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TECHNOLOGY - Seeing the Future

Returning the control of data to the farmers!

- The use of *drones* and *smart technology* to manage the farm -

Dr. Armin Werner

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Unmanned Aerial Vehicles (UAV)

UAV Overview

- = Unmanned Aerial Systems (UAS) (or ‘drones‘)
- UAVs are a developing technology
- Limited regulatory framework
- Huge range of systems, applications
- impact of 2.1 billion USD in 2015

***Ag drones* are not military drones!**

Photo source: http://www.ndsu.edu/research/press_room/feature_stories-2013/UnmannedAerialVehicles.html

UAV-Helicopter for Spraying (Japan)

UAV Type Comparison

	Rotor	Fixed-wing
Range		
Flight time		
Hover		
Manoeuvrability		
“Perch & Stare”		
Take-off/landing		
Cost		

General concensus: use a fixed wing if you need to cover a large area (greater than a few km^2)

and a rotor UAV for everything else!

UAVs *FROM* New Zealand

(Droidworx UAV)

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MISSION CONTROL

Typical Specifications

- 40minutes flight time
- ~ 200ha of a farm / station
- ~ 1.2 kg payload
- ~ 5kg own weight
- ~ 60cm x 20cm size

droidworx
http://aeronavics.com/products/showroom/bot/bot-2/

UAVs *FROM* New Zealand

(Hawkeye UAV)

Typical Specifications

- 90minutes flight time
- photogrammetry
- surveying
- hand launched
- parachute landing

Hawkey eUAV
http://www.hawkeyeuav.com

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Remote Sensing with Private UAV

e.g. Trimble UX5 UAV

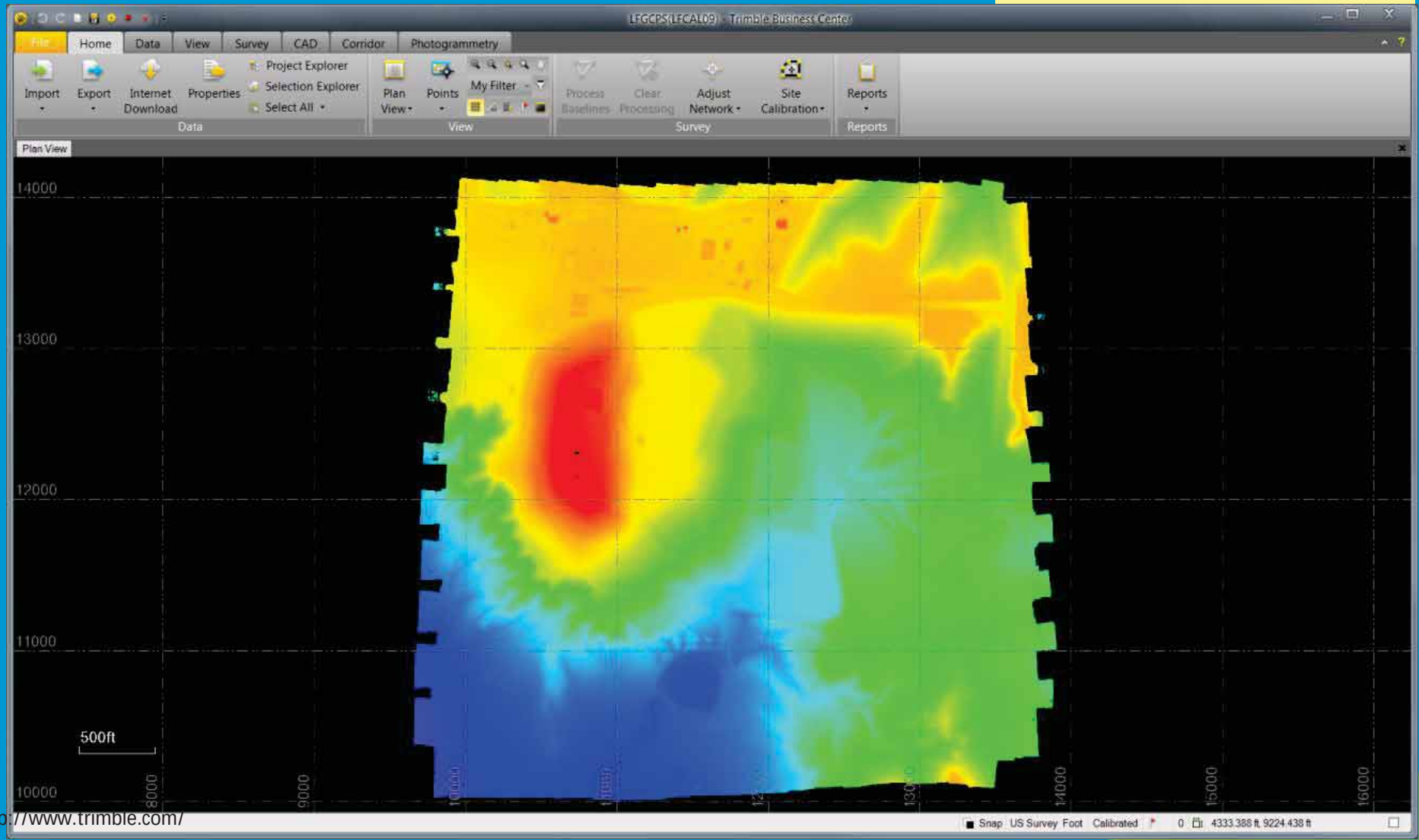
- UAV for aerial imaging and mapping
- Target: agricultural service providers
- Near-infrared camera included
- Service package may include
  - Mission and flight planning
  - Flight monitoring
  - Image acquisition
  - Image processing

Image source:
http://www.suasnews.com/2014/01/27077/trimble-adds-unmanned-aircraft-system-to-its-agriculture-portfolio-for-aerial-imaging-and-mapping/

Stereoscopic Surface Survey

e.g. Trimble UX5 (Screenshot)

