6.D

Aviation in Forestry

by

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Approved:

_____
Professor of Forestry

ACKNOWLEDGMENT

The writer wishes to acknowledge his indebtedness to Professor George H. Schroeder, who, with his interest, so kindly offered guidance; to members of the Regional Office of Region Five and Six for helpful material and personal conferences; to members of the Forest Service at Juneau, Alaska, who offered their knowledge by helpful information; and to Mr. James Moran of the State Foresters Office for his personal conferences and details of his practical experience. Through the help of these individuals this thesis was made possible.

APPROVED:

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In Charge of Major

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Dean of Forestry

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I. INTRODUCTION

The part aircraft plays in forestry has gained tremendously in magnitude and scope within the last decade. With the modern trend of travel turning to airplanes more and more, and with the more intensive use of airplanes being brought to the eye of the public as a need for national defense, it is only natural that wings of aviation take on strength, and that aeronautics should find an increasingly important place in the field of forestry.

The Forest Service has conducted experiments along many lines in aviation resulting in a number of important developments. These experiments are but a stepping stone to something greater in the field of aviation and its relationship to forestry.

The use of airplanes is increasing each year, as well as the number of aircraft, with the huge defense program stressing the manufacturing and need for more airplanes. What will happen when this defense program ends? What will the government do with the enormous number of airplanes that it is manufacturing at the present? These are only a few of the many questions that should be considered for the future, but they can be determined only by time. There is the possibility that airplanes can be

used to a good advantage for forestry work in the future. This is food for thought.

In this treatise I am going to present a resume of the many uses that aviation and aircraft play in forestry, and also its future possibilities.

Will the present decade make as many advances, and will they be as great as those made in the last decade?

II. HISTORY OF THE USE OF AIRCRAFT IN FORESTRY

A. Early Use of Aircraft

Airplanes drew the interest of forest officers soon after the first world war. The Forest Service's first use was for forest protection by systematic patrol for detection of fires in 1919. This program was sponsored by the army which stood the entire expense for this first year. This program was carried on until 1924, being sponsored by the Army Air Corps which furnished the pilots and planes. Congress appropriated the funds for this air patrol work. The Forest Service supplied the observors and other incidental items.

During these years it was proven that the lookout system was more reliable for initial detection of fires and faster, thus providing too much competition for regular patrol flights. Following this era airplanes for patrol were confined to special flights during emergencies, such as, detection flights after lightning storms and the scounting of going fires.(1) Aerial detection always was and always will be worthwhile when systematic stationary lookout service is not in effect.

In 1925 an appropriation by Congress made it possible for the Forest Service to operate Army airplanes with civilian pilots and mechanics. This was the first appropriation made possible for the Forest Service to operate aircraft. The same service was continued during the fire

seasons of 1926 and 1927.

Contracts with commercial aviation concerns at stipulated rates per hour came into existence during 1928. At the present time, nearly all airplanes used in National Forest work are privately-owned and contracted for by Regional Offices on a flying hour basis. The light and economical "cub" planes can be hired at a cost little higher than the cost of foot patrolman and motor patrolman. Their low initial and operating costs are very important factors.(1)

The year 1930 was the start of the dropping of supplies on going fires. The tight-package method of dropping supplies was first developed, but this was superseded first by the loose-package method which in turn was followed by the small burlap parachute method. These small burlap parachutes were developed in the Pacific Northwest Region. Condemned Army silk parachutes are recommended for the work, but they cannot always be obtained.(1)

B. First Experiments with Parachute Smoke-chasers

In 1935 in the Intermountain Region the parachuting of men to fires was advocated, and some experimental work was done, but they arrived at no definite solutions. This work was abandoned until 1939, when Harold King was hired by the Forest Service, given a plane, and told to develop the idea. A new type of steerable parachute was manufactured by parachute manufacturers who were interested

in these experiments. The Chelan project was the first to test premeditated parachute jumps in timbered mountain country, and it was found to be surprisingly successful. Mr. King's results were very encouraging. The result was a new method of transportation for the forest fire control forces.(1)

As far as is known the Forest Service has purchased only one airplane, and that was in 1938. This was the plane used by Harold King while he was in the Pacific Northwest conducting his experiments on finding new methods of use for airplanes in the Forest Service. In 1939 the Civil Aeronautics Authority transferred a cabin seaplane to the Forest Service; this ship was used on the Superior National Forest for fire control work. It is adapted to use in this country because of the large number of lakes located herein.

C. Appropriations to Forest Service

In 1939 Congress appropriated $300,000 for the development of rotating wing aircraft. What the outcome was, and what happened to the money, is a mystery.

III. THE AIRPLANE AND FOREST FIRES

A. Scouting Fires

The regular use of airplanes in scouting large going fires is now a common practice by the Forest Service. The air patrol is occasionally more practical than a ground force set-up for scouting because it is mobile; thus when a reconnaissance of the burning area is made the ground forces are advised of any smoldering fires and of the position and movement of the fire. Circling above the fire, the observer can quickly determine its intensity, location, extent, rate and direction of burning; also the character of the material that is burning and what kind of material is in the path of the fire can be ascertained. He can determine what natural barriers are opposed to the spread of the flames and the most advantageous routes of approach for combatting the fire.

When this practice was first employed, the costs were extremely high. However, due to the advent of the smaller, more economical ships and their rapidity of development the costs were lowered considerably. One of the reasons that aircraft does not have more use in forestry is that the Forest Service cannot justify the keeping of aircraft during the winter months. The experiments conducted in Montana and on the Chelan National Forest within the last several years have proven that airplanes can be of

very great use. It is only natural to assume that aviation in the Forest Service will make more and longer strides in the years to come, especially if a solution to this problem is found. Within the next several years one will find the costs of aircraft lower, and the airplane will become more and more a mode of transportation.

B. Use of Aerial Photographs in Scouting Fires

There are other uses to which the airplane can be put when it is used for the scouting of fires. Taking pictures of going fires, dropping of film to the ground, and the development and printing of these pictures has proven a great aid in the scouting of fires. Many times the lack of detailed scouting information hampers quick organization of fire suppression forces. The developed aerial photograph gives the fire boss the necessary information regarding topography, fuel type, streams, roads, trails, and other features in the vicinity of the fire. The use of these photographs will also eliminate discrepancies that might creep in when one tries to visualize conditions through the eyes of another person. The photographs can be utilized to a great extent by the fire boss, especially if he has to combat a fire at night. These pictures give him all the information that is necessary to utilize his fire forces to a finer and more economical degree.

In Montana Forest Officers equipped with a camera and an improvised developing and printing outfit photographed

a fire, developed and printed a picture, and dropped it to the ground within twenty minutes. This picture was judged to be much better than any map that could possibly have been sketched by the most expert scout. This method has the advantage over the old method in that it is faster and performs the task as one unit.

The use of aircraft as a detection agent is justifiable only when an emergency exists, such as, following the path of a lightning storm for sleepers, where the lookout system has not been fully developed in a new forest, or where the smoke and haze cut down the visibility distance of the look-outs. When these conditions exist the air patrol is more mobile and faster than foot or motor patrol.

C. Picking Routes of Travel

The airplane has also been used advantageously in saving time and money by picking out the quickest and easiest routes of travel for fire fighters, as was demonstrated on the Los Padres National Forest of California in 1939. Lightning had started a fire on one of the many brushy slopes. The area was exceptionally rough with no trails. It was difficult for the dispatcher to direct crews without first having a passable and comparatively safe route located. This matter was soon cleared up by an observer in a scout plan which flew low over the fire. He selected the shortest and easiest way in and communicated the information to

headquarters within a half hour. This resulted in saving considerably more time and money that would have been spent by the fire crew in trying to reach the fire by following an uncertain trail without any definite idea of where they were going.

D. Communication Facilities

Communication facilities have developed along with the use of airplanes in the Forest Service. The first mode of communication was by dropping notes and instructions from the scouting plane to the ground crew. Use of a one-way radio set with the aircraft sending instructiong to a receiving set on the ground followed next. These methods served their purpose, but they were lacking in completeness in that doubt and discrepancy occupied a gap between the two parties. As the saying goes, "No two people think alike and look at a situation in the same light."

The Forest Service has developed a low-cost, two-way radio set for airplane communication with a portable ground unit. The radio promptly relays information regarding fire action and fire threats. The observer can report his findings directly to the boss on the fire line, discuss the situation, receive instructions, and straighten everything out to the last degree. Direct contact between headquarters and the fire line is also facilitated by this radio equipment. As a result, more effective use of fire fighting

forces and better coordination of fire control action have been achieved, which is the aim of the Forest Service.

The transmission of messages by voice-amplifying equipment from the air to the ground has been tried. The use of the airplane in this capacity is limited, but it might serve as a good publicity stunt for a fire prevention week during the hunting and recreational seasons. The voice can be projected to the ground for about two or three miles. This different method of transmitting messages may prove successful, because it is the tendency of the human race to retain or remember anything that happens out of the ordinary, and what is more different than to hear "a voice from the sky"?

E. Cargo Dropping

One of the outstanding and the most important roles that aircraft plays in fire control in the last decade is that of emergency transportation of supplies. It should be recognized at the outset that the method of aerial delivery has its limitations, and that it cannot be depended on to function at all times without failure.(2) When smoke or fog conditions are too bad, flying is too hazardous, and the work of forwarding supplies by air comes to a complete standstill. Consequently when such conditions are anticipated, and when it is practicable to do so, camps should be provided with supplies in excess of immediate needs in order to tide them over such periods of interrupted

service.(2) Fire fighters must have food, camp equipment, tools, and medical supplies, and they must have them promptly. The amount and kind of supplies a fire crew receives may determine whether they will fight a winning or losing battle.

The use of aircraft started out as an experiment and it has developed into something of vital importance, especially in remote areas. Besides being faster, air transportation to the more remote areas also compares favorably with overland transportation in cost. Where formerly supplies could be delivered to inaccessible areas only by use of pack animals--necessarily after the fire was off to a good start--the airplane can now drop them exactly at the spot where they are most needed, greatly decreasing delivery time between supply bases and remote fire camps.

Where a fire is within 15 or 20 miles of both airplane and pack stock base, and where at least 50% of the chutes are returned, the cost of delivery may be about the same by either method. The round trip would take two days for pack stock and 3/4 hour or less for the airplane. Over a period of time it would be possible for an airplane carrying a load of 1,000 pounds to keep up with the work of 75 pack animals. The airplane could deliver 3½ tons the first day. It would take 40 horses to deliver the same amount the first day. Where the air distance is very much greater than the distance to be covered by pack stock, or where pack stock

could make the round trip in one day, the comparative cost of aerial delivery increases and may amount to two or more times the cost of packing over trails. Where there are no trails, packing is again at a disadvantage from a standpoint of cost. A transport airplane hauling 1,200 pounds will make a 50-mile airline round trip in 1½ hours at $35 per hour.(2)(5)

In the last several years, airplanes used for delivering supplies to fires in Region Six and Region Five have delivered many tons of supplies to going fires.

The airplane is a valuable emergency adjunct to ground methods of delivery which continue to be more practical where fires are near roads and civilization. This is the main reason why the use of aircraft as a potential piece of equipment for the fire protection force has not made longer strides in the Forest Service as a whole. However, when the time element is considered, we get a different picture, and since time is the very essence of fire suppression every practicable method which contributes to a reduction in the time required to suppress a given fire will eventually be reflected in lower ultimate cost and damage.(2) Air transportation to the more remote areas also compares favorably with overland transportation in cost. These costs are surprisingly lower at the present in comparison with when they first started using aircraft for transporting supplies to going fires.

The above advantages are offset to some extent, however, by the small carrying capacity and the lack of specialization of the planes used. Air delivery of supplies is generally used only where roads are lacking or topography is unfavorable to rapid ground transportation.

Crew Organization

The servicing of fire crews by airplane requires a highly developed, trained, and efficient crew organization. The present day organization of such crews has developed step by step with the use of aircraft in forestry. To really attain its goal such an organization is likened unto a house, "It must have a good foundation." In other words, the delivering of supplies must have a good ground crew as well as flight crew. Whether the project will pay dividends or not depends on the products, the time taken to be delivered, and their condition upon delivery.

The first method of dropping supplies from an airplane was the tight-package method. This method was soon superseded by the loose package or "bean" bag method of dropping supplies. In the above methods the packages were dropped without parachutes or retarders. Although, with careful packing, it was possible to drop certain kinds of supplies without great loss, a high percentage of breakage did result. As these methods were not too successful, another method of delivering supplies had to be found. This method

had to be cheap, within reason, and easy to prepare. Sage Wernstedt of the Portland Office of the Forest Service hit upon the idea of using simple homemade parachutes of burlap about 7 feet by 7 feet with shroud lines about 17 feet long made of number 7 sash cord. This method requires a certain amount of special packaging for some kinds of materials and equipment.(3)

Methods of packing the supplies:

Canned Goods

"A larger quantity of tins can be released in one chute if the tins are placed in a single layer on a 24" x 24" x ½" board with 20" x 20" board on top, suspended accurately level." (2)

Sacked Items

"The following items should be placed in a grain sack, and a board should preferably be placed under sacks of oranges, vegetables, or potatoes." (2)

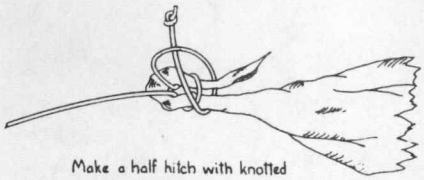
Boxed Items

"Place head lights, files, saw sets, wedges, batteries, telephones, dry foods, bread, emergency rations, etc. in boxes, preferably rather flat boxes. Put heavier items on the bottom." (2)

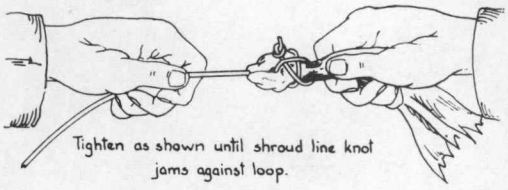
Saws, Crosscut

"One to six saws nailed, wired, or bolted to ½" board, 1" wider than saws when in place, with rakers back from edge of board. Use hose guards or building paper between

Methods of Packing Supplies



Make a half hitch with knotted end of shroud line to lock the tie.

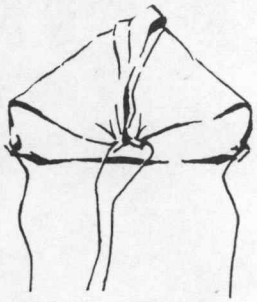


Tighten as shown until shroud line knot jams against loop.

1

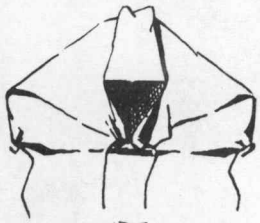
The lines are tied to the chute corners by a tight square knot, the chute being considered as another line. Then lay the chute flat on the ground with lines clear.

