FOREST FIRE CONTROL PROBLEMS AND RESEARCH NEEDS IN GEORGIA

BY

KENNETH PICKETT DAVIS

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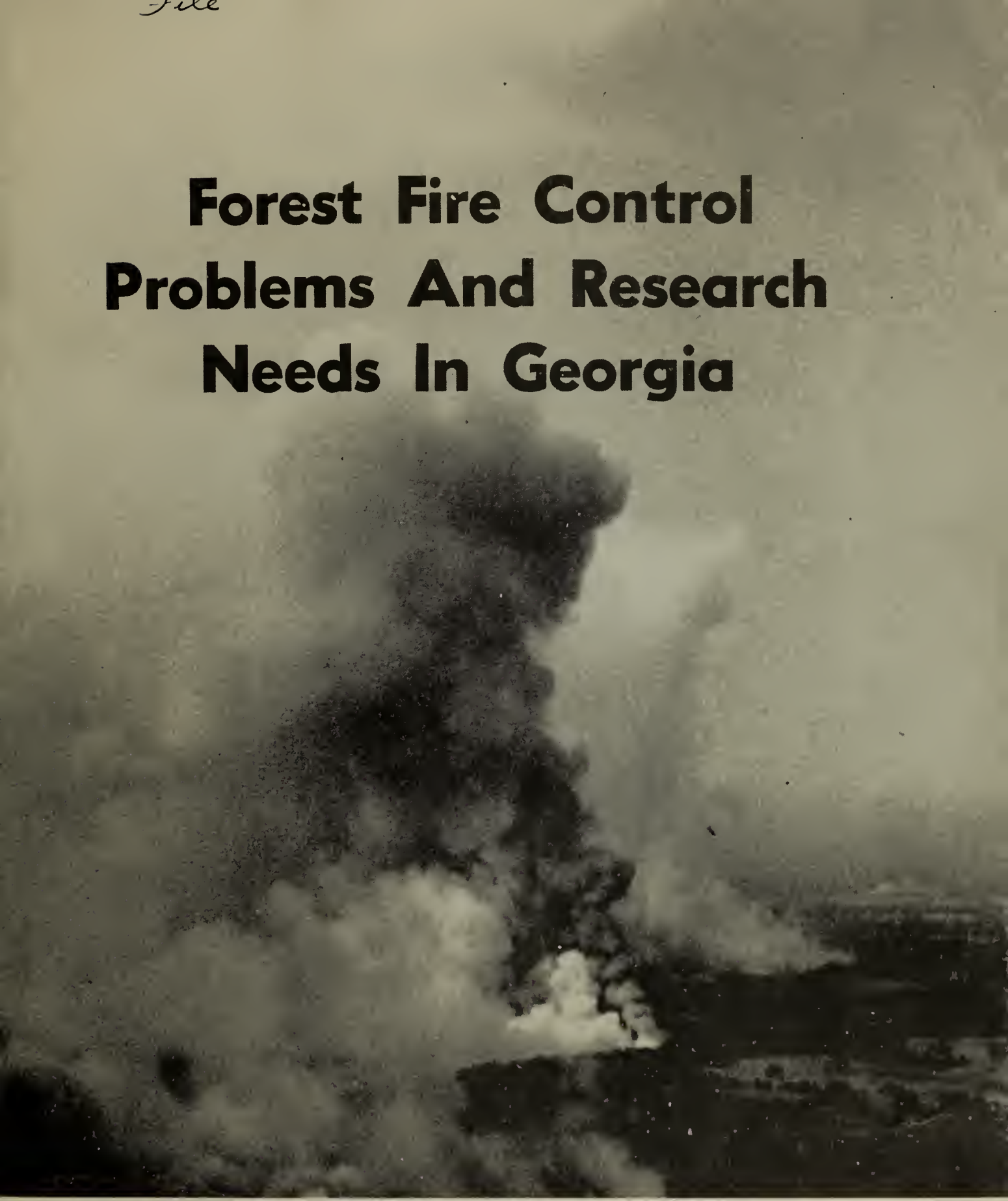

by

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This study was requested and financed by the Georgia Forestry Commission. By means of a cooperative agreement, I was employed through the Southeastern Experiment Station of the U. S. Forest Service who furnished a car and gave substantial assistance. The Commission went all-out in every way to furnish information requested, arrange field travel with Commission personnel, make contacts with other people, and give unstintingly of time and assistance in analyzing problems and in getting materials for the reports. The same was true of the Forest Service.

While abundant help was given, I was left entirely free to carry on the study, analyze and report as I saw the situation and consequently accept full responsibility for the results. Independent contacts were made with a good many organizations, public and private, in an attempt to sample as wide a range of interests as possible in the time available.

A comparison report, "Forest Fire in Georgia—Problems and Research Needs," were prepared and printed for general distribution to give findings in brief and highlight the study. It should be regarded as an illustrated supplement to this report.

INTRODUCTION

The overall purpose of the study was to probe the fire control situation in Georgia with emphasis on the larger fires to see where and how research could help. Research was broadly conceived as a function, the application of fact-finding, study, analysis and objectivity in meeting problems. So regarded, research needs permeate every aspect of fire control.

Research needs grow out of problems and cannot be considered independently of them. Particular emphasis accordingly was placed on trying to get a grasp of problems. The applied nature of much research in the fire field is frankly accepted although it should be stressed that this places no limitation on the technical penetration and calibre of research needed.

The general reasons prompting the study were a series of large fires occurring in the state in late 1954 and in 1955, a rapidly growing and powerful control organization, and a general feeling that research was needed. This study is a part of a hard appraisal of the whole fire situation being made by the Georgia Forestry Commission.

The scope of the study was limited to what could be accomplished in a two-month period, September 10 to November 10, 1956, including preparation of reports. Approximately half the time was spent in field travel and contacts and the other half in analysis and writing. Opportunity for detailed and original fact-finding was consequently limited and attention was concentrated on problem analysis. Description and presentation of general material is sharply limited in this report.

Forests and Fires in Georgia

While no attempt will be made to describe the forests and forest fire history of Georgia, some facts of overall significance in fire control stand out that deeply affect the situation.

A first group of facts concern magnitude. Georgia is the largest state east of the Mississippi. It leads the South in commercial forest land area being second (by less than two million acres) only to Oregon in the United States. In terms of accessibility and total productivity, it is probably first. It leads the nation in area of privately-owned commercial forest land. It leads the South in both pulpwood and lumber production and nationally is second in total wood production only to the three Pacific Coast states which still cut heavily in virgin timber. More trees are planted annually in Georgia than in any other state. The figure of $750,000,000 commonly quoted as annually returned to the state from its forests probably considerably understates its full economic contribution. Forest industry has billion dollar plus investments in the state. No matter how viewed, forestry is big business in Georgia.

A second group of facts center on forest distribution. There is no place one can go in Georgia and be more than three or four miles from substantial areas of forest land and closer to some forest land. The state is 64 percent forested and 99 percent of this is classed as commercial. Very large and continuous forest areas exist in the mountainous areas of northern Georgia and in the lower coastal plain of southeastern Georgia. The central part of the state is more broken by agricultural lands but there are large continuous blocks of forest land especially along the stream drainages. The area in forest is substantially increasing. The total forest area of Georgia increased 2,600,000 acres in 20 years from the middle 1930's, and 58 percent of this increase was in the central part of the state. While somewhat concentrated in the northern and southern parts of the state, the fire control problem is consequently statewide and concerns every one of its 159 counties.

A third group of facts deal with the tremendous changes and progress that have taken place in forests and forestry in Georgia. It is hard to realize how much and how fast the forestry situation has changed. The major industrial development of forestry is within the past decade. Most of the growth of the Georgia Forestry Commission has been in the past five years. Major developments in forest research, in planting, and in timber practices generally have also occurred in the last half-decade.

Changes in land use patterns and in the forests themselves have been no less striking but are a little harder to see. When one looks back on the panorama of plantation development, the boll weevil, the eroded red cotton lands that have been re-clothed and stabilized with trees, and the great impact of organized protection against fire in recent years, the extent, degree and rapidity of change in land use affecting forest lands is indeed striking. Equally great changes have occurred and are occurring in the livelihood and outlook of people on the land too.

A fourth set of facts concern the history of forest fire in the state and people's attitudes regarding it. The impact of past wildfire on the forests is profound. It has shaped the composition, density and quality of forest types in major degree. Fire has been a commonplace of agricultural life for generations. Interest in positive management of forests and recognition of their value as a crop is comparatively recent. The "light burning" tradition and generally casual regard of local people about forest fires shows up in many ways. In one form or another it underlies the stubborn man-caused fire problem that exists. It is also a factor in suppression, promoting a lax attitude toward urgency of action and aggressive patrol and mop-up of fires.

With control of forest fire needed on well over two-thirds of the entire land area of the state, all these groups of facts are significant. The control and use of forest fire is an inseparable part of the land economy of the state. The fire problem is not what it was ten to fifteen years ago and undoubtedly will be different in the future. Fire control must be viewed against a background of change and development, present and prospective.

Analysis of Major Fire Control Problems

The preceding discussion sets the stage for direct consideration of major fire control problems. The aim in this section is to probe for reasons; constantly to ask the question: *Why* does Georgia still have too many and too large fires? While the immediate suppression problem largely focuses on the why and wherefores of the larger fires, this should not deflect attention from all fires and total effectiveness of control.

Forest Fuels

The abundance, distribution and arrangement of forest fuels is of basic importance since, obviously enough, it is fuels that support fires. Georgia has a serious forest fuel problem and it is getting worse. Fuels are characteristically light and flashy; the problem centers on their amount and distribution. Heavy fuels are comparatively scarce.

Paradoxically, the abundance of fuels is in substantial degrec a direct result of the great progress in forestry that has been made in Georgia. As more areas are planted or naturally seed in, forest stocking is improved and as areas are protected successfully against fire, there is more fuel available to burn. The problem is both one of accumulation of fuels on the same area and addition of more forest areas.

