ANALYSIS OF USING UNMANNED AERIAL VEHICLES IN FORESTRY

by

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Second Reader

A CAUTION TO THE READER

This HBScF thesis has been through a semi-formal process of review and comment by at least two faculty members. It is made available for loan by the Faculty of Natural Resources Management for the purpose of advancing the practice of professional and scientific forestry.

The reader should be aware that opinions and conclusions expressed in this document are those of the student and do not necessarily reflect the opinions of the thesis supervisor, the faculty or Lakehead University.

ABSTRACT

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Key words: Compliance monitoring; Drones; Forest fire; Forestry; SWOT analysis; Unmanned aerial vehicle (UAV); Wildlife.

Unmanned aerial vehicles are a growing market within the forest industry. They provide opportunities for enhancement of data collection, monitoring of wildlife, forest fire detection and monitoring, compliance monitoring and more. Unmanned aerial vehicles is not a new idea however with technology advancements the uses are becoming more common and continually expanding into all aspects of life. This study was conducted by a S.W.O.T analysis to determine if the strengths of UAVs outweigh the weaknesses for the use of forest management. The greatest limitation to UAVs in forestry is the increasing rules and regulations. As it is becoming a popular tool more certification is required to operate the UAV and new rules are constantly being implemented. UAVs will become a great asset to foresters as they provide safe, accurate and fast results.

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INTRODUCTION

Unmanned aerial vehicles (UAV) provide fast, accurate and safe results for studying multiple aspects of forestry. UAVs, also known as unmanned aerial systems (UAS) or drones are two types of small aircraft, either fixed-wing aircraft or rotorcraft, that can be operated from the ground and do not require a pilot on board (Launchbury 2014). These small aircrafts can be equipped with still photography, video or even thermal imagery systems, providing a wide range of opportunities for uses. UAVs are used to capture high resolution imagery over relatively small areas. The concept of using UAVs as another imaging tool was first introduced in 2011 (Launchbury 2014). Over the years advancements have allowed drones to be equipped with global positioning system (GPS) and imaging technologies which require no remote controls and can be programmed to be fully automatic (Launchbury 2014). For the purpose of forestry, UAVs are usually equipped with a multi-spectral camera which means it captures data at specific frequencies across the electromagnetic spectrum (Launchbury 2014). The drones are usually flown between 60 m and 150 m above ground which provides 20 to 30 times higher resolution than satellite imagery (Launchbury 2014).

UAVs are becoming a great asset in the forester's tool kit. UAVs provide numerous benefits to the forestry industry such as; reduced costs, highly accurate data, fast results, and little threat to human safety. These new advancements in technology allow a forester to obtain highly accurate data in a timely manner. It can be used to collect data for pre-and post-harvest surveys, inventory, fire management, and compliance monitoring (Launchbury 2014). The images captured through UAVs contain so much information that it is becoming more accurate and efficient than conducting ground surveys. Although ground surveys are still needed for some aspects of surveys, UAVs provide complimentary data to go along with the ground survey results.

STUDY OBJECTIVE

The objective of this study is to conduct a S.W.O.T analysis (strength, weaknesses, opportunities, and threats) to determine whether companies should be investing in a drone for future forestry work. It will look at the benefits and limitations of using drones in the field.

HYPOTHESIS

The hypothesis for this study is that drones are going to be one of forester's main tools in the years to come. Companies need to determine if UAVs should be integrated into forest management planning. This study will provide insight for industries to help determine if investing in drones is something worthwhile and if the benefits outweigh the limitations that will arise with investing in a UAV system.

LITERATURE REVIEW

HISTORY

Unmanned aerial systems were established 95 years ago when aerial torpedoes were developed. These systems were used in military services to provide strike and scouting opportunities to the battlefield commanders (Keane and Carr 2013). The first recorded use of an unmanned aerial vehicle was demonstrated in July of 1849 (Buckley 1999). The first UAV was in the shape of a balloon and was designed to drop bombs on cities from the balloon. In later years, experts developed UAVs into three classes: i) pilotless target aircraft that were used for training purposes (such as target drones); (ii) nonlethal aircraft designed to gather intelligence, surveillance, and reconnaissance (ISR) data; and (iii) unmanned combat air vehicles (UCAVs) that were designed to provide lethal ISR services (Keane and Carr 2013). Furthermore, after experimenting with these UAVs troops had difficulties launching and recovering the vehicles and while the UAVs were in flight, operators had difficulty maneuvering the machines (Keane and Carr 2013). In World War II (WWII) UAVs were being used as a weapon delivery system such as target drones and radio-controlled drones. However, during the Cold War the UAVs had limited achievement as weapon delivery platform's when used as IRS systems (Keane and Carr 2013). During the early stages of UAV development, technology was not advanced enough to become effective and crews were not supportive in operating these new devices which led to failures. Drones are no longer used exclusively for military purposes. They are used for a wide array of activities due to their versatility and the technological advancements that have been made in these devices.