TYING THIMBLE:



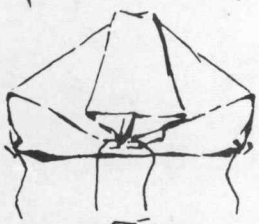
2

Two of the corners are brought together.



3

The folds are straightened and formed into a pocket to facilitate the opening of the chute.



4

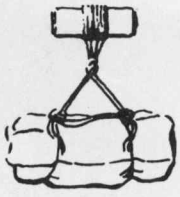
The two sides are folded to the center and then folded again to the center to a width of 18 inches. If roll is less than 18" long, the chute will be too stubby, will fall too fast, and may not open.

5 The streamer is rolled up and tied to a line at one corner of the chute.

6 The chute is rolled up reasonably tight to form a cylinder approximately 22 inches in circumference or 7 inches in diameter. If the roll is made too long and loose, the ends will bend upward and prevent the roll from unwinding.

7 Before the lines are rolled up on the chute, they are straightened to lie without crossing. The lines should be rolled up snugly on the middle third of the roll in order to prevent any loop slipping off the end. A rubber band made from discarded inner tube and snapped across the lines will prevent loosening of loops until ready to drop.

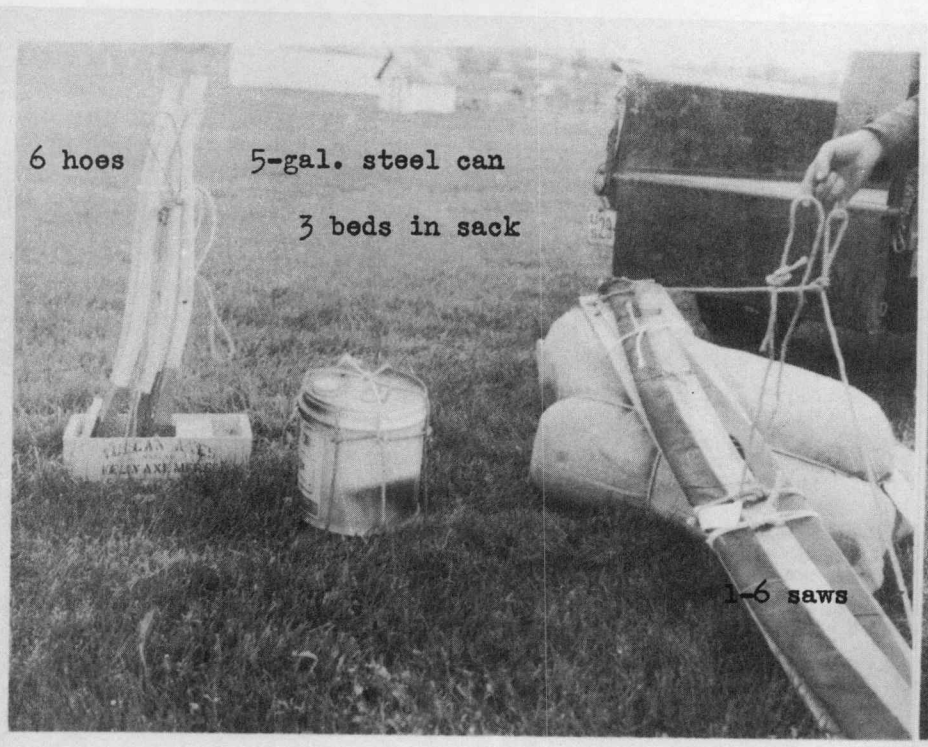
8 When the lines are rolled up, a knot is tied in the four strands two feet from the ends.

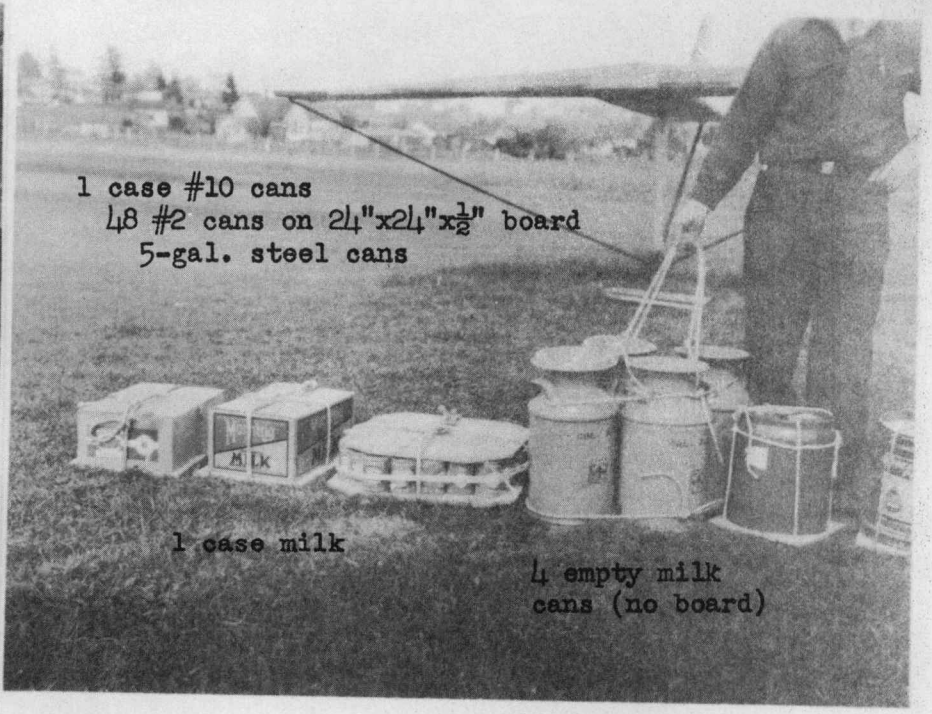


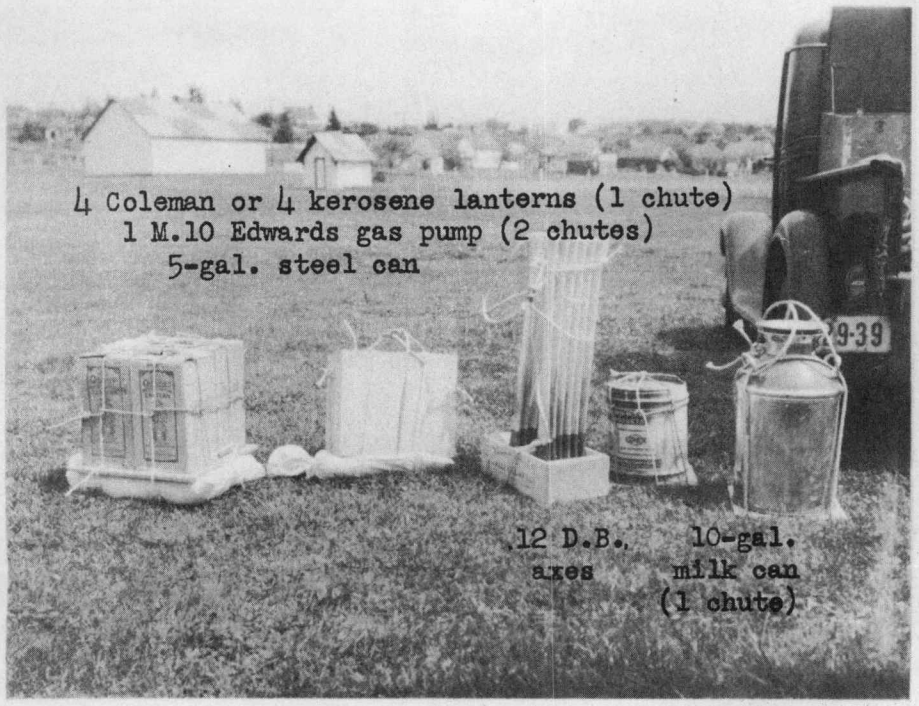
9 The ends beyond the knot are tied to the bundle.

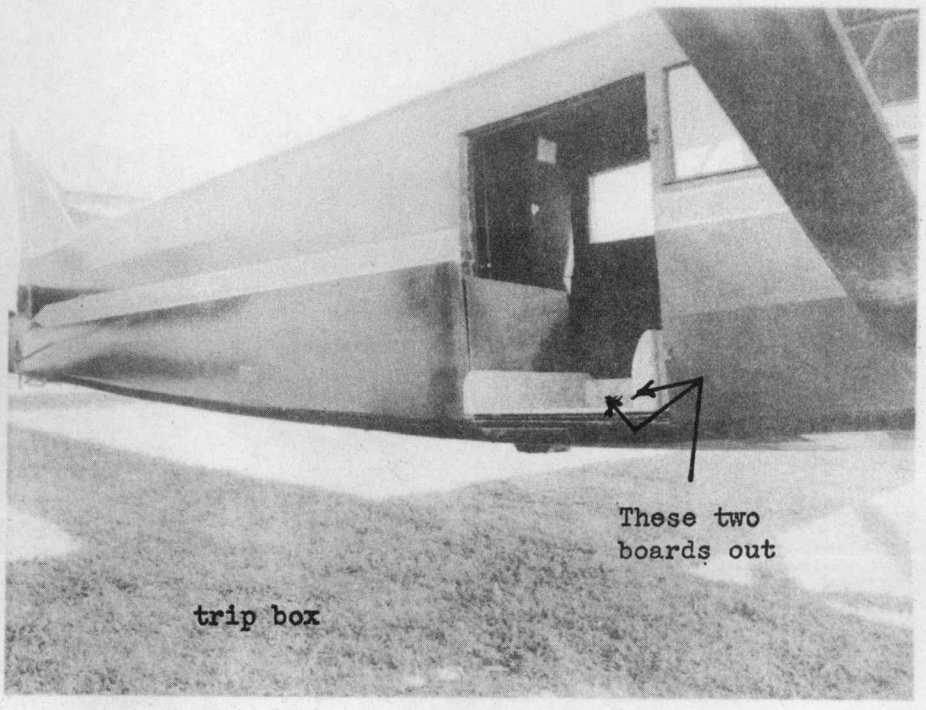
If the chute is flattened by the weight of other loads in the plane, it should be shaped before discharging.

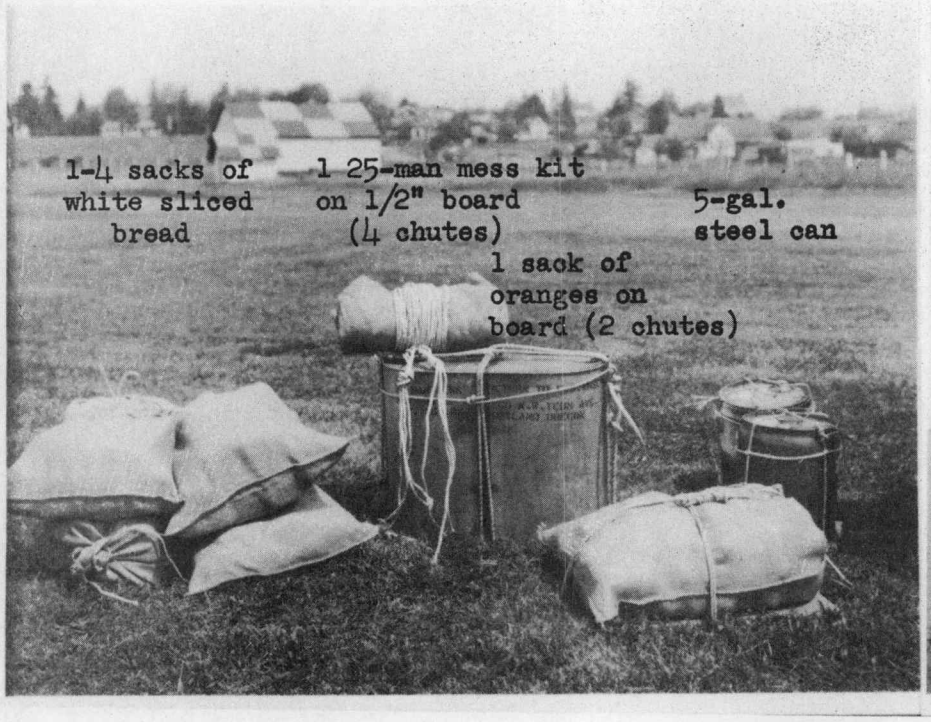
When the bundle is discharged from the plane, a few feet of slack should be left between the load and chute if the load is bulky.

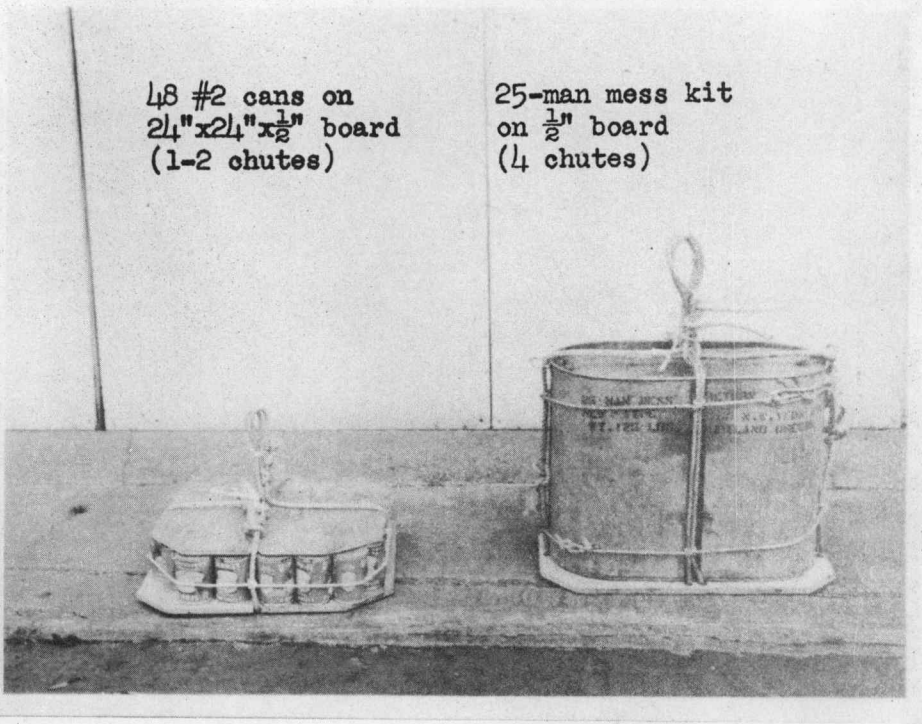

6 hoes
5-gal. steel can
3 beds in sack
1-6 saws

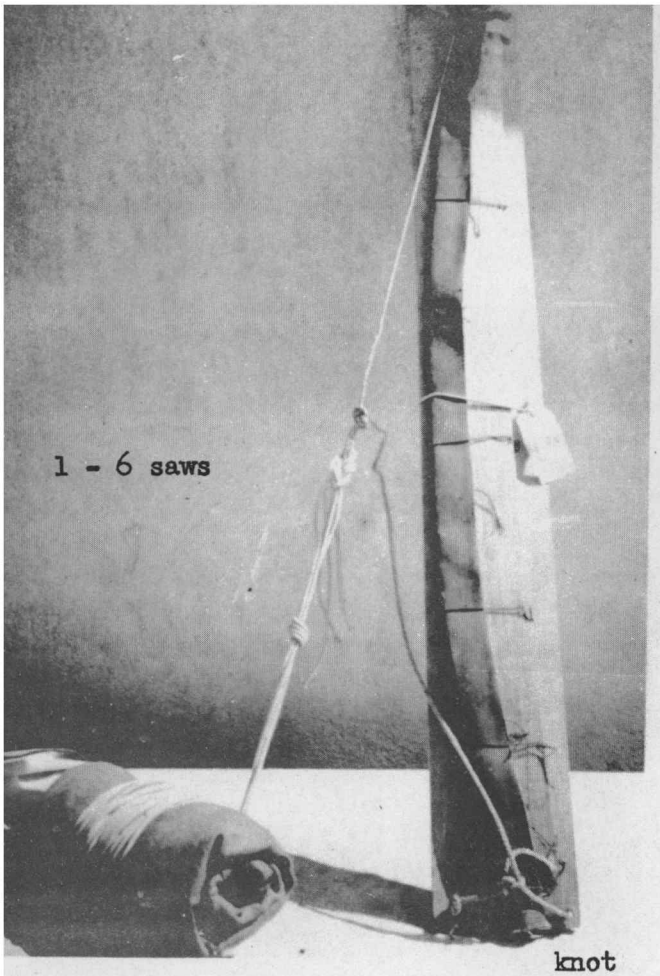

1 case #10 cans
48 #2 cans on 24"x24"x½" board
5-gal. steel cans
1 case milk
4 empty milk cans (no board)


