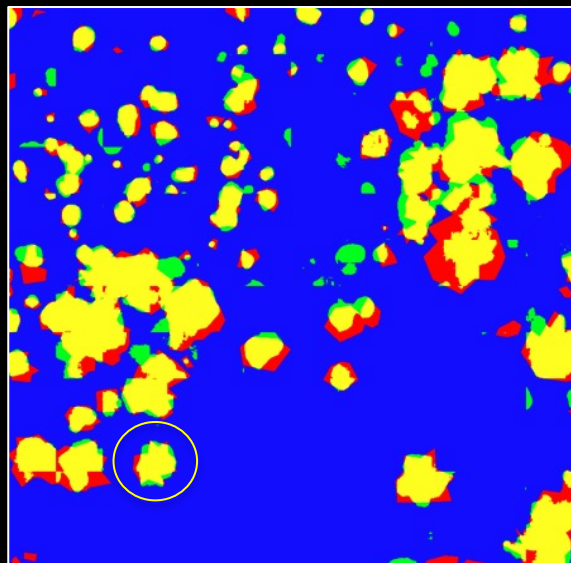
The solution: imperfect training data



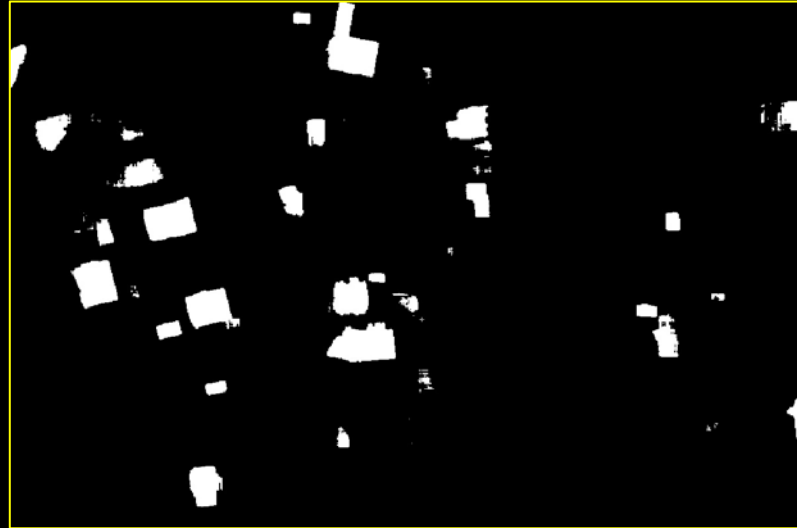
- Train model on historic imagery but *current* labels?
 - Buildings may have been built, demolished or modified
 - Image may be displaced because of distortion issues
- Select tiles with “reasonable” match
 - What is “reasonable”?
 - Enough tiles?



Segmentation label error tolerance



Imperfect data results: 1940



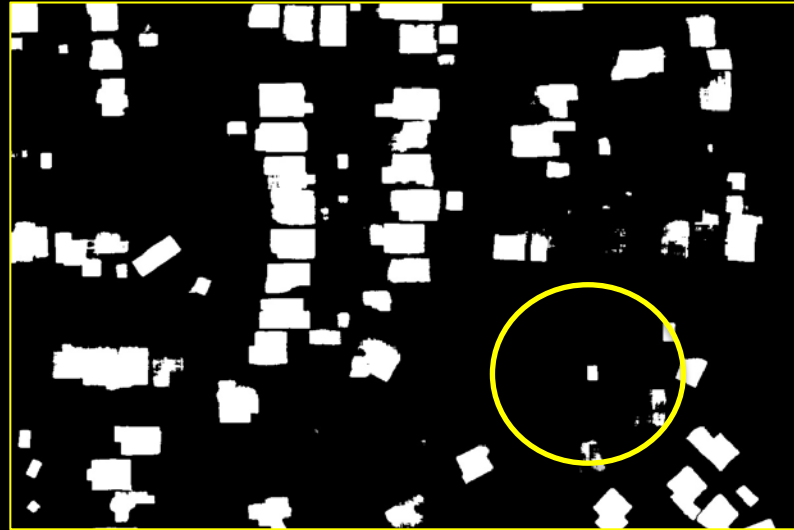
Wellington: 1940 image

2016-based mask

1940 imperfect data mask

Training on 1940s imagery with imperfect data significantly improved

Imperfect data results: 1980



Wellington: 1980 image

2016-based mask

1980 imperfect data mask

1980: significantly improved recall (but reduced shape precision)

