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Perspective

Free and open-access satellite data are key to biodiversity conservation

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Abstract

Satellite remote sensing is an important tool for monitoring the status of biodiversity and associated environmental parameters, including certain elements of habitats. However, satellite data are currently underused within the biodiversity research and conservation communities. Three factors have significant impact on the utility of remote sensing data for tracking and understanding biodiversity change. They are its continuity, affordability, and access. Data continuity relates to the maintenance of long-term satellite data products. Such products promote knowledge of how biodiversity has changed over time and why. Data affordability arises from the cost of the imagery. New data policies promoting free and open access to government satellite imagery are expanding the use of certain imagery but the number of free and open data sets remains too limited. Data access addresses the ability of conservation biologists and biodiversity researchers to discover, retrieve, manipulate, and extract value from satellite imagery as well as link it with other types of information. Tools are rapidly improving access. Still, more cross-community interactions are necessary to strengthen ties between the biodiversity and remote sensing communities.

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1. Introduction

Biodiversity underpins the health of ecosystems and the services they provide to society. Yet biodiversity is in rapid decline globally, despite commitments by governments to reduce the rate of loss (Butchart et al., 2010). Monitoring is an essential part of biodiversity conservation, allowing governments and civil society to identify problems, develop solutions, and assess effectiveness of actions and progress toward meeting the Aichi targets set by the Convention on Biological Diversity (Secades et al., 2014). Satellite imagery has emerged as a vital tool for monitoring the status of environmental parameters relevant to biodiversity conservation (Horning et al., 2010; Pettorelli et al., 2014; Buchanan et al., 2009). Tackling a global challenge like biodiversity loss requires the assembly of global information products across multiple spatial and temporal scales. Satellite remote sensing is especially useful at generating consistent observation records of key drivers of biodiversity change (i.e. land cover and land use dynamics, climate variables, and sea surface conditions) from a local to global level (Hansen and Loveland, 2012; Townshend et al., 2012; Zhu et al., 2012). A recent review of the needs of the biodiversity research and conservation communities for satellite remote sensing (Leidner et al., 2012) uncovered three factors, which are rooted in government and commercial policies and actions, that ultimately have a disproportionate impact on the utility of satellite data for understanding changes in biodiversity. These factors are data continuity, data affordability, and data access.

1.1. Data continuity

Data continuity refers to the need to preserve and improve existing long-term archives of satellite remote sensing products. Habitat loss and degradation, species invasions and changing climatic conditions are among the most significant threats to biodiversity globally (Millennium Ecosystem Assessment, 2005). These threats can impact biodiversity at a range of spatial and temporal scales, requiring global data collection and long time series of data acquisitions to understand trends and develop robust predictions about their future impacts on biological diversity. Multi-decadal, continuous Earth observation information is only available from a very few satellite systems. The joint U.S. Geological Survey (USGS) and National Aeronautics and Space Administration (NASA) Landsat program and the U.S. National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) instrument provide the longest global-coverage time series. For four decades, Landsat satellites have enabled detection of change on the Earth's land surface and in its shallow coastal waters. AVHRR instruments on NOAA satellites have captured ocean and land surface observations for over three decades. While other satellite data sets provide complementary information, they do not provide such long and consistent time series.

Systematic data acquisition strategies that capture inter- and intra-annual environmental changes (natural and anthropogenic) are critical to achieve and enhance data continuity. Programs such as Landsat provide an excellent example of the challenges associated with developing a strategy. Currently, international cooperators have captured approximately 5 million Landsat scenes, which now reside in archives outside the U.S. Although not all of these scenes are unique to those already in the U.S. archive, there are more images outside the USGS central archive than within it. Consequently, the USGS has begun a Landsat Global Archive Consolidation (LGAC) program Wulder et al., 2012. LGAC is updating all international cooperator imagery into a common format for users and retaining a copy in the global archive at USGS. To date over 3 million scenes have been received from different international ground stations, a third of which are unique additions to the USGS archive. The repetitive global nature of these images is especially important for those working in places with persistent cloud cover, where capturing every available clear pixel of imagery is a necessity due to frequently obscuring clouds. These areas are among the most biologically diverse and often located in places having less capacity for *in situ* monitoring (Romijn et al., 2012).

Data continuity requires both ensuring the long-term records of imagery together with bringing additional satellite systems into a global network that will increase the total amount of useful data. In February 2013, NASA and USGS launched the next Landsat, the Landsat Data Continuity Mission, now known as Landsat 8. With the launch of the Sentinel-1A C-band radar in April 2014, the European Space Agency (ESA) and the European Commission have initiated an important series of dual satellite constellations known as Sentinels. The Sentinel-2 mission, planned for launch in 2015 and 2017, will provide medium spatial resolution (10 m to 60 m – comparable to Landsat resolution of 30 m at most channels) imagery of global land surfaces and coastal waters every five days (Landsat currently has a revisit time of 16 days) (Berger et al., 2012; Drusch et al., 2012). Together with Landsat, these satellites will provide the potential to observe any area on our planet's surface with landscape-scale data every three to four days. Finally, there is a need for continuous availability of reference data as the use of remote sensing imagery requires *in situ* information for calibration and validation. International initiatives like the Committee on Earth Observation Satellites (CEOS) Land Product Validation Working Group foster community consensus on protocols for land product validation (Olofsson et al., 2012), data collection, analysis, and accuracy reporting and make these reference data available for free.

1.2. Data affordability

The cost of satellite imagery matters as it has a large impact on its use and the resulting societal benefits (Mathae and Uhlir, 2012). If too expensive, imagery will not be used as extensively as originally intended. Conservation is chronically underfunded (McCarthy et al., 2012) and governments and civil society will only use these data for implementing conservation policies and monitoring their progress if they can afford them. Many global satellite products are still expensive. In 2008, the USGS began providing open access to all Landsat imagery – new imagery and the entire U.S. archive dating back to 1972, over 5 million images – at no cost to users via the internet (Woodcock et al., 2008). This policy shift, in line with data policies previously instituted by NASA, NOAA, and the Brazilian Government, had a tremendous impact on data availability and greatly fostered the current movement to derive global products from Landsat imagery. It also resulted in a dramatic increase in the distribution of this imagery by over two orders of magnitude within two years (Fig. 1). Although difficult to quantify, the biodiversity and conservation communities are important users of these satellite images. Roughly 10 percent of publications for 2013 found in a Web of Science search on "Landsat" also contain the terms "biodiversity," "biological diversity," or "conservation." Through this policy change, users around the world are accruing the full return of the U.S. investment in Landsat satellites over four decades. National government satellite imagery developed for research and applications purposes is a public good of the highest order (Raunikar et al., 2013). We envisage that Europe too will see its investment in Sentinel missions rewarded over the coming years as the research and conservation communities take up these free data.