Digital Surface Model



http://www.trimble.com/

Aeromapper Ground Control Software

Image source: http://www.aeromao.com/aeromapper_uav

Image Stitching Software

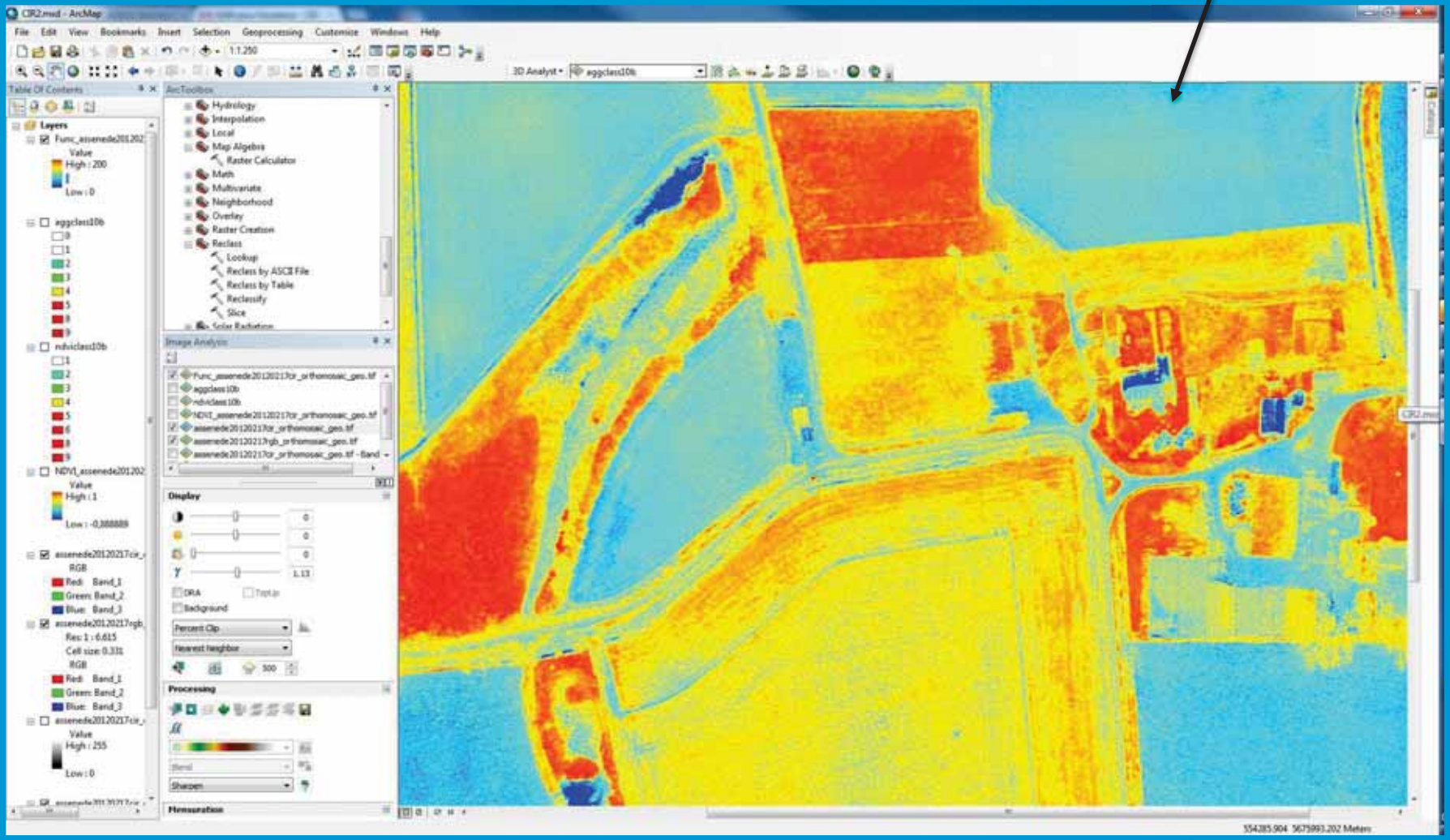
Image source: http://www.aeromao.com/aeromapper_uav

UAV for Monitoring
- feed production -

NDVI map (indication of vegetative health)

(e.g. Trimble UX5 for Agriculture)

Stitch of 288 images over 1.5 km^2



The Future of Pasture Monitoring

UAV based multispectral images

"The software allows us to **measure biomass** over the area that the UAV has flown and also **identify the different species of plants** growing on rangeland"