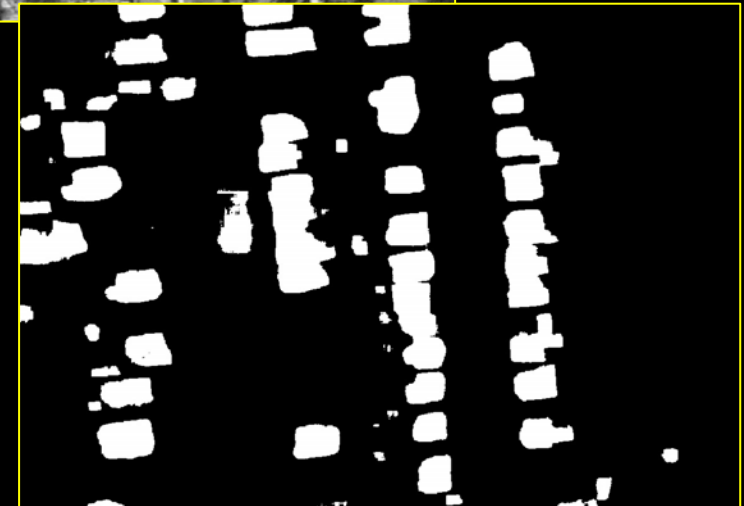
City transfer: Wellington to Auckland



1980



1940



Wellington models transfer well to Auckland

Hamilton



1940

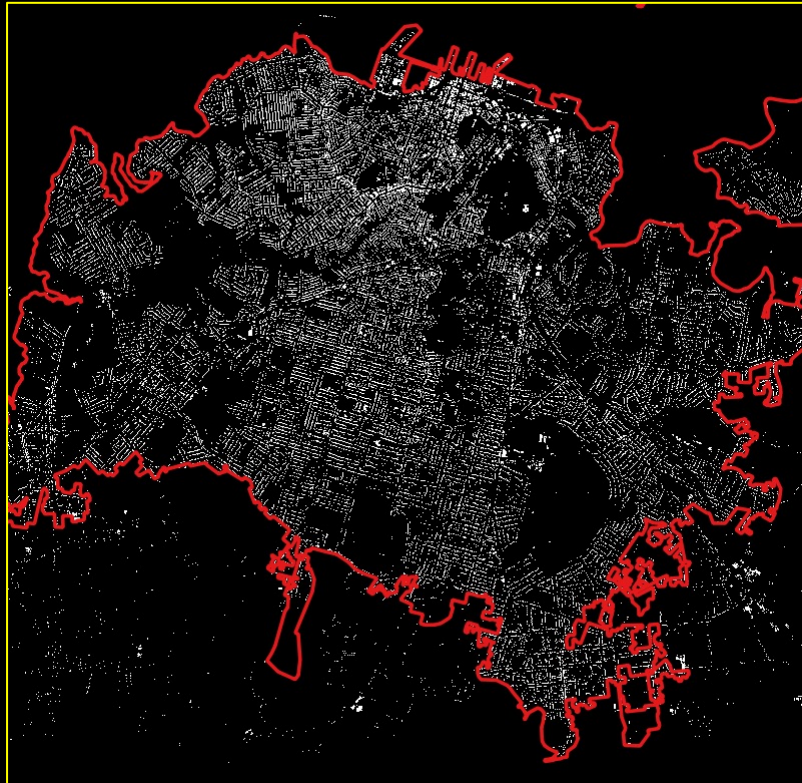


1980

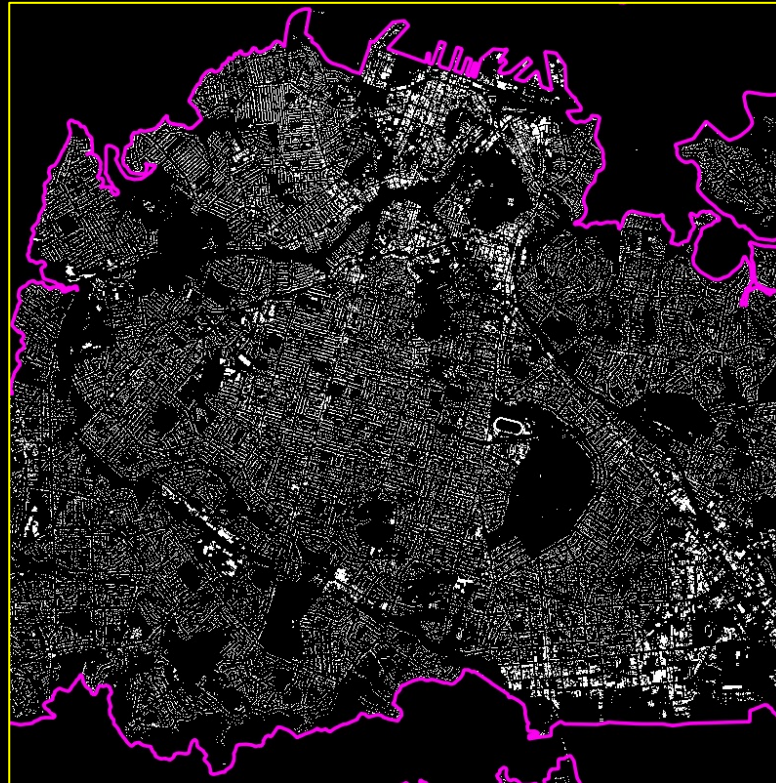


2016

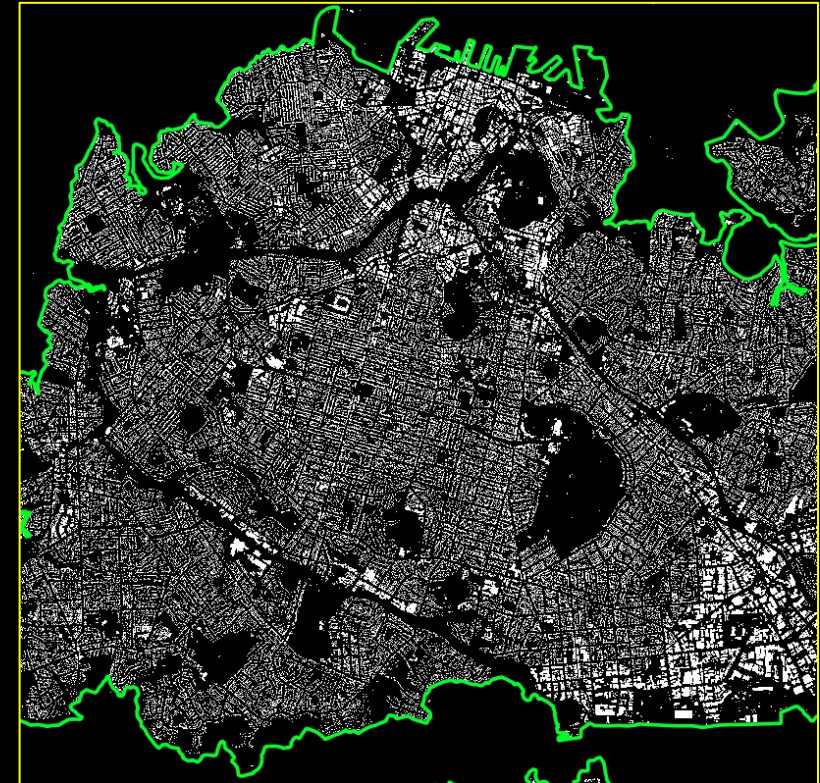
