TRAINING PROGRAMS FOR BUSHFIRE CREWS
AND
RETARDANT TECHNOLOGY FOR
FIRE SUPPRESSION OPERATIONS

IAN DICKER

1990 GOTTSTEIN FELLOWSHIP REPORT

JOSEPH WILLIAM GOTTSTEIN MEMORIAL TRUST FUND

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are,

1. Fellowships - each year applications are invited from eligible candidates to submit a study programme in an area considered to be of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

4. Study Tours - industry group study tours are arranged periodically and have been well supported.

Further information may be obtained by writing to,

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J.W. Gottstein Memorial Trust Fund,
Private Bag 10,
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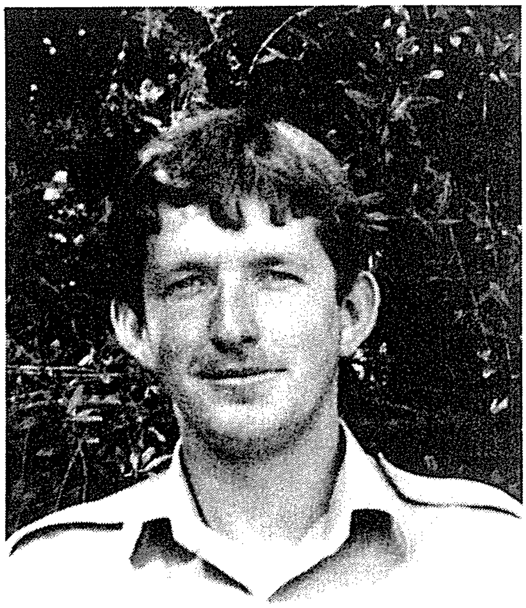
TRAINING PROGRAMS FOR BUSHFIRE CREWS

AND

RETARDANT TECHNOLOGY FOR FIRE SUPPRESSION OPERATIONS

A REPORT ON APPROACHES USED BY THE ALBERTA FOREST SERVICE, CANADA AND THE UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE

IAN DICKER



Ian Dicker is a Forester with the N.S.W. Forestry Commission at Tumut. He graduated from Australian National University in 1987 and joined the Commission in 1988 after 12 months with the C.S.I.R.O. National Bushfire Research Unit. He has been directly involved in supervising and administering pine plantation harvesting operations and with fire protection. This latter area of work is of special interest and led to his Gottstein Fellowship. He has been able to take advantage of the intensive fire crew training programs available in the United States of America and Canada adding to his knowledge of fire suppression and fire management technologies. His recommendations and observations contained in this report concerning the training of fire crews will be of particular interest to the many agencies in Australia involved in bush fire suppression.

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The author would like to thank the following people for their advice and assistance with the operation of the study tour. I would especially like to thank the Joseph William Gottstein Memorial Trust for their financial support. Thanks also go to the Forestry Commission of New South Wales with whom the author is employed, for the support given to the program.

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Finally I would like to thank Dr Hans Porada, Mr Marty Alexander, Dr Chris Trevitt and Mr Phil Cheney for their guidance in developing this study tour program.

SUMMARY OF RECOMMENDATIONS

Much of what has been observed as part of this study tour is not directly applicable to the fire management programs of the authorities involved in fire suppression in Australia. This is primarily because of the resources required to make them feasible. Such resources include both financial as well as man power. In comparison to the vast resources available to the fire suppression organisations of the north American continent, Australian fire services have to make do with very little. Due to a large military budget and the associated turnover of large quantities of relatively cheap aircraft, the use of fleets of large sized air tanker bombers is feasible in the United States and Canada compared to Australia. This is also the case for the use of small and medium sized helicopters. The US Forest Service budget for fire suppression is very large. The overall population of the United States is also substantially larger than Australia, making it possible to employ much larger numbers of people for the purpose of fire management.