4 Coleman or 4 kerosene lanterns (1 chute)
1 M.10 Edwards gas pump (2 chutes)
5-gal. steel can
12 D.B. axes
10-gal. milk can (1 chute)

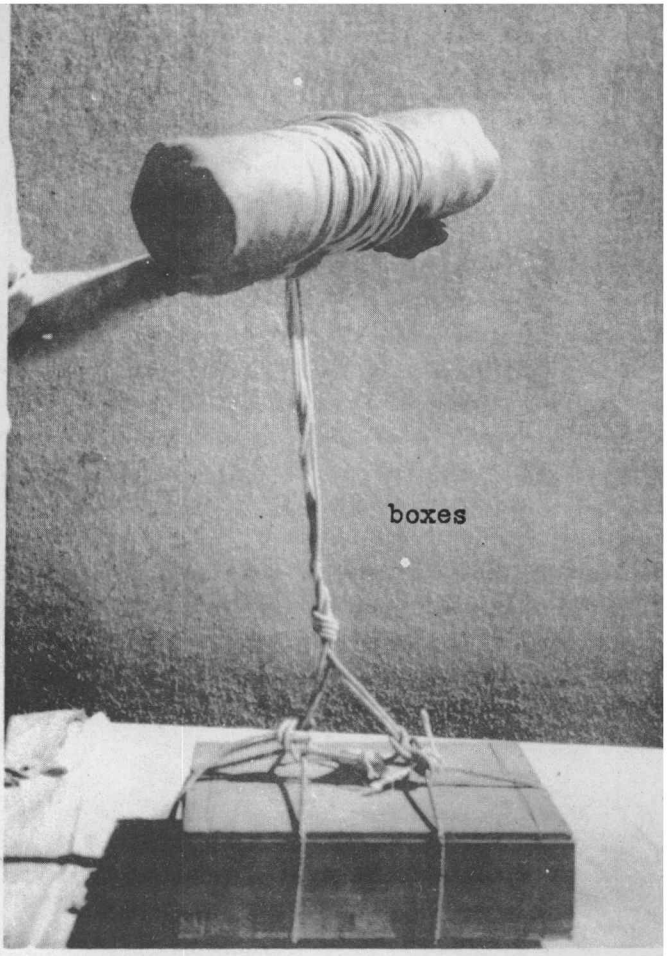

These two boards out
trip box

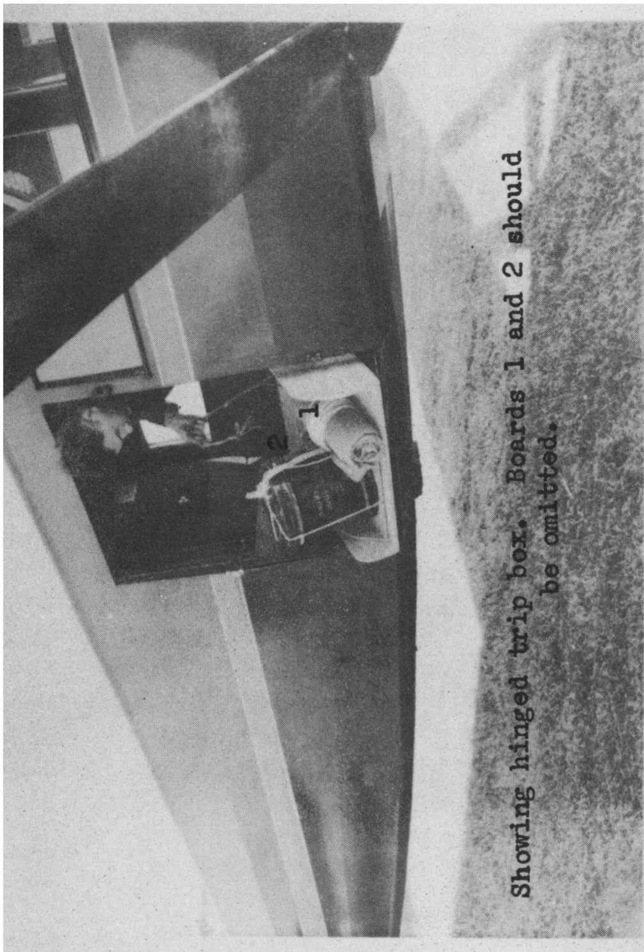

1-4 sacks of white sliced bread
1 25-man mess kit on 1/2" board (4 chutes)
5-gal. steel can
1 sack of oranges on board (2 chutes)


48 #2 cans on 24"x24"x½" board (1-2 chutes)
25-man mess kit on ½" board (4 chutes)

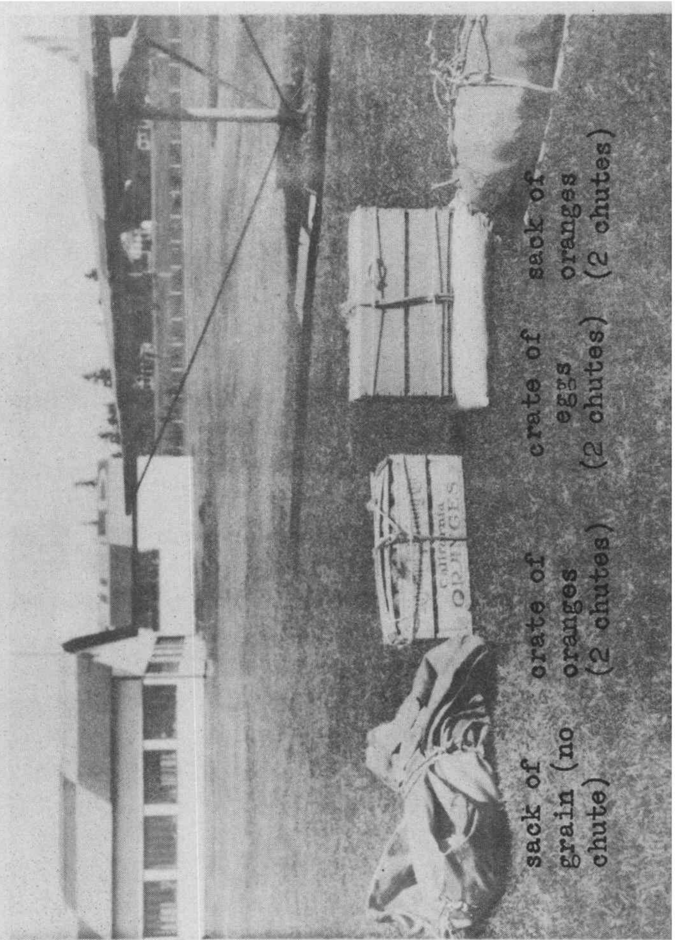


knot
stops

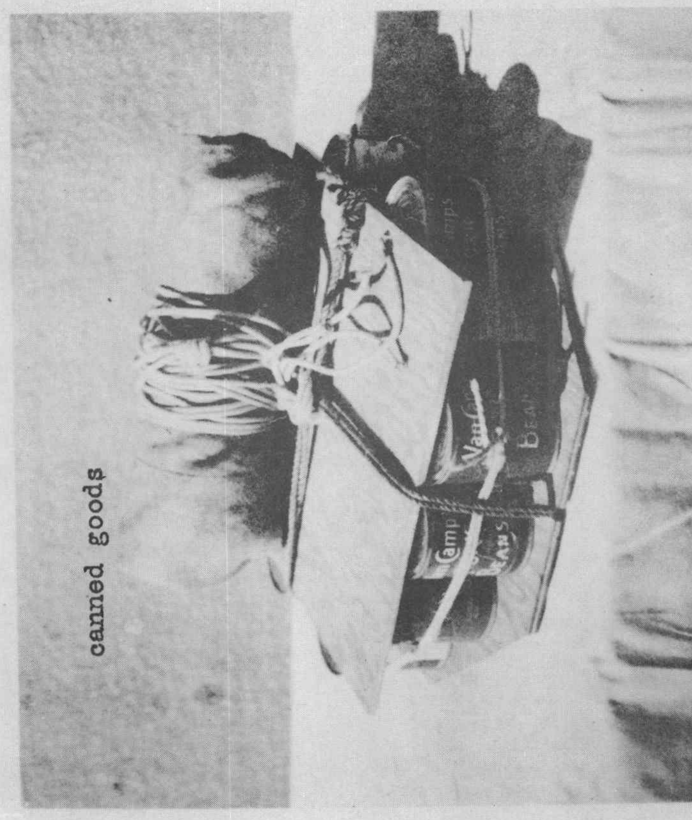




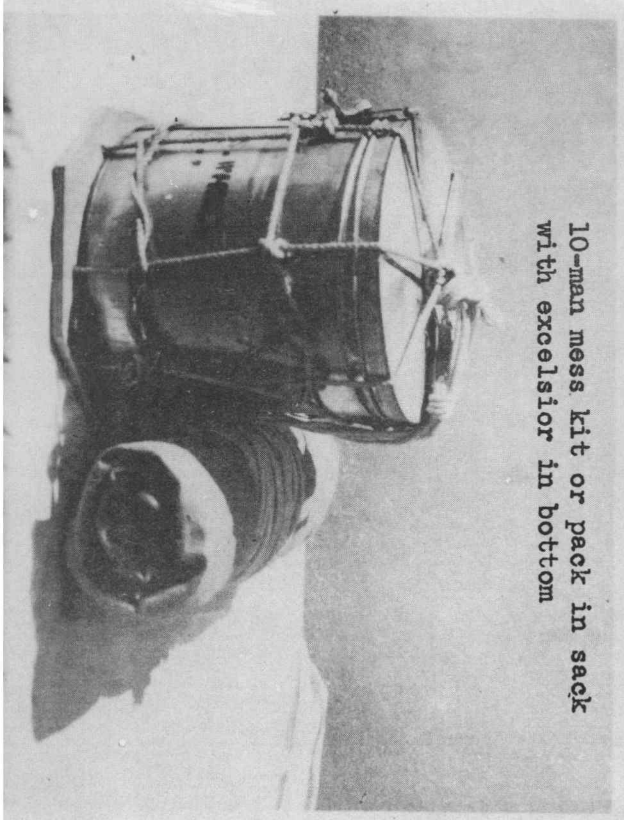
Showing hinged trip box. Boards 1 and 2 should be omitted.