DEFINTITONS

Drones are the most commonly used term when it comes to these newly arising aircrafts that can be operated without a pilot on-board. Drones can vary in sizes, shapes, arrangement, speed, and so much more. They can be used for a wide range of activities such as; work purposes, recreational use, aircraft surveillance along with the original military applications. More terms correlated to drones are as follows: unmanned aerial vehicle (UAV), unmanned aerial system (UAS), remote piloted aircraft systems (RPAS), and model aircraft (OPCC 2013). UAVs are defined by the Canadian Aviation Regulations (CAR) as a battery-operated or power-driven aircraft that does not require a pilot to be on board. UASs are defined as the support system behind the UAV. It is the control station, data link, telemetry, communication and navigation system of the UAV (OPCC 2013). Furthermore, RPAS is used to acknowledge the fact that drones are not completely automatic. They require an operator on ground to control the drone while it is in flight.

POLICY AND LEGISLATION

In some cases, operators flying a UAV will need to obtain a certificate called "Special Flight Operation Certificates" (SFOCs) which is issued by Transport Canada as a way of protecting the safety and privacy of individuals (Thompson and Saulnier 2015). Those who wish to fly drones for fun do not require the SFOC as long as the drone weighs 35 kg or less. Flying drones for recreational use still requires the pilot to follow safety rules outlined in the Interim Order Respecting the Use of Model Aircraft. Some of the rules for flying a drone are as follows; fly below 90 m above ground, either 30 m from vehicles, vessels and the public or 76 m (depending on the weight of the drone), must be at least 5.6 km away from any manned aircraft take-off and landing bases and airports, and must be flown outside of controlled or restricted airspace (GOC 2018). Failure to follow the rules of flying a drone will result in serious penalties and fines. For the purpose of flying UAVs for work or research, or it weighs over 35 kg, the operator must obtain an SFOC. In most countries, UAV regulations are similar and are classified by weight, operational range and the purpose of its utilization (Stöcker et al. 2017).

As of June 1st 2019, new rules for flying drones will come into effect. All pilots of drones within the weight restrictions must have a drone pilot certificate, either basic or advanced, depending on the type of operations they are using the drones for (GOC 2019). The new rules apply to RPAS and drones that weigh 250 grams (g) and up to 25 kilograms (kg) (GOC 2019). All pilots must be aware of the rules and individuals operating these devices can be subject to fines or jail time if they put people or other aircraft at risk, flying without a drone pilot certificate, or flying an unmarked drone (GOC 2019).

While in flight, there is a set of standards the pilot must follow. These include; having visual location of the drone at all times, must be flown below 122 meters, avoid bystanders, avoid emergency operations, fly away from airports (5.6 km from airports), and must be far away from other aircrafts (GOC 2019).

The new set of rules indicates two classes of licenses: one being basic and the other advanced. The two classes of licenses are based on distance from bystanders and whether its operated in a controlled or uncontrolled airspace. Basic operations are conducted in uncontrolled airspace, never operate the drone over bystanders and must fly the drone more than 30 m horizontally from bystanders (GOC 2019). Advanced operations allow the pilot to fly in a controlled airspace, fly over bystanders, and operate 30 meters from bystanders (GOC 2019). Essentially, advanced licenses allow a pilot to fly within a closer proximity to airports. A pilot must pass an advanced exam and perform a flight review examination.

Furthermore, the new rules outline specific types of drones that are only to be operated under the advanced license. These drones are specified under safe declaration rules. There are numerous drones that qualify and have an RPAS Safety Assurance declaration submitted by the manufacturer (GOC 2019). Table 1 displays the approved drones for certain advanced operations as stated on the GOC (2019) website. As well, recently the DJI manufacture stated a number of drones that now qualify for advanced operations. These drones that qualify for advanced operation use are: M600 Series, M200 Series, M200 V2 Series, Inspire 2, Mavic 2 Series, Mavic Pro, Mavic Air, Phantom 4 Series, and Spark (DJI 2019). As technology advances and the use of drones become more commonplace, rules and regulations will continue to evolve.