-Kevin Price, Kansas State University

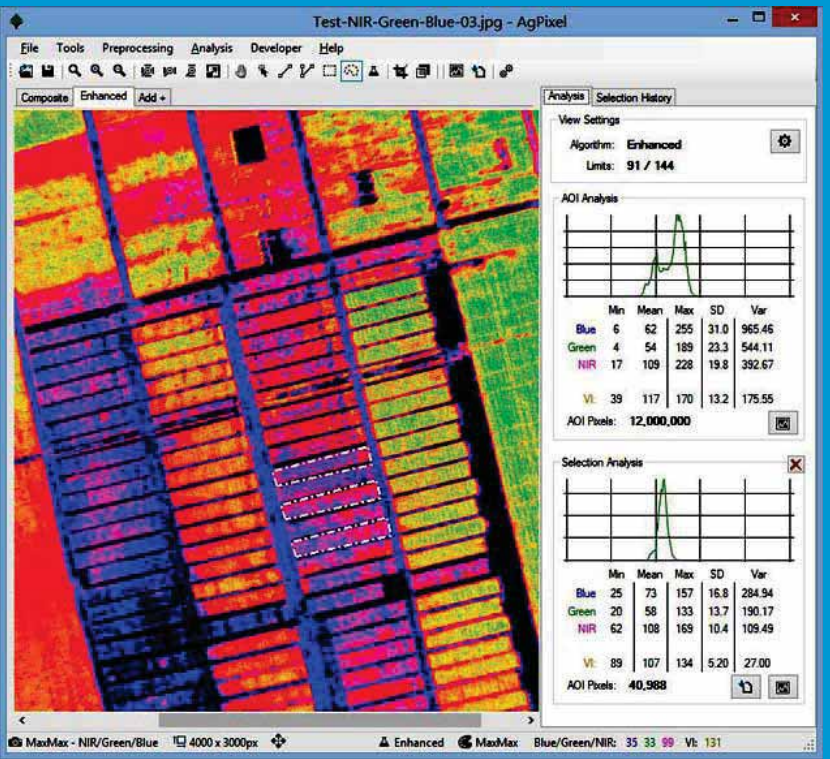


Image source: https://www.soils.org/publications/csa/articles/58/12/4

Pasture Mapping and Analysis

New Zealand Centre for Precision Agriculture

- Massey University
- Multispectral Aerial Imaging of Pasture Quality and Biomass with UAV

Image: von Buren, 2013

Pasture Mapping and Analysis

Beyond Biomass Yield

- Spectral data can also be used for
  - Nutrient level estimation
  - Soil analysis
  - Moisture level estimation

- Thermal data can be used for
  - Pest detection
  - Crop stress indication

"The Holy Grail is ... dry-matter measuring and we are well on the way to get that"

-Neil Gardyne

Photo source: http://snr.unl.edu/sandhills-biocomplexity/gdex.htm

UAV for Monitoring
- livestock -

UAV Livestock Surveillance

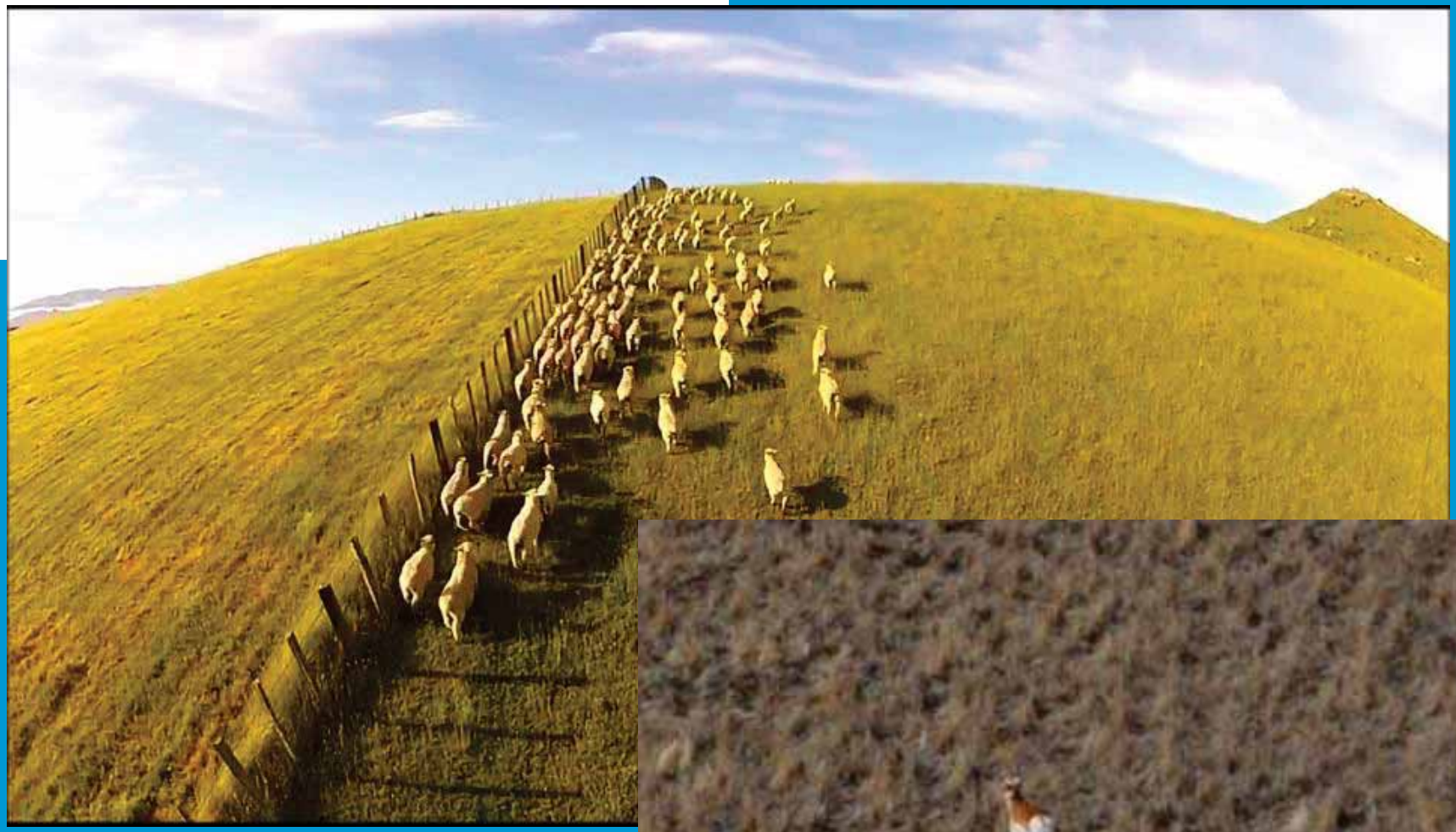
Current Research

- *tracking and locating* wayward sheep (Scotland)

Future Direction

- *Autonomous detection* and classification of livestock
- Could be used in conjunction with *other technology* e.g. Robot Shepherd-Dog

Mustering Livestock



Using a UAV to monitor infrastructure

"Checking the water troughs takes an hour-and-a-half job on the four-wheeler and it takes 10 minutes by drone‘‘

-Neil Gardyne, Southland Farmer

Image: http://www.motu.org.nz/research/detail/new_zealand_emissions_trading

UAV Livestock Surveillance

Current Products

- MarcusUAV
  - Zephyr system
  - Small UAV system for cattle tracking

- Other UAV companies offer similar products

How It Works

- Preprogram UAV *flight path*
- Monitor *live video* feed
- Manual override if trouble area identified

http://www.marcusuav.com/small-uav-systems-for-cattle-tracking/

MarcusUAV Surveillance UAV

Zephyr 2 Specifications	
Weight	2 kg
Range	40 km
Wingspan	1.4 m
Flight time	60 mins
Cost	US $13,000

Cost depends on UAV range and flight time, may not need a 40 km range for NZ farms

http://www.marcusuav.com/

Livestock Tracking

Taggle Systems, Australia
Livestock location ear tag

➔ link to a reader on a UAV?