FLATWOODS OF THE LOWER COASTAL PLAIN

The fuel accumulation problem is especially acute in the lower coastal plain of southeastern Georgia and is made more serious by the existence of large continuous forest areas. Volumes of lighter fuels, the "rough," increase in volume for 15 to 20 years following fire exclusion. As much as 25 tons of well-distributed flammable fuels consisting of pine straw, grass, gallberry, palmetto, myrtle and other dead and living material may build up not including the tree crowns. The result is truly explosive and hand-operated tools are utterly futile in dealing with such fires. Only heavy plows arc effective in fireline construction.

The fuel problem is greatly aggravated by the fact that most of the country is interlaced and peppered with wet areas — the ponds, bays, branches and swamps as they are variously termed and constituted. Fuel accumulation is worse in these areas and they are practically impenetrable. Organic material builds up on the ground topped by nicely arched and loose chimney-like mats of leaves and other debris. A heavy needle-drape on shrubs and smaller trees furnishes a perfect bridge of flammable and well-aerated fuels from the ground to the crowns. These fuel combinations have to be seen to be fully appreciated.

Normally, swamps do not burn and can be used as fire barriers. But under periodic extreme drought conditions, as occurred in 1954 and 1955, the swamps dry out and become both fire receivers and spreaders. Fires building up in swamps and either spreading to or throwing spot fires on upland pine areas were a major hazard and problem in the large fires of 1954 and 1955. The swamp problem is particularly difficult because at present there are no effective means of suppressing fires in them. The usual practice is to put control lines on the edge of the swamp and hope the fire doesn't blow-up and jump outside. Too often, it has.

Fires in the piney woods characteristically burn on the surface with much flame and heat because of the large amounts of light fuels. Except in swamps and where moss is abundant they spread into the crowns in the denser stands only when heat builds up underneath and there is a gradation in crown levels to help bridge the fire from the ground. Crown fires, in the sense of fires making initial spread through the crowns independently of fire on the ground, are comparatively rare. Fires seldom run in the crowns for any distance. It is the light fuels that carry the fires. The more fuel the hotter the fire and the more it crowns, causes damage, throws spot fires and the more difficult it is to control. Almost every large fire in recent years gained its momentum in areas supporting large volumes of light fuels whether swamp or upland.

The finger of logic inevitably points to the need for reducing hazard, to create forest conditions less conducive to disaster fires. There is very grave doubt whether, under adverse conditions, direct control of large fires in areas of heavy fuel volumes is possible with any kind of suppression equipment reasonably foreseeable. Certainly not when a fire is really rolling and throwing spot fires for miles ahead. If this is so, then something must be done to prevent development of conditions that make these unmanageable fires possible.

Managing the forest to make it less hazardous must be accepted as a basic part of protection. This point seems fundamental. Fuels are a product of the forest; they are simply forest cover viewed from the particular viewpoint of fire control. They are affected by whatever is done to the land. It is neither realistic nor safe to press for increased timber production and for adequate fire control as separate and independent things. One cannot go about his timber business and assume that a protection organization can take care

of fires. Timber management men must be fire conscious and able to see the consequence of their actions in forest fuels and fire hazard as well as in timber.

A part of cost of fire control rests on management and this point should be recognized. Hazard reduction is necessarily a part of timber management because it is something done on the land, in advance of any wildfire, that has many silvicultural as well as entomological and pathological ramifications. In some situations, timber managers are going to have to spend dimes on hazard reduction work to make, or save, dollars in timber produced.

This is not the place to enter into a discussion of the complex subject of prescribed fire use. Many silvicultural as well as fire considerations are involved. While many people have understandable reluctance to deliberate use of fire, it is felt strongly that it has a vital place in some areas and that it should be faced frankly, squarely and fully. The need is to use fire as a tool wisely and effectively, not to avoid it.

It should also be recognized that the handling of areas to make them less dangerous from a fire standpoint means much more than prescribed use of fire to reduce fuels. It includes control of timber stand density, crown stratification and even composition. It includes control of ground cover by silvicultural or other means, and development of a barrier, block and zone system. Construction of roads and ditches and the nature of forest cover types may have substantial effects on surface soil hydrology that are little understood or appreciated. Swamps may dry out faster and oftener as a result of some of these things. Much remains to be learned about the whole subject of management effects on fire control.

These matters are introduced here because they have particular bearing on flatwood fire control problems. In varying degree, however, they apply to many other parts of the state. The central point is that management is directly related to fire control and that in many areas a part of the control cost must be borne by management.

UPPER COASTAL PLAIN & PIEDMONT

Fuel problems of the upper coastal plain and Piedmont are diverse and harder to characterize than the flatwoods because there are more variations and transitions. In the stream bottoms especially, there are large lowland wet areas with much the same general characteristics and problems of swamps in the lower coastal plain. Upland fuels are light and flashy but do not accumulate as heavily as in the lower coastal plain. They usually reach a volume peak in three to five years after a fire. Slopes enter in as a complicating control factor in varying degree. Prescribed use of fire for fuel reduction purposes has less and more localized application but much more possibility as a means of species composition control, primarily directed against low value hardwoods.

Forest areas are more broken by agricultural areas though there are a number of large solid forest blocks of several thousand acres. Much land is being planted or is seeding in naturally, and there are large areas of young stands and semi-open areas supporting dangerous grass, weed and other flash fuels. A large belt of forest area is developing in the lower Piedmont as a result of land conversion from agriculture. The full impact of the fuel and related fire control problem has not yet been felt in these areas.

While the large fire potential is less in central Georgia than in the lower coastal plain, big fires can and do develop in some areas and no part is at all safe from damaging fires. Forest values in general are very high. Definite standards for both speed and strength of attack are consequently necessary throughout the area. In the long run, it appears that the character and intensity of timber management practice will have a large bearing on the total fire control problem. Better-stocked stands, closer utilization, species control and high economic interest in the land all will affect the fire problem but it is hard to judge their total net effect.

NORTH GEORGIA

Mountainous North Georgia offers different but also difficult fuel and fire control problems. It is characterized by large continuous forest areas predominantly hardwoods though with many conifer mixtures. The fuel problem centers on the hardwood leaf-fall which, during dry periods, creates highly flammable conditions in the fall and spring when the leaves are down. The hazard extends rather evenly over almost the entire area. The fuels do not accumulate to any degree from year to year; areas are just as flammable a year as several years after a fire. Sometimes they are worse just after a fire because there tends to be more grass and weeds then. Prescribed burning has no place for fuel reduction purposes.

Long slopes and rock make accessibility frequently difficult. In recent years, however, there has been an amazing extension of the use of tractor-drawn plows into mountainous areas where they were not before considered practicable. The Commission sends plows as first-dispatch equipment to practically all fires. It is also true, however, that most fires in the area can be fought successfully by hand tools if labor is available. In the rougher areas under National Forest Administration, fires are principally suppressed by hand tools.

Man-Caused Fires

The outstanding fact of fire causation is that man starts 97 percent of the fires and nearly all of them are at least theoretically preventable. The overall situation is shown in Table 1. While these figures point to man's total responsibility and to certain groups, general statistics like these conceal about as much as they reveal about the situation.

TABLE 1. Number of Fires in Georgia by Cause, 1951-1955

Cause Group	Number of fires (protected lands)				
	1951	1952	1953	1954	1955
Lightning	150	262	84	710	320
Railroad	339	278	163	390	320
Campers	104	130	77	155	135
Smokers	751	1,011	987	2,280	1,517
Debris burning	2,165	2,248	2,249	4,713	3,267
Incendiary	3,043	2,968	2,960	3,879	2,565
Lumbering	373	480	381	627	662
Hunters	429	851	718	1,366	909
Miscellaneous	2,215	959	501	1,072	564
Total	9,569	9,187	8,120	15,192	10,259

Protected area has increased from 17,263,087 to 21,085,150 acres during the past five-year period, an increase of 22 percent. Fires are reported only on protected lands. In proportion to the area protected, the number of fires has been reduced.

The number of fires is, to a considerable degree, related to the intensity and quality of protection. As detection gets better and cooperation with the public increases, more fires are reported, with actual total level of causation remaining the same.

Fire weather also has a direct connection to number of fires, the drier the more fires. The number of fires was decreasing 1951 to 1953 despite large additions to protected areas but, as might be expected, jumped in 1954 and 1955 which were outstanding drought years.

It should also be recognized that, from the standpoint of holding down acreage burned, the total number of fires is of limited significance. A relatively few fires can cause a lot of trouble. This is particularly true of spite fires. As forests become better stocked and more valuable, spite fires can become increasingly potent weapons of retaliation. It is a sober fact that an owner is almost helpless against an informed and smart incendiarist. Only the more stupid ones are likely to be caught. The burning conditions at the time the fire is started obviously makes a great deal of difference. A relatively few fires started at extremely inopportune times and places — as is likely to be the case with incendiary fires — can result in a disproportionately high amount of total cost and loss. This does not mean that wildfires at less critical times should be tolerated, but it does focus attention on the importance of causation in relation to fire danger. The season of fire occurrence in relation to cause for all fires, 1951 to 1955, is given in Table 2.

TABLE 2. NUMBER OF FIRES IN GEORGIA BY MONTH AND CAUSE, 1951-1955

Month	Light-ning	Rail-road	Campers	Smokers	Debris Burn.	Incen-diary	Lumber-ing	Hunters	Miscell-aneous	* Unknown	Total
January	2	139	30	556	1,785	1,954	142	685	341	376	6,010
February	1	227	53	917	3,170	3,294	207	701	479	470	9,510
March	7	245	128	1,148	3,450	5,115	349	746	725	434	12,347
April	18	159	73	588	1,645	2,082	277	77	317	188	5,424
May	128	110	67	473	688	600	535	42	235	146	3,024
June	296	55	30	288	398	226	257	32	140	9	1,731
July	489	36	31	352	406	189	259	34	148	39	1,983
August	456	65	24	287	408	217	301	31	116	16	1,921
September	61	101	38	343	518	202	207	100	129	14	1,713
October	26	118	37	582	663	460	293	548	195	13	2,935
November	0	111	56	554	768	573	223	930	270	13	3,498
December	1	108	42	400	722	606	162	707	231	21	3,000
Total	1,485	1,474	609	6,488	14,621	15,518	3,212	4,633	3,326	1,739	53,105

* "Unknown" recorded only in 1951 and 1952. Thereafter distributed to most likely cause.