Table 1. Approved drones for advanced operations (GOC 2019).

Manufacturer	Model	Type	Controlled Airspace	Fly Near People
WINGTRA AG	WINGTRA ONE	Fixed wing	Yes	Yes
SMARTPLANES	FREYA	Fixed wing	Yes	Yes
SKYX SYSTEMS	SKYONE 1.0C	Fixed wing	Yes	Yes
SILENT FALCON UAS TECHNOLOGIES	SILENT FALCON	Fixed wing	Yes	Yes
SENTERA INC.	PHX	Fixed wing	Yes	Yes
SENSEFLY	ALBRIS	Rotary wing	Yes	Yes
SENSEFLY	EBEE (EBEE CLASSIC)	Fixed wing	Yes	Yes
SENSEFLY	EBEE X (EBEE X & EBEE AG)	Fixed wing	Yes	Yes
SENSEFLY	EBEE+ (EBEE PLUS & EBEE SQ)	Fixed wing	Yes	Yes
MINERAL SERVICES CANADA INC.	REMOTE MAPPER	Fixed wing	Yes	Yes
MICRODRONES CANADA INC.	MD4-1000	Rotary wing	Yes	Yes
MICRODRONES CANADA INC.	MD4-3000	Rotary wing	Yes	Yes
LOCKHEED MARTIN	INDAGO 2	Rotary wing	Yes	Yes
LOCKHEED MARTIN	INDAGO 3	Rotary wing	Yes	Yes
KESPRY INC.	KESPRY DRONE 1.0	Rotary wing		Yes
INTEL CORPORATION	FALCON 8+	Rotary wing	Yes	Yes
INFINITE JIB	NEXUS	Rotary wing	Yes	Yes
INFINITE JIB	SURVEYOR 630	Rotary wing	Yes	Yes
INFINITE JIB	ORION	Rotary wing	Yes	Yes
INDRO ROBOTICS	M210C	Rotary wing	Yes	Yes
INDRO ROBOTICS	SCOUT MKIII	Rotary wing	Yes	Yes
EPOC UNMANNED INC.	STRYDER MK-II	Rotary wing	Yes	Yes
EPOC UNMANNED INC.	STRYDER MK-I	Rotary wing	Yes	Yes
ENVIRODRONE LTD.	EXPLORER	Fixed wing	Yes	Yes
ENVIRODRONE LTD.	SPEXTER	Rotary wing	Yes	Yes
DRONE DELIVERY CANADA CORP.	SPARROW X1000	Rotary wing	Yes	Yes
DRAGANFLY INC.	X4ES	Rotary wing	Yes	Yes
DRAGANFLY INC.	X4P	Rotary wing	Yes	Yes
DRAGANFLY INC.	GUARDIAN	Rotary wing	Yes	Yes
DRAGANFLY INC.	COMMANDER	Rotary wing	Yes	Yes
DELAIR SAS	UX11	Fixed wing	Yes	Yes
DELAIR SAS	DT18	Fixed wing	Yes	Yes
DELAIR SAS	DT26X	Fixed wing	Yes	Yes
AERYON LABS INC.	SKYRANGER	Rotary wing	Yes	Yes