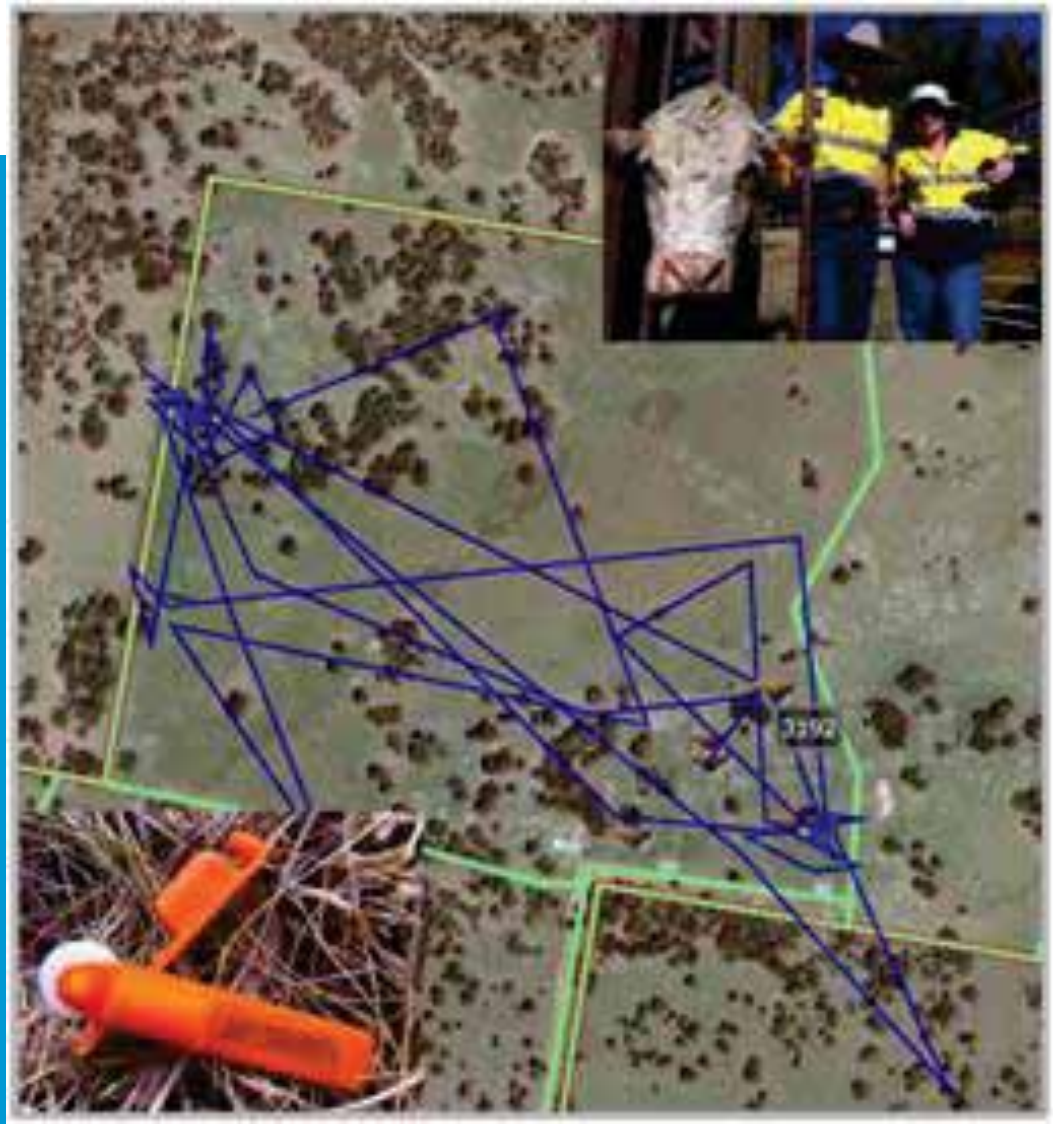


Image: http://www.pinterest.com/pin/160018592982913509/

Collecting Individual Animal Data
‘Intelligent Ear Tags’

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Variables

- body temperature
- heart beat rate
- chewing activity
- animal movement

Feed Conversion Rate (available in future?)

- eating
- chewing / ruminating

➔ link RFID to a reader on a UAV?

