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Data Collection and Analyses Applying Unmanned Helicopter (UAV) Remote Sensing to Survey Water Chestnut Invasive Species

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ABSTRACT

Unmanned aerial vehicles (UAVs) can be utilized for large quantity data acquisitions. The major objective of this research is to apply UAV technology to perform rapid data collections and to predict coverages of water chestnut (*Trapa natans*) invasive species along the lower Erie Canal. The second objective of this research is to assess the effectiveness of the physical removal by US Fishery and Wildlife Services (US-FWS) since 2010 using the collected data. Third, both micro-climatic conditions of temperature and relative humidity (RH), land use and land cover types were analyzed to assess habitat conditions of water chestnut. The results indicate that the physical removal of water chestnut by US-FWS was very effective. Four plant patches were detected applying drone (UAV) sensor in the summer of 2016. Temperature and RH survey show that temperature decreases in general as altitude increases. RH values both at the canal surface and at 12 meters above the surface are higher than those at the surrounding land areas. However, a few exceptions exist at the ground level, which might be influenced by grassland moisture evapotranspiration. In summary, 1) no sufficient evidence in this study to illustrate the effects of temperature and RH on the growth of water chestnut; 2) the highest concentration and re-appearance of water chestnut are either at the public parks or at the boat docking sites in the urban areas. 3) This research demonstrates UAV is an emerging technology of large data collection and analysis.

KEYWORDS

Invasive Species, *Real-Time Data Collection*, *UAV Remote Sensing*, *US Fishery And Wildlife Services*, *Water Chestnut*

INTRODUCTION

Systematic environmental monitoring of the land, atmosphere, oceans and collecting concurrent datasets using unmanned aerial vehicles (UAVs) is one of the major approaches of data science (Tripolitsiotis et al., 2016). With the new advancements on flight control and integrated circuit (IC) technology of data acquisitions, UAVs have been widely used in various applications. One of the typical application scenarios is data collection for large geographic areas and connected remote sensor devices in the Internet of things (Qi Pan et al., 2018). UAVs have been integrated with wireless sensor networks (WSNs) to create data collection platforms with high flexibility. Cao et al. (2017) tested

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the cloud-assisted drone (UAV) data collection for multiple emerging events using the distributed wireless sensor networks (WSNs). Some examples of previous UAV applications are: a) sampling microorganisms in a freshwater lake (Benson et al., 2016), b) forest monitoring (Zhang et al., 2016), c) coastal survey (Turner et al., 2016), d) mining survey (Lee and Choi, 2016), and e) 3D digital model building and photogrammetry (Nex and Remondino, 2014; Achille et al., 2015).

In this research, we acquire data in the field to study water chestnut invasive species. *Trapa natans*, commonly called water chestnut or water caltrop, is an exotic annual aquatic plant with a floating rosette of leaves (Figure 1) which is native to Eurasian and African continents (Countryman, 1978; Naylor, 2003). Water chestnut is one of the most controversial plants (Hummel and Kiviat, 2004). In Asia, especially in China and India, people plant water chestnut as an agricultural species. In Europe and Russia, it is a species with conservation concerns (Hummel and Kiviat, 2004); while, the invasion of water chestnut is a serious environmental problem in North America. This plant grows easily and has already invaded freshwater rivers, pools, and lakes, including the Hudson River and the Great Lakes watersheds (Kiviat, 1993; Countryman, 1978; Hummel and Kiviat, 2004).

The spread of water chestnut has already caused many ecological and economic impacts. The leaves of water chestnut cover the water surface, block the waterway, and cut off the air that fish and other aquatic life rely on to live (NYIS, 2014; Hummel and Kiviat, 2004; Naylor, 2003). The management of controlling water chestnut has been done during last several years. Various mechanical and chemical methods have been applied to remove extensively spreading water chestnut. However, these methods of removal take a long time to ensure complete eradication and are expensive (NYIS, 2014). For example, from 1982 to 2011, state and federal government agencies spent $9,600,000 on water chestnut control in Lake Champlain (Hunt and Marangelo, 2012). Scientists also attempted to apply some biological controlling methods, for instance, introducing a leaf beetle (*Galerucella birmanica*) from Asia (Ding et al., 2006). However, whether the result of these biological methods is environmentally friendly is still under research and discussion.

Researches (Hummel and Kiviat, 2004) identified three types of control methods for water chestnut. These are 1) chemical method, 2) physical method, and 3) biological method. An herbicide, 2,4-dicholorophenoxy acetic acid (2,4-D), was applied to the Mohawk River, the Hudson River, and the Lake Champlain. This action reduced water chestnut population successfully (Greeley, 1960; Countryman, 1978; Rector et al., 2015). However, the high concentration of 2,4-D also impacted many native wetland plant, fish, and aquatic invertebrate species (Cronk and Fennessy, 2001; Countryman, 1978; Kiviat, 1993). Physical removal is the most common method used to control water chestnut spreading. Water chestnut, as an annual plant, is best removed before its fruits mature and seeds fall to the bed of the waterways (Hummel and Kiviat, 2004), which is exactly what US-FWS has been doing in the Erie Canal and Tonawanda Creek waterways. Normally, physical removal can be accomplished with machines, such as underwater cutters and harvesters, or by hand pulling (Countryman, 1978; NYIS, 2014). During a mechanical removal process, workers should be careful not to let any mature fruits to fall into bed sediments; the process ensures that no potentially activated seeds are hiding in sediments, which could be dormant for 10-12 years (Elser, 1964). Therefore, the annual water chestnut removal activities should be done no later than July before mature fruits may start to drop (Countryman, 1978). Physical control methods have been proven effective in many cases, such as the management plans in the Lake Champlain, the Hudson River, the Chesapeake Bay region, the Potomac River, as well as other water bodies (Bickley and Cory, 1955; Elser, 1964; Hunt and Marangelo, 2012; Bove and Hunt, 1997; Madsen, 1993). However, physical control methods always consume a long period of time, a lot of money, and large quantity of human resources. For instance, it cost several hundred thousand dollars and took more than 20 years at the Potomac River to achieve a success result (Madsen, 1993).

The basic idea of biological control of invasive species is to employ the natural enemies of the species. In order to control water chestnut, several different species were introduced to establish competition. According to the literature, grass carp (*Ctenopharyngodon idella*) were introduced from