As shown, number of fires peaks up in February and March but causation is fairly heavy from October through May, an eight-month period.

There is considerable uncertainty about the cause groups. The general groupings used are an inconsistent mixture of occupational and specific causation. Railroads, lumbering and hunters are occupational groups of a sort but they also include smokers and campfire builders. The debris burning and incendiary groups stand out as major problems each responsible for nearly a third of the total number of fires.

Inconsistencies also arise through reporting practices. "Unknown" was eliminated as a cause class in 1953 and these fires were thereafter assigned to the most likely group. There are differences between years and reporters in how fires were assigned to different groups. As a matter of cold fact, the specific cause of a great many fires is unknown and is assigned to a cause classification largely by process of elimination.

To get at specific causes in the last few years, these nine general groups have been broken down into no less than 100 subgroups attempting to pinpoint causa-

tion. This breakdown makes the *how* of fires much more definite but does not penetrate very far into the *who* and *why* which requires understanding of people's attitudes and motives.

To summarize fire causation, particularly from a study and action standpoint, the following seem to stand out:

1. There are still too many fires caused by man through carelessness or intent. The largest single opportunity for improvement in overall protection lies in reducing their number.

2. The *where, when* and, to some degree, the *how* of fires is fairly well covered by present reporting practice and serves as a basis for fire control job load planning where the location and fact of there being fires is the primary consideration.

3. There is considerable uncertainty on the *who* and especially the *why* of fire causes. Better information on this is vital to formulation of fire prevention programs aimed at changing the attitudes and actions of people.

4. Until causes are pinned down much more accurately and related to fire danger more consistently, it is impossible to measure the effectiveness of prevention effort.

Adverse Fire Weather

Weather determines whether and how fires burn. It can always be fire season someplace in Georgia; as shown by Table 2, no month is safe from fire. Fall, winter and early spring are the worst periods but fires can and do occur any month of the year. Some of the worst fires have occurred during normally off season periods.

There are three major problems of fire weather in relation to control.

LONG-RANGE BUILD-UP

Really difficult fire control situations almost always include protracted drought conditions as a major ingredient. This is true in Georgia despite the preponderance of flash fuels in the state that can dry to a flammable condition in a few days or even hours.

General drought conditions, starting in about 1951, and most severe in 1954, were the underlying cause of the big fires of 1954 and 1955 centering in southeastern Georgia. The swamps and other wet areas dried out. The heavy fuel volumes in these areas thus brought to flammability, lack of means of suppressing fires in swamps, and the generally heavy fuels that had accumulated in upland areas following years of successful protection against fire, combined to create an unprecedented and almost impossible control situation. The existing control organizations, public and private, had never seen anything like it. Drought periods had occurred before, as in 1910-11 and 1941-42, but because of general light burning practices of earlier times, they were not accompanied by such heavy fuel volumes. *Droughts are recurrent* and don't have to come very often to be important.

It is extremely difficult to pinpoint cumulative effects of drought on water table levels from existing weather data. Not only the total amount of precipitation but its intensity and seasonal distribution are important. So are general temperature and wind conditions.

A fifty-year record of total annual precipitation from five stations more or less representative of southern Georgia gives a general measure of drought severity. The five years, 1944-1948 were wet averaging 58 inches compared to a fifty-year norm of 47.5 for these five stations. The next two years, 1949 and 1950, were just average, probably being about neutral in cumulative effects. The next five years, 1951-1955, were dry averaging 42.5 inches or 15.5 inches less than 1944-1948 figure. This change of 15.5 inches must have had considerable total effect on water levels. A fifty-year low of 31 inches was received in 1954, rising to only 41 inches in 1955 which was still 6.5 inches below the norm.

While seasonal cumulative drought effects on fuels are most evident in swampy areas, they seem to exist in significant degree in other areas too. The whole question of defining and relating the longer range cumulative weather effects to fuels and fire behavior has rather baffled fire research for years. The problem is important in Georgia and demands better answers.

CURRENT DANGER RATING

Great progress has been made in current danger rating as reflected in the danger meters. These ratings are an anchor point in control work and used in many ways. The present Southeastern Station Type 8 meter includes an excellent but limited build-up feature that measures current cumulative effects well. Theoretically, it can achieve maximum build-up in ten days. The general subject of danger rating will not be discussed here.

Current danger rating is by no means perfect but it is an operating tool. Problems remaining center on its improvement on relating it to fuels and fire behavior, in improving the general efficiency of rating systems, and in making better use of it in fire suppression.

FORECASTING SPECIFIC WEATHER CONDITIONS

Useful as are the present meters for current rating of fire danger, they do not adequately meet the need for gauging specific and unusual fire weather conditions. Much interest centers on interpreting and forecasting weather conditions that seem to be associated with blow-up fire conditions. Present danger meters are limited to what can be observed on the ground. They cannot predict weather front changes bringing shifts in wind and temperature. Neither can they measure higher level atmospheric conditions of instability, turbulence, and the like that may generate unusual fire behavior.

Present danger ratings have not been adequately related, and perhaps they cannot be, to the specific range of conditions, with emphasis on limits, during which prescribed burning can successfully be done. The many purposes of prescribed burning and the variety of fuel conditions encountered call for a high degree of specificity in weather forecasting.

Fire Control Organization And Administration

Major problems of fire control center in the organization and administration of the control agencies themselves. It is here that most of the money is spent and research is applied. The strength and efficiency of the organization also determines how much loss will be sustained, which is the key consideration in the whole protection effort. It seems entirely logical consequently that the operational aspects of control should receive full scrutiny from the standpoint of applicability of the research function. Fire control in Georgia has been marked by great and rapid growth in recent years, the past five dwarfing all others. It has grown so fast it has hardly had a chance to keep pace with itself.

A detailed description of the fire control structure and organization in the state does not seem necessary here. Attention will be limited to some problems of general significance particularly as they have a bearing on a research and technical development program discussed in the next section.

The Georgia Forestry Commission is the state agency charged by law with general responsibility and interest in the protection of all forested lands in the state. While legally not so restricted, the Commission has developed protection on a cooperative county unit basis. County units and county consciousness are facts of profound sociological, political and administrative importance that have much significance in fire as in other state matters. There are 159 counties in the state with 145 under organized protection of which 135 are in consolidated protection units.

The Commission has pressed to do first things first; to get areas under organized protection as rapidly as possible, to get badly needed power equipment on the ground, to strengthen personnel in number and quality, to strengthen organizational relationships, to improve flexibility and mobility in meeting control situations anywhere in the state, and to improve detection, reconnaissance and communication. It is developing one of the outstanding state fire control organizations in the country in size, organization, equipment, determination and morale. Having recently experienced a particularly bad fire situation that tested it to the utmost, this is a logical time to review its situation and technical needs.

Besides the Commission, there are a number of agencies doing organized control work, mostly suppression only, in the state. They are the U. S. Forest Service on the Chattahoochee National Forest in North Georgia, the Soil Conservation Service, the Department of Defense on air and army base lands, a few private timber protective organizations (well integrated with the state), and several suppression organizations operated by a few of the major industrial forest land owners — pulp and paper only.

Public inter-agency relationships are well worked out and mostly involve definite agreement on who is to protect what areas. This is not true of forestry industry organizations. They have a tremendous and broad economic interest in large areas of forest lands, both on owned lands and on other private lands from which they purchase timber. Several of the major pulp and paper companies, maintain rather strong suppression organizations essentially to supplement and strengthen what the state can supply. The companies follow a liberal policy of willingness to fight fire on lands other than their own but company-owned lands are naturally of primary interest. Since their lands are, for the most part, intermingled with other industry lands, there are protective organizations several layers deep in some parts of the state. No formal cooperative agreements have been made with the state or between companies but a high degree of cooperation has been developed on the ground. In the main, it works out astonishingly well.

A few of the larger owners consequently shoulder a substantial part of the fire suppression load in areas where they have economic interest. Other owners do not and most of them essentially cannot. It is not practical to maintain small fire control units that are worth much. But all can participate in fire prevention and in hazard reduction particularly. In fact, hazard reduction can be accomplished only through and by the landowner. *Everybody must get in the act in fire prevention and hazard reduction.*

Industry-state cooperation works best, as would

be expected, on the smaller fires and in the less critical situations. Problems of coordinated dispatch and control of equipment, fire boss designation, overhead manning and organization do arise in the more critical multi-fire situations and on large project fires. Industry-state relationships are consequently an important factor in fire control planning studies.

Similar problems also arise within the Commission, stemming largely from the strong county consciousness characteristic of the state. There is a tendency for a county unit to try to meet its own control problems as a point of honor and not ask for help soon enough. The same can apply to a district. Technically, the Commission has authority for complete inter-county mobility but it is neither practical nor desirable fully to achieve it in practice though the trend is strongly toward state-wide mobility and integration, and a substantial degree of it now exists.

A general problem of all control organizations in the state is that competent manpower is in short supply. In many situations, the Commission has barely enough machine operators to man its plow equipment. There should be at least two and sometimes three or four men available to dispatch with and support a plow unit to make it most effective. A control organization primarily built on power equipment, with just enough regular personnel to operate it and limited ability to recruit more help on short notice, is relatively inelastic in its ability to enlarge its organization in times of emergency. It has only so much to commit. It can concentrate equipment in one place but only at the expense of correspondingly reducing it elsewhere.

It appears that a substantial amount of fireline is lost through lack of sufficient manpower adequately to back up line building equipment. Lack of radio control on tractors is a contributing cause. It often happens that a tractor-plow operator works alone, or nearly so, with consequent lack of help in line location and in making it safe through prompt backfiring of unburned areas inside the line, vigilant checking for spotfires, and thorough patrol and line strengthening. Much line is inevitably lost if these things are not done well. A common practice if one line does not hold is to plow another — and another — until one does hold. This can be very wasteful of equipment.

Patrol and mop-up seem to be generally weak spots. In part, this stems from lack of adequate manpower and overhead to direct it. In part, it comes from a traditional casualness on the part of local people about forest fires. There is a tendency to feel that if the fire is somewhere inside control lines everything is all right, to go home at the end of the day and come back sometime next morning. This does not extend to the professional organization but is a factor to deal with just the same.