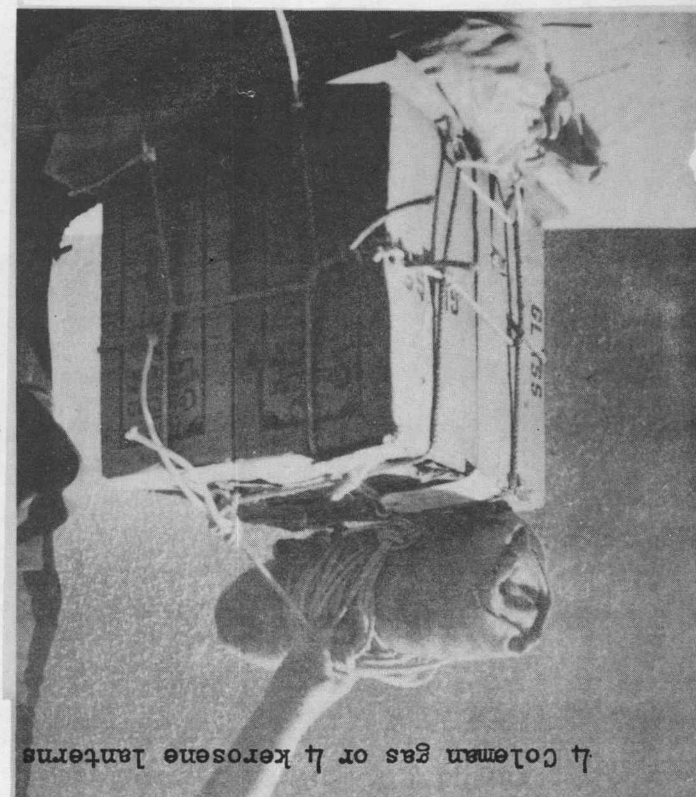
5-gal. steel container



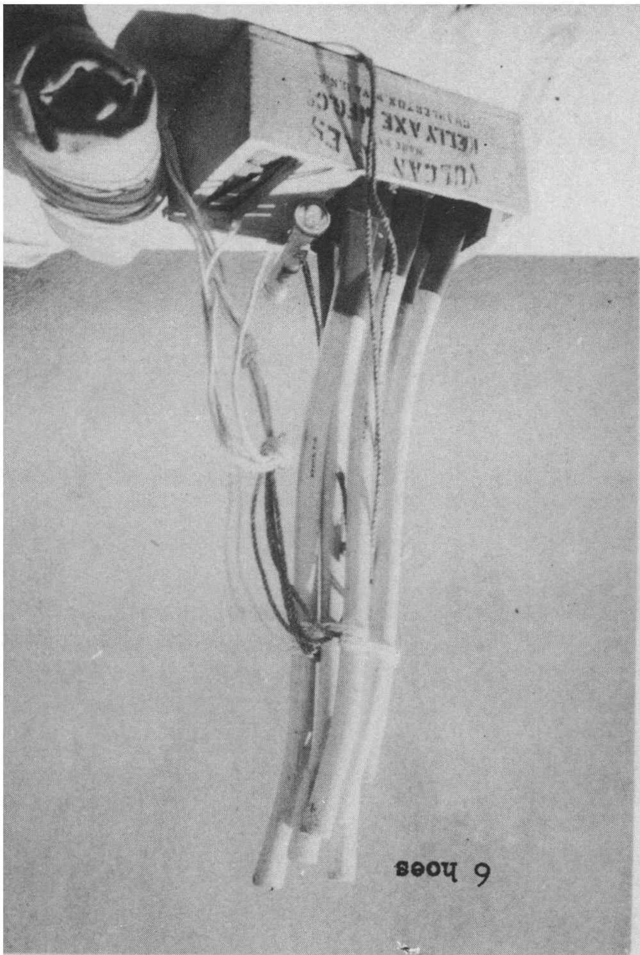
canned goods



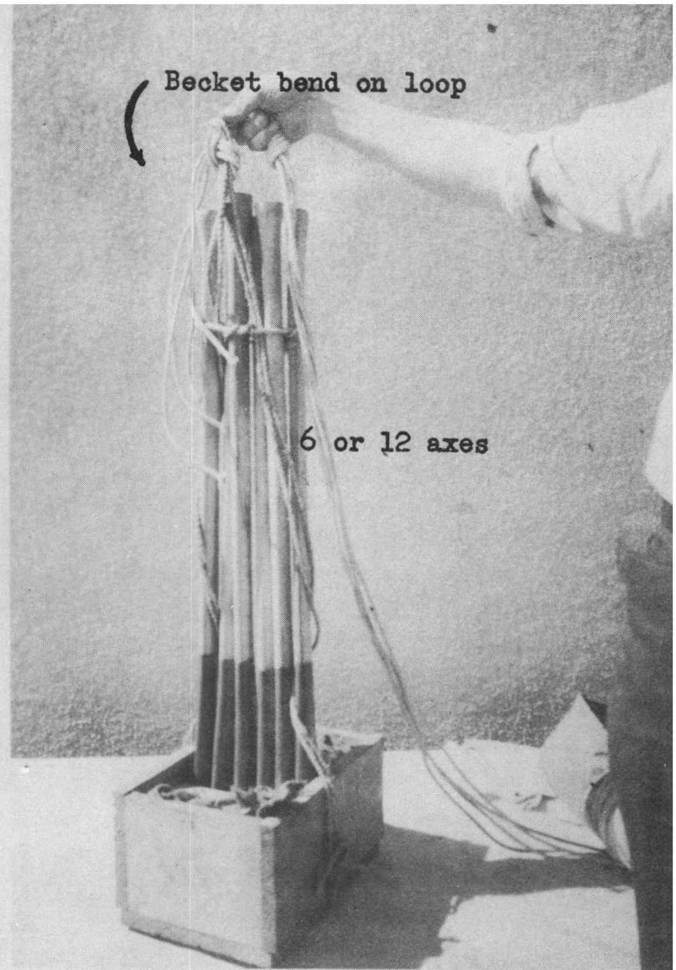
10-man mess kit or pack in sack
with excelsior in bottom



4 Coleman gas or 4 kerosene lanterns

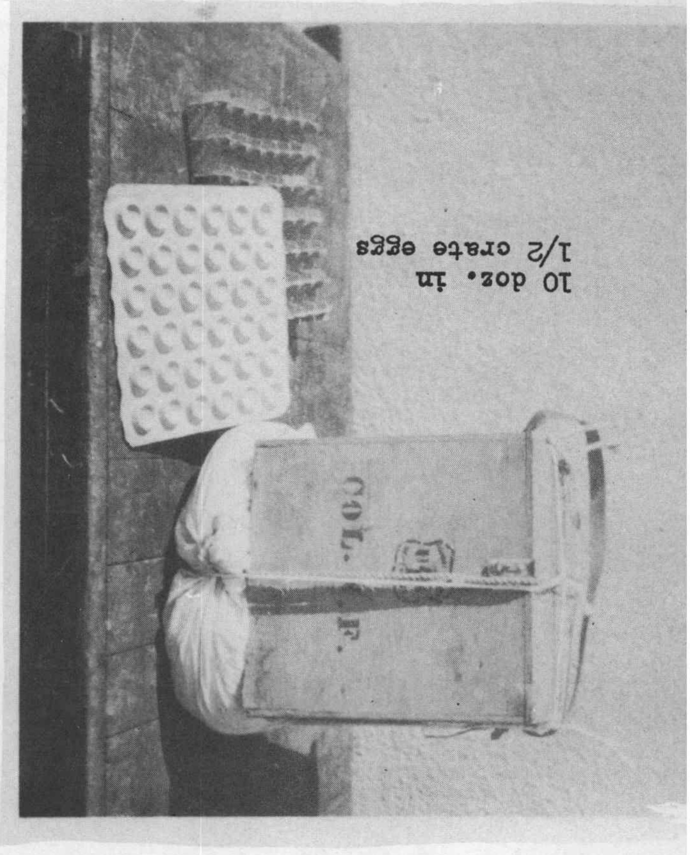


6 hoes



Becket bend on loop

6 or 12 axes



10 doz. in
1/2 crate eggs

Dropping Supplies

It Is Part of the Fire-Fighting Technique for Airplanes to Drop Burlap 'Chutes With Food and Supplies, Amounting to More Than 100 Tons a Year, to Ground Crews in Inaccessible Sections.

saws. Suspend in bridle as shown, with stop knots on back-sides to prevent turning." (2)

"Such items as cantaloupes, melons, fresh tomatoes, and anything supplied in glass jars should not be accepted for packing." (2)

For the transportation of supplies the preferred type of aircraft used must be a high wing monoplane with the door behind the wing braces, and it must have high flying tail surfaces in order to clear packages and chutes.(3) The job of transporting supplies is very tedious. A pilot has to have many hours of flying experience, ability to think fast, and fast reflexes to cope with the tricky currents that exist around and over large going fires.

There are many items that need to be considered in air transport planning; a few of them are,

1. Number of men to be supplied.

   This is essential in determining how many aircraft to hire for the job to be done.

2. Conditions of trails.

   You must know what kind of trails exist in the area and where these trails are, for consideration in segregating or choosing what supplies are to be transported by plane, and what ones by pack train.

3. Need for speeding up initial deliveries.

   The supplies that are to be transported by

plane should depend upon their importance and immediate demand on the fire line.

4. Urgent need for available pack stock to pack water for back-pack pumps or to pack other equipment from point to point.

The use of aircraft for carrying supplies will allow what pack trains that may be on the fire to be used for other purposes.

With this new method of delivering supplies by parachute the losses are low. The most serious of these are due to carelessness and imperfections on the part of the warehouse packers and those making and rolling the parachutes. These losses depend upon the crew and its capability, along with losses in elapsed time and extra costs for non-contract packages can easily exceed the savings in the cost of flying time. When such things happen, doubt creeps in as to whether the use of aircraft for transporting supplies is justifiable or not. From experience the Forest Service has developed special rations along the same order as "iron rations" that are commonly used in the small one-man fire packs. In filling out orders that fire-camp cooks send in, any special items that are listed and do not come under special rations are filled only if and when the room and weight capacity are available in the aircraft over and above the regular ration requirements.(3)

The organization should be a highly efficient working

unit under strict supervision of a man who knows all the factors that need to be contended with. He must keep things moving to bring results. He must select competent and capable men to be in charge of the different units of the organization; e.g., warehouse, field, and flight.

Two things that are of importance in this plan are:

1. To have a satisfactory landing field at the supply base.
2. (If more than one ship is used) There must be no lost time in costly and useless flying waiting for one ship to unload or take off.

The ground crews are located at the landing field or supply base. They are under the supervision of a boss, if four or more men are employed.

A few of their duties are:

1. Refueling the ships.
2. Dampening down the runways to lay the dust.
3. Keeping at least one load ahead at the field.
4. Helping load the cargoes.

If the operation is a large one, a highly competent dispatcher may be necessary at the landing field. He must be a qualified forester, have a good knowledge of aeronautics, and have good common sense and reasoning power. He must understand the needs and requirements on the fire; judge when flights can be successfully completed and when it is advisable to permit the ships to take off; be able to judge

the correctness of the contentions of the pilots as to the load limits, visibility, wind conditions, and like matters; be able to take advantage of the lookout system, the haze meter, the wind gauge, and vane at forest fire danger stations, and the telephone system and radio nets to assemble information on local flying conditions. This man should have practical experience in all these phases of his job, especially, from the pilot's viewpoint and the viewpoint of the fire boss on the fire line. A rounded knowledge of all these factors is necessary.(3)

The ground crew boss should supervise the loading of the aircraft. This should not be left to the pilot because:

1. He is not in position to determine what must be left behind with the least sacrifice to the fire fighting forces.
2. He has the tendency to underload the rated capacity of the ship thus increasing the costs. There is a tendency for the psychology angle to enter the pilot's mind, which may happen unsuspectingly.

We must not forget that the pilot does have the last word regarding all flights. He is the captain of his aircraft.(3)

A dropper is included in the flight crew along with the pilot. The dropper must supervise the proper loading of the cargo in the ship, seeing that the cargo is

distributed evenly as to weight and in such a manner as to be handled quickly and without any chance of snagging or hanging up when he drops them out. He must know how to properly and safely bale out packages of different sizes, weights, and shapes. Also he should be able to quickly recognize any chutes which are improperly rolled and to tell when the package is too heavy for a safe delivery.(3)

The flight crew must keep enough supplies ahead in the fire camp to assure a sufficient amount to last the fire crews for two or three days in case the weather turns bad or the smoke obstructs all chances of visibility, thus grounding all flights. This is very important and must not be slighted by the overhead or the officer in charge at both the fire camp and supply base. Visibility has presented a difficulty many times, and it will continue to do so in the future.

The warehouse crews are supervised by a steward and a package boss. The steward must be a competent man and must know his business thoroughly because the men on the fire line depend upon his knowledge of what food is necessary and best for them. He supervises the purchasing and distribution of all the rations; he also plans the "iron rations". The Forest Service has found that he is of vital importance, but they had to find this out by practical experience. In the Northern Region several incidents

happened where anything that the camp cooks ordered was sent in and before long the men on the fire line started complaining about the food; they were not getting enough staple supplies, and their working ability was starting to suffer. After these experiences the Forest Service hired a man on all large fires. His job was to see that the fire crews got their staple supplies and rations.

The packers work under the steward's supervision. If four or more packers are used, a package foreman is employed to supervise the packing of the foodstuffs and rations at the warehouse, and also the rolling of the chutes. Truck drivers are also employed for the transportation of the supplies from the warehouse to the landing field.(3)

The true role of aircraft in fire control is that of transportation. The more inaccessible the fire, the more valuable the airplane becomes for transportation and observation.

During the last several years while the use of aircraft was in the experimental stage, all the aircraft and pilots used were contracted. Now the Forest Service contracts aircraft long before the fire season starts. From the standpoint of the Forest Service it was found to be cheaper to rent aircraft when they were needed than to buy a plane and pay storage and maintenance charges over the winter and derive no use whatsoever from it.(4)

F. Transportation of Fire Fighters by Air

For some time airplanes have been used to transport key fire fighting personnel to landing fields near going fires. Small units of fire fighters have been flown on occasions to landing fields or lakes in the vicinity of the fires. Often fire control officers, supervisors, and trained men for leadership have been flown to large fires because of the lack of overhead on the fire. This method of transportation has been in action for a long time, but the Forest Service has been seeking new methods of transporting fire fighters to fires.

About 1935 parachuting men to forest fires was considered, but it was not until 1939 that experiments in jumping were actually made on the Chelan National Forest in Washington. As a result of this experiment "Smoke jumpers" are likely to comprise the next and newest addition to the forest fire control forces of the United States Forest Service. The selected terrains for the premeditated jumps varied from sea level to 8000 feet. Men wearing specially designed helmets, masks, and protective clothing of padded, tough material were dropped safely in tests conducted on mountain meadows, on rough slopes and ridges, and even in dense forests. Parachuted fire tools and supplies followed after these "smoke jumpers" completed their descent. With jumps completed safely the men were ready to attack the fire

in record time and report to their forest station by means of a small, light-weight, shortwave, portable radio set.(6)

These experiments were conducted with parachute jumpers because many of the disastrous forest fires of the West caused by lightning or by man's carelessness occur in the rough mountainous country many miles from roads and trails. At present the Forest Service uses highways and a system of forest roads and trails to speed fire fighters to fires by truck or other motor vehicle, on horse back, on foot, or by combinations of these means of transportation. There are large back-country areas without roads in the National Forests. They require ten to twelve or more hours of hard travel to reach a fire--just ten or more hours too many if a fire is to be put out while it is still small.

Seventy-six Forest Service landing fields in the National Forests have already been carved out in the mountainous country, and many lakes are large enough to permit the landing of seaplanes, also. But at the best, the number of landing fields and lakes is not great enough to permit aircraft to serve largely in transportation of fire fighters with the conventional planes of today. The Forest Service has been faced with the problem of building many miles of costly roads and trails or of finding other means to deliver fire fighters on the spot a short time after a fire is reported.(6)

Fire travels rapidly. If the wind and other weather conditions are adverse, a small fire may cover a large area before the fire fighters arrive, thus large crews of men must be called out to control it. Such men traveling over rough country often spend a great deal of their energy in travel before they reach the flames, and they arrive too exhausted for immediate effective work.(6) Providing them with food and supplies either by plane or pack train then requires further time-consuming work and financial outlay. One or two men reaching a fire soon after it starts are more effective than an army of men a day or so later, when the fire may become a roaring inferno.

Air transportation of "smoke jumpers" has opened up an era of fast dispatch of fire fighters which will help materially in protecting the nation's forest resources. Since landing fields are comparatively few and far between in the vast areas of the National Forest, the landing of men by parachute, making plane landings unnecessary, is a long stride for early suppression of inaccessible forest fires. Parachute equipment for fire fighters has proven to be more than a fancy aid in extinguishing forest fires.

In the experiments to determine whether men could be safely landed in rough, forested terrain, dummies weighing 180 pounds attached to condemned army parachutes

were first dropped from elevations varying from one to eight thousand feet. Different forest types of cover and topography were selected to find out just how the parachute would perform and whether such an experiment with parachuting of men to fires would be practical in any kind of terrain and whether the men would be able to land close enough to be able to reach a fire in a short time so that he could control a small blaze before it spreads over many acres. These experiments proved successful, and the men instead of dummies soon started descending in the parachutes.