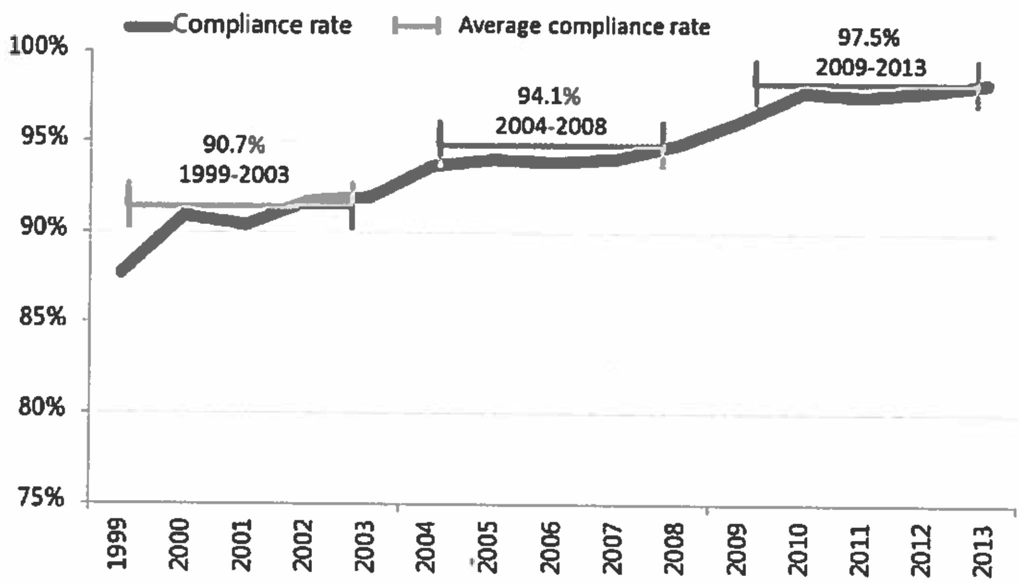
Source: GOC 2019

USES IN FORESTRY

Drones have multiple applications in forest management. They provide precise information about forest composition, structure, and health which is crucial for sustainable forest management (Shao 2012 in Tang and Shao 2015). Drones are also used in harvesting operations, regeneration prescriptions and compliance monitoring. As well, they aid in assisting with wildfire data collection and can be used to monitor wildlife.

COMPLIANCE MONITORING

Compliance monitoring is an important role in assuring that forest operations on Crown land are being conducted in a sustainable manner (OMNRF 2015). The government implements a thorough procedure that forest operations on Crown land must follow in order to practice sustainable forest management. These procedures are applied through several policies, legislation, regulations, standards and guides (OMNRF 2015). Compliance monitoring must be completed for all forest operations on Crown land. This provides suggestions on how well operations are being conducted and if the operations have met the requirements for practicing sustainable forest management. Compliance monitoring occurs in collaboration with the Ministry of Natural Resources and Forestry and the license holder of a forest (or forest industry). These inspections are completed for a number of different operations; timber harvesting, road construction, water crossings and regeneration (OMNRF 2015). A non-compliance occurs if the operation has failed to follow specific requirements and either warnings, penalties or charges may be applied. A follow-up on the non-compliance is mandatory in order to be deemed sustainable and meet the requirements outlined in the management plan. The examinations are written up by certified compliance inspectors and are filed into a database called Forest Operations Information Program (OMNRF 2015). As shown in figure 1, compliance monitoring in Ontario has seen an overall increase from 90.1% in 1999-2003 to 97.5% 2009-2013 (OMNRF 2015).



Source: OMNRF 2015

Figure 1.Comparison of compliance rates in Ontario from 1999-2015.

UAVs are being incorporated in compliance monitoring as a safe, fast and effective tool. UAVs allow the inspectors (or foresters) to view the compartments being reviewed in a timely manner and allows the forester to address any issues as soon as they arise. An example of how UAVs are benefiting foresters is stated by Bilyk (2018 in lecture), "a company received a non-conformance for bundles of timber left behind post-harvest". The UAV is being used to fly the compartment prior to a snow storm to identify and map the bundles of timber so operators can accurately locate where the bundles are post snowstorm. This insures that no timber is being left behind and allows operations to commence in a sustainable manner and therefore, has increased the overall compliance rates. Increased compliance rates indicate that there are improvements in the way forest operations are being conducted.

FOREST FIRES

UAVs are becoming a great asset to aiding forest fire suppression efforts. Forest fires are a natural disturbance that can cause significant damage to properties and the ecosystem. Being able to detect and suppress forest fires before they cause significant damage is essential for saving provinces and countries billions of dollars in economic loss (Casbeer et al. 2011). Advancements in technology have allowed UAVs to detect forest fires through thermal and infrared imagery. The thermal imagery allows for early detection of fire suppression efforts. As stated in the study completed by Ollero et al. (2006)), there are different ways UAVs can be used before, during or after a fire. UAVs before a forest fire can be used for observing the forests and being able to identify and map areas that are of high fire risk. There are a variety of different types of UAV that would be best equipped to complete these tasks depending on their durability, endurance, and payload. Furthermore, UAVs are a great asset during a fire for the use of fire detection and mapping. This eliminates non-critical work for the helicopters as they are trying to maintain safety for workers on the ground and provide them with whatever tools they need in order to remain safe and effective at suppressing the fire. As well, helicopters have to map the fire and by eliminating that process with the use of UAVs the helicopters are freed up to help maintain control and spread of the wildfire. Lastly, after a fire has been put out UAVs can be used to map the area burnt and provide fire managers with a post-fire analysis (Ollero et al. 2006).