It is true that most fires do die out rather promptly once checked and that unburned areas inside the line often are not particularly dangerous. But under unusual conditions, almost any burning area may be dangerous and some are. There are too many instances of fires once believed to be under control breaking out again. Most big fires have, in fact, such a history. It is very hard to get local people to do vigorous mop-up work *inside* control lines. They seldom do. In swamps, there are good reasons since there are no present means of putting out fires in such areas. In upland areas of heavy fuel volumes, manpower may be relatively ineffective in mop-up, and power equipment is often not available. Mop-up is dirty and dull work at best. Just the same more aggressive patrol and mop-up action seems to be indicated.

Means must be found of getting more supplementary manpower on fires more effectively. It seems clear that this need cannot be met by yearlong personnel only. Some way of tapping part-time help needs to be developed. Basically, some way must be found of translating into fire help an economic interest in and tie to the forest that many people have who live and work in and near the forest. It is true that, untrained and inexperienced, volunteer and pick-up labor can be about as much hindrance as help. It is not particularly favored in many localities largely for this reason. Through patience, good public relations at the local level, organization and training, better local sources of manpower can, however, be developed. It is not wise, anyway, to separate suppression work too much from local people. They have a stake in it and should be a part of it.

A spot study made of the larger fires occurring from July 1, 1954, to July 1, 1956, points up some general aspects of the control problem. This period approximately brackets the group of larger fires that occurred during the 1954-55 drought period. The aim was to take a look at what were considered as being "large" fires relative to the part of the state where they occurred. The figure was arbitrarily set at 750 acres and over in the lower coastal plain and 350 acres and over in the rest of the state. Information on these fires, as given by the district foresters and checked by others with first-hand information, is summarized in Table 3. While these are not the 45 largest fires in Georgia for the period, it is outstanding that only 0.2 of 1 percent of all fires during the period accounted for 56 percent of the total area burned. The reason for special interest in the larger fires is obvious. One percent of the fires undoubtedly accounted for well over 90 percent of the total area burned.

The principal reasons as to why the fires attained

large size are judgment answers and to a large degree subjective. High rate of spread naturally figured in most of them but not all. Swamps and high fuel volumes mean the same thing to some extent but it is noteworthy how many times swamps figured prominently in the picture. It is likely that the personnel figure should be higher. There tends to be a lot of confusion around a big fire and it must be remembered that these big fires were a new experience, particularly in their behavior, to many of the participants.

Spot fires were a major means of spread on nearly half of the fires and on over two-thirds of those in the lower coastal plain.

Only 9 of the 45 fires were credited as being hold-overs in the sense that the origin of the fire was not immediately followed by its major run. The hold-over figure probably is low.

An overall judgment was made whether, everything considered, major spread of the fire could have been prevented. In 18 of the 45 fires, the answer was, "Yes." This question is highly subjective but gives some indication of current opinion. By strengthening some known weak spots, the number that get away can be cut down substantially.

TABLE 3. ANALYSIS OF 45 LARGE FIRES OCCURRING IN GEORGIA JULY 1954 TO JULY 1956

ITEM	Lower Coastal Plain (Dists. 1, 8)	Upper coastal Plain and Piedmont (Dists. 2, 3, 4 5, 6, 10)	Mountains and upper Piedmont (Dists. 7 & 9)	All Georgia
Number of fires				
Large fires only	26	13	6	45
All fires	7,950	10,558	3,510	22,018
Area burned (acres)				
Large fires only	210,879	10,428	3,796	225,103
All fires	243,393	131,024	29,923	403,340
Principal reasons for large fire 1/				
High danger and rate of spread	26	9	3	38
Insufficient equipment	4	5	3	12
Large fuel volume	16	2	0	18
Inaccessible swamps a major factor	13	6	0	19
Personnel - fatigue, org., etc.	1	3	2	6
Major means of fire spread				
On edge of fire	11	13	5	29
By spot fires	19	1	1	21
Timing of major spread				
By initial run following origin	18	12	6	36
Resulting from hold-over fire	8	1	0	9
Was major spread reasonably preventable				
Yes	8	6	4	18
No	18	7	2	27

1/ Gives frequency of major reasons listed. Totals add to more than the 45 fires because more than one upset reason for large fire was often listed by the district foresters.

A Research and Technical Development Program

The foregoing has presented some of the major problems of control but not their solution. Research and related technical needs grow out of problems and cannot be separated from them. As pointed out, the research function has broad application. It must also be recognized that ability to use the results of research is as important as doing it in an applied field like fire. In the South, application is primarily by the state agencies as increasingly they are the dominant protection agency.

It seems logical, indeed inescapable, that the protection agency itself, in this case primarily the Georgia Forestry Commission, actively participate in a research program. There are two major reasons for this. One, is that the research function extends to their activities. There are many problems of control that can be attacked only through and with the interest and support of the control organization. The other, is that an alert study and analytical-minded organization is in a much better position to define problems upon which project research is needed and to make effective use of such work. While it is necessary to define and isolate problems, sometimes rather sharply, to make research progress on them, there is a high degree of interrelatedness in most fire studies. The overall goal of adequate protection at reasonable cost constantly must be kept in mind. This can be achieved only through the integrative effort of the control organization itself.

Emphasis on meeting the large fire problem underlines and in many respects points up a research program. The basic questions to ask are: what circumstances and situations make large fires possible, and, what can be done to make their occurrence at least extremely unlikely? When these questions are answered, the rest of the control problem will be mostly solved.

Solving the large fire problem is the hard core residuum of control. The basic need is prevention, either of the fire in the first place or of it escaping initial attack. Big fires occasion most of the loss and cost and the larger they are the more this is true. They can wipe out in hours years of successful protection. The average fire season can and is met with little trouble and the "average bad" without great difficulty. But the unusual and extreme situation that breeds big fires is a threat that hangs like a smoke pall over the heads of the fire control organization. Continued successful protection most of the time does not make this threat less but greater especially from the standpoint of fuel accumulation and increased forest values. While there is sound reason to believe that the large fire problem can be beaten in Georgia, it can never be forgotten.

With these points in mind, fire research projects proposed for consideration are summarized in the following section. This listing does not include all work that could be done on fire of interest and benefit to Georgia but certainly does include much more than can be undertaken immediately. There is also full awareness that few if any of the studies presented are new and that considerable work has been done on many of them in different parts of the country. They are selected from the standpoint of what seems most important to Georgia.

It should also be recognized that these studies are presented in general terms and in no sense constitute working plans for specific projects. Considerable further breakdown and analysis is necessary before embarking on actual studies.

Some general discussion regarding these projects aimed to give further orientation and perspective is given in the section immediately following the summary presentation. Recommendations for implementation of this work and suggestions regarding priorities are given later in this report.

Summary of Proposed Fire Research Projects And Studies

I. Fuels And Fire Behavior

Measurement, classification and rating of forest fuels in relation to fire behavior and burning potentials. Rate of spread and large fire behavior.

Subproject or study	General Description
1. Fuel burning potentials under specific conditions as regards rate and volume of heat energy release.	Study to "calibrate" major fuels as to their burning potential probably using controlled area-ignition, techniques. Needed as a basing point in gauging behavior of large fires of high heat energy release and in appraising spot fire possibilities. Basic to classification of fuel types.
2. Fuel type classification, and the rating of protection units for fire control planning.	Develop a useful and basic fuel type classification related to the burning behavior and control characteristics of fuels. Rating of total fuel situation a large area with respect to kind and continuity of fuels and existence of barriers and breaks. Possibilities for large fires.
3. Firebreaks and barriers.	Study of methods, possibilities and needs for establishment of a break and barrier system in certain areas of high fuel hazard and fire potential. Consider very wide breaks, of ½ to 1 mile perhaps. Involves means of controlling palmetto, barrier maintenance, and management of timber stands on such areas without taking them out of timber production.
4. Hazard reduction	Continued study of hazard reduction through prescribed burning on areas. Large subject — not broken down here. Study should include analysis of supervisory and cooperative relationships so that protection men may get continued fire experience through prescribed burning work. Also strong emphasis on dissemination of good information to forest owners.
5. Moisture content gradients of trees and of subordinate vegetation in relation to season and drought.	Little is known of changes in tree leaf moisture content in relation to season and drought conditions. Study pines as a group first. Much conjecture on this matter but little knowledge. May or may not prove important in control but should investigate at least on a trial basis.

II. Effects

Effects of fire on tree and other vegetative cover and on soil. A very large subject in total only touched here.

Subproject or study	General Description
1. Thermal conductivity of bark and other protective mechanisms of woody vegetation.	Practically no specific information is available regarding the insulation properties of tree bark of varying thickness, density, moisture content, composition and degree of fissuring. Such information could be obtained through controlled heating research and would be extremely valuable in prescribed burning. Further study of effect of bud size and protective leaves.
2. Temperature of and heat transfer by forest fires under field conditions.	Companion study to #1 above drawing upon basic heat transfer research. Data are extremely scanty on distribution, intensity, and duration of heat from forest fires burning in given fuels under specified conditions. Information needed to guide prescribed burning and understanding fire effects on trees and soil generally.

III. Weather

Weather conditions affecting fire behavior and control. Closely related to fuel studies. Purpose is to understand weather conditions better in relation to fuels and fire behavior, to apply this information through better danger rating and forecasting, and perhaps to temper weather through weather modification in certain situations.

Subproject or study	General Description
1. Weather modification to augment precipitation.	This work being done on a research and commercial basis. Involves research and application of meteorological phenomena contributing to fire weather forecasting.
2. Long range drought build-up.	Study of hazard build-up resulting from continued drought. Development of drought index to measure cumulative changes.
3. Current danger rating.	Continued study of fire danger rating systems. Analyze present distribution, use, number needed and present standards of operation and inspection. This work should be closely related to prescribed burning, prevention, and fire control organization and action. Present meters are not, and by their nature, cannot be responsive to flammability of individual fuel types.
4. Large fire behavior as related to atmospheric conditions.	Continued study of weather conditions associated with unusual or blow-up fires. Purpose to develop a basis for effective forecasting and to determine the particular elements of weather that should be included in fire-weather predictions.
5. Forecasting of extreme fire weather conditions.	Basic purpose to improve fire weather forecasting to give advance knowledge of unusual and severe burning conditions. Necessary to localize and interpret usual weather forecasts for fire control use. Partly an administrative and organization job to get a fire weather forecasting system into operation.