Parachute jumpers who had previously been fearful of the prospect of landing among tree branches were surprised to learn that trees usually act somewhat as springs in cushioning the landing and are preferable to the hard, rough ground. The jumpers called close stands of lodgepole pine "feather bed landings." The adaptability of this method of fire fighting was tested in various types of terrain that might be encountered: open meadows; rough, steep slopes; mountain sides covered with down timber or old snags from former fires; thick virgin forest; rocky ridges; and open stands of high timber.(6)

It was necessary to seek the advice and demonstration of professional or stunt jumpers. And since premeditated jumping had never been attempted in rough timbered mountain

terrain, new equipment of all kinds had to be developed. The invention of a new parachute especially adapted for this work was the result of cooperation from several parachute manufacturers. This new parachute was of a specially developed type 30 feet in diameter, constructed with a wide scalloped periphery or surrounded by a wide apron for a comparatively slow rate of descent (estimated at about 12 feet per second) enabling the jumper to look up and observe the condition of his canopy and shroud lines, and down, to locate a favorable landing place, not too far from the fire, the objective of his premeditated jump.(6) An ordinary chute descends at about a third faster rate. This new chute also has a minimum oxcillation, and is equipped with long flaps for steering. With the aid of the steering "flaps" the chute can be guided slightly to right or left during the descent with surprising accuracy; the forward drift can be somewhat retarded or accelerated, also, thus enabling a man to land within a few yards of his goal.(6)

During the period that this experiment was carried on there were several changes made in the equipment that added to the accuracy of the jumps, the protection of the jumper, and miscellaneous equipment necessary for him to reach the ground. Some of these changes are:

1. During the experiment several of the jumpers were dragged along the ground resulting in painful injury

to their bodies, especially their faces. A special protective helmet equipped with a convex mask of heavy steel mesh that hinges over the face, thus protecting his face.

2. A new type of harness was developed, because the standard type of harness that is used on ordinary parachutes proved a handicap in tree landings. It was found that the standard type of harness when it snagged in a tree was constructed so that the pressure from the weight of the jumper was so distributed as to make it impossible for the jumper to unsnap the connections and get free. The new harness was of the detachable type. It was made in such a way that it came loose from the parachute.

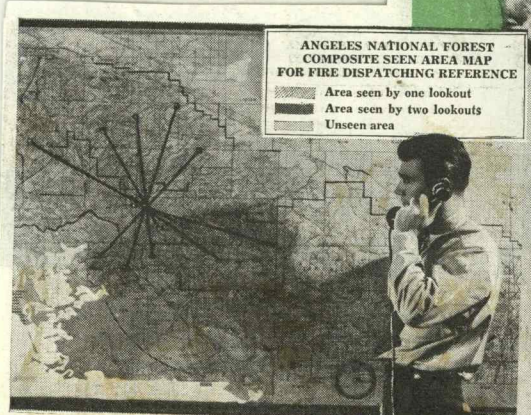
3. A special padded suit became necessary for the jumpers to wear as a protection against injury from hanging against trees or rocks.

4. A lowering rope became a very vital part of the jumper's equipment, because often times he got hung up in a tree and the rope was handy for lowering himself to the ground.

The method of delivering a jumper to a fire in the Northwest has developed into practically a routine, and is as follows:

"The airplane pilot and the jumper fly across the spot of smoke and at what they believe is the proper moment, they let go a small burlap test chute with a ten

Chelan Experiment



Top, ranger gets radio report from parachute jumper who has just landed at forest fire. Below, right, jumpers are protected for rough landings; left, crossed strings on dispatcher's map show location of fire

Pictures of Parachute Jumpers
on the Chelan National Forest

Chelan Experiment

Top, CCC boy weights down "X" marker after starting smudge to attract pilot's attention. Right, jumper wearing experimental suit and carrying supplies for fighting remote fire.

Chelan Experiment

FIGHTING FOREST FIRES

Above, dressing two parachutists for a jump from the specially built monoplane. At right, parachute mantles a tree as the jumper lands in Chelan National Forest. Below, guiding a parachute down within seventy feet of target

Pictures of Parachute Jumpers on the Chelan National Forest

Chelan Experiment

The "Smoke Jumper," Looking Like the Man From Mars, Uses a Two-Way Radio to Keep Him in Touch With the Airplane or the Nearest Lookout Station, and He Carries a Rope to Lower Himself to the Ground in Case He Landed in a Tree Top.

The Latest Development in Scientific Forest Fire Fighting Is the Parachute Man or the "Smoke Jumper" Who Leaps From an Airplane Near the "Smokes" Like a Modern Blitzkrieg Trooper Being Dropped Behind the Enemy Lines.

Chelan Experiment

The Parachutes Have Lobes to Insure Landing in the Proper Spot and Ingenious Snap Devices to Enable Jumpers to Free Themselves From the 'Chutes If They Land in Trees.

Photos by U. S. Forest Service

On Landing, the "Smoke Jumper" in Mask and Helmet Can Shed His Bulky Suit in a Minute and Get Hold of Another Parachute That Brings Him the Necessary Fire Fighting Equipment.

pound bag of sand attached. Then the pilot circles so that the two can estimate the wind drift by watching the flight and landing of the test chute. Approaching the mark for the second time the pilot makes his correction for wind and other factors by changing course and timing before he signals the jumper to go. Mountain currents of air are difficult to estimate, but the jumpers have been landing within 50 to 200 yards of the desired spot. The pilot, circling again, watches the jumper land and as he approaches over the target for the third time, he releases a burlap parachute with a fire fighting pack containing tools, lamp, two days of rations, first aid kit, water canteen, and other small articles. The entire delivery time requires not more than five to ten minutes. (Burlap parachutes used for the equipment delivery have been employed by the Forest Service for the past two or three years in dropping hundreds of tons of food and supplies to back country fire crews, everything from corss-cut saws to eggs having been dropped successfully from planes.) Meanwhile, the smoke jumper, already landed can watch the descent of the equipment chute and spot its yellow streamer so that he can make his way to it as soon as he has divested himself of his suit. Then he is ready to tackle the fire and later report to the nearest forest fire tower or other Forest station by means of a small short-wave radio which he carries and which weighs 6 pounds. Its size is 3 by 5 by 11 inches.(6)"

Among the observations noted during the course of these preliminary experiments are the following:

1. The parachute skeleton supports the weight and protects the surface, thus limiting rips and tears in the chute canopy.

2. Accuracy in hitting the ground target was exceptionally good.

3. The jumper either came straight through to the ground or he was held securely suspended in the trees. The canopy did not catch, only to be followed by slipping and dropping through the trees.

4. It is dangerous and unnecessary to reach out

instinctively in passing through the limbs of a tree to try to stop your fall. The canopy does the job more safely.

5. The closer the stand of timber, the easier the landing, and trees comprise a softer landing place than the ground.

6. Fatigue was not noticed from the ordeal of jumping.

7. Air density does not make any difference in the landing jolt.

8. A system of signalling the pilot is essential and needed for the future. (6)

The quick control of bad forest fires by strategically located small crews of woodsmen is not new. Neither is the use of parachutes. However, the adoption of parachutes by these woodsmen to form a corps of fire fighters dropping from wilderness skies is new. That, plus an awakened public interest in national defense, has brought unusual attention to the experimental use of parachutes in the national forests.(7)

The whole project developed from the Chelan experiment and was overhauled during the winter of 1939. Following the decision to extend the work to the Intermountain Region, additional equipment was designed and procured; detailed plans were made for employment of personnel and training and expansion of the scope of the

work.(6) As a result of this expansion it can be definitely said that the method with all its necessary techniques and equipment is mechanically or technically feasible. It has been proven that forest guards (and there is no lack of volunteers) can fly out over practically any type of forest, jump, land successfully, and extinguish fires.(7)

"On August 20, 1940, ten fires were reported on the Bitterroot National Forest in Montana. Smoke jumpers were sent to two inaccessible fires which past experience indicated would be most likely to develop into big ones. Ground crews went on foot from road ends to the other eight. Suppression of the fires handled by the smoke-jumpers cost $160 each. The eight fires controlled by ground crews varied in cost from $2,000 to $17,000 each.(9)"

"On the Nezperce National Forest in northern Idaho, two parachutists made the initial attack and held a fire to a cost of $500. In 1934, a fire handled by ground transportation in the same area cost $12,000 to suppress. Other reports record similar savings.(9)"

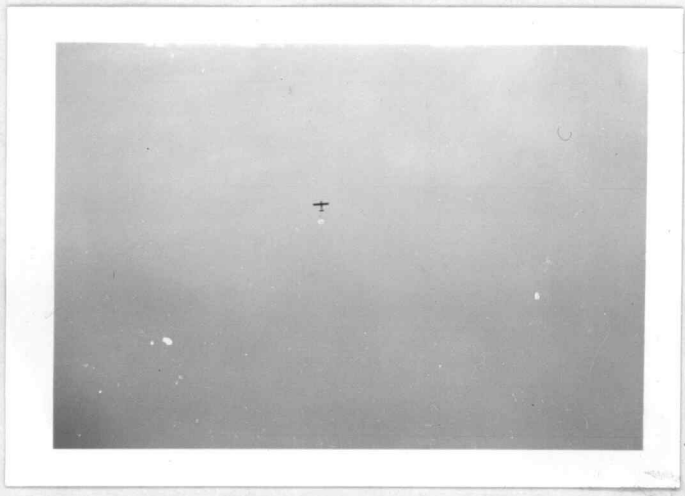
These two reports have been taken directly from the Forest Service fiels and they bare out the fact that the use of aircraft in forestry is a profitable enterprise, and has more future possibilities above the present uses.

Region One Experiment
Parachute Smoke Jumpers

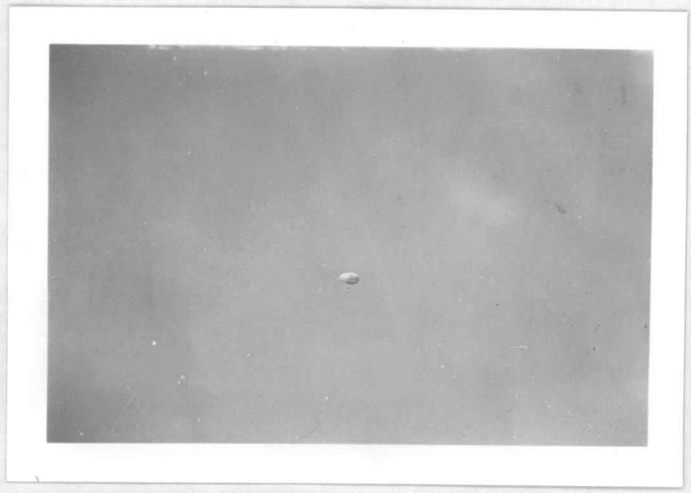
Getting into the suits before the
premeditated jumps
Notice different type of suits.
Compare them with the ones used on
the Chelan Experiment.

Plane ready for takeoff

Region One Experiment
Parachute Smoke Jumpers



A white speck in the sky



On the way down

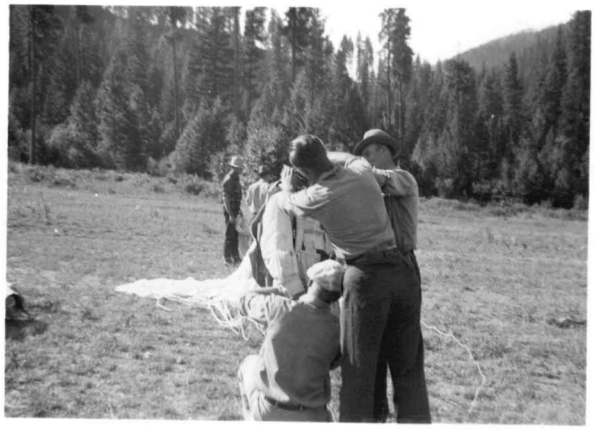
Region One Experiment
Parachute Smoke Jumpers

Notice the special apron around the edge of the parachutes.

Region One Experiment
Parachute Smoke Jumpers

Coming to a landing

Region One Experiment
Parachute Smoke Jumpers



Getting out of the suit after a jump

Rolling the parachute up to be packed again

Region One Experiment
Parachute Smoke Jumpers

Jumper has opened the emergency parachute.

The following chart shows the training expenditure of a squad of parachuting fire fighters who conducted tests in the national forests of Northern Rocky Mountain Region during 1940 fire season.(7)

Summary of Training Expenditures 1940
Wages--Five Men

Instructor rigger[1]	$116.05	
Head rigger[1]	70.29	
Second rigger[2]	70.29	
Project leader[2]	61.05	
Crew, six men	421.74	
Total Wages		$ 739.42
Total subsistence, 10 men		99.00
Total per diem, 10 men		76.00
Total flying time[3]	692.50	
Flying time to and from training quarters	390.00	
Total flying time for training		302.50
Travel cars, mileage		45.00
Cost to train five men		$1,261.92
Flying time to and from Seeley Lake		390.00
Total expenditures		$1,651.92

The total cost of the Region One parachute project for the year, including personnel, depreciation on equipment, and flying was $9,047. The savings are appreciable when this item is compared to the $32,270 estimated cost of control if parachutists had not been used.(7)

Costs of the 1940 Season in Region One

Item	Cost F.Y. 1940 Dollars	F.Y. 1941 Dollars
Wages	678	2,849
Supplies and small equipment	445	315
Nonfire transportation and training flying . . .	602	531
Travel and miscellaneous .	282	361
Subsistence and freight to Moost Creek	700	-
Flying time on fire suppression	-	1,484
	2,707	5,540
Estimated calender year 1940 depreciation on equipment (5-year life) . .		800
Grand total for 1940 season		9,047

A Comparison of Parachute and Ground Crew Suppression Times and Costs

Name of fire	No. parachuters used	Travel time landing field to fire		Est. travel time ground crew to fire	Cost via parachuter	Estimated cost via ground crew
		Hours	Minutes	Hours	Dollars	Dollars
Martin Creek	2	-	40	24	190	500
Robbins Creek	2	-	50	24	350	10,000
Cox Creek	2	6[2]	30	30	150	20
Monte Creek	2	2	30	12	150	200
Elbow Creek	2	13[2]	10	25	150	50
Lizard Creek	2	1	15	30	300	300
Smokejumper	2	-	30	40	190	10,000
Scout Mountain	2	2	18	40	190	10,000
Isaac Creek	3	3	15	30	550	1,200
Average	2.1	1	41	28+	247+	3,500

[2]Excluded from average because of special conditions

"The average cost including all initial attack and follow-up expense was $247 per fire. Competent fire control men, familiar with the history of similar fires during the past, estimated the average cost of the fires would have been $3,500 each, or a total of $32,270 for the nine fires, if no parachuters had been used. Most of the savings occurred on three fires; on two of the fires there was a loss by using parachute crews and on four fires the savings were $200 to $1,200. The estimated savings are admittedly debatable but are the best comparison possible. No attempt was made to estimate the value of the resources that would have burned if quick control had not been established."(7)

Following are the conclusions that are the result of the experiments conducted in Region One during the fire season of 1940:

1. "Delivery of skilled and well-trained parachute jumping fire-fighters can be safely accomplished in rough timbered terrain with wind velocities as high as 30 miles per hour and at altitudes up to at least 8,000 feet. Higher elevations may present no added difficulties but limited experience indicates noticeably harder landings at high altitudes."(7)

2. "Equipment and jumping methods can be simplified and thus reduce the costs."(7)

3. "Training should be intensified in physical conditioning, jumping, and fire fighting."(7)

4. "Long season employment is essential to insure retention of trained men."(7)

5. "Organized parachute squads will prove effective as a highly mobile and badly needed follow-up force to supplement the organization now provided in some eight million acres of the inaccessible sort of the Northern Rocky Mountain Region."(7)

6. "The investment in the parachute project resulted in substantial savings in suppression costs and damages during the first year. Larger savings per dollar invested should be made as additional experience is gained."(7)

7. "From the partial analysis of past records and guided by the principle, developed and used by Sutliff

in Region One fire planning, which indicates that 10 men in one hour are normally equivalent to 75 men who arrive hours later, it is concluded that a minimum of approximately 50 jumpers will pay dividends in normal seasons in Region One."(7)

8. "Final determination of the number of parachutists which will prove most economical for a given forest area probably cannot be made for a number of years."(7)

9. "The dispatching of parachutists should be done by a man with the best possible judgment and a good knowledge of the conditions existing so the fires selected will be those on which quick action will pay the greatest returns for the special control service. Though important, this is no new problem since the back country district ranger with limited forces and a peak fire load has always been faced with it."(7)

10. "The project should be considered and managed as experimental for many years even though application was successful and proved a money maker in the first year of trial. Probably no less than 10 years of use will be required to turn parachutes from a mysterious fear-producing piece of equipment into a trusted means of traveling from a flying air transport to earth below."(7)

11. "Parachuting, as an aid to forest fire control, will probably not prove economic in forest areas where the planned road system has been completed."(7)

12. "Parachuting will probably not prove feasible or economic as a means of providing initial attack for the normal fire load under normal season conditions."(7)

13. "The required type of airplane and a pilot skilled in mountain flying must be available during times of possible need."(7)

14. "Irresistible forces in man's nature have caused him to adopt faster and faster methods of transportation. Fear of the unknown delayed the adoption of the automobile and airplane, but could not prevent it. The use of parachutes opens a field of transportation in which speed stands out as the dominating motive."(7)

All the statistics point to a net savings in the use of parachutists on fires. There are arguments for and against this unit as a part of the Forest Service, but we have not gone far enough to form sound conclusions. Sufficient comparative figures on enough fires have not been accumulated. This method appears to be economically sound within certain limits, but it must withstand a harder test than any to which it has yet been subjected.

This experiment has produced an intangible value. This spectacular work has brought more public attention through press, movies, and radio than any one forest activity in several years. These experiments will result in greater public interest in forest protection.(8)

Plans are now under way to expand the parachute forces. This phase of the work offers such possibilities, that even the private flying concerns are going into it on a larger scale with their eye to the future. Both the private flying companies and the Forest Service are training larger corps of men for this type of work. The Forest Service has requested appropriations for increasing the expansion of parachute work and to cover all expenses.

IV. AERIAL PHOTOGRAPHY IN THE FORESTS

A. Uses of Aerial Photography and Factors Governing Its Use

There are many uses to which aerial photography can be put. The value and the potentialities of aerial mappingin nearly all phases of forestry show great promise. The Forest Service uses aerial mapping in nearly all of its regions. With the extensive survey that the Army air corps has been conducting in the last several years and in cooperation with them, the Forest Service should have nearly all of its National Forests mapped.

The Forest Service is not the only agent making use of aerial photography in forestry. The private operators in the logging industry in the recent years have shown a great interest in it.

There are several factors of importance limiting the use of aerial photography in the logging industry, and they are namely:

1. The item of cost is the biggest deterrent. When this item of cost comes down within the grasp of the smaller operators, and they can be shown benefits from aerial photography, they will use it. Aerial photography is now being used in agriculture planning for farms. It is found to be accurate and fast.(10)

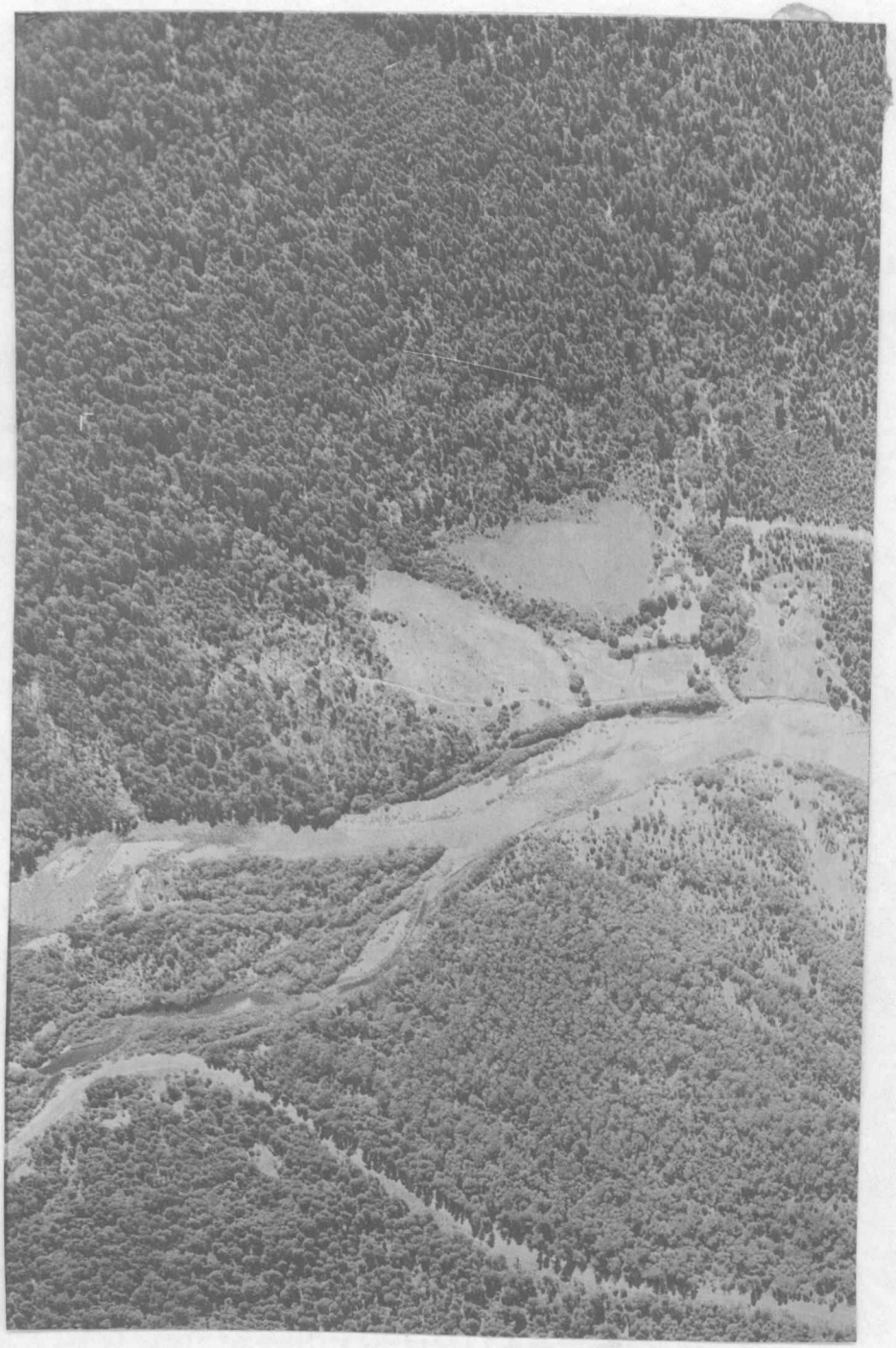
2. The lack of elementary literature on the subject, particularly in relation to forestry. A little information on this subject can be found, but it is described in terms that the average woods operator is unable to understand; thus he becomes disgusted and considers it just a waste of time.(10)

3. Special photographic requirements are necessary to obtain pictures for forestry use.

The commercial aircraft companies that make aerial photographs and supply the aircraft do not take this factor into consideration. Before a company is hired to do this type of a job, it should know what is to be accomplished, what the picture is to be used for, and the factors that are to be encountered. Just an ordinary picture will not be sufficient to accomplish this purpose.(10)

In some cases photographs are made which when viewed through a stereoscope produce a tri-dimensional image in which ridges, mountain canyons, vallyes, streams, roads, trails, buildings, general cover types--grassland, forest or wasteland--and other features stand out in relief just as they would appear to an observer flying over the country. They also provide considerable information as to the kind of site and the identification of forest types.

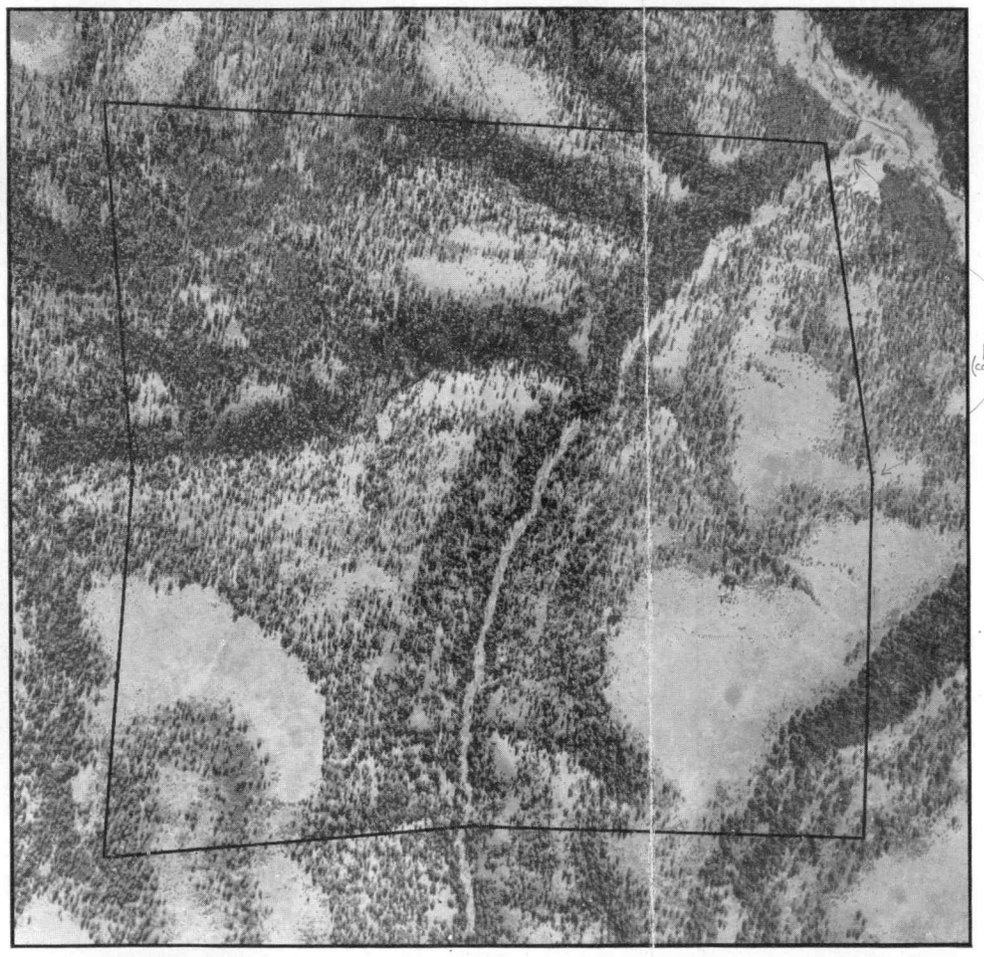
An Aerial Contact Print



Notice the shadows of the trees, the drainages, and the different sizes of the ground cover.

MORE INFORMATION -- LOWER COST

AERIAL CONTACT PRINT OR MOSAIC



N.B. actual points (corner posts) were identified from picture in the field.

SECTION OF PINE TIMBER - OREGON

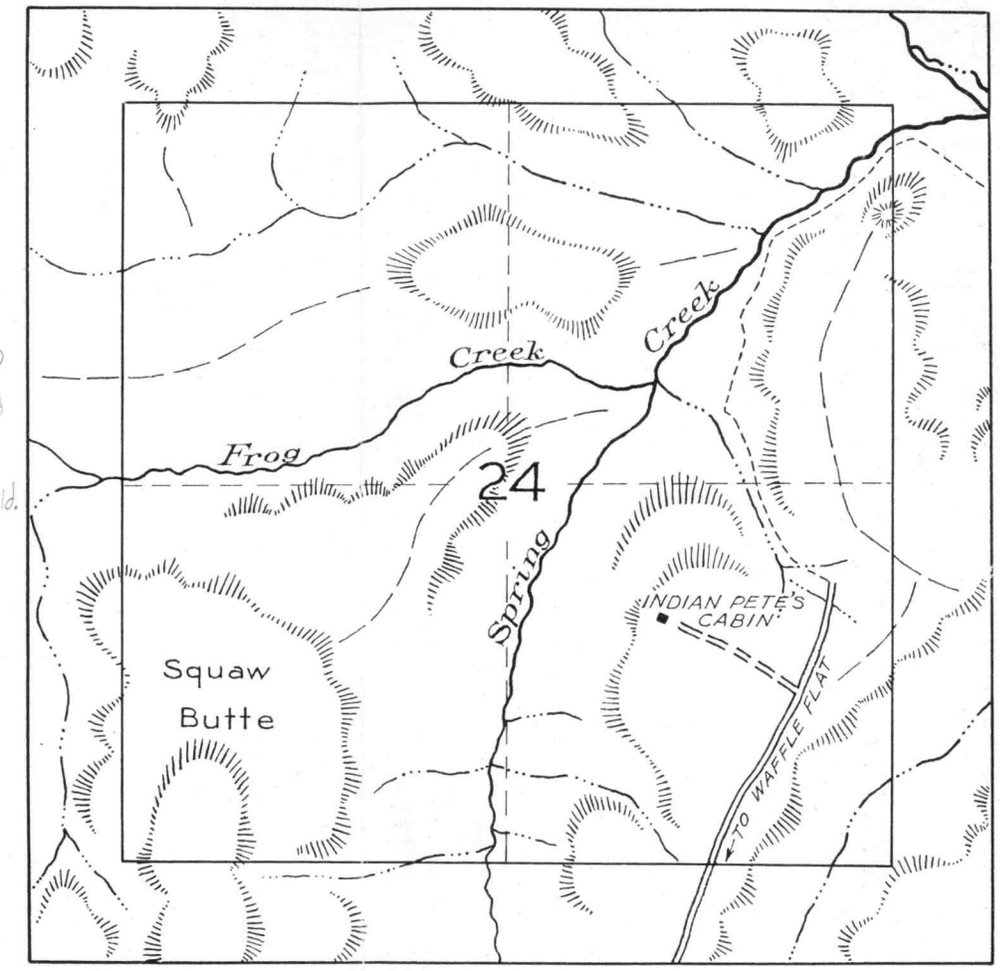
THE PICTURES SHOW:—
(When Used With Stereoscope)

Timber Classification - Age, Volume, Species Types.
Where the Timber is - and where it isn't.
Topographic Obstacles and Aids to Logging.