Information Management on Farm

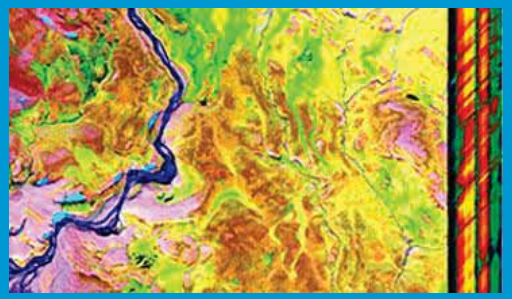
The Unmanned Aerial System

Management decisions from UAV data

Unmanned aerial vehicle

Remote sensing devices

Visual, spectral or thermal data



http://blogs.berkeley.edu/2013/07/22/an-mvp-is-not-a-cheaper-product-its-about-smart-learning/

http://www.aweimagazine.com/article.php?article_id=124

http://www.eetimes.com/author.asp?doc_id=1320855

UAVs for Personal Farm Use

Used in the Massey study

	Aeronavics BOT	Mikrokoptor Hexacoptor	Aeromao Aeromapper	Trimble UX5
Type	Rotor	Rotor	Fixed	Fixed
Sensors Included?	No	No	No	Yes
Weight (kg)	5	1.2	1.5	2.5
Range (km)	3 (appx.)	--	10	60
Width (m)	0.8	0.7	2	0.1
Flight time (min)	40	36	50	50
Cost (NZ$)	1,310	3,000 (appx.)	2,000 (appx.)	60,000

Data Platf
Precision

AgHUB

UB IN ACTION

FARMERS:

TrackMap

JOHN DEERE - FarmSight

TRIMBLE – Connected Farm

UAV
- the Future -

UAVs
– an enabling technology
– realisation & impacts unclear

Conclusions
Demand for UAV in the Future

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	← *ground platforms* →		← *UAV* **platforms** →	
activities	**sensors at the *ground* (ATV ..)**	**sensors on a *robot platform***	**sensors on a UAV**	**camera on a UAV**
fertilization	++			
weed control	++	+	+/-	
pest management	+/-	+/-	+/-	+/-
feed assessment	++	++	++	+/-
gen. surveillance padd.		+/-	++	++
surveill. infrastructure		++	+/-	++
stock surveillance	+/-	+		++
animal scoring	+/-	+	+/-	++
stock mustering		+	++	+/-

UAV-Developments

Nano Hummingbird

- my ‘pet-UAV’ -

?

UAV-Developments: *SmartBird* from FESTO

UAV-Developments: *SmartBird* from FESTO

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THANK YOU

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UAVs for New Zealand Farms

The Way Forward

- Applications include
  - *Crop* mapping and analysis
  - *Pasture* mapping and analysis
  - *Livestock* monitoring
  - *Infrastructure* monitoring

- UAV imaging services to replace traditional airplane imaging
  - Cheaper
  - More flexibility

Image: http://hornofafrica-abdikarim.blogspot.co.nz/2011/05/ethiopia-to-buy-unmanned-planes-from.html

UAVs
- in the real world -

UAV Regulations

Current Regulatory Environment

- Often UAV regulations are relics of radio controlled model aircraft

New Zealand CAA

- Legal to buy UAV and operate (with restrictions) for personal use

- CAA model aircraft flight limitations (CAR Part 101)
  - < 25 kg
  - 120m ceiling
  - UAV must remain in line of sight
  - 4km no-fly-zone around airports

- Commercial Use requires a permit is required to operate a UAV in NZ

Who we are

ABOUT US //

ROLE / STRUCTURE:

- R&D company, NZ
- Agriculture, Industry, Environment
- 100% subsidiary of *Lincoln University* (independent board)

PROFILE:

- Turnover ~ $7.1 M$ / a
- ~ 41 FTE's
- Christchurch & Hamilton

SENSORS

GROUNDWATER

PRECISION AGRICULTURE

SPRAY MODELLING

IT IRRIGATION

UAVs for Animal Surveillance in Research and Nature Protection

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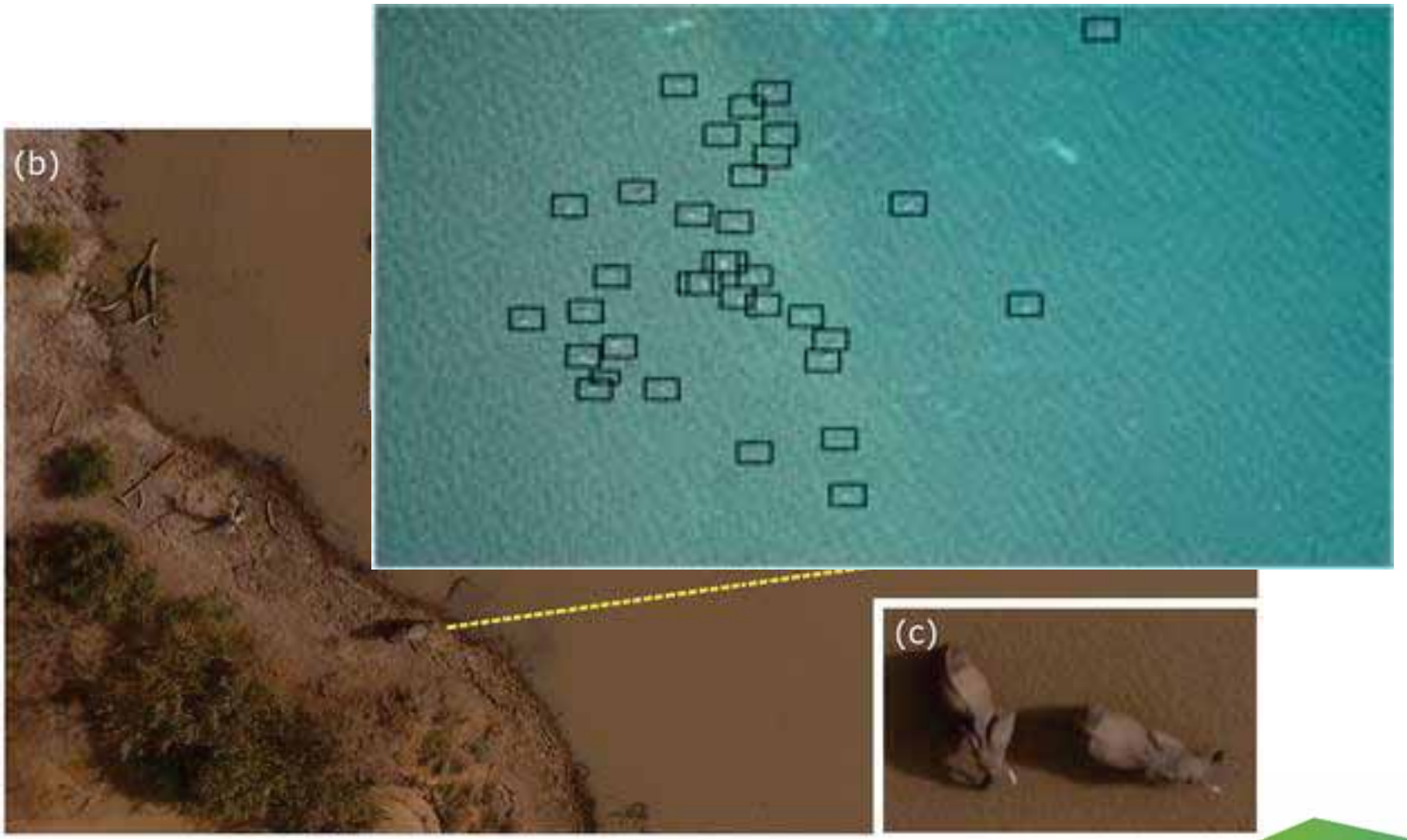

