Aerial Detection Surveys in the United States

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Abstract—*Aerial detection surveys, also known as aerial sketchmapping, is a remote sensing technique of observing forest change events from an aircraft and documenting them manually onto a map. Data from aerial surveys have become an important component of the Forest Health Monitoring, a national program designed to determine the status, changes, and trends in indicators of forest condition. Aerial surveys are an effective and economical means of monitoring and mapping insect, disease and other forest disturbances. Information from aerial surveys can be considered the first stage in a multi-stage or multi-phase sampling design. Aerial skecthmap surveys have been utilized in the United States since the 1950s. Today, USDA Forest Service, State & Private Forestry, Forest Health Protection, together with other federal, state, and county cooperators conducts annual sketchmap surveys across all land ownerships. In 2002, approximately one million square miles were surveyed in the United States alone. Traditionally, forest damage has been sketchmapped on USGS base paper maps. Recently, the USDA Forest Service's Forest Health Technology Enterprise Team has developed a Digital Aerial Sketch Mapping system which automates this process allowing users to digitize polygons directly onto a touch-screen linked to a Global Positioning Unit (GPS) unit and computer or onto a tablet PC with an integrated GPS.*

Introduction

Forest health has gained popular attention in recent years because of environmental concerns about air pollution, acid rain, global climate change, population growth, and long-term resource management. In response to these environmental concerns and to legislative and policy direction, Federal and State agencies have been working together to develop a program for forest monitoring and reporting on the status and trends of forest health. The national Forest Health Monitoring (FHM) program has been established to accomplish this objective.

The FHM program is comprised of three interrelated monitoring activities: Detection Monitoring (Plot and Survey Components); Evaluation Monitoring; and Intensive Site Ecosystem Monitoring. A fourth, related activity is Research on Monitoring Techniques. Each monitoring activity provides a different level of information and each has specific, complementary goals.

Detection Monitoring consists of two components: the Plot Component and the Survey Component. The Plot Component of Detection Monitoring employs a set of plots systematically distributed across the entire United States providing data on forest mensuration, tree crown condition, tree damage, ozone injury to vegetation, soil chemistry and erosion, vegetation diversity, lichen diversity, coarse woody debris, and fuel loading. The Survey Component of Detection Monitoring makes use of both ground surveys and *aerial surveys* to collect data on the occurrence of some insects, diseases, and other forest health stressors. Both Plot Component and Survey Component information, in combination with data on weather and climate change, fire incidence and damage, and observations on shifts in land use, are required to interpret forest condition. This paper describes aerial surveys, how aerial survey data is collected, and how aerial survey programs are managed.

What are Aerial Detection Surveys?

Aerial survey, also known as aerial sketchmapping, is a remote sensing technique of observing forest change events from an aircraft and documenting them manually onto a map. The observer views a particular forest change event, such as mortality caused by bark beetles or defoliation caused by gypsy moths, and delineates the affected area onto a map to record its size, shape, and location as accurately as possible. Attributes, such as host, causal agent, symptom, and an estimate of intensity or number of trees affected, may also be recorded.

Aerial surveys have been recognized for over fifty years as an efficient and economical method of detecting

and monitoring forest change events over large forested areas. It is a relatively low cost remote sensing method that provides a coarse, landscape-level overview of forest conditions. Today, USDA Forest Service, State & Private Forestry, Forest Health Protection (FHP), together with other federal, state, and county cooperators conducts annual sketchmap surveys across all land ownerships. Approximately one million square miles were surveyed within the United States in 2002.

Aerial surveys can be used as the first step of a multi-tiered process of detection, monitoring, and evaluation, utilizing other remote sensing and ground sampling techniques to gather additional data on significant forest events or change. As with all remotely sensed data, some amount of ground-truthing is required before the data can be considered reliable.

How is Aerial Survey Data Collected?

In order to collect aerial survey data, the following elements are needed: a high-winged aircraft providing good visibility and capable of flying at relatively slow speeds, a pilot who has a sincere interest in safety and is motivated to perform at a high level, and a sketchmapper who has the ability to relate forest damage observed on the ground to features on a map without experiencing the debilitating effects of motion sickness. The map base onto which the sketch-mapped information is recorded varies from sketchmapper to sketchmapper and from program to program. For the more general "overview" surveys, the map base will often be of the 1:100,000 scale topographic or satellite image variety. For more intensive "special" surveys, using 1:24,000 scale maps is common. The data from the maps is then digitized and entered in a national Geographic Information System (GIS) database using common standards that are required for Forest Health Monitoring reporting efforts.

Since forest pests and the damage they cause are dynamic and highly variable, the resulting data will also be highly variable. No two sketchmappers will or can be expected to record the same outbreak in exactly the way. For this reason, sketchmapping should be regarded more as an art than an exact science. It is important at the outset that this be understood, not only by conscientious sketchmappers who find that their data may not be in close agreement with their peers or with a subsequent statistically reliable aerial photo survey, but also by the forest manager, who may want to put the information to use. Sketchmapping is highly subjective, and the resulting data can be no more accurate than the competence of the sketchmapper and the conditions under which the data was obtained (Klein and others (1983).