WARNING:- An expert knowledge of special color filters required is essential to successful timber photography. Obsolete technique may result in photographs uneven and glary - practically useless for showing timber details.

TIMBER PHOTOGRAPHY IS A RYKER SPECIALTY

PLANIMETRIC MAP



SCALE 4"= 1 MILE

0 1000 2000 3000 4000 5000

FEET

THE PLANIMETRIC MAP:—

Shows drainage, culture and water-shed lines all plotted accurately on a map projection to uniform scale. . . . . .

The aerial photograph has many uses. Whenever the average person hears aerial photography mentioned, he thinks only of mapping and forgets the other uses. In some instances the other uses of the aerial photographs have proven of more value than mapping. A few of the other uses are timber type surveys, range surveys, fire detection and suppression, transportation planning, planting surveys, erosion studies, flood control studies, game counts, and forest inventory. The uses of aerial photography are becoming more important and have shown tremendous strides in the last decade.

From the viewpoint of the woods operators aerial photographs are the only accurate and complete method of map making; they show the detail accurately. A prediction is that all progressive operators will make more use of aerial photographs in their future work.(10)

B. Timber Estimating

Estimating and classifying timber from aerial photographs sounds like a far fetched and impossible idea. Why a certain degree of accuracy for rough estimating or classification cannot be attained remains to be seen. To get precise and accurate results necessitates more information relative to the site by additional field work.

There are only three factors available from aerial photographs; they are: height, crown density,

and crown diameter. In making a determination of timber quantities a correlation of these factors is essential. The height of the stand is the main factor, and the only present method of determining the height of a tree is from its shadow. Only a few trees can be measured to use as a reference and a comparison with the other trees in the stand. The crown diameter may have some possibilities in timber estimating. With study and research one should be able to make a set of rules, similar to marking rules, that would give an estimation or classification to certain trees according to their crown diameter from the top. This rule could be a diagram rule that considers the crown diameter and crown density of the tree. The vigor and susceptibility of a tree is shown in the condition of its crown, with certain specifications considered. There is no reason why an approximate amount of volume cannot be estimated and why each tree cannot be segregated into a class according to its susceptibility and marked according to the order in which it is to be removed. A comprehensive view is outstanding in air estimates of the crown density.

In Canada the Dominion Forest Service has tried several experiments along this line, but their method of determining the volume is only good for broad forest-inventory purposes. To get it more intensively necessitates

securing more information relating to the species, age, site, and defective timber, as well as volume measurements taken at random on the ground, which must be coordinated with the estimates from the aerial photographs. (11) Their method for determining volumetric estimates was as follows:

1. The tree height methods are used to determine the height of the dominant and co-dominant trees.(11)

2. By the aid of intensity curves a figure is set for the volume per acre of the stand.(11)

3. The crown density is appraised from an examination of the photographs, and an adjustment in the volume per acre is made in accordance with the variation from the normal crown density.(11)

4. The final step is to estimate the percentage of hardwoods present in the stand.(11)

It is easier to estimate and classify the volume of hardwoods. If aerial photographs are taken during the winter when all the leaves are off of the trees, one has a better opportunity to see exactly what the bole and main branches look like. This does not apply to softwoods though.

One important use of aerial photographs is a type map, because types affecting the accuracy of an estimate most profoundly (unmerchantable types) are the easiest to distinguish on aerial photographs. Stem counts can

be made on large scale pictures, but the diameter breast height dimension is still lacking. Some study is being made to correlate crown diameter to diameter breast height. When such a correlation is established operators will realize the value of aerial photographs.

C. Forest Inventory Requirements

The use of aerial photographs for extensive inventory purposes is a cheap and quick method of getting a complete look at the tract to be considered. Within the last several years aerial cameras have greatly improved. With the development of a special camera that will show more forest detail and result in a special forest-inventory photograph, which shows the forest cover and type, recent burns, drainages, cuttings, and other changes, the extensive method of inventory by use of aerial photographs will be established. We must not forget these are many things essential to forest inventory that can not be obtained except from actually working on the area.

D. Logging Cost Estimating

Aerial photographs can be of very valuable use in estimating costs of logging. Outside the stand per acre and the total volume, the important factors affecting logging costs are: the total miles branch and main haul roads, the skidding distance, and the

topographic features. These factors are readily determinable from a stereoscopic study of photographs, and when carried out in connection with ground provide the best possible data for estimating costs.(11)

If an operator uses aerial photographs to estimate logging costs, a set should be taken each year to show the accurate area cut and any variations in the amount cut from year to year and whether these variations are a result of a physical feature. It shows the cut and the total miles of branch and main roads constructed. These are important if figuring logging cost statistics. The aerial photograph makes available a ready solution to these survey problems.(11)

When the cost of getting the pictures or having the work done is reduced sufficiently, the extensive use of aerial photographs will be universal.

E. Road Location

Aerial maps can be used extensively in locating roads, especially in very mountainous country. The advantage of having a clear, concise picture of the country through which the road must run and being able to lay out all possible or potential road locations on the map is a factor that cuts costs to a minimum. After locating all possible routes the next step is a field trip to explore all the possible routes and determine the most desirable one. When the desired route is picked and located on

the aerial map, the entire road is laid out as a series of tangents. Each tangent will be carefully located with respect to these features: creek crossings, marshes, small clearings, definite changes of timber types, etc. These features are not difficult to recognize and are easy to locate on the ground and on the photographs. The use of aerial maps is considerably cheaper and faster than a topographic map.(10)

The aerial photographs can be used to accomplish the preliminary work, determine the bearings, the distances, the grades, and the bridge locations, after the route is selected. The advent of the stereoscopic photographs which produce a tri-dimensional image, making all features of relief stand out, will make this use less complex. The final step in this method of road location is the picketing of the center line of the road.

With the improvement of cameras and equipment aerial photographs for locating roads will be popular and economical. This method will be used extensively by the woods operator in locating main logging roads, which require care due to their importance to the operation. It will be up to the operator to determine what kind of logging road can be located by this method.

F. Forest Protection

The use of aerial photographs and the airplane is

classed under two headings, fire and insects, when being considered for forest protection.

From the suppression point of view the airplane and aerial maps cannot be surpassed. Aircraft enters the picture under the heading of transportation and observation when the fires become inaccessible.

Aircraft has been used only to a limited extent in the detection of insect infestations and outbreaks through the use of aerial photographs. As photographic equipment and new improvements are discovered the use of aerial photographs will greatly increase in the future. Areas of infestation can often be readily detected and mapped from the air, thus making it possible to determine quickly the extent of the area involved and apply control measures where necessary. If an epidemic occurs, the use of aerial photographs taken at a periodic time will form a quick and accurate means of determining its progress or extent, and whether it is necessary to intensify the control measures. Aerial photographs will act as measuring sticks. This is particularly true in the case of bark beetle outbreaks in the western states where surveys by ground crews are difficult and time consuming. Preliminary tests in the use of airplanes for this purpose have been very encouraging.

Aerial photographs of areas where bugs are working can be enlarged as high as sixty to one. This has

possibilities of accomplishing the same work as bug spotters and will give a more accurately plotted location of the bug infested trees. Experiments along this line may bring surprisingly successful results.

It is a known fact that photographs are a valuable aid to the forest pathologist in analyzing forest composition in relationship to fungus diseases.(10)

G. Planting Surveys

Aerial photographs are rapidly assuming a place of importance as an effective and valuable administrative tool in the Forest Service organization. There are a multitude of uses for aerial photographs in forest administration work which are now beginning to be utilized; among these is the application of aerial photographs to planting surveys. As an aid in planting surveys they have been utilized to a limited extent. The air photos reveal the size, the location, and distribution of open areas needing reforestation, and aid in planning tree planting programs.(12)

Where there are many small tracts to be planted, it is important that the location of areas to be planted in relation to one another and their proximity to roads is known beforehand. Travel, a costly item in any planting program, can be reduced to a great extent by planting fields which are close together while the crew

is working in that particular area. Aerial photographs are invaluable for this purpose in that they not only show available roads, but also the relative position of the fields.(12)

Within certain limitations, aerial photos can be utilized to determine the species best adapted to certain areas. The species of stock to be planted can be easily determined when fields are identified as being located on a ridge, botoom, or side hill. Aerial photographs supply the needed information at a glance where exposure is an important factor in the selection of species to be planted.(12)

Pictures show the degree of natural restocking present. Of course they are limited in their use, eliminating many areas from the planting program. The photographs are useless in determining soil type, soil structure and degree of erosion on the area to be planted.

For a preliminary plan aerial photos give the foreman of the planting crew a place to start from in locating his property corners, lines, and fields and getting his crew organization planned before sending it into the field.

This use of aerial photographs is limited, because reforestation to any extent is not being carried on except in areas where other material is available.

H. Range Survey Work

Range survey work in the National Forests is carried on with the aid of aerial photographs. The range management officer takes contact prints of vertical, aerial photographs to the field. Upon these prints he outlines his grazing types and writes in the type designation and forage condition. He also notes all watering places, includes springs and streams; classifies the roads and trails; locates fences, particularly fence corners, ranch buildings, and all possible section corners. The use of air photos in the field is an accurate and faster method of locating these features and gives the examiner a complete picture of all the area. If in the office a question arises, all he has to do is spread these prints before him showing a complete picture of the area. Aerial photographs are an easier method of explaining an area to somebody else, because this other person does not have to rely on the examiner's word, but he can actually see what is on the area.

These prints also show the shades of browns, yellows, greens, and other signs which indicate the difference between unused, moderately used, and "pulverized" range. These factors unite to tell whether the range is being utilized by the right method, or whether anything is wrong.

The use of aerial photographs over maps is of material help to a range management officer, and it will continue to be in the future.

I. Game Counts

In the making of game counts the airplane and aerial photographs are limited in their use. They can only be utilized when no other method will suffice. Aerial photos have been very effective in making game counts in the winter when deep snows make ordinary travel difficult or impossible. In southeastern Oregon aerial photographs have been employed for making a count of the antelope, as there is no other method of getting close enough to these fleet animals to determine accurately their numbers. Another use to be considered is counting groups of game concentrations and indicating where and how much supplemental ground work should be done, and what plans need to be worked out in connection with the control of such a situation.

The important factor in considering the use of airplanes and aerial photographs is that they provide a quick method of arriving at an accurate game estimate. This is especially important and basic in developing wildlife plans and programs.

I have presented a resume of a few of the uses to which aerial photographs can be put and profitably used. In considering and bringing out their main points in the

future we will find more uses for aerial photographs in the Forest Service and private forest industries. With such a concentration on modern developments and improvement of equipment there will be a trend towards a better and broader field in this work.

V. THE AIRPLANE AND MANAGEMENT OF THE WILDLIFE RESOURCE

A. General Management of Wildlife Resource

The use of airplanes as an aid in the general management of the wildlife resource is still in an experimental stage; although, aerial work has been very effective in winter when deep snows make ordinary travel difficult or impossible.

Use of aircraft in game counts in conjunction with aerial photographs is one phase; another phase is the showing of game concentrations and indicating when and where supplemental ground work should be done or plans worked in connection with game counts and game controls. An estimate of big game populations is necessary as a basis for intelligent management plans and often indicates cases of overcrowding or depleting of game by disease, predators, and starvation.

In some areas a shortage of salt can be determined from air as the larger game animals often paw deep holes in natural salt licks. The condition of the trails and the holes will serve as an indicator of the use that the salt licks are receiving. If a shortage of salt is indicated, dropping of salt blocks from the sky will compensate this shortage.

When a small group of game is found in some isolated section of the country with a shortage of forage due to extreme winter conditions and hindrance of travel brought

about by deep snows, dropping feed from airplanes may save them and prolong their life until a ground party can reach them. In Idaho and the intermountain states during a hard winter in 1938 when forage shortage resulted and the deer were starving, aircraft was used to supply them with feed. This use of aircraft is used only where an emergency arises and rapid transportation and quick action are necessary.

In the Middle West and areas with similar terrain airplanes are used for hunting predators. When the terrain is smooth, rolling, and adaptable to landings, this is great sport and a profitable business. Pelt bounties is the compensatory aspect.

B. Stocking Lakes with Fish

Restocking streams in the mountains and stocking fishless lakes of the back country have always presented difficult problems of transportation. When fingerling trout are carried any distance, the water needs to be aerated; so the problem of transporting fish to inaccessible regions by pack horse is complicated.(13) This process of stocking back country lakes has been difficult, costly, and not always successful; the result is heavy losses before the fish are planted in the lakes. Also there is a low rate of survival.(14)

The use of containers was first thought of and experimented with, but because of the crowding of the

fish in them, and the shock to the fish when they strike the water, they had to be discarded. Next, cans were dropped by parachutes with the fish escaping through holes cut in the top of the can. No ill effects either from the descent or the shock of landing were noted.

The idea of dropping fish and water from the plane was discovered by accident. It was found that the fish were not even stunned when they hit the water; the force of the fall was broken by their fluttering in the air.(13) A special tank is needed so that the water for the fish could be aerated. So "the flying fish tank" has taken its place in the stocking of remote mountain lakes from Alaska to Mexico, lakes that are accessible on the ground only to the slow moving pack string. With this discovery the Bureau of Fisheries found that fingerlings three and one-half inches long could be dropped or poured from a plane flying eighty miles per hour and at an altitude of two hundred and fifty feet.(14)

This method of planting is only a matter of minutes instead of hours as was the old method required. In Alaska the lakes are large enough for safe landings of seaplanes, and cans of fingerlings are merely poured directly into the water, just as they would be from land.(14)

In utilizing the airplane to keep remote back country lakes stocked with fish the federal government is merely following the progressive sportsman who uses the airplane as a quick means of reaching these wilderness waters. This is particularly true in Alaska.

Before this type of fish stocking can be accomplished, it is necessary to secure a permit from the Civil Aeronautics Authority: first, to drop objects from a plane, and second, to fly less than five hundred feet above the ground. These two conditions are contrary to their regulations.(13)

As it becomes necessary to stock back country lakes, the use of aircraft will be justified more now that fingerlings can be dropped from the air. Saving time and lowering the mortality rate of the small fish will more than balance the extra cost that has to be contended with when an airplane is used.

VI. OTHER USES OF AIRCRAFT IN FORESTRY

A. Planting of Trees and Their Seed

If broadcast seeding of tree species held promise of success at a reasonable cost, it is logical to assume that scattering from an airplane would undoubtedly be an effective way to distribute the seed of some small-seeded species. The cost of collecting the enormous quantity of seed required would be high. Tests have indicated that planting nursery grown stock is the best method, and that, except in unusual cases, direct seeding by airplane is impractical. There are many factors existing on the ground which cause a very low rate of survival.