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http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0054700

Next Generation UAVs

Hybrid UAV Technology

- Combine vertical takeoff and landing (VTOL) with fixed wing technology
- In air tilt-rotor to fixed wing flight
- Lockheed Martin Vector Hawk (photo)
  - VTOL
  - Fixed wing speed up to 130 km/h

Image source: http://www.gizmag.com/lockheed-martin-vector-hawk-suas/32073/

Current UAV Projects

Gardyne Farm, Otama, New Zealand

- Six propeller hexagonal UAV (photo)
  - Imported to NZ
  - Cost of about $4,000
  - Top speed 100 km/h
  - Range of 3km

- Project partners
  - BLNZ
  - AbacusBio

- Project goals
  - Collect data
  - Establish UAV as a farm tool

Source: http://agrinews-pubs.com/Content/News/MoneyNews/Article/Drones-could-take-flight-in-agriculture-industry/8/27/9186

New Zealand UAV Services

DroneSolutions

- UAV aerial imaging service
- Based out of the West Coast, SI
- Could be hired for agricultural imaging

SycamoreUAV

- Aerial imaging service
- Extensive UAV fleet for wide range of aerial imaging

No UAV imaging service in New Zealand explicitly targets agriculture!

Image source: http://www.dronesolutions.co.nz/hello-world/

Current UAV Uses

Gardyne Farm, Otama, New Zealand

- Monitor stock during calving or lambing
- Search for cast sheep
- Check paddock feed levels
- Record herd or flock images
    - Image processing software for automated stock count

Future Uses on the Gardyne Farm

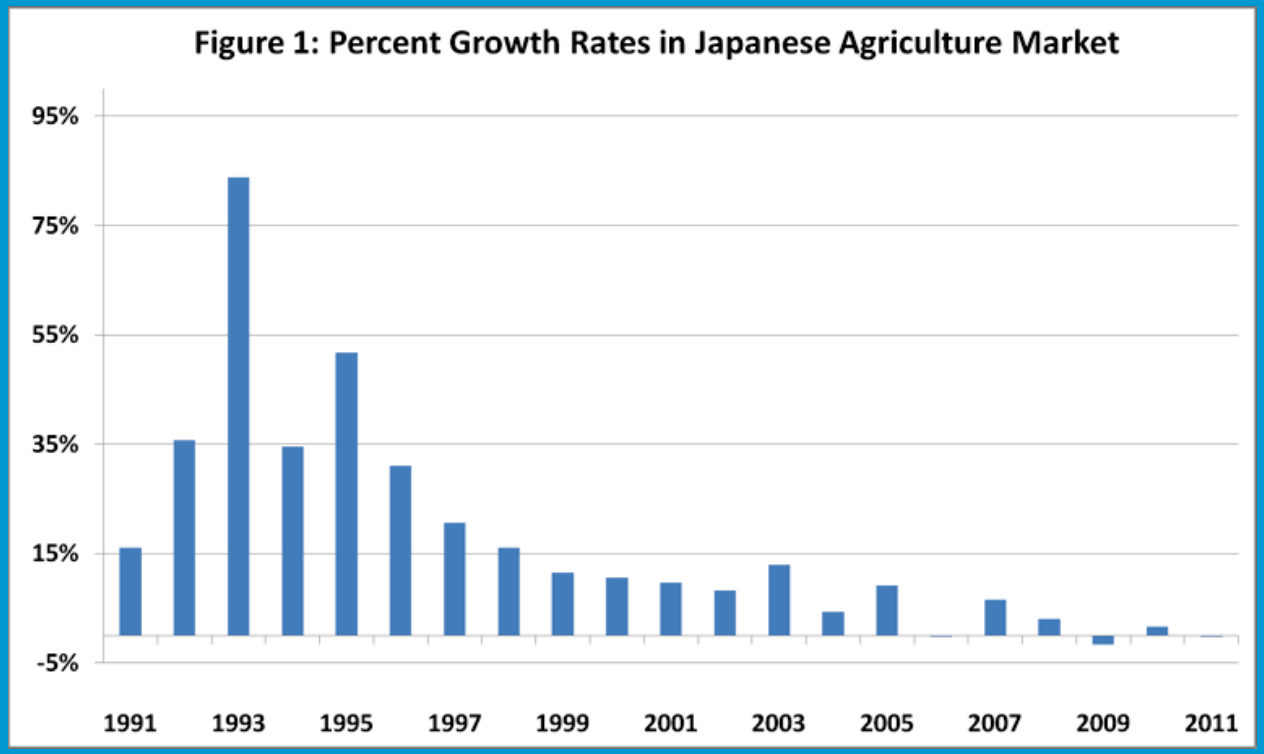
- Identify porina, grass grub and aphid infestations

“The Holy Grail is ... dry-matter measuring and we are well on the way to get that”