IV. Soil, Water And Forest Cover Relationships

Effect of land management practices on soil hydrology and vegetative covers.

Subproject or study	General Description
(Not broken down into subprojects)	In the lower coastal plain particularly, there is reason to believe that water-soil relationships may be rather close and delicate. Changes in cover type and density resulting from planting, cutting and other timber management practice, and the construction of roads and ditches into wet areas may change surface hydrology substantially. Swamps may get drier oftener. The whole question needs to be given careful overall thought and analysis and if research seems warranted, broken down into operable study projects. Subject seems of considerable total importance in the long pull. Need to know effects of land management practices on surface water levels.

V. Prevention of Man-Caused Fires

Overall objective is to reduce incidence of man-caused fires. A very large subject in its entirety only partially considered here.

Subproject or study	General Description
1. Fire causes — *who* starts fires and *why*.	Rigorous causation analysis. Includes both care on the ground to determine the "cause behind the cause" and analysis of such data area by area, year by year and season by season. Fundamental to prevention action.

Subproject or study	General Description
2. Fire occurrence, the *where* and *when* and *how* of fires.	Continued analysis of fire occurence in relation to season, burning index, etc., as a guide to control planning. This is actuarial sort of information of value in planning somewhat irrespective of the who and why of fire causation. The facts of occurrence are a measure of the timing and size of the control job.
3. Development of *fire control* programs in public relations work.	Study possibilities of broadening prevention work to include consideration of fuels and fuel reduction work as a part of prevention placing emphasis on the total goal of fire control. At present, about all public hears about is prevention of risk — which is surely important and actionable by the individual. But in some areas and with some groups, inclusion of hazard reduction *as a part* of prevention — as do city fire departments as a matter of course — is most logical.

VI. Detection and Reconnaissance

Studies of fire detection from aircraft and ground points and reconnaissance of going fires.

Subproject or study	General Description
1. Detection under adverse conditions of smoke and haze.	More or less normal visibility is fairly well understood and applied. But smoke and excessive haze can cripple both ground and aerial detection preventing detection of new fires and including spot fires. Study of visibility under adverse conditions and investigation of infrared or similar means of detecting fires despite smoke. Need to determine detection time requirements under different burning conditions.
2. Lookout in relation to aerial detection.	Continued study (as by Worrell) of tower in relation to aerial detection as regards cost and efficiency.
3. Fire reporting.	Analysis of initial reporting of fires by lookout and aerial sources in relation to reporting by public. Is reporting by public important, should it be, and if so, what can be done to strengthen it? Consideration of more "report fires here" posting. In long run, fire reporting by local people may be important both in cooperation on control and as evidence of interest in prevention.

VII. Suppression

Includes whole range of activities involved in suppressing existing fires promptly and efficiently. Subject only partially covered here but includes operational study and analysis whether normally considered as "research" or not.

Subproject or study	General Description
1. Equipment development.	A very large subject with ramifications into nearly every phase of fire suppression and of control as a whole. Subject only sketched here. Overall purpose is to develop better tools to do the job. Some problems and needs are: a. Better use of water or with chemicals in admixture as a retardent or extinguisher. b. Means of area attack to blanket or hold down potentially dangerous fires during periods of high hazard. Chemicals or water, air or ground transported and applied. c. Improvement of bulldozer blade equipment to make it a more versatile tool. d. Improvement of bulldozer equipment on tractor - plow units.

Subproject or study	General Description
	e. Study of chemical retardents that may be rapidly applied on going fires to check initial peripheral spread. A "chemical" fireline. f. Development of light, narrow but powerful tractor-plow units of high mobility and usability in densely stocked stands. g. Development of rapid means of ground or aerial-operated backfiring in emergency situations. h. Development of equipment for rapid jetting in of temporary wells if such proves possible. i. Study of use of helicopter and fixed-wing aircraft in fire suppression generally. Air transport of suppression equipment.
2. Map and or photo needs in control of going fires.	Study existing situation and need for fairly detailed maps for use in suppression work. County maps often inadequate; industry maps good but cover only ownership. Need to exchange maps between major owners and develop better county-unit maps for fire boss and related control purposes.
3. Water sources.	In critical areas, as in lower coastal plain, study possibilities of developing supplemental water sources either by rapid jetting-in of temporary wells or by development of auxiliary permanent wells. At present, water is little used in suppression work.
4. Suppression methods	Continued critical review and study of tactics and strategy on large fires especially. How successful is backfiring in some situations, would flanking out more reduce total acreage, etc? Study of plow operation techniques and combination with separate bulldozers or with other equipment. Analysis of manpower needs adequately to support plows and other equipment, and remedial action as needed.
5. Organization planning.	Continued study and action in overhead, manpower, equipment mobilization, and dispatching on project fires stressing cooperative relationships between state and other control organizations. Development of the compact principle both with other states and within the state between state, federal and private agencies.
6. Patrol and mop-up practices	Primarily for lack of sufficient and competent manpower, patrol and mop-up seems to be weak on large fires. Situation needs to be thoroughly analyzed. Perhaps better equipment is needed — as bulldozers — to mechanize the work and make it more effective.
7. Training	A major and continuing problem that can be aided and pointed up by study and analysis to improve methods and test results but which is primarily a "doing" job. Extends to all phases of fire control including: a. "Dry runs" to test control organization on project fires and review of action. These are extremely important. b. Specific training of and practice by equipment operators. The better a control organization becomes, the less practice it gets and ready-made skilled operators are scarce. Also train manpower to support equipment. c. Specific training in patrol and mop-up. d. Development of case study materials based on past history for training purposes.
8. Analysis of fire reports.	Much can be learned from analysis of records of past fires both in board-of-review study and through analysis of mass statistics. Existing records should be appraised for the possibility of useful analysis based on them.

VIII. Fire Control Management

Integrative study, analysis, and planning involving several or all phases of fire control

Subproject or study	General Description
1. Barrier, block and zone study and control planning.	Integration of fuel type knowledge, barriers, danger rating and forecasting, suppression equipment and methods, and cooperators into county and district control plans. This should be done on basis of best knowledge and improved as better knowledge becomes available. Work essential to make effective use of information available. Start with a good sample area to develop principles and procedures and work out from there.
2. Analysis of speed and strength of attack requirements in relation to organizational units and facilities.	Continued study and analysis of equipment placement and use by county and larger units in relation to present needs and estimated future trends. Inter and intra-unit relations, consideration of special assault teams and reserve equipment depots by district or larger units. Air and or ground transport. Closely related to Item #1 above.
3. Cost analysis and comparison of all phases of control work to achieve minimum total cost.	A continuing job that enters into all aspects of control work. Basic aim is to be cost conscious and informed and to use cost information effectively in good financial management of fire control.
4. Fire damage.	Continued study of fire damage and its evaluation. Essentially resource evaluation.

Discussion And Appraisal Of Proposed Fire Research Projects

The preceding summary of research projects proposed for consideration has presented a wide range of material without much orientation. The purpose in this section is to discuss and appraise these projects giving some suggestions on research approaches. The break-down follows that given in the summary and follows the same numbering plan.

Fuels and Fire Behavior

Fuels in general have been a rather neglected subject of large importance. The basic trouble has been lack of ability to measure significant aspects of fuels in terms of fire behavior under specified weather conditions. It is very difficult to separate fuel-weather-behavior relationships. Fuels themselves are extremely complex as regards their distribution, quantity, fineness, arrangement and compaction all of which affect their combustion characteristics.

Study 1 is aimed to get at an understanding of the combustion characteristics of key fuel associations or types through measurement of their heat energy release potential. This information would serve as a sort of basic calibration of fuels. Through simultaneous area ignition techniques, it is possible to generate minature "fire storms" and to measure their intensity and duration. Crowning and spot fire propensities of specified fuel associations can be evaluated and also total heat energy release which is of significance in understanding large fire behavior. The job of setting up and carrying out such tests is highly technical and requires considerable instrumentation. It is a new approach and field techniques have not yet been fully developed. It is a job for a professional research group to engineer but one in which control men can participate with much benefit in learning about fire behavior.

Study 2, fuel classification, is a large subject that can be approached on two levels. First, and ideally, the sequence would be to base upon and develop out of Study 1. A second, and more realistic approach is to proceed on the basis of best current empirical knowledge and refine it as more precise data become available. The basic aim should be to classify fuels

on the basis of what fire control men really need to know and can act on. Such a classification should cut through forest cover types as such and be based on fire behavior. Several criteria are suggested as follows:

1. Weight and character of suppression equipment needed — kind and weight of plows required, etc. This is classification by means of control.

2. Rate of spread possible — largely a light fuel distribution function. A number of rate-of-spread classes could be defined.

3. Crowning and spot-fire potential. Relates to vertical distribution of fuels from ground to crown, abundance of firebrand material and crown density.

4. Large fire potential — a joint function of amount of fuel, crown or spot fire potential, rate of heat energy release possible and continuity of fuel bodies. This is a rating applicable to large areas.

A multiple classification of this sort could be developed, probably in numerical terms, that would be a concise useful tool in suppression action. While such a classification should be susceptible to application over extensive areas as a guide in general control planning, the major virtue is in aiding suppression action. I am not at all sure that general field mapping and preparation of fuel type maps is the answer. This has been done in other parts of the country. Such maps are difficult to keep up to date and as a matter of cold fact tend not to be used too much in current suppression action. It would seem that *ability* quickly to appraise fuels in a particular situation from type maps, aerial photos, etc., is more important than existence of prepared fuel type maps which are very hard to keep up in sufficient detail to serve suppression needs. The overall objective in fuel classification should be to provide criteria which will permit ready identification and evaluation of a given fuel combination under given burning conditions. The net result should be such that a man unfamiliar with a given fuel type can immediately size it up for what it is from a fire behavior standpoint.