As the preceding passage implies, there are certain limitations as to how the data obtained from aerial sketchmap surveys can be used. During a typical aerial survey mission, the survey plane speed is approximately 100 knots (115 MPH) flown at an altitude from 1,000 to 3,000 feet above ground level. Observers on average are evaluating a swath of about 1.5 miles wide at any one time, which only gives them about 30 seconds per mile to recognize, classify, and record all of the activity they see. Because of these circumstances, aerial sketchmap data should only be regarded as a coarse "snapshot" of landscape level forest health and/or forest change condition. Spatially, the data is best displayed at small scales such as 1:100,000, 1:250,000 or 1:500,000. The data is better used for demonstrating trends rather than exacting precise measurements.

How are Aerial Survey Programs Managed?

There is much more to aerial sketchmapping besides looking for damaged trees from an aircraft; a great deal of preliminary work must be done before anyone is sent up in the air to do this type of work. Some of this work includes developing an aviation management plan and an aviation safety awareness program; providing for suitable, safe, cost-effective aircraft; and ensuring the availability of trained, qualified personnel to do the work, including experienced, qualified pilots.

Aviation Management Plans

An aviation management plan provides all of the program participants with information about the nature and intent of the mission and the program. It includes: a description of the program along with its purpose and scope; the personnel involved and their responsibilities; and a definition of all of the pertinent policies, procedures, operations, safety plans, and documents that apply to the program. By reading the aviation management plan, anyone unfamiliar with the program should be able to quickly grasp the intent, authority, and extent of the program.

Aviation Safety Awareness Program

The purpose of an aviation safety awareness program is to ensure that all participants understand the importance of conducting an aerial survey program safely. It is the responsibility of management to provide adequate

safety awareness training. It is the responsibility of all participants to be aware of all safety implications in an aviation program. Proper training includes formal aviation safety and management courses, which should be repeated every few years. Approaching and solving problems through continual training ensures a high standard of job performance where instilled safety practices are an integral part.

Suitable Aircraft

Having the right tool for the right job also applies to aerial surveys. Aircraft specifications can vary depending on many factors, some of which include: terrain, number of observers, flying altitude, flight speeds, flight patterns, size of survey area, ferry distance to the survey area, and expected accuracy levels. With increased horsepower comes an increased cost. A mission should never be flown with an underpowered airplane. Finding the appropriate aircraft is a matter of weighing the benefits with the costs yet never compromising safety.

Personnel

The most critical element in aerial sketchmapping is also the most variable: the sketchmapper. Conducting an aerial survey with a trained, experienced sketchmapper is the best way to assure a quality aerial survey. Although it helps that a sketchmapper is good with maps, is able to endure riding in an aircraft without experiencing motion sickness, has a background in forestry and an interest in aviation, and has had some form of aerial sketchmapping training; there is no substitute for experience. An individual cannot be expected to collect quality aerial survey data without receiving months, perhaps even years, of on-the-job training.

A good pilot contributes greatly to the safety and quality of the survey. A well-qualified pilot works as a team player to position the aircraft at the appropriate altitude, speed, and location to give the observer the best view. An aerial survey program benefits greatly by using stringent requirements for pilot qualifications.

Along with personnel flying the aerial survey, the survey team includes someone on the ground responsible for "flight following": that is, monitoring the location of the aircraft through regular radio contact. The flight follower, or dispatcher, maintains radio contact with the flight crew in case of an emergency or the need to pass along important information. A good dispatcher is diligent about constantly monitoring the aircraft's position and follows proper procedures in the event of an emergency.

New Technologies

New technologies are constantly being sought after and integrated into aerial surveys. The USDA Forest Service's Forest Health Technology Enterprise Team has recently developed a digital aerial sketchmap system (DASM), where observed forest damage polygons can be directly recorded onto a touch-screen linked to a Global Positioning Unit (GPS) unit and computer, or onto a tablet PC with an integrated GPS. This eliminates the need for using pencils to draw on paper maps and the ensuing lengthy process of post processing the maps into a digital format. The DASM also helps the observer to stay on course via an aircraft icon linked to a GPS receiver that flashes on the screen across a moving map display.

Automated flights following systems have now been established in many aerial survey programs nationally. A GPS unit installed in the aircraft transmits position locations to a centralized dispatch center responsible for following the aircraft's route. In the event of an emergency, help can be immediately dispatched to the incident's exact location.

References

Klein, W.H., S. Tunnock, J.G.D. Ward, and J.A.E. Knopf. 1983. Aerial Sketchmapping. In: Forest Insect and Disease Survey Methods Manual, USDA Forest Service, Forest Pest Management, Methods Application Group, Davis, Calif., 15 pp.