-Neil Gardyne

Precedence for UAV Uptake

UAV Spraying in Japan



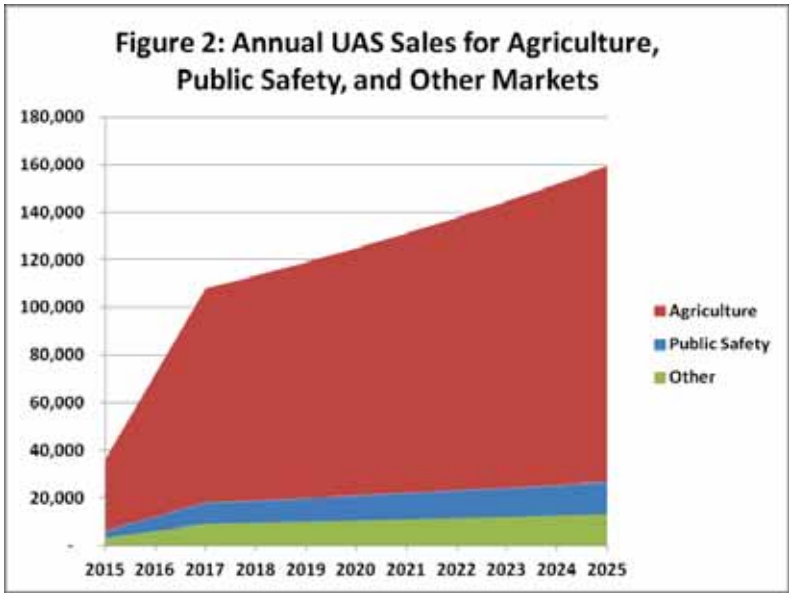
Could we see a similar rapid uptake of UAVs in New Zealand in the next few years?

Source: The Economic Impact, 2013

Economic Impact on Agriculture

The Economic Impact of UAS Integration in the United States

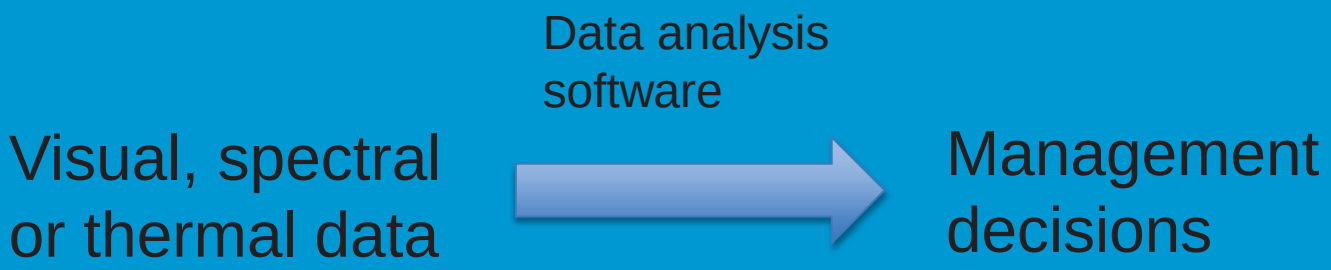
- Report produced by the Association for Unmanned Vehicles International in 2013
- Pro-UAS organization
- Agriculture is the sector which stands to benefit the most from UAVs
- The Report predicts a **total agriculture economic and employment impact of 2.1 billion USD in 2015**
- The estimates are contingent upon new UAV regulation set to be released in the USA in 2015



Source: The Economic Impact, 2013

The Unmanned Aerial System

Management decisions from UAV data



For example, spectral data can be correlated to nitrogen content of pasture using data analysis software. The nitrogen content can be used to make management decisions about fertilizer application.

UAV Regulations

Commercial Use

- A permit is required to operate a UAV for commercial purposes in NZ
  - CAR Part 101 still applies

Future Direction

- The CAA has commented that UAV specific regulations will be released in the near future
- Current discussion topics
  - UAV pilot qualifications
  - Airspace regulation
  - Privacy issues

Variable Rate Application (VRA)

Fertilizer and Pesticide Input

- VRA can be achieved through aerial or ground application
- Traditionally use GPS guided helicopter or airplane
- UAVs will perform the same service at a lower cost

"Because you're using a quadcopter [UAV]…more of the spray ends up on the plants and less on the ground. So, you have to buy less of it, and you can apply it in a more efficient and effective way."

-Scott Tuscano, President, AUVSI*

*Association for Unmanned Vehicle Systems International

Pasture Mapping and Analysis

Current Research

- Studies on estimating biomass in Canterbury and Waikato pastures
  - Based on satellite imagery
  - Reasonably accurate

- Kansas State University is investigating **UAV based yield estimation**

Future Direction

The objective is to develop a UAV capable of mapping the variable biomass yield for an entire farm

UAV Pilot Project Benefits

- Improved efficiency of monitoring
- Reduced carbon footprint
- Monetary benefits

"We think it will provide about **$15,000 in savings per annum**, and another **$35,000 added value** by allowing us to make much better [on-farm] management decisions"

-Neil Gardyne, Beef and Lamb Farmer

Current UAV Research Projects

North Dakota State University (NDSU)

- Thermal imaging
  - Detect heat during breeding season
  - Elevated temperature can indicate illness
- Visual imaging
  - Scan for biosecurity
    - Invasive plants
    - Invasive animals
  - Livestock monitoring
  - Infrastructure monitoring

Source: http://www.ag.ndsu.edu/CarringtonREC/

Invasive Species Detection

- UAV image data
- Analyzed using computer program
- Invasive species identified (red Mesquite in photo below)

