How drones are changing environmental monitoring

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Image supplied by author

The impact of humans on our environment is undeniable. But as we work towards a more sustainable future, it's important for us to understand the details of where and why we are having an impact. Environmental monitoring is one way we can detect human driven change.

Yet distinguishing human impact from the natural behaviour of the environment is challenging because of nature's inherent variability. Weather, the interactions of millions of organisms, and more can all significantly affect the environment, even before humans come into play.

To detect impact well, you often need lots of good quality data. The inherent variability of nature means that to detect change, you need enough data to find patterns in amongst the noise. The more data you have, the sooner you can detect a problem and the easier it generally is to address. Traditionally, scientists have collected environmental monitoring data through either fieldwork, or satellite observations. While these methods can collect valuable information, they also face significant limitations. Drones are helping to overcome these limitations, offering a new, cost-effective method for collecting high quality monitoring data for ecosystems around the world.

How drones are supporting fieldwork

Fieldwork is the oldest form of environmental monitoring. Data collected in the field is usually high quality, since there are lots of opportunities to directly and indirectly measure many important variables. But fieldwork is also very time consuming. Researchers may have to actively traverse large areas, which can take a lot of people power and be quite expensive. Not all environments are well suited for fieldwork either. Some environments, like glaciers, can be difficult or dangerous to navigate on foot.

Glacier D'Orny, Switzerland – Mapped by Andrea Blindenbacher, images processed on GeoNadir.

Glaciers are a valuable source of water to many around the globe, an important indicator of climate change and a potentially dangerous natural hazard. Monitoring them is important, but they can be very dangerous to traverse on foot to collect data. Drone mapping offers a new, safer way to map these natural wonders.

Other ecosystems can be particularly sensitive to the disturbance that researchers would create when conducting fieldwork.

Guidadarri Bat Caves, Western Australia - Mapped by Glen Schloderer, images processed on GeoNadir

Mining in the Pilbara region has the potential to damage caves that form crucial habitat for the vulnerable ghost bat (Macroderma gigas). The caves need to be monitored to make sure no cracks or rock falls are damaging the habitat. However, the caves are difficult to access and surrounded by other delicate ecosystems. Using drone photogrammetry, surveyors can regularly map the caves and produce a 3D output. They can compare these 3D models over time to detect change, while minimising unnecessary habitat disturbance.

Drones can help researchers survey large areas, quickly collecting lots of high quality data without damaging the environment. This makes it easier for researchers to monitor larger areas in more detail more frequently, supporting better environmental monitoring.

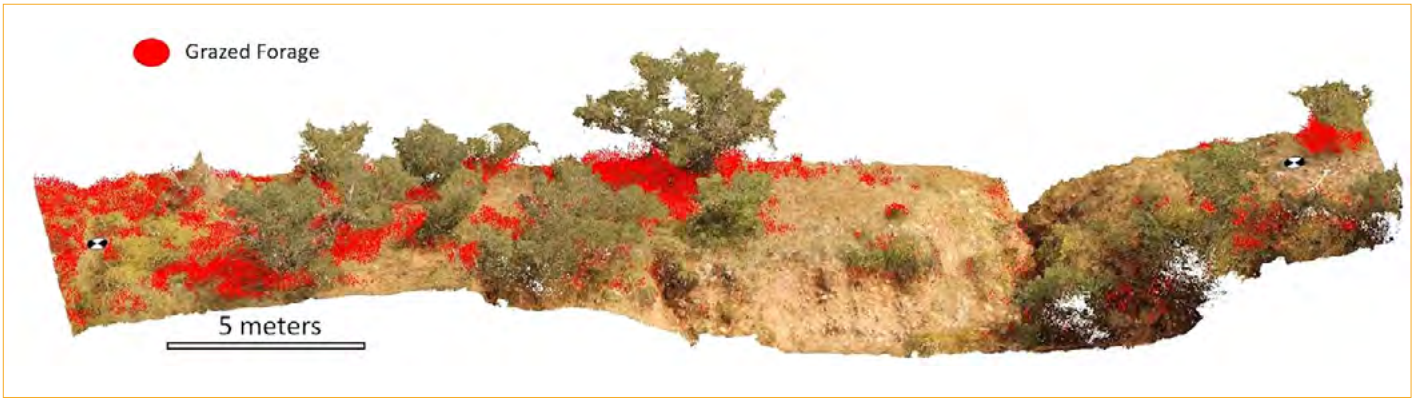
Supporting fieldwork with drone mapping for rangeland monitoring

Rangeland habitats cover over 30% of the USA, and are largely used as grazing land for stock. However historical mismanagement of grazing has led to the degradation of these ecosystems. Dr Jeff Gillan and his colleagues from the University of Arizona have tested drones as a way to map the impact on these systems and develop new management strategies. Traditionally, these ecosystems have been monitored with fieldwork. However, by mapping and creating a 3D point cloud of an area before and after grazing, his team could directly measure the amount and impact of grazing.

Other important metrics, such as the amount of bare ground can also be more accurately quantified using drones than ground-based fieldwork. However, despite the unique perspective drones can offer, they can't replace fieldwork entirely. For example, even high spatial resolution drone imagery is sometimes not detailed enough to distinguish species of grasses, an important factor when monitoring rangelands. Nonetheless, drones have proven a valuable tool for offering a new perspective on these ecosystems.

What about satellite imagery?

