Drones for Conservation: Lessons Learned in Antigua and Barbuda

Aviones no Tripulados para la Conservación: Lecciones Aprendidas en Antigua y Barbuda

Drones pour la Conservation: Leçons Apprises à Antigua-et-Barbuda

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EXTENDED ABSTRACT

Introduction

Unfortunately, basemaps and elevation models fundamental for managing natural resources are not routinely available, due largely to the cost associated with extensive airborne field surveys and *in-situ* measurements, which can be financially and logistically burdensome (Baldwin and Oxenford 2014, Norse 2010, Yang 2009). Over the last decade, advances in remote sensing have seen the development and application in the use of 'drones' or small Unmanned Aircraft Systems (UAS) as a valuable tool for environmental management (Whitehead et al. 2015). UAS encompass a whole system: comprising a lightweight Unmanned Aerial Vehicle (UAV) or remotely piloted aircraft and ground control station; its' imaging payload (RGB camera, infrared, thermal and multispectral sensors); as well as flight planning, surface reconstruction and spatial analysis software applications (Whitehead and Hugenholtz 2014). These small and flexible platforms are emerging with an array of payload systems tailored to specific management needs, including habitat mapping, elevation modeling and vegetation health assessments (AIA 2013, Nex and Remondino 2014, Paneque-Galvez 2014) and more recently for marine monitoring applications (Hall 2016, Hodgson et al. 2015, Schill 2015). UAS are now providing researchers a relatively easy-to-use platform, well-suited for mapping at intermediate spatial scales (1 - 10 km^2), at a fraction of the cost, time and technical skill required by traditional aerial survey techniques (Greenwood 2016).

The Environmental Protection and Management Act (2015), established the Environmental Information Management and Advisory System (EIMAS) to improve national data collection efforts (i.e. accurate, reliable, up-to-date, accessible) and support environmental management and decision-making in Antigua and Barbuda. The Drones for Conservation Project, funded by the World Bank and implemented by the Nature Conservancy, seeks to enhance the nation's ability to collect and manage spatial data through the use of UAS. The Project provided UAS equipment, software and training; a UAS policy and operations protocol; comparative analysis of mapping techniques; and a data management protocol (geodatabase schema, data standards, access and use procedures) for the EIMAS.

Methods

To highlight the utility of UAS for conservation, imagery was collected on the southwest coast of Antigua at two demonstration sites (coastal mangrove, nearshore reef) within the Cades Bay Marine Reserve. Detailed description of the UAS survey methods, surface reconstruction results and lessons learned are provided in Baldwin (2016). Surveys were conducted using a 3DR® Solo UAV quadcopter outfitted with a GoPro® Hero4 camera allowing for real-time viewing from the ground control station outfitted with a Samsung® GalaxyA tablet (Figure 1a). The imaging system payload used for these trials comprised of a Sony® ILCE-QX1 20.1 megapixel mirrorless digital camera with a Sony 20mm/2.8 E-mount lens (Figure 1b), natural color and infrared GoPro Hero4 modified 4.35mm focal length cameras (Figure 1c). Payload was mounted on the airframe pointing directly downwards using shock-absorbing mounts to reduce vibrations.

Mission Planner® was used to geotag, or connect the UAV log file information to the analogous aerial images thereby adding the corresponding geospatial metadata to each image acquired. The Tower® flight planning mobile application was used to fly a series of parallel line transects across each survey area. Image capture rate was set to shoot continuously (5 sec intervals) using a 75% overlap along each transect to allow for the surface reconstruction software to correctly match adjacent images during mosaicking. The Pix4Dmapper Pro® 2.1 image processing software employs stereo-photogrammetry techniques to estimate the 3D position of an object based on measurements from two or more images with different vantage points and allow for the creation of a seamless, spatially correct orthomosaic. We used Pix4D to post-process the acquired imagery and create orthomosaic, 3D point cloud, 3D mesh, Digital Surface Model (DSM) products for further analysis in GIS.