WILDLIFE MONITORING

Wildlife monitoring is essential for maintaining a diverse ecosystem. UAVs are currently being applied to assist wildlife conservation, protection, habitats of endangered species, tracking various wildlife species, migration populations, nesting sites, management implications and so much more. A variety of different studies across the world are being completed to look at population levels of animals, habitats and the effects of forestry on wildlife. Over the years the use of UAVs in wildlife management has been given the most attention by aquatic researchers (Chabot 2015). This is due to the fact that it is difficult to determine habitat and wildlife species in aquatic environments due to the vastness of the oceans and seaways. UAVs can provide real-time videos under water and allows for multispectral imagery. There are many different ways UAVs can be incorporated into wildlife management and provides fast and effective results. The use of UAVs in this field will continue to grow and flourish with technology advancements.

LIMITATIONS OF TECHNOLOGY

As with most technology there are limitations that arise when using drones within the all professions. The greatest limitation of using drones in forest management is the small payload. UAVs are limited to the amount of equipment they can carry due to their size and weight (Paneque-Gálvez et al. 2014). The small payload decreases the effectiveness of the resolution. To make these devices more effective an increase in payload and resolution increases the purchase price of the drone which makes it less cost-effective. For the purpose of forest management, expensive drones are not always needed as ground surveyors may be the most cost-effective method of monitoring the forests if drones become too expensive. Essentially, there are alternatives to reduce the cost rather than spend lots of money on a drone.

Furthermore, the structure of a drone can place limitations on the technology available to the drone. Drones are not equipped to travel far distances and the endurance of the drones is quite low depending on the choice of drone (Paneque-Gálvez et al. 2014). This coincides with the small payload, depending on the size and type of drone there is limited space to carry large batteries or fuel. Although, as stated by Goodbody et al. (2017), technology advancements are leading to increased payload capacities, ability to attach multiple sensors and may provide advancement to increase the improvement of battery capacity (Goodbody et al. 2017).

Due to the size of the drones there is an increased sensitivity to atmospheric conditions (Paneque-Gálvez et al. 2014). Drones have difficulty withstanding strong winds, heavy fog, and rain. This puts constraints on when a pilot is able to operate a drone (Paneque-Gálvez et al. 2014).

COST ANALYSIS

Cost effectiveness and accuracy are an important aspect of sustainable forest management. Managers need accurate data to make informed decisions and reducing the costs of having a surveyor on the ground is becoming more predominant. The two most common types of drones (fixed-wing and rotary) are available in a variety of different sizes. Costs can range anywhere between $10,00-$150,000 (Goodbody et al. 2017). A study conducted by (Koh and Wich 2012) found that UAV's are more efficient and cost effective in local forest monitoring. The time and money it takes for ground surveyors to complete their work is substantially higher than the use of a small UAV system. With the use of a UAV, the work can be completed in a much shorter time frame while using ground surveyors could take weeks or months to complete. Thus, making the UAV system more cost-effective.

TECHNOLOGY

UAVs use thermal and infrared cameras. Thermal and infrared cameras are capable of operating in adverse weather conditions. Thermal cameras use emitted energy while infrared sensors use reflected energy (Pajares 2015). An infrared thermal sensor can detect radiant energy using a function of wavelength and temperature (Pajares 2015). This allows the drones to access areas in adverse weather conditions that ground surveyors could not reach.

Drones are equipped with live videoing capabilities. As stated by Pajares (2015), videoing allows for vision-based monitoring which provides a pictorial for large areas needed to be either monitored for the purpose of surveillance (for the use of illegal logging) or for thermal imagery analysis (fire suppression efforts). Although vision-based monitoring is a great asset, it also has some setbacks. Adverse weather conditions will limit the quality of the imagery either by gusting winds, rain or heavy fog (Pajares 2015). When using thermal imagery for the purpose of fire suppression efforts, errors occur as the UAV imagery may detect hot rocks (emitting from the sun) instead of fire caused hot spots.