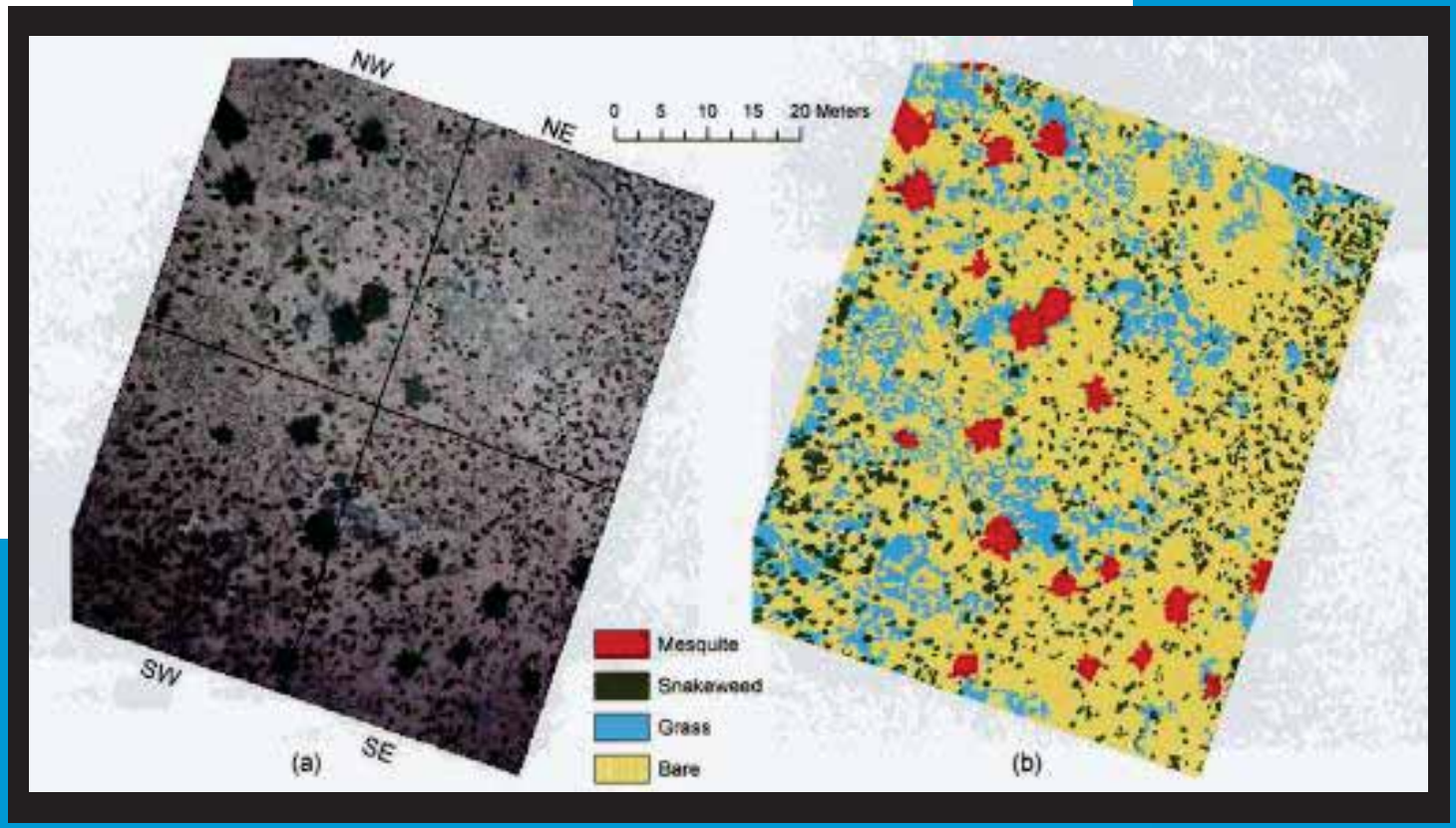


Image: http://www.livescience.com/42108-drones-wildlife-earth-science.html

New Zealand UAVs

Aeronavics Ltd.

- Multi-rotor UAV design and manufacture based in Raglan
- Traditionally target aerial photography and filmmaking sectors
- Discussions with Federated Farmers about agricultural applications of UAVs
- BOT Series
  - Designed for range of applications including farm and agriculture

Image source: http://aeronavics.com/products/shop/bot-airframe-kits/airframe-bot-ti-qr/

New Zealand UAVs

Hawkeye UAV

- Fixed wing UAV design and manufacture based in Palmerston North
- Data collection and processing services included with UAS
- Aerohawk UAV
  - Professional grade data acquisition
  - Visual and multispectral image capture

Image source: http://www.hawkeyeuav.com/aerial-systems/areohawk.html

UAV Crashes

Exploring UAV Crashes

What happens if the UAV crashes?

- Many suppliers offer warranties of at least 1 year
  - Warranty covers parts/machine malfunction
  - Does not cover crash unless directly related to UAV malfunction
- Crash rate depends on
  - Hardware
  - Operator experience
  - Use/mission of UAV
  - External weather conditions
- In NZ UAVs are controlled on the same frequency as wifi networks
  - Drones can lose signal and crash in urban areas

*Source: Reimann et al. 2013

UAV-Helicopter for Spraying (Japan)

UAVs for Grazing Animal Production

- Rangeland monitoring
  - Rangeland quality
  - Invasive species detection
  - Estimating biomass yields
  - Monitoring infrastructure

- Livestock monitoring
  - Livestock herding
  - Livestock surveillance and tracking

Image: http://www.livescience.com/42108-drones-wildlife-earth-science.html

UAV Reliability

Modes of Failure

- UAV experience different types of failure
  - Mechanical failure
  - Control failure
  - Collision
- Risk of failure is acceptable because human risk is low
  - Especially true for rural/agricultural applications

The total risk of UAV failure is about 0.1 failures per hour of flight. This drops to 0.02 failures per hour for catastrophic failures.*

*Source: Reimann et al. 2013

UAVs in Agriculture

Limitations and Future Research

- Improve UAV range and payload capacity
- Sensors/data collection
  - Reduce size
  - Increase resolution
- Convert raw data to useful information
  - Data processing
  - Software development

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