Lessons Learned

UAS plays a critical role in mitigating the lack of current and accurate data to support informed decision-making and management (CTA 2016, Vincent et al. 2015, Whitehead and Hugenholtz 2014). Advances in UAS and remote sensing technologies now allows environmental managers to quickly collect and process real-time data to guide management based

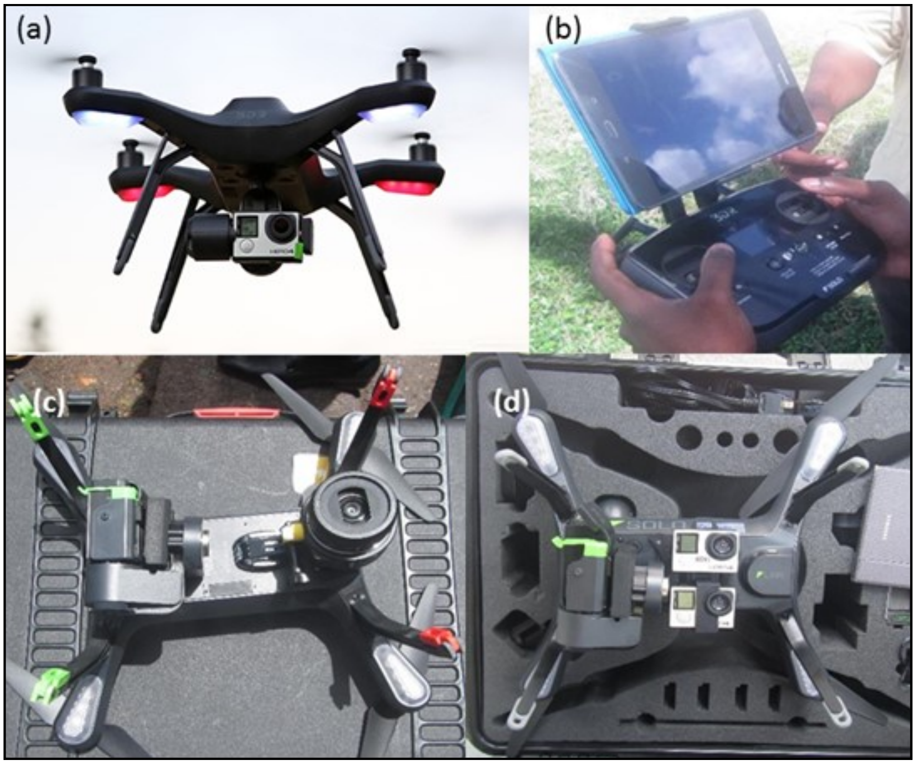

Figure 1. Aerial surveys were conducted using: (a) 3DR® Solo UAV quadcopter with a GoPro® Hero4 camera, (b) the ground control station outfitted with a Samsung® GalaxyA tablet. Payload was mounted on the airframe pointing directly downwards and comprised: (c) Sony® ILCE-QX1 20.1 megapixel mirrorless digital camera with a Sony 20 mm/2.8 E-mount lens, and (d) natural color and infrared GoPro Hero4 modified 4.35 mm focal length cameras.

Table 1. Benefits and limitations of using drones for conservation applications.

Benefits	Limitations
Fun	Short flight endurance
Cost effective	Mapping extent / scale
High resolution imagery	Payload weight restrictions
Real time data collection	Significant initial investment
High temporal resolution	GIS & technological skills
Volumetric measurements	Marine environment
Low technical expertise	Atmospheric conditions
Insensitivity to cloud cover	High potential for loss/damage
Access to remote terrain	Policy & regulatory environment
Strengthen community-based management	

on accurate information (Table 1). We were able to map approximately 5 ha per battery and obtain image resolution of less than 2 cm. Feature identification as small as 20 cm are identifiable and quantification of the area of the mangrove and the identification of threats (e.g. flooding, erosion, land clearing) is easy discernable. The 3D mesh provides a new means to visualize the watershed and quantify flooding and erosion impacts to the coastal mangrove ecosystem. Having a previous foundation in GIS and strong technological skills (e.g. tablets, cameras, apps) we found the UAS and software were both relatively easy to use. Pix4D allowed for relatively automated post-processing and surface reconstruction; nevertheless continued experience and training will continue to refine skills and render even higher quality results. There are a wide range of UAS, flight planning and photogrammetry software packages available so carefully evaluate your potential UAS applications to identify the UAS, payload and software most appropriate for your needs, budget and technological capacity.