Study 3 is a somewhat omnibus study of breaks and barriers obviously drawing heavily from numbers 1 and 2. It is especially aimed at the lower coastal plain. From maps and other data, an analyst should plot out a block and barrier system in an area of high large fire potential that would seem to offer a basis for either prevention of unmanageable fires or a chance of controlling large ones that may develop. Effectuating such a system, if it seems to stand up under analysis, is largely a silvicultural problem since it entails control of density and stratification of the timber and of ground vegetation. As visualized, the aim of broad strips is not to make them fireproof but to bring down a fire to the ground in relatively light fuels where it can be stopped. By no means is it envisaged that the areas involved would be taken out of useful timber production. An effective and economical method of killing palmetto by chemical means is a specific need.

Number 4, hazard reduction through prescribed area burning, is a complex subject that cannot be explored in full. Three particular items are suggested for consideration here:

1. Study and analysis of hazard reduction needs by areas to develop a program and schedule of fuel reduction tying in to block and barrier development. Entails consideration of all ownerships in an area.

2. Development of cooperative relationships and arrangements so that state and other control men can get continuing fire experience through participation in prescribed burning work, possibly as a part of general barrier and block planning. There are some legal liability problems to work out.

3. Effective dissemination of know-how information to landowners.

In general, a first need in prescribed burning for fuel reduction seems more to bring together and make effective use of what is known. Considerable is already known about where and how to burn under favorable conditions. The difficulty is that these favorable conditions do not come often enough. The time during which burning can be done needs to be lengthened. To do this, much more accurate information is needed to determine limits or the *range* of conditions under which successful burning can be done.

II. Fire Effects

The subject of fire effects is extremely involved, has a long literature, and has been the subject of considerable research by the federal experiment stations and other groups. In general, research on fire effects is of broad application. There is little about fire effects peculiar to any one state. The subject is certainly important and far from being fully understood. It is only partially considered here, largely because the work is already well recognized.

Two complementary studies are recommended that seem fundamental to the whole subject and regarding which practically no specific information is available. The first, on thermal conductivity of bark, is a laboratory study using sample materials brought in from the field. From an engineering standpoint, the techniques should not be too difficult. They would require a controllable heat source, and temperature measurement at the outer and inner surface of

the material. Density, moisture content, corky content, etc., of the material tested would have to be determined.

The second study on forest fire temperatures has been studied a number of times but information is still scanty. Most of the work has been directed toward soil heating from forest fires. While there is some knowledge, the relationships between intensity and duration of temperatures at varying distances above the surface on downward penetration of heat are very imperfectly understood. Temperatures are also very poorly related to fuel characteristics. While above surface temperatures have been measured at various times and places, there is little systematic knowledge. This study will require considerable instrumentation and will be elusive. It is a job for qualified technicians only. Both thermal conductivity of bark and temperatures in fires are of especial significance in prescribed burning since permissable heat tolerances are often close. At the present time, knowledge on the intensity and duration of a fire that will kill certain hardwoods up to two-inches in diameter and not injure larger pines is, for example, wholly empirical.

III. Weather

The "weather" is another subject entirely too big to cover here. The five studies listed are all well known and considerable research is in progress on most of them. Frankly, I do not know what to make of the first, weather modification. It is certainly related to fire control through influence on precipitation and the work involves research and knowledge of much the same type as required in study of large fire behavior and fire weather forecasing. This work and research should be supported but not directly as a fire project.

All these studies require specially trained men with a considerable range of skills. They are jobs for a professional research organization with wide technical resources and the last one especially, fire weather forecasting, requires close cooperative relationships with the U. S. Weather Bureau and other meteorological interests.

IV. Soil, Water and Forest Cover Relationships

Surface hydrology study in the general field of forest influences is not commonly thought of as a fire control concern. In the lower coastal plain, however, it may well be important in the long run. What is proposed here is an exploratory study to see what information is available and whether soil — forest cover — water relationships seem important enough to warrant more thorough study from a fire control standpoint. The subject seems to me possibly to have large long-time importance and is likely to be overlooked. The general subject has application elsewhere as well.

V. Prevention Of Man-Caused Fires

It is impossible to over-emphasize either the importance or the stubborn nature of the man-caused fire problem. It does not seem appropriate or necessary here to review prevention programs and enforcement action. I did not go into law enforcement to any degree, perhaps erroneously. The work seemed to be well-organized and handled, adequate, and to pose more administrative and politic problems than study and research needs. There are wide differences of opinion on just how far to go with law enforcement in particular situations that seem unprofitable to debate here.

One hears considerable about the need to bring sociological and psychological skills to bear on prevention. It is perfectly true that prevention is a problem of human rather than of forest engineering, a fact which foresters are sometimes unwilling to recognize with all its implications. But it does not seem to me that the answer is to hire sociologists and/or psychologists to work on the problem though their skills and knowledge are most germane. In fact, I personally take a somewhat dim view of the productivity of what might be termed "high powered" social science research in this field. We know considerably better than we do now.

My inclination is to approach prevention as an applied problem more akin to advertising and selling which is the practical application of psychology and sociology and rests solidly on them. The two study projects suggested, designed to get better information on fire occurrence and causes, follow the normal business procedure of getting sound consumer information (the where, when, how, who and why of fires) on which to base a merchandizing campaign (the prevention program). This work should be kept as close to the ground as possible; present fire prevention programs probably tend to do a better job in reaching the public in general than, for example, debris burners or incendiaries who collectively start about two-thirds of Georgia's fires.

The third item is more a suggestion than a study but a point which I feel should be explored. At present, prevention in the public mind is practically synonomous with risk prevention. There is no con-

nection with fuels and fuel reduction which is accepted as a part of prevention as a matter of course by urban fire departments.

People should be fuel-conscious as well as risk-conscious. The central objective is to reduce wildfire loss to an acceptable level. Recognizing that there are abundant fuels in Georgia with more accumulating, and that fuels are a product of the forest and consequently a responsibility and immediate concern of the landowner, it seems inescapable that fuel management should be an important part of any program directed toward people close to the land — and who start most of the fires. Much more than prescribed burning is involved though that is the most obvious and critical item.

I am aware that objections can be raised over mix ing risk and hazard reduction in prevention. But it would seem that both forests and people have or are growing up to the point where a broader-based prevention program is called for and can be made effective.

VI. Detection and Reconnaissance

Detection is in general good in the state and it is a large job. Primarily, it is based on a system of 356 towers operated as follows:

State of Georgia	305
Timber protective organizations	13
Soil Conservation Service	9
U. S. Forest Service	21
Private industry	8
Total	356

Staffing and operating all these towers is a large and difficult administrative problem. Under normal visibility conditions, coverage is reasonably adequate; around 90 percent as a generality. Tower detection is supplemented by aerial detection when fire danger becomes critical. Planes are also extremely valuable in checking smokes that may or may not be wildfires and in scouting going fires. Detection and reconnaissance are closely related.

While initial detection under more or less average visibility is reasonably adequate, this is not true under adverse conditions when visibility is the poorest yet needed most. Lookouts are readily blanketed in with smoke and airplanes are definitely limited to how closely they can scout going fires and how much they can see. Spot fires are especially hard to detect and there are also difficulties in relaying such information directly to ground crews.

Analysis and study of visibility and fire detection under adverse conditions is recommended as briefly outlined in Study 1. Continued work should be done on tower in relation to aerial detection (Study 2) as has been done by Worrell and others. From very limited contact, it would seem that the map equipment in towers needs improvement and strengthening.

Study 3 on who initially reports fires is a suggestion for an exploratory investigation to appraise the possible importance of local people in reporting fires at least in some areas. The number of fires reported by the public is a good index of public relations. Large differences between different parts of the state may exist and be significant.

VII. Suppression and Equipment Development

The large emphasis on study and analysis in the suppression field may seem surprising but appears logical for reasons that have been given (pp. 8-10). The various studies listed should be reasonably clear as to intent without further discussion with the exception of equipment development which merits further consideration.

Equipment Development

It is strongly urged that an equipment development center be developed in the Southeast and Georgia seems a natural location. The reasons are many but center on the fact that fire suppression is done by means of equipment and cannot be much better than the equipment employed. This is in sharp distinction to prevention which involves no equipment, and hazard reduction which requires little special equipment.

Fire suppression in Georgia is highly mechanized. Except on the Chattahoochee National Forest in mountainous North Georgia, plow units are first-dispatch equipment on practically 100 percent of the fires. The Commission places great reliance on equipment and feels that it has been able to cope effectively with the control job only as it has been able to cope effectively with the control job only as it has been able to get good equipment on the ground (which mostly means plows). This, it certainly has done.

The current trend, in southern Georgia particularly, is toward heavier plow equipment which naturally means bigger, heavier, slower and more expensive tractors and trucks to pull and transport it. While the reasons for the trend are understandable, one wonders where it will come out. There are some definite shut-offs to increasingly heavy equipment. As forest areas become better stocked and trees average bigger, there will be increasing limitations on where heavy tractor plow units can go. Even heavy equipment cannot ride down and plow out much stuff eight

inches in diameter and larger. Basically, a plow is a digging and not a land-clearing instrument.

Looking ahead, there consequently may be need to consider narrower, more maneuverable yet powerful plow units. There would seem need to make more use of bulldozers in conjunction with plow units, or to mount bulldozer blades on tractor-plow units, etc. There may be trends in more than one direction as forests and the fire control situation change as they inevitably will.

Substances may be developed that can be sprayed on surface fuels to act as an effective fire retardent obviating much of the need for digging wide lines and generally tearing up the country which requires so much power and weight.

Aircraft, so far, have not been used for other than detection and reconnaissance purposes in Georgia. As a means of gaining greater mobility and access in suppression, it is entirely possible that aircraft can and will be used extensively both in direct suppression and in transport of men and equipment. All this involves equipment problems; for stuff to be airborne, it also must be designed for such transport.

Blanketing down fires in swamps at critical times almost necessitates aircraft as the transport means. Some way must be found to deal with fires in swamps and since this need is periodic, aircraft are strongly indicated to get mobility of seldom-used equipment over large areas. Emphasis on control of large fires inevitably means emphasis on equipment — both suppression and transport.

At present, water and chemical solutions are but little used in suppression. Possibly this is a result of preoccupation in developing and using plow equipment effectively. At any rate, if water and other liquids have a larger place as it seems to have, it will be equipment that effectuates it.