The Forest Service in southern California has seeded wild mustard from the air when it was necessary to quickly establish a vegetative cover for watershed protection on burnt over areas, and to protect these areas from erosion.(4)

Transportation of seedling trees to remote areas by air has been used with success. In such cases fairly large quantities of small trees have been delivered to planting sites in good condition because of their rapid transit.

On the Hawaiian Islands and surrounding islands some experimenting has been conducted in planting trees by use of the "bomb" method. The seedlings are put in

a small container with a very sharp apex. When the airplane was flown over an area, the miniature bomb was released. What the results of this experiment are is unknown. The experimentors were going on the idea that the damp humid climate would be an aid to the survival of the seedling. This idea may have possibilities if a type of container could be obtained that would serve the purpose of getting the seedling into the ground and then disintegrate.(15)

B. Planting of Range Seed

In November 1939 the Soil Conservation Service seeded some 2,500 acres of range lange in Idaho for the purpose of reestablishing desirable vegetation.(16)

Because of the relatively high precipitation and potential productivity of the site artificial revegetation of portions seeded was considered practicable. With a proper protective cover the area will be valuable for range forage production, will serve as a means of conserving water and controlling flood, will provide a habitat for upland game including deer, birds, and fish, and can be used to a limited degree for timber production. (16)

It was decided that airplane seeding was the most effective means of broadcasting the seed because of the inaccessibility of the area. The actual seeding operations were carried out by flying at a height of 300 to

500 feet, so that the seeds were distributed in a swath about 100 feet wide.(16)

The following recommendations and suggestions, developed during these seed operations are presented to assist in conducting future seeding from airplanes:

1. "The cost of seeding was not excessive for this area and should be considerably less for larger areas or areas having less broken topography."(16)

2. "An adequate site analysis should be made to determine suitable species and possibilities of obtaining a forage-producing and erosion-resisting cover commensurate the cost."(16)

3. "Provisions should be made to protect the seeded area from livestock until the new plants are well established."(16)

4. "Suitable base operations should be located in the vicinity. They should include landing field and means of protecting the plane and supplies from livestock and weather."(16)

5. "Provision should be made for the ground crew, both on the area to be seeded and at the base of operation."(16)

6. "Cross-seeding is recommended only when a full stand in the shortest possible time is desired, as in revegetating burned-over watersheds above municipalities or other valuable areas endangered by severe flood hazards."(16)

7. "Agreement should be reached regarding the minimum requirements for distribution of the seed as a basis of checking the distribution by the number and size of greased cards. Cards one yard square would be adequate."(16)

C. Range Management

The airplane affords a quick and easy means of inspecting livestock range. Although no very close figure on the degree of use of forage can be determined

from the air, the shades of browns, yellows, greens, the trails, and other signs all indicate the differences between unused, moderately used, overused, and "pulverized" range.

One of the permittees on the Deerlodge National Forest in Montana, unable to ride a horse for a long enough time to get over all his range, and distrusting the verbal descriptions given by his men, decided to try an aerial inspection to see how his cattle had used the rough and well-timbered range. At its conclusion he reported to the Forest Ranger describing the range utilization in almost the same terms the Ranger had formulated after an on-the-ground inspection.

The use of aircraft will give the whole picture of the country at once; although, the minor details will not be considered. By this method of range management the permittee is able to pick out the areas that may need a closer inspection on the ground.

D. Insect Control

Aircraft has been used only to a limited extent in detecting outbreaks of forest insects in this country. It is believed, however, that such use will greatly increase in the future. Areas of infestation can often be readily detected and mapped from the air, thus making it possible to determine quickly the extent of the area involved and apply control measures where necessary.

This is particularly true in the case of bark beetle outbreaks in the western states where surveys by ground crews are difficult and time consuming.

The use of ordinary high speed airplanes in applying insecticides for the control of defoliating insects in the forests has been found not to be as successful as was thought at first. Airplane dusting has been very successful when used for insects on field crops, especially in the south. With this in mind the Bureau of Entomology and Plant Quarantine and other agencies determined to develop this method of control for defoliating insects that inhabit our forests. Several attempts to control such forest insects as the spruce budworm, gypsy moth, and hemlock looper from the air has been only moderately successful. The Forest Service in British Columbia has employed the use of airplanes in controlling hemlock looper, and they meet with fairly good success. One of the chief difficulties has been the extreme hazard involved in flying sufficiently low over the tree tops to insure the insecticide where it is needed and to obtain uniform distribution. The kind and ruggedness of the terrain is another factor that has to be taken into consideration in dusting.

Development of slower speed planes with the ability to carry large loads is something for the dusters to

strive for. Some recent tests with the autogiro have demonstrated its great superiority for such work because of greater maneuverability. The present autogiro is at a disadvantage because it is unable to carry extra large loads which are necessary in dusting. The recent development of concentrated liquid spray mixtures or oil-dust mixtures for application from an autogiro appears to offer considerable promise for success in treating forest stands of high value. The development of this kind of a mixture has the advantage of being adhesive or glutinous in nature, thus enabling it to cling to the leaves more solidly. These two developments may find airplanes coming into more use in Forest Service in the future, especially when some emergency arises that is too large for the Forest Service to handle by ordinary means and requires fast and prompt action.

E. Transportation of Overhead and Freighting

Aerial transportation as used in the forest administration falls under two main heads, viz: freighting and supervision or taxi service.

The element of speed is the controlling factor. Aerial freighting becomes practical only in emergency operations such as fire suppression, fire detection, and rescue work. Mercy fliers sometimes drop food and

supplies to persons lost in the forest to alleviate suffering until actual rescue can be affected. Early in this thesis I dealt with the use of aircraft in freighting supplies for fire fighters.

In eastern Canada aircraft was used to haul freight to logging camps located in areas that were being "cleaned up," and where the remaining stand was not sufficiently large to justify building roads into it. It is not likely that aircraft will ever be an important factor in transportation on the well managed forests of the future as far as logging operations are concerned.(10)

In the line of supervision, the high-salaried executive who has his office in the city can well afford to use aircraft to inspect his logging operations. Aircraft will permit the busy executive to come in closer contact with his woods operations and thus permit him to supervise them properly by direct contact. (10)

Use of aircraft in the movement of man-power, especially overhead is of great importance in some regions of the country. Especially is this true in the western section of the United States and Alaska.

In the forests of Alaska the principal modes of travel are via boat and airplane. The Forest Service

has a small fleet of "Ranger Boats" for their administration work. The operation costs of these boats are about twenty-five cents per mile. Their personnel travels via air either as regular passengers or by chartering planes. The passenger rates are almost double the regular steamer rates, but are only slightly higher than the cost of operating their own boats. Charter airplanes run from $32.00 to $40.00 per hour, depending upon the seating capacity. Charters allow free standby time equal to flying time. Usually a charge of ¼ flying rate is made for additional standby time.(17)

The big disadvantage in boat travel, of course, is travel time. By using boats it often takes several days to cover a few jobs that can readily be covered by use of airplane in a day or less, thus cutting down the per diem expense. The use of airplanes for Forest Service work in Alaska is increasing each year. (17)

Region 10 Takes to the Air

By William N. Parke, R-10

The present decade might properly be termed the "soaring forties" in the annals of Alaska forestry for Region Ten has inaugurated airplane travel as a regular means of transportation. Not that the airplane has not been used in previous years, but the policy permitting wider use of this mode of travel in our regular administrative work was definitely established this year. And why not?

Those who are familiar with the intricate system of inland waterways in the Southeastern Alaska archipelago realize how complex our transportation system really is. Transportation in the National Forests has naturally followed the course of least resistance. In Alaska this has so far been accomplished through the use of a fleet of our own boats which are skippered and maintained by our regular F. S. "navy" personnel.

Whereas boat travel has been reasonably cheap and moderately fast, it is becoming more evident as times goes on that airplane travel will supplant boat travel in much of our work. This is not meant to infer that our boats will eventually be discarded. They will always be needed for towing scows loaded with supplies and equipment. They are necessary to tow wanigans which are used for quartering larger work crews on isolated projects near tidewater. Boats will continue to be used for quartering resource survey and other smaller crews that usually remain in certain areas for periods of short duration. And they will continue to be used in our administrative work where boat travel is less costly and more convenient than airplane travel. But the advantages of airplane travel for much of our administrative work are becoming so pronounced that it is simply good business to travel more by air.

Competition between air transportation companies, and other causes, have lowered the cost of airplane travel so that rates between the larger communities is only slightly higher by air than by commercial boat. The cost of operating and maintaining a Ranger boat, exclusive of crew salaries, is only three cents a mile less than the cost of airplane travel. On the other hand, airplane travel effects such a saving in travel time that the saving in salaries and per diem more than off sets the slightly higher travel rates.

In the three month period from July to September, inclusive, Region Ten used 48 flying hours for administrative travel purposes. This amounts to roughly 5,200 miles which is not an alarming distance but at the same time it is considerably more than any previous corresponding period.

We are anticipating much wider use of the airplane in our future work, and the time is not far distant when land plane service will supplement our present sea plane service. The Forest Service, at least in Alaska, may eventually find it entirely practical to maintain and operate a group of airplanes. The Alaskan ranger of tomorrow will quite likely find it just as commonplace

to cover his district in a plane as he now attempts to do by boat. And this is no idle thinking.

F. "Bombing" Fires

Experiments have been conducted along the idea of dropping chemicals, explosives, or water on small fires to keep them small until ground forces can reach them. Region 6 carried on experiments along this line during the summer of 1939, but the results were not useful. They used only liquids spread by the explosion method. This method of "bombing" fires was expensive and relatively inaccurate.(5)

There are possibilities that some day a chemical in powder form will be invented that will act as a suffocator when the fire comes in contact with it; the flames will be extinguished. The same method of dispersion as is employed in dusting will then be used more accurately.

VII. FUTURE IMPROVEMENTS AND POSSIBILITIES

A. Types of Future Aircraft

They should be of the type that can use small landing fields and yet carry a large load.

Some consideration has been brought forward in the idea that the development of rotary winged ships which will carry enough useful load capacity will be of great service in the transportation of supplies for fires and the transportation of parachute jumpers. This type of ship will be believed to utilize very short runways.

The army has developed a courier plane that has braking surfaces on its wings enabling it to land at 25 miles an hour and hop from small fields. The slots on the leading and flaps on the trailing edges of the wing, in a slow speed position, are adjustable.

The autogiro has been considered for such work due to its maneuverability, but it cannot carry large loads and thus as it exists at the present it can be of no use, only as a scouting plane.

B. Improvements in Present Aircraft

Airships that are used today in fire protection should be standard, even to take offs and landings, so that time will not be lost by unnecessary flying as is so often the case when one ship is faster than the others.

Low Speed Plane of the Future

FORT BENNING, GA. A courier plane which pilots call "jeeps" has braking surfaces on its wing enabling it to land at 25 miles an hour and hop from small fields. The slot on the leading and flaps on trailing edges of the wing, in a slow-speed position, are adjustable. (AP Wirephoto)

C. Improvements in Landing Fields

When such ships as the above come into use for freighting and transportation of fire-fighters smaller landing fields will be built and the ridges and narrow canyon bottoms, as well as the flat woods, will soon be dotted with little fields usable by these types of ships.

D. Other Possibilities and Improvements

The use of small dirigibles has possibilities for timber cruising, mapping, carrying of equipment and supplies for surveying parties and logging camps. As the army at the present time is developing these small dirigibles or balloons for reconnaisance work, why can't they be used for forestry work after this world crisis is over?

The placing of numbers on lookouts for quick identification for a pilot to determine where he is, especially if the smoke and haze are completely covering the ground and blotting out all valleys and land marks.

Another idea that has possibilities of future development is the building of some kind of portable beam to guide aircraft to the fire camp or target. If an airplane pilot has something to serve as a guide, he feels more secure and confident, and it is easier for the pilot to figure wind drift and compensate for

the wind when it comes to dropping his supplies.

The dropping of cooked food in cans to fire crews on the ground would be a great saver of time, especially in rough country with large crews. Time would not be consumed by packing the food in and then cooking it. The food could be cooked at a rolling kitchen located on the air field. The Forest Service is conducting experiments along this line at the present time.(5)

During the summer of 1940 a jumping first-aid man saved a man's life. A parachute jumping physician who together with trained first-aid men is prepared to jump to ill or injured men wherever they may be in the wilderness, will open a field of service which should be supported and extended.

E. Aviation in the Future

When we look back over the last decade and notice the changes that have been made in the use of aircraft in forestry and then look at the present condition of the world with stress being laid on airplanes, we can only stop and wonder whether the countless numbers of airplanes that are being manufactured today will find a use after the present chaos is finished.

When the disturbed conditions of the present have quieted down, what will be the result? During the first World War this country was in the beginning of the automobile age. Did the manufacturing of automobiles stop

at the end of the war? Decidedly not, economic conditions would not allow the manufacturing to stop; it had to keep right on and as the result of this condition automobiles became a part of this country. Will the same condition exist at the end of this war, and will the momentum of the manufacturing of airplanes carry on over into the post war period as the manufacturing of automobiles did in the past world war?

Will aviation play a part in future forestry? As one looks back into the history of aviation and sees how it entered forestry at the close of the first World War, the question "Will history repeat itself?"

Within the last several years foresters have revolutionized the use of aircraft in their work and it is only logical to assume that the use of aviation, now that it is started, will grow in magnitude as new developments are found and people realize its place in forestry.

VIII. SUMMARY AND CONCLUSIONS

It has been proven that aviation has a part in forestry and will produce beneficial results when properly established and systemmatically handled. The utilization of aircraft for mapping, fire protection, transportation of men and supplies, timber estimating, reforestation, timber management, range management, game counts, road location, planting surveys, scouting fires, insect control, stocking lakes with fish, and management of wild life resource is not just a myth but an actual fact. Aviation has become increasingly important within the last few years, and we can expect additional developments and increases in use in the future. Several years hence one should find aviation, therefore, an established and essential part of forestry. At the present time the use of aircraft in the transportation of supplies and parachute fire fighters is very vital to the fire protection units of the Forest Service in some regions of this country. Other uses of aircraft may at the present time be obscure and ordinarily unheard of, but tests have shown that they can be utilized. With more interest, technical advice, and research there is every indication to believe that the practice of forestry without aviation will be a rare thing.

Yet, the progress made to date represents only a modest start in the right direction, and until people become conscious of the one or more multiple uses of aviation in forestry mentioned in this thesis this forward progress will be slow and deliverate.

The developments of the different uses of aircraft in relationship to forestry opens up all kinds of possibilities in this field. The field in certain uses is new and where their results will end is unpredictable. With future improvements developing one can only come to the conclusion that aviation will in time be essential to forestry.

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