Light detection and ranging (LiDAR) devices are another source of technology currently used in UAS. These devices measure distance by using pulses emitted by a laser (Pajares 2015). These pulses explore the scene with the light projected on the target (Pajares 2015). LiDAR devices are light weight systems and can be used for surveillance or mapping both natural and artificial forested areas and can enhance the improvement of stand structure (Pajares 2015).

MATERIALS AND METHODS

A S.W.O.T analysis was conducted to review any problems or opportunities that may arise with using drones for the purpose of sustainable forest management. A S.W.O.T analysis is an acronym that stands for strengths, weaknesses, opportunities, and threats. This analysis is typically completed by businesses to help improve their industry and production or for new market opportunities. UAVs in forestry fall under new market opportunities as they are a new commodity and, although there may seem like endless benefits to using UAVs for forest practices, there are some disadvantages as well. The questions asked to complete this study are listed below in table 1. These questions provide guidance in determining if UAVs are applicable for all aspects of forest management practices. The results used to create S.W.O.T analysis were compiled based on the literature review.

Table 2. S.W.O.T analysis template used to complete study.

	Opportunities	Threats
Strengths	Strengths-Opportunity strategies What are some of the strengths UAVs provide that can maximize foresters opportunities?	Strengths-Threats strategies How can the use of UAVs strengths be used to minimize the threats associated with UAV use in forestry?
Weakness	Weakness-Opportunity strategies What action (s) can be taken to minimize UAV weaknesses in forestry practices using the opportunities identified?	Weakness-Threats strategies How can the use of UAVs weaknesses be minimized to avoid the threats?

RESULTS

Table 3 illustrates the strengths correlated with using UAV systems for forest management. The strengths support the hypothesis of this study that UAVs will prove workers with fast, safe and accurate results.

Table 3. Strengths associated with flying UAVs for forestry practices.

Strengths	
High spatial resolution	Assist ground surveys
No negative impact due to cloud cover	Safer Work Environment
Low purchase price possible	Efficient data collection
Cost-effective	Consistent data
Enhanced monitoring	Greater access to inaccessible areas

Table 4 identifies the weaknesses that stem from using UAVs in forestry. These weaknesses constrain a worker in some day to day duties.

Table 4. Weaknesses correlated with UAVs in forestry.

Weaknesses
Small payload
Adversely affected by weather conditions
Limited flight endurance
Safety issues – distance to people and aircraft

Table 5 demonstrates the opportunities that arise with the use of UAV systems. The strengths provided in table 3 support how UAVs can provide ways to maximize forester's opportunities for faster, safe and accurate results.

Table 5. Opportunities that arise with UAVs in forestry.

Opportunities
Environmentally friendly process
Growing market
Reduction of workload

Table 6 lists the threats associated with using UAV systems in forest management. The greatest threats being policy and regulations. As well as, the constant visual line of sight.

Table 6. Threats of UAVs in forestry.

Threats
Policies and regulations
Visual line of sight
Certifications

Table 7 provides the differences in strengths for a fixed wing UAV and a rotary wing UAV. The greatest strength for fixed wing systems is the increased flight times and speeds. Although, rotary wing does not require a launch pad making them a bit more valuable for the use of forest management as a worker might not always be in a location where a launch pad is available.

Table 7. Strengths of fixed wing versus rotary wing.

Strengths of Fixed wing	Strengths of Rotary Wing
High flight speeds	Limited Launch space
Increased flight times	Hover capabilities

Table 8 displays the weaknesses for fixed wing and rotary. The greatest weakness for fixed wing is the space it requires to take-off. The rotary is limited to speeds and the distance it can travel.

Table 8. Weaknesses of fixed wing versus rotary wing.

Weaknesses of Fixed Wing	Weaknesses of Rotary Wing
Require launch path	Shorter range
Constant state of forward motion	Slower flight speeds

DISCUSSION

STRENGTHS

There are many strengths of using UAVs as a tool for monitoring forest management practices. The greatest strength of using UAVs in forestry is the high spatial resolution. Flying at lower altitudes allows for better imagery analysis. This benefits foresters because it allows for individual tree identification which provides more accurate results of species composition. UAVs provide opportunities for silvicultural improvements as the UAV system can detect any mortality or compliance issues in regenerating a stand. Flying at lower altitudes also mean that the imagery is insensitive to cloud cover. This provides opportunity for more flight operations without the constraints of adverse weather conditions. When flying stands with a helicopter there are many restrictions on when a pilot can and cannot fly due to weather conditions.