The current training programs for many bush fire suppression personnel employed with the Forestry Services and Bush Fire organisations of Australia are limited, when compared to well established programs carried out by Forest Services in North America. For example, the basic course completed by fire personnel employed with the USDA Forest Service is a minimum of one week or 40 hours, and is generally carried out over a two week period. This training is for the equivalent of basic fire fighting staff such as the field staff employed by the various forestry services, or the many volunteers involved in fire operations. To carry out duties of responsibility such as those of a Brigade Captain, Technical Assistant, Foreman or Forester, further, more advanced training courses are required to be completed in conjunction with increasing levels of experience. At present, in NSW for example, no framework exists for a state wide program for training field staff to similar standards as overseas, and there are minimal training programs for supervisory staff such as Foresters, Brigade Captains etc. Other States such as Western Australia and Victoria have much better structured training programs for fire fighters, however, there is room for further improvement.

A curriculum of training and experience requirements for different job allocations should be developed. This concept follows the 'Incident Command System' employed overseas, which has been found to be an effective method of ensuring qualified staff filling positions of responsibility at large fire events.

The following represents the recommendations for possible development for the training of fire management personnel in Australia.

1. Increase the level of training for all field staff employed in the task of fire suppression. The basic level that all staff should be trained to should involve a comprehensive training program conducted over a period of approximately one week. Within this envelope of training, the following topics can be included:

: Comprehensive courses covering fire weather and fire behaviour.
: Field Navigation for both daylight and night operations.
: Safety considerations at fires (smoke inhalation, flying embers, how these dangers may change at night etc)
: Basic first Aid requirements likely to be encountered on or near a fireline
: Use of water in fire suppression/ operation of pumps
: Correct use, maintenance of and safety aspects of tools and powered equipment used in fire fighting. Efficient use of water and hand tools.
: Correct use and maintenance of burning devices (Drip torches etc.)

1.1 Experience overseas and in different industries has found that simulation of possible incidents is the most effective method for training personnel. Examples of simulation training in other areas are: Commercial aircraft pilots, mining industry, large factories using expensive machinery, and city fire brigades. It is recommended that an increase in the level of simulated fire training programs for field and professional staff be made. Initially, simulated fires set up in the field, possibly in conjunction with hazard reduction burning programs could be set up to simulate bush fire events, giving crews and supervisors the opportunity to make decisions regarding suppression strategy in the field rather than in a classroom.

1.2 An investigation into the feasibility of establishing a video laser disc simulator training facility should be made. Overseas experience has found the use of such facilities to be a very effective training tool due to the life like situations created with both Audio and Visual stimuli. These systems are sufficiently flexible that the training scenario can be modified to suit the type of training required. For example, supervisor level, tanker operator, hand crew supervisor, basic fire fighter level etc.

One major advantage of the use of simulators will be provision of continued training capabilities, particularly in poor weather. Hazard reduction burning is limited in this regard. The cost of establishing such a training facility is limited compared to the quality in training achieved. Simulators have been found to significantly increase the retention of information by participants, associated with a potential reduction in the time required for instruction.

1.3 Actively pursue the participation in cooperative fire training programs and transfers of technology. Support the introduction of inviting members of other organisations to participate in District and Regional training programs and promote any reciprocal offers.

2. Pursue the introduction of a minimum fitness level for employment of field staff. Increased fitness is directly linked with reduced accident rates and increased productivity. Produce a minimum fitness standard for work on specialty crews such as Helitack. Investigate the feasibility of introducing a fitness program for professional staff so that higher fitness levels are developed for the fire season. Recommended ideas include with financial and time allocation for professional staff to participate in sporting activities or physical development (gymnasium) programs in the off season.

3. Further investigation of the suitable fuel types in Australia for the application of foaming chemicals should be made. There should also be a push to increase the use of foaming chemicals applied from the air. The most relevant example of this type

of technology observed was the use of foam injection systems for use in light and medium sized helicopters equipped with buckets, and small inductor units linked with with tanks on skidder tractors. The use of foam, applied from the air as a direct attack against the fireline, in support of ground crews has been found to be very effective as a fire retardant. Such an injection system is light enough not to significantly reduce the amount of water carried by the machine and is considered to provide a positive cost benefit. Several helicopters used for fire suppression in Victoria are already fitted with such systems, and their value in fire suppression is claimed to be high.

4. Increased use of cotton and light woollen clothing by fire fighters rather than introduction of high cost, high technology clothing such as 'Nomex'. Light weight cotton and woollen fabrics provide better radiant heat removal, in conjunction with better evaporation of sweat and heat caused by exertion, whilst providing adequate protection to the firefighter from hazards experienced in suppression operations.

