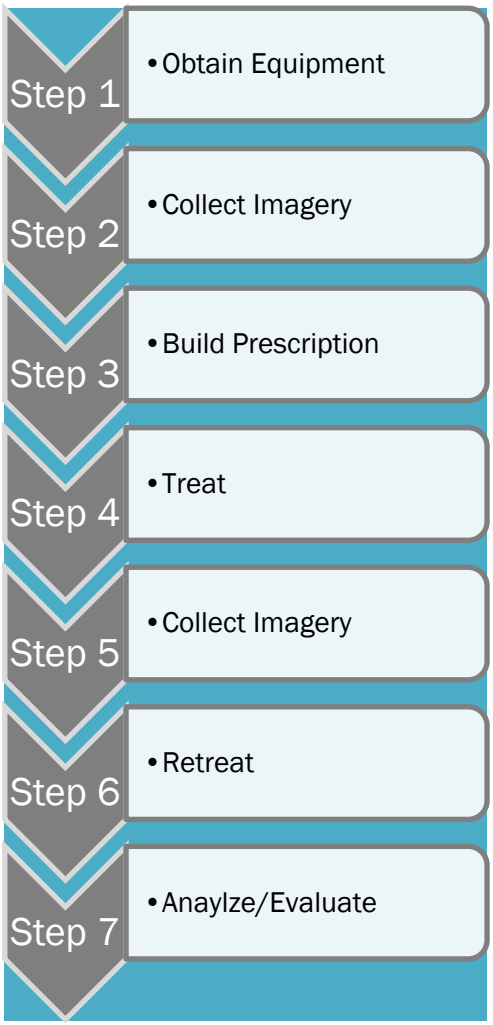
Conservation Innovation Grant:

Utilizing Drone Technology for Pest Management Application and Planning

Background

In 2019, the Nez Perce Soil and Water Conservation District (NPSWCD) received a Conservation Innovation Grant to purchase drone based remote sensing equipment and analysis software to develop pest management prescriptions for use in precision agricultural technologies.

The NPSWCD is located at the confluence of the Snake and Clearwater River basins, which are important surface and ground water source areas. In addition, these streams provide critical Endangered Species Act (ESA) habitat for Snake River Steelhead and Spring Chinook. Because the major land use within the region is agricultural production (75%), proper farming practices are critical in protecting the area's source waters.



One of the water quality pollutants which has been difficult to address are herbicides. Monitoring data collected in the lower Clearwater River tributaries by the Idaho State Department of Agriculture have documented pesticide detections in surface water. (Campbell, 2004).

Idaho agriculture relies on the use of pesticides for crop protection and crop health. The use of pesticides through the implementation of a pest management plan can benefit crop production as well as minimize risk to the environment and human health. The potential for surface water pollution from agricultural practices is a function of chemical properties, soil properties, land management at the application site, application techniques and the weather (Campbell, 2004).

Producers in the Clearwater and Palouse regions traditionally apply herbicides over an entire agricultural field. Herbicide applications are applied whole field versus targeting specific areas due to the lack of timely field scouting and prescription development.

Over 80% of new farm equipment sold today has some form of precision farming component (Adam, 2019). With the growth of precision farming technologies and the availability of high quality remote sensing tools available on drones, the NPSWCD and its partners hope to lead the local effort in obtaining the technology and developing specific agricultural uses for many aspects of conservation planning and implementation efforts.

The use of drones for remote sensing has been demonstrated for several applications in various industries. However, applications for conservation planning and implementation have not been thoroughly explored.

Methods

A field trial was conducted to demonstrate the use of drone technology and pesticide application with two agricultural producers on 40 acres of winter wheat. Each producer provided 20 acres of cropland for the project. Each participant applied herbicides to 10 acres through the traditional method of entire field applications. They documented the production process and associated costs. These fields were used as a baseline for comparing the precision agriculture application methods. Each producer also had a 10 acre parcel where weed areas were identified with the drone based remote sensing and analysis used to build a pest management prescription and then the participants would apply herbicides as per the identified prescription.

Tools:
A DJI Matrice Drone with a MicaSense Altum multispectral was used to obtain aerial and spectral imagery the four plots (10 acres each). The imagery was post processed using Pix4D software. This software provided a georectified image for viewing in ArcGis. The color spectrum for different vegetation was used to assist in identifying weeds within the wheat canopy.

Software:
Pix4D Mapper software was used to convert aerial images and multispectral data from the UAV into geo-referenced mosaics, digital surface models and point clouds. Output file types include GeoTIFF and polygon shapefile formats. These products were used to generate NDVI and NDRE analyses as well as thermal heat maps.

Field Testing:
Our overall strategy was to employ the infrared sensor over approximately 40 acres of non-irrigated cropland. The initial drone imagery would then be processed to identify weeds within winter wheat fields. This information would be used to target herbicide application on the specific areas versus whole field application. A prescription would be built and uploaded to the producers existing precision agriculture equipment which will allow the use of precision ag technologies to turn on/off the sprayer in the targeted areas.