This kind of discussion can be continued at length; there is an equipment need and problem to almost everything that is done in fire suppression. One should be at least two jumps ahead rather than a step behind in equipment thinking and design. It seems highly important, therefore, that action be taken to develop an effective facility for equipment development.

Following are principles and requirements recommended for consideration in establishing such a facility:

1. The coverage should be regional — Southeastern. The work will benefit a large area and no one state or organization should carry the job alone.

2. Leadership should be stable and not limited in interest or tied to any one state. The U. S. Forest Service seems the logical agency.

3. While coverage should be broad and leadership stable, an equipment center must not become "institutionalized" in outlook and remote from its customers who are primarily state control agencies.

4. Some sort of quasi-private financing system and organization needs to be developed to give business flexibility and make it possible for states or other particular customers to buy in on what they want and have a reasonable degree of local control.

5. Work must be centered on real problems, a definite need; an equipment center must not become a gadget shop. Must constantly keep the emphasis on the problem, the job to be done not only as it appears now but also looking well ahead. Should not work from the standpoint that here is a fine gadget, a plow or something, so let's improve it. That is a part but only a part of the total job. These kind of problems need to be met by a good advisory board and constant research to help identify what the real needs are.

6. A wide range of skills, facilities and materials need to be available; much more than can be directly hired or bought by a forest equipment center. The center should be hooked up with an engineering school and located in an area where there are machine shop, foundry, metallurgical and related facilities available. The Atlanta-Macon area seems the logical location in these respects and also because of its central geographic position in the Southeast.

7. An equipment center should not be limited to fire equipment only but be able to deal with all sorts of forest equipment. It might well start with fire but should not be so restricted. Broadening the base of interest would tend to cut down overhead costs and strengthen assemblage of technical skills possible.

8. Practical arrangements and understandings would have to be worked out regarding the undertaking of quantity production work in relation to development of working models. A general objective should be to promote standardization and to foster commercial production.

Meeting these various prescriptions is not easy. But the need is great and a successful equipment center can be a vital force in the forestry development of the Southeast.

VIII. Fire Control Management

Fire control is a highly interrelated field with ability to integrate many things the crux. A difficulty of project research work is that a total job has to be somewhat arbitrarily broken down into parts to make specific progress on problems and sometimes there is

no place or medium for putting these parts together again and seeing the job in perspective as a whole. It seems important and appropriate, therefore, to recognize an area of general studies and analyses involving several or all phases of fire control. The term fire control management is employed to designate it and to emphasize the integrative nature of the work. Whether to regard fire control management as research, study, analysis, planning, or what is fruitless to debate. There is such a thing and it includes important jobs to be done.

Several such jobs are indicated. Item 1 is necessary to complete fuel, zone and barrier studies in terms of specific fire control plans specially aimed at beating large fire possibilities to the punch. There is nothing automatic about developing workable action plans. It is hard, exacting work of high professional requirements. In fact, if it is not done well little net benefit in the final analysis is gained from supporting research.

Item 2 concerning manpower and equipment placement is never done as the fire problem is dynamic and ever-changing. A first requirement is to recognize that this is so. The fire suppression picture changes as do fuels, equipment, organizational framework, level of financing and attitudes of people. At present, equipment is distributed mainly by counties and consists essentially of plow-tractor units kept on a standby basis. These units are expensive and not divisible; one cannot have one and one-half units per county, for example. County headquarters are mostly between 20 and 30 miles apart. It would be interesting and valuable information to guide policy to make a study of equipment placement as if there were no county lines. The point is to determine just what effect county lines and organization have on the cost and efficiency of control. This would then have to be set against the political facts of life regarding counties and a judgment made. The existence of counties should not prevent one from making searching analysis of equipment placement.

Looking ahead a bit, this general line of thinking can lead to some interesting conclusions — or possible conclusions. First, a few assumptions:

1. That successful statewide control requires having both special suppression strength in large forest blocks of high large fire potential and also maintaining good standards of speed and strength of attack throughout the state since there are valuable forest lands everywhere.

2. That fuels will get touchier and more abundant in general because there is more forest, more stocking, better protection, etc.

3. That fire causation (the number of fires) will be further reduced as almost surely can and will be the case.

Now for a few conclusions — or deductions:

1. The trend will be to get fewer fires, but some of high danger resulting from debris burning and incendiary, etc., that are distributed thinly over a very large area. The large fire threat will become greater rather than less.

2. The pressure will be for increasingly mobile equipment emphasizing ability to knock down potentially dangerous fires promptly — though not necessarily putting them out. The logic here points to increased use of aircraft in suppression and development of highly mobile assault teams.

3. The present county organizations will become increasingly uneconomic as they are too small to support the kind of equipment needed. Perhaps a trend should be towards having fairly light equipment in the county units able to deal with most fires. This should be possible in much of the state, with emphasis on patrol and mop up to support assault units operating over larger areas.

The main point here is simply that the over-all picture can and undoubtedly will change. A basic logistical problem is how to get speed and strength of attack at reasonable cost on relatively few fires occurring over large areas. This is rather a sticker that has to be solved through better equipment as well as by organizational structure.

Item 3 is concerned with cost analyses. I avoided the term "fire economics" as I have been round and round on this subject a number of times and have never been able to pin it down in terms of actionable and useful study. There are certainly economic problems in fire control but my inclination here is to approach them from a business management — cost control standpoint rather than by economic analysis per se. This is based on a strong feeling that what constitutes "adequate" control in an area has not been and never will be directly determined through any economic formula or prescription. Rather, it is worked out in an evolutionary sort of way combining business, political and social considerations in a judgment-oriented manner. Regardless of general economic levels and relationships, a first and clear responsibility is to operate a control organization at maximum business efficiency. In fact, if this is not done, data needed to quantify economic analysis are not available. Good financial management comes first.

IX. Some General Problems of Fire Control

A few other general problems of fire control not listed in the summary of research projects fit in here and should be mentioned. They are not advanced as studies but as matters the Commission should think about and which certainly require study.

1. Desirable degree of professionalization in fire control. The present tendency, increasingly forced by increasing mechanization and shortage of manpower, is to more and more professionalize fire control. The Commission is strongly equipment and supression-minded — rather naturally as it has been and is a major struggle to get equipment and to get on top of the immediate control problem. However, as with other affairs of man, as George can do it better, there is also an increasing tendency to let George do it. The control organization can become separated from the people on the land. Why bother to report fires or volunteer for fire fighting—let the State do it? Difficulty in getting supplemental labor needed to back up equipment is in part a consequence of professionalization of the job. People on the ground must feel a close and direct concern for fire control. They are needed in detection and suppression and absolutely indispensable in prevention and hazard reduction. Increasing specialization and professionalization in fire control does not naturally work in this direction.

2. Continued support and morale without headlines. I suspect that a central and coming problem of fire control is how to dramatize success, which means staying out of the headlines. An organization that really does its job, that prevents most fires and gets nearly all the rest while small without fuss does not get into the news and is likely to be taken for granted. This results in complacency, indifference, lack of public and financial support, and a lessening of general cooperation. It can be a problem within as well as without the organization. In large part, it is a problem of public relations. Means must be found to dramatize people, organizations, machines, success in averting fires, etc., to take the place of automatic black headlines when large fires occur. As in fire prevention, maybe a recurrent tag line needs to be developed like "and so another bad fire was prevented, stopped in its tracks, etc."

3. Balancing of suppression and prevention work. Prevention and suppression are quite different things in terms of people and approaches. A top suppression man is a driver, a man of action. His preoccupation is to get there quickly and with power to do the job. The approach of prevention is almost entirely to obtain voluntary action of people outside the organization. This is true in both risk and hazard reduction. A major share of prevention work in actual practice is not handled through the suppression organization. It often centers in I&E groups. The question is how effectively can a dominantly suppression organization develop and give full support to prevention work. A desirable relationship is by no means automatic.

4. State — industrial responsibilities and relationships in fire suppression. The present situation is that a few of the larger industrial companies spend a good deal to supplement state fire protection and the rest spend little or nothing. There is some basic inequity here. The need for close coordination and integration in mobilizing total resources for fire suppression in an area makes it virtually impossible for parallel organizations covering the same area, like the state and a company, to function independently. Small units are of little help in meeting more than a very local situation. What should be the long time trend? Should the state (with federal assistance as at present) eventually take over, or should coordination and cooperation be continued and strengthened as a desirable pattern?

5. Skill without practice. A direct result of increased effectiveness by a control organization is that it gets less practice in actual fire suppression. Real tests may come over intervals of years. How to maintain a high level of morale and efficiency without the continuing acid test of fires? This is closely akin to the problem of getting continued support without headlines. The only answer seems to be willingness to support practice use of equipment, "dry runs" to test field organization, and recurrent "command schools" to study control problems and develop overhead. Participation in prescribed burning seems especially important as this offers a major opportunity for men to work with fire and learn its behavior. This is a major opportunity and advantage southern control men have over those in the north and west in general.

Organization of Research

It is relatively easy to see and list research problems. The really difficult part is to finance, organize and staff to do something about them, and to get the results of research into practice. A wide range of skills and facilities are needed and no one organization or group can do all the job alone.

Requirements for worthwhile research can be briefly and definitely stated. It takes:

1. Leadership
2. Personnel — competitive pay, professional opportunity and favorable climate for research are essential to attract and hold good personnel without which nothing can be done
3. Facilities
4. Continuity — work cannot be started and stopped arbitrarily; there must be a continuing program.

Of these needs, personnel should be stressed particularly. Men with fire background and research ability and interest in the field are extremely scarce. To a considerable degree, they will have to be developed and trained. It is believed that liberal scholarships will be necessary to enable men to get training needed. Lack of personnel is an exceedingly stubborn problem and should not be minimized. It alone will prevent starting any large program in a year or two. Leadership is also vital. Uncoordinated work in two or three different places should not be started.

It is believed that research organization should rest on a firm basis of state and federal cooperation as has now been developed in Georgia. Some work, by its nature, is of particular state concern and should be financed and/or undertaken by it. Other research benefits a wide area and may call for skills and organization that no one state can or should supply. Such work should be federally undertaken. It is hard and often undesirable to draw sharp lines as to which is which but the general principle seems clear. Complex as it may be and sometimes fraught with difficulty, there seems no better answer than a well-structured and clearly understood state — federal cooperative relationship. Neither can do an adequate job alone.