Furthermore, UAVs can have a relatively low cost. As stated above there are many different types and sizes of drones and they vary in prices. A forester is likely not going to buy the top of the line UAV system to perform day to day duties. There are other methods to monitor a stand at a lower cost (i.e. ground surveyors or helicopter aerial imagery). A realistic price to spend on a drone for the purpose of forestry work is around $10 000 CAD. This price includes the initial price of the drone, the camera, extra batteries, and a carrying case. Using a drone for forest monitoring increases the cost-effectiveness and saves a substantial amount of time. A ground surveyor may take weeks or months to complete a pre-determined block inspection where a drone may take a couple days to fly the whole block or sometimes just a day. As well, this can assist ground surveyors. If there is an inaccessible part of the forest (streams, rivers and hills or slopes that are too high) the UAV can fly this area to complete the needed work for the surveyor.

WEAKNESSES

The weaknesses associated with using UAVs in forestry are small payload, sensitivity to atmospheric conditions, short flight endurance, possibility of collisions which increase the cost of repair and maintenance, and safety issues. A drone has a relatively small payload due to the small size which restricts the capability to carry larger items or fuel to fly long distances. Drones are sensitive to atmospheric conditions such as rain, fog, or any other condition that restricts the image quality. This limits the drones to only fly during favoured conditions or limits the quality of work. A more expensive UAV system can work around the undesirable weather conditions but then a manager must determine if it is cost-effective to purchase an enhanced quality UAV system. Furthermore, due to the size of the drone they are not equipped to fly long distances. Batteries or fuel storage are limited and restrict the endurance of the system. Lastly, there is an increased chance of collisions when it comes to take-off, landing and in flight sessions. Crashing a drone can cost a lot of money depending on the severity of the collision. Finally, safety issues arise when using UAV systems for forest management and monitoring. A pilot must be aware of all infrastructure (potential tourist camps or cabins) or possible bystanders (blueberry pickers, hunters, or other operations) to ensure they are respecting others privacy and are compliant with the rules and regulations of safe operating.

OPPORTUNITIES

The opportunities that arise with using UAV systems in forestry are the growing market, reduction of workload and the environmentally friendly process. UAS are a growing market providing opportunities for use in the forest industry. These opportunities may present a reduction of workload for on ground foresters and can provide an environmentally friendly process of working within the industry. The use of UAV systems present the opportunity to provide a safer work environment for workers within the forest industry.

THREATS

The threats associated with using a UAV system as a tool are the continually changing policy and regulations, the need for a constant visual line of sight, and certifications requirements for a pilot to operate a UAV. The increasing policy and rules being implemented make flying drones in a forest setting are difficult. A constant visual line of sight is difficult to obtain in a forest as some canopies are quite high and dense, often limiting the ability to operate the UAV within regulations. The continually changing policy and regulations make it difficult to maintain certification for operates. The new rules implemented are increasing the need for more certification thus, lowering the cost-effectiveness of the UAVs.

FIXED VS ROTARY WING

Lastly, there is a difference when choosing what UAV system to fly. Both applications have strengths and weaknesses. The greatest difference between the two is one requires a launchpad where the other does not. A launchpad in a dense forest setting could be difficult to obtain unless a road is nearby. The fixed wing requires the launchpad and is always in a constant state of forward motion. Fixed wing however, have the ability to fly longer distances and at greater speeds. The rotary wing UAV do not require a launchpad, and have the ability to hover. However, they are limited to flight times and speed.

CONCLUSION

UAVs are becoming a great asset to foresters. They provide regularity of data, which allows foresters to make informed and accurate decisions based on species composition and health of the forest. UAVs can be used to monitor wildlife, forest fires and can aid in compliance monitor reporting. UAVs aid foresters in day to day tasks and allow them to acquire data in a safe and timely manner. They are a cost-effective tool that can be used in a variety of aspects of forestry. However, with the increasing rules and regulations being implemented, constraints are arising with the constant visual line of sight and certifications required to operate. UAVs are not going to necessarily replace workers (i.e. ground surveyors) but simply aid the forest industry as a complementary tool to established practices. As technology and time progress more opportunities may arise for a variety uses. UAVs are a continually growing market that provides numerous opportunities for the industry while enhancing the safety of the workers.

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