Results

This project was an excellent opportunity to obtain and utilize new technology within the conservation district. The equipment, knowledge gained, and opportunities identified will assist landowners within Nez Perce County in their future conservation needs.

The project was a collaborative effort between the growers, the conservation district, Nez Perce County and the University of Idaho Extension program.

A large benefit to this project is that it helps familiarize the key players on the ground with the realities of what it takes to use these new technologies in the field. So as a more out of the box ready to use technology comes on line; this familiarity will help new practice adoption become smoother and easier for adoption when it becomes available.

Three videos were developed as part of this project to provide technology transfer to other growers as well as to document project results. These videos can be found at:

- Video 1 – Drone Technology Project Overview
  Link: https://youtu.be/O59cwWWFhWU
- Video 2 – Drone and Data
  Link: https://youtu.be/jz7tl72fXCc
- Video 3 – Drone Project Results
  Link: https://youtu.be/j51N6OAPBrQ

Several job aids were developed at part of this project. These are pre-flight checklists, Pix4D Processing Guide, Drone Flight permission form, and a flight checklist. Select the link below to view or contact the NPSWCD at npswcd@co.nezperce.id.us to obtain a copy.

- Pix4D Processing Guide
- UAV Flight Permission Form
- UAS Flight Checklist
- Ag Application Study Flight Checklist

The project was evaluated through four components: 1) technical feasibility, 2) herbicide use reduction, 3) economic analysis and 4) weed control efficiency. A discussion on results of each component follows. Evaluators included the growers, a conservation district board member, county extension agent, information technology specialist and data analyst.

1. Technical Feasibility- feasibility was determined by obtaining and evaluating feedback on ease of use, identification of processes that need improvement, and identification of processes that worked well.

   Overall, the equipment functions well, however, the feasibility of using the drone as a data collection tool for weed control in winter wheat is not feasible at this time.

   The review team noted that the application would be better suited to a spring crop scenario where the crop canopy does not cover the weeds.

   Review team feedback and comments are outlined below.

   Equipment:

   Nez Perce County provided the information technology (IT) staff for the project. Having the dedicated, trained, personnel to assemble the drone, the computers, and work with the manufacturers was key to ensuring that all of the components worked well together. We recommend that a dedicated, trained, person with IT background be part of the setup team. Each component has a different operating manual and integrating all of them together takes time and trained resources. This would not be a task that someone without specific IT training could do.

   The pre-flight planning component of this specific drone works well. A field or plots can be mapped and programmed into the gps flight controller and then the drone plans the best flight path to capture the data.

   Field technicians marked the plots in the field and used large fiberglass flags to mark the 10 acre plot boundaries. These were also marked with large painted X's on the ground to help identify the plot boundaries during processing. This system worked well and served as the basis for the plot boundary markers (ground control points).

   Processing and Analysis: The Pix4D software requires training to use. Our team took basic on line classes and read manuals. Through this process we developed a set of startup procedures for processing the imagery. This resulted in the ability of multiple people being able to pre-process the imagery, which saved time and personnel resources. Anyone wishing to gain experience using this software would be well served by taking the online beginning class (instructor led), then processing some imagery on a small scale and then taking another advanced class. Also, to become proficient the end user needs to process enough drone flights to become familiar with all of the procedures. There are multiple steps when processing the imagery. It is important that all of the steps are completed in the correct order prior to analyzing the imagery.

   A 10 acre plot's imagery will take at least 4 hours of computing time to develop the cloud points which are used in the geo rectifying phase. In our case, we had four, ten acre plots so each flight needed 16 hours of processing time. We ran most of these at night. A dedicated computer is needed for processing. Also, the computers need to have a lot of data storage and processing speed capabilities. The Nez Perce County information technology team built the computers to be able to process the imagery.

A flight pad or takeoff and landing pad is needed for the drone to prevent dust from getting onto the cameras on the drone. When landing and taking off, dust control and micro debris can be a problem. We used the back of a pickup bed for part of the flights, which worked well. In addition, we fabricated a piece of plywood and cut it to a 3 by 3 foot square, which was easy to transport and provided the dust control needed.

Battery storage, charging, and capacity is an issue. During the use time, the batteries need to be only partially charged and the battery capacity drains fast. The batteries can only be fully charged within 24 hours of use. This means that you cannot conduct a flight on the same day you plan to take the imagery. Of the equipment, the batteries are the most restrictive component for both timing of flights (in that you can only charge them up to 24 hours prior to use) and also battery life during a flight. We purchased 8 batteries to overcome the flight limitation. The batteries last about 20 minutes during a flight. The battery life is a piece of the technology that will need improved if this technology is used on a large sized field.

Data Collection: The color spectrum is not available for several of the weeds in our area. We believe that several universities are working on color spectrum and identification by shapes. We provided the University of Idaho with several flights at different altitudes and angles for them to be able to work with machine learning in order to identify weeds by shape.

Scale: It is not feasible to fly entire agricultural fields and having timely data in order to control weeds in the narrow window of time for herbicide application. The technology needs further developed and the battery, processing time, and weather conditions need further development.