The Georgia Forestry Council is by law the state agency charged with general responsibility for promoting and coordinating forest research at the state level. It has wide powers but is not yet developed to the point of having a Director and its pattern fully established. It is the appropriate agency to request state funds and to expend them where it is felt they will do Georgia the most good. This may be through the Commission, the School of Forestry — which can also do research independently of the Council —, the U. S. Forest Service, or with any other appropriate agency. The general concept of the Council, at least so far, is that it would act as a coordinating and promoting agency rather than as a research institution itself like an experiment station.

It would seem that the School of Forestry has a large part to play in the total program partly through research but more vitally through training of personnel. A state of Georgia's size and interest in forestry and fire control could well support strong instruction in fire. There are only one or two schools in the country, and none in the South, that make forest fire major teaching portfolio. Work at the graduate level is especially needed to turn out qualified technicians.

The Georgia Forestry Commission is, of course, the state fire agency. It is the principal user of fire research information in the state and also must be a major participant in a research and technical development program. Participation by an action agency in research always raises some difficult problems. Men charged with a daily operational job, and particularly in one so demanding as fire control, seldom have the time and opportunity to get the detachment and objectivity necessary to carry on studies. Yet they must be students of their jobs and in many ways are the ones best qualified to see and appreciate problems. There is a tendency for researchers to get too far away from control action and control men to be too close to it.

There is no wholly satisfactory solution to the problem of how to organize and carry on research in an administrative organization. In this situation, it is recommended that the Commission set up in the office of the Chief of Fire Control two professional-level positions detached from direct operational responsibility that can carry on administrative studies and do research application. The point seems fundamental that if there is anything to operations research and general administrative studies, some definite provision has to be made for it.

The Branch of Research of the U. S. Forest Service, represented in this area by the Southeastern Forest Experiment Station, is the dominant fire research agency of the country. Over the years, it has done or has had an active part in nearly all fire research accomplished. Project strength in fire in the Southeast is at present woefully undermanned, but the Forest Service has the organization and framework to give

effective leadership, coordination and supervision. Georgia should keep checking on that leadership, press for work on problems that seem important to it, and either directly or cooperatively support work on projects of special state interest.

Accordingly, it is emphasized that a major plank in development of an adequate and balanced Georgia forest research program is to press for federal funds to support a much more adequate federal program in the Southeast.

Priorities and Recommendations

Research priorities are approached on the basis of:

1. Desirability of getting started now on a moderate program emphasizing work bearing on the large fire problem.

2. Full acceptance of fire control operations themselves as being open to application of, and a full partner in, the research function.

3. Continuation and further development of a cooperative state-federal framework between the Forestry Commission, Research Council, School of Forestry and the Southeastern Forest Experiment Station.

4. Initiation of equipment development work on a regional hasis.

Research priorities are naturally related to what is available and when, and I have no knowledge of when and how much financial support may be forthcoming. To give a specific basis for recommendations, it is assumed that, as an initial program, the Council gets an appropriation of ahout $50,000 annually and the Southeastern Station an increase of around $25,000 for fire work. The Council money can be expended for cooperative support of work in the Commission, the School, or the Station. Since the School is not currently estahlished in fire research, it is not figured in here though it would be highly desirable for it to finance some work itself and to take an active part in the program as soon as possihle.

On the basis of the above, the following recommendations are made for consideration:

1. *Georgia Forestry Commission*:

Establish two professional-level positions in the Fire Control Chief's office.

One of these should he a qualified prevention man to press fire causation study, analysis and action in formulating prevention programs in "hot spot" areas of the state. Inevitably, he will be concerned with both risk and hazard reduction. It cannot be spelled out here just what he should do hut there does seem urgent need for a strong prevention focal point in the Commission framework going beyond, but obviously working closely with, the present enforcement organization. The cost of such a prevention man and necessary travel and help to make him effective would be considerably less than the purchase of one additional tractor-plow-truck unit a year. Such a man should much more than save his cost through reduction in suppression expenditures.

The other position might be called a fire control planning or administrative studies portfolio, the basic aim being to provide an anchor point for such work in the Commission. Such a position would also serve as a bridge to other men employed directly as researchers who may work on operations and other studies closely related to the fire control work of the Commission. It would appear desirable, if it can be worked out, for the position to be filled on a rotating basis by technical men of particular promise in the organization. The purpose of rotation (one to three year assignments) is to keep these positions from becoming static. Support of graduate professional training could well he considered as a part of strengthening the position technically. An over-all aim should be to use this position as a means of strengthening the Commission technically and to help keep it study-minded. Other Commission men would be detailed to work on administrative studies as need and opportunity indicate.

2. *Georgia Forest Research Council*

Consider support through cooperative contracts of three technical men together with necessary assistance, travel, etc., with general portfolios as follows:

a. Fuel studies.
Fuel classification, study of hreaks and barriers, hazard reduction. Work closely with Commission and Southeastern Station.

b. Fire control planning and general operations studies. Team up with the Commission "planner" on detection and suppression studies. Specific priorities to be developed in consultation with the Commission.

c. Fire weather danger and forecasting studies. Specific priorities to be developed. Basic aim to do work aimed at Georgia needs, supplementing more basic work by the Southeastern Station of general application.

All of this work should be done in close cooperation with the Commission and the Southeastern Station. Further funds, if available at this level of appropriation, should be cooperatively expended through the Experiment Station or the School of Forestry. It will be noted that work recommended for support by the Council emphasizes Georgia situations and needs as would seem appropriate for a state agency.

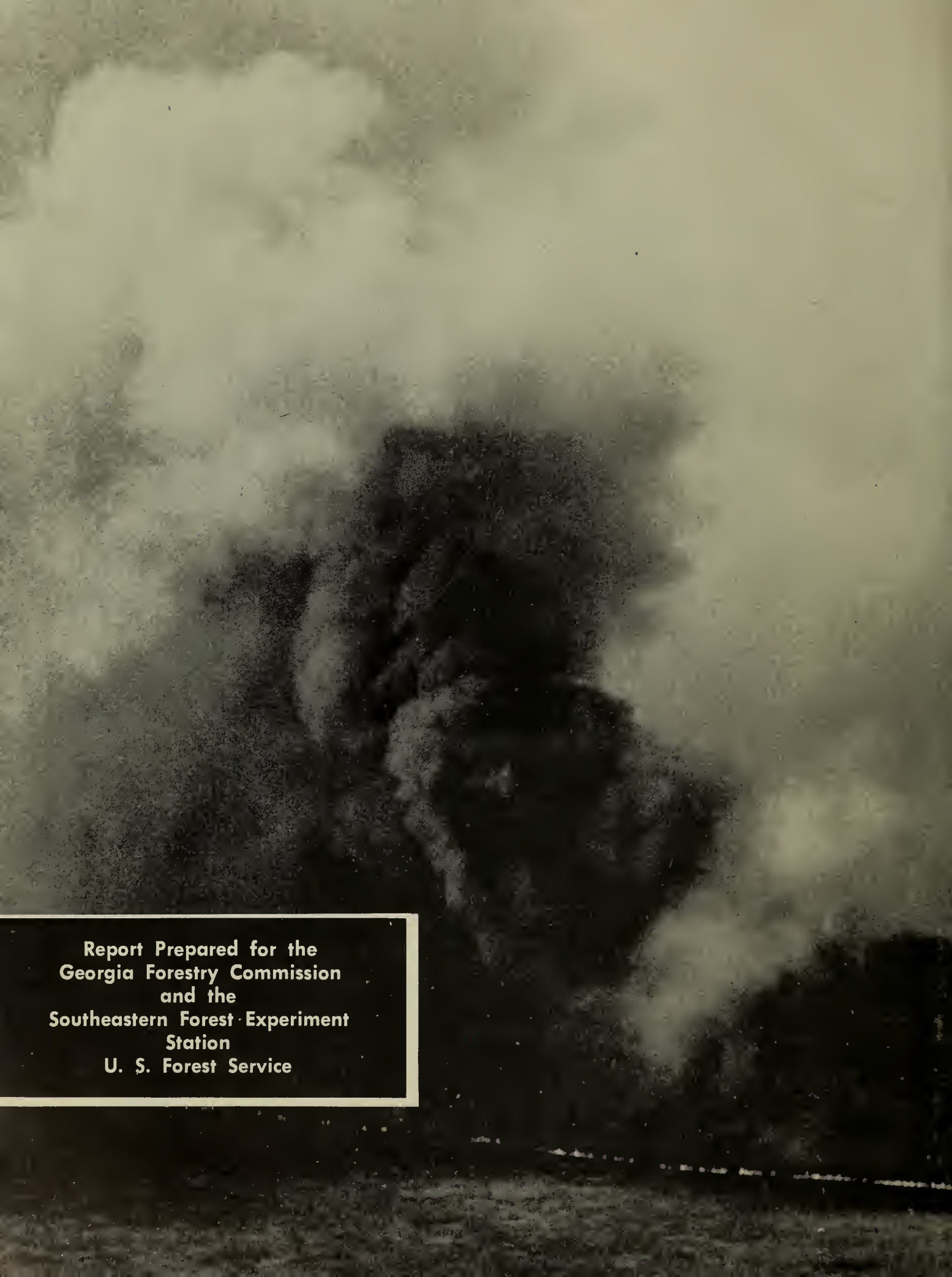
3. *Southeastern Forest Experiment Station.*

The Station, as a part of a nation-wide research organization, has wide interests and responsibilities and I would in no way presume to define its program. Studies suggested here are those that are of direct interest to Georgia as well as having rather general application.

Fuel burning potentials
Drought build-up
Danger rating development and improvement
Large fire behavior and "blow-up" analyses
Weather forecasting
Fire effects
Fire damage and economic aspects

4. *Southeastern Equipment Development Center*

It is urged that strong support be given to organization of a Southeastern equipment development center along the general lines discussed in the Organization of Research Section, Pages 48 to 51. This is necessarily an inter-state and state-federal undertaking with Georgia in a particularly strategic position both as regards location and need for such work. Improvement in suppression heavily depends on continued equipment development.



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