Over the course of this study we obtained the best results when we flew earlier in the day (9 - 11 am), flew higher (>100 m), decreased flying speed (< 800 cm/s) and applied a large image overlap (75%). Attention to atmospheric conditions and monitoring the weather and winds (< 12 mph) was also essential. Maximum water clarity is an important consideration when mapping the marine environment, thus limiting the depth of the survey (< 5 ft) as well as taking into consideration the sun angle (oblique, behind the sensor), amount of sun-glint and sea surface state (no white caps) were fundamental for these areas.

Globally policy restrictions are the largest reported barrier (CTA 2016, Vincent et al. 2015, Whitehead and Hugenholtz 2014). Carefully research your national policy environment, regulations and flight request protocol before you purchase a UAS. Moreover the development of a UAS operations manual and data management protocol as well as adequate training and practice are essential for safe and secure UAS operations. Lastly advanced training with Pix4D software and GIS are recommended to improve the surface reconstruction outputs and spatial analysis thereby maximizing the efficiency of data acquired from your UAS.

KEY WORDS: Marine Protected Areas, ecosystem-based management, livelihoods, coral reef resilience, Reef Guardian Program

LITERATURE CITED

Aerospace Industries Association (AIA). 2013. *Unmanned Aircraft Systems: Perception and Potential*. http://www.aia-aerospace.org/assets/AIA_UAS_Report_small.pdf.

Baldwin K. and H. Oxenford. 2014. A partici patory approach to marine habitat mapping in the Grenadine Islands. 2014. *Coastal Management* **6**(42):36-58.

Baldwin, K.. 2016. *UAS data acquisition, processing and mapping methods in Cades Bay Marine Reserve, Antigua.* For the Department of Environment, Ministry of Health and Environment, Government of Antigua and Barbuda. CERMES, University of the West Indies, Cave Hill Campus, Barbados

Centre for Agricultural and Rural Cooperation (CTA). 2016. *Drone Governance: A scan of policies, laws and regulations governing the use of Unmanned Aerial Vehicles (UAVs) in 79 ACP Countries.* CTA Working Paper 16/12. Series: ICTs for agriculture.

Greenwood, F. 2016. Drones on the horizon: new frontiers in agricultural innovation. *Information Communication Techology (ICT) Update*: Issue 82. http://ictupdate.cta.int.

Hodgson, A., N. Kelly, and D. Peel. 2013. Unmanned Aerial Vehicles for surveying marine fauna: a dugong case study. *PLoS One 8(11): e79556*. http://DOI: 10.1371/journal.pone.0079556.

Nex, F. and F. Remondino. 2014. UAV for 3D mapping applications: a review. *Applied Geomatics* **6**(1):1-15.

Norse E. 2010. Ecosystem-based spatial planning and management of marine fisheries: Why and how? *Bulletin of Marine Science* **86**:179 –195.

Paneque-Galvez, J, M. McCall, B. Napoletano, S. Wich, and L. Pin Koh. 2014. Small drones for community-based forest monitoring: an assessment of their feasibility and potential in tropical areas. *Forests* **5**:1481-1507. http://DOI:10.3390/f5061481. http://www.mdpi.com/journal/forests.

Schill, S. 2015. *Mapping Coral reefs and mangroves using low cost drone systems*. The Nature Conservancy, Caribbean Program, USA.

Vincent, J., L. Werden, and M. Ditmer. 2015. Barriers to adding UAVs to the ecologist's toolbox. *Frontiers in Ecology and the Environment*. Ecological Society of America. http://DOI: 10.1890/15.WB.002.

Whitehead, K. and C. Hugenholtz. 2014. Remote Sensing of the environment with small unmanned aircraft systems (UASs), part 1: a review of progress and challenges. *Journal of Unmanned Vehicle Systems* **2**:69-85.

Whitehead, K., C. Hugenholtz, S. Myshak, O. Brown, A. LeClair, A. Tamminga, T. Barchyn, B. Moorman, and B. Eaton. 2015. Remote sensing of the environment with small unmanned aerial systems (UASs), part 2: scientific and commercial applications. *Journal of Unmanned Vehicle Systems* **2**:86-102.

Yang X. 2009. Remote sensing, geospatial technologies and coastal ecosystems. Pages 1-14. in: X. Yang, (ed.) *Remote Sensing and Geospatial Technologies for Coastal Ecosystem Assessment and Management.* Springer Publishing, Berlin, Germany.