2. Herbicide Use Reduction-the comparison of the amount of herbicide used in the traditional application field versus the precision agricultural field. The reduction in herbicide use was not documented as planned as the drone flights could not be used to determine weed locations within the winter wheat canopy.

   The color spectrum of the winter wheat and the target weeds was too close and could not be separated to identify the weeds. In addition, the winter wheat canopy was taller than the weeds, which blocked the emerging weeds from being captured on the imagery. The two producers documented the herbicide use for the control plots and treated plots, but no differences were noted. The review team felt that the use of the drone to identify and target weeds in winter wheat in order to target herbicide application was not feasible at this time. The group noted that the technology may be applicable within 2 to 3 years and that use of this technology in spring crops would be more feasible than winter crops due to the weed and crop emergence timing being similar in spring crops. See discussion under challenges for additional details.

3. Economic Analysis- the comparison of the treated/untreated filed production costs. No difference in the costs of production for the control plot and the drone prescription plots

were found. See notes under item 2 above and discussion under challenges for additional details.

4. Weed Control Efficiency- the scouting of field and quantifying the weed density using the drone technology, treating the field with herbicides, and then re-flying the treated fields to determine the weed population.

This part of the trial was very difficult to achieve. The time between collecting, analyzing and providing the data took too long. In addition, we had planned for weekly flights during the growing season. Due to weather, we could not fly the drone and capture data on the schedule, which did not provide timely data to the grower to spray the weeds. In the future, a better approach might be to field scout the target weeds present in the field and utilize the drone to document their presence and geospatial location, then build a prescription for treatment the following field season. Trying to fly, capture data, analyze and treat in a short time frame exceeded the staff resources we had available. On a larger scale, using the technology in this format, timing will be a concern that needs to be addressed. Winter wheat crops have a canopy in the spring that is taller than the emerging weeds. Trying the technology on a spring crop where the weeds and the crop emerge at similar rates may be a better first step for using the technology.

The application does have use for comparing one growing season to another though. This would allow the comparison of weed density over time, which would be valuable to the grower.

Challenges

During the project several challenges occurred. The review team noted those that required the most time commitment to resolve. The NPSWCD documented nearly $10,000 dollars in matching contributions over what was planned in the original project proposal. This was due to the need for additional time inputs that were either unplanned for or underestimated. Those items are noted in the bullet statements below.

- Weather conditions were a limitation for flying the drone. The drone could not fly in the wind or the rain. Spring weather on the Palouse region is rainy and high winds at the project site limited the dates and timing of flights. In addition, a cloudy day impacts the color spectrum sensor readings, making it difficult to post-process the imagery and determine differences in vegetation using color.

- The post-flight data processing time is too long. Growers have a small window of time to apply herbicides for weed control. This time is limited due to plant growth, wind conditions, rain, and air temperature. The turnaround time from flying, to processing data, to providing a prescription map was too long and limited the grower's ability to timely control weeds.

- Data transfer between locations and machines requires at least an 8 terabyte external hard drive designed for rugged outdoor use. At our location, we did not have adequate

internet speeds to transfer files from the drone pilot to the processing staff. The data transfer phase worked well and this style of external hard drive is rugged enough to be handled in field conditions.

- The equipment required one month to set up. The equipment was purchased and set up in the fall – about six months prior to the planned field trial. A limitation was that the equipment did not all arrive at the same time, so setup and testing was delayed. Our goal was to set up the equipment and have it tested prior to spring field flying. The second item that delayed set up and testing was the winter weather conditions prohibited flying until about 30 days prior to our field testing window.

- The ability of the technology to differentiate between crop and weeds was limited. Either the crop was too tall and the weeds could not be identified or the weed was too close in color and shape for it to be differentiated.

- The DJI firmware did not function with the drone during the testing phase. This means that the drone would not fly and capture the multi spectrum data as planned. This limitation took about 50 hours of extra time to work out the problems with the manufacturer.

- The Pix4D analysis software is from Sweden. Communication delays from the manufacturer and the IT team due to differing time zones created delays in Pix4D set up. Our recommendation is to expect a 4 to 5 day response time for question answering when setting up the software.

- Covid 19 public restrictions prohibited the completion of the outreach components of the original proposal. We could not attend or organize a public event which prevented us from completing the outreach and technology transfer portions of the project. The NPSWCD modified the grant proposal to change the outreach from a grower meeting and trade show presentation to the development of three outreach videos. The videos will be used in outreach efforts locally and shown in zoom presentations.

- The flight minutes are limited by the battery life of the drone. The batteries last 20 minutes and a 10 acre parcel takes about 20 minutes to fly. This meant that additional batteries were needed to complete the 40 acre parcels on the same date.

Next Steps

The technical team identified many possibilities where the drone technology has applications in conservation planning, design and implementation in our region. We intend to test its application for stream habitat inventory, soil moisture and bank recharge, construction inspection, identification of Japanese knotweed along streams, post flooding and wildfire inventory, and identification of water line leaks.

References

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