Auckland



1940



1980

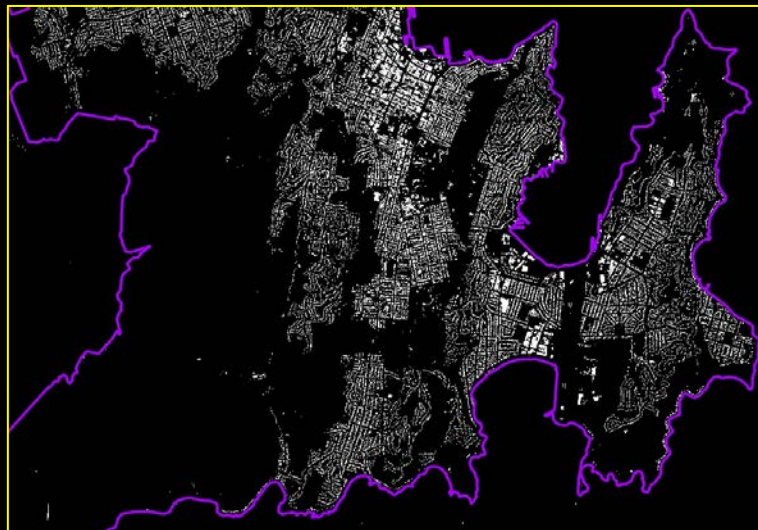


2016

Wellington and Lower Hutt



1940



1980



2016



Summary



- Acquiring training data is a big challenge
- Learning from imperfect data reduces this burden
- Deep learning has great potential for taming the data deluge