Unlike fieldwork, satellites can have enormous spatial coverage and offer a series of data acquired over a long period of time (Landsat has been imaging the world since 1972!). But although satellites can give us a lot of data, the spatial detail within these data can limit its applications to environmental monitoring. Free satellite imagery often has medium to coarse resolution (10 m-1 km) and although some commercial satellites now offer resolution of less than a metre, these can be expensive to access. Even when satellite imagery is high enough resolution for what you want to monitor, other factors like clouds, the tides, or even the time the satellite passes over can impact the availability or quality of the data.



A comparison of a transect before and after grazing. The red shows regions of difference between the two 3D point clouds, indicating where grazing has occurred. Source: Jeff Gillan

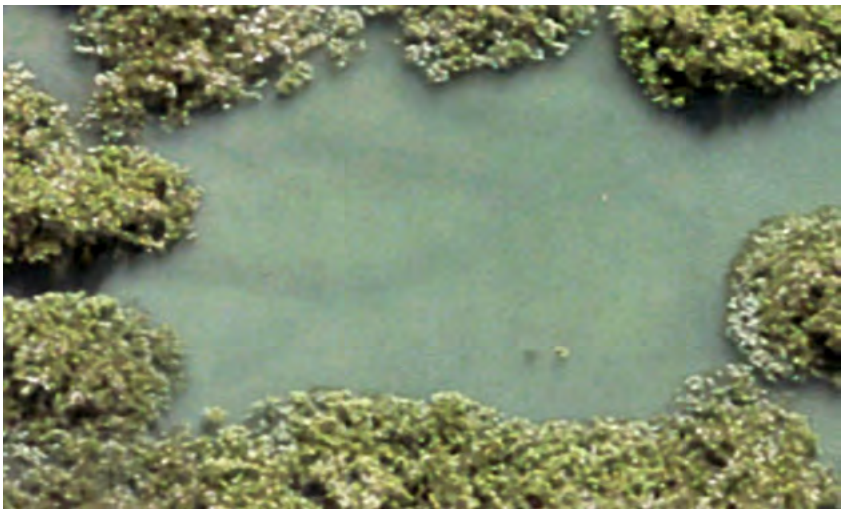
Both drones and satellites collect the same kind of data - images, usually in the visible part of the electromagnetic spectrum. Satellites can map much larger areas than drones, making them useful for detecting broad scale trends and changes. But where the spatial resolution, sensors, and overpass times of a satellite are fixed, drones are flexible. Provided the weather is suitable, an operator can fly a drone as frequently as they need to monitor a feature of interest. It is also easy for them to adjust the time they fly for when a feature of interest is most clearly visible. Drone pilots can also increase the resolution of imagery they collect by changing the camera on the drone or by flying the drone at a lower altitude. All of these characteristics give drones an advantage over satellite imagery for detailed environmental monitoring.

Drone mapping to monitor oyster reefs

Marine ecosystems, like oyster reefs, are particularly difficult to monitor, but it is important that they are monitored well. Oyster reefs provide many valuable ecosystem services, like improving water quality, providing habitat for key fisheries species and coastal protection. But they are also vulnerable to the many disturbances that often occur in heavily populated coastal regions.

In the past, it's been hard to consistently monitor oyster reefs. They can only really be monitored at low tide, when the retreat of the water makes them clearly visible. This leaves a very short window when fieldwork can be conducted, and the muddy terrain can be difficult and slow to navigate, limiting the amount of data that can be collected. The restriction of monitoring to a low tide window also limits the usefulness of satellite imagery. Earth observation satellites usually image any given area at the same time each pass over. This rarely coincides with low-tide however, so oyster reefs often aren't visible in satellite images. Oysters are also quite small making them very difficult to consistently identify even in high resolution satellite imagery.

Drones offer a way to quickly collect data across a large area in the limited low-tide window. This provides a valuable baseline to detect any future change in the oyster reef. It can also help environmental managers identify areas of concern that they might want to investigate in more detail through fieldwork.



Meola Rocky Reef Te Tokoroa, New Zealand - Mapped by Subhash Chand, images processed on GeoNadir. Open-source satellite imagery of an oyster reef in comparison with imagery captured at low-tide with a drone.

Limits of drones for environmental monitoring

Not every ecosystem or feature is going to be suitable for monitoring with drones. There are some restrictions on where you can fly drones (like near airports), and ultimately, drones only collect data on a few bands of the electromagnetic spectrum (usually visible light). While there's a lot we can directly observe or extrapolate from this data, it can't tell us everything. Direct field measurements of other variables, like species counts, contaminants or bioacoustics, are still invaluable tools for environmental monitoring. Similarly, although drones can provide better resolution than satellites, they cannot offer the same scale of coverage satellites provide, meaning satellites remain a critical tool for large scale environmental monitoring.

The value of drones for environmental monitoring fundamentally lies in their ability to affordably fill the niche between the ***scale*** of satellite and imagery and the ***quality*** and ***detail*** provided by fieldwork.

Want to learn more?

We know these stories of drones and their benefits for environmental monitoring thanks to researchers uploading their datasets to GeoNadir. GeoNadir is a free online platform for the storage and sharing of drone mapping data. Users have uploaded datasets that show incredible natural and urban landscapes across the world, from the Great Barrier Reef in Australia to landslides in Brazil.

You can read more about each of the examples in this article on the GeoNadir *Stories from Above* blog. The blog also has many other examples of the cool and innovative way drones are being used to solve problems around the world if you want to learn more! You can also explore the datasets in detail yourself by visiting the GeoNadir platform, accessible via www.geonadir.com.

BELOW: Orthomosaic of Meola Rocky Reef Te Tokoroa, New Zealand – Mapped by Subhash Chand, images processed on GeoNadir.