5. Introduction of improved safety and survival equipment for use with vehicles. It is recommended that Australian fire organisations investigate higher levels of training to increase the awareness of potentially dangerous situations and how to avoid them, rather than consider relying upon the deployment of survival equipment. Examples of the incorrect use of such devices has been found to lead to fatalities.

SECTION 1: INTRODUCTION

The Australian Bush Fire Fighting environment is recognised as one of the most hazardous tasks in the world. Historically, much of the burden for fire fighting bush fires in Australia has rested with the numerous volunteers found throughout the country. It is only over the past 100 years or so that professional crews from the various Forestry services, National Parks and Wildlife Services, and other Government land management Authorities have become involved in fire suppression in this country. The Volunteer Brigades still contribute the largest body of fire fighters in Australia, however it would be fair to say, the least trained.

Due to the nature of the work of these volunteers (farming being the most common career), and the difficulties associated with co-ordinating burning programs to fit in with farm work schedules etc., fire training programs have until recent years been either non existent, or relied upon 'on the job' training. Professional organisations also were guilty of relying on the experiences of older crew members to be passed on by word of mouth, as part of the job, to younger, inexperienced crew members. This situation made it impossible to quantify the level of training received by each crew member, and can introduce the risk of hazardous situations developing on the fire line, following poorly based decisions.

Events such as the Ash Wednesday fires in South Australia and Victoria saw the start of more formalised training programs for crews in those states. Following the occurrence of several deaths and bad injuries to fire fighters in recent years in other states, there has been a start towards quantifying the training of Australian fire fighting crews, including those involved with volunteer brigades.

Although it is acknowledged that the threat of injury or death cannot be fully removed from the fire fighting environment, steps must be takento minimise the hazards. It is to be expected, based on international experiences, that, by increasing the level of training (to both crew leaders and crew members making them more aware of the hazards and how to minimise or avoid them), will lead to a reduction in the accident rate associated with fire suppression. Associated with a reduction in accident rates will be an increase in the work efficiency and output of fire crews.

Australia, is climatically a hot, dry environment. During periods of bad fire danger, the eastern and particularly the south eastern parts of Australia are influenced by low rainfall and warm, dry air masses originating from the desert inland areas of the continent. Water, the most effective fire suppression tool is often a limiting factor in the fire suppression operation, particularly in late summer and times of prolonged drought. Technology, in the form of chemicals to improve the effectiveness of water as a fire suppressant are now becoming more readily available to the fire fighter. The two areas that seem most applicable to bush fire suppression are: 1) the use of retardant salts, which have a retarding effect on fire behaviour by reducing the heat produced in combustion, by chemical means, and, 2) foaming agents, which increase the effective volumes of water by bubble expansion and cause the fuels, treated with water to stay moist for longer periods. This result is due primarily to better penetration of water into the fuel and insulation of the fuel from heat by the air filled bubbles, requiring greater amounts of heat energy to achieve combustion.

The use of retardants is not a new concept in Australian bush fire fighting, with some of the first examples of its use thirty years ago. Improved chemical compositions and knowledge of its effects on fire behaviour are more recent. Initial moves towards the introduction of foaming agents followed the use of wetting agents to increase the penetration of water into fuel components. Foams of different expansion and density have been employed by fire fighting organisations involved in the fighting of chemical spills and aviation fires for sometime. Modification of this technology was employed to create a foaming chemical that has applications to bush fire suppression. This foam has a lower expansion rate than foams such as aviation fire foams, but still cause a significant increase (by as much as 30 percent) in the quantity of effective water.

Both the United States of America and several of the Provinces of Canada have well structured fire training programs for their forest fire suppression crews, and are the countries where most retardant research and implementation is being conducted. For these reasons the United States Department of Agriculture Forest Service (USDA Forest Service), and the Alberta Forest Service (AFS) were approached to ascertain the feasibility of a study tour program, with the main emphasis on Wildland Fire Crew Training. Following promising responses from both organisations, avenues were investigated for financial assistance to support such a study program. The Author was selected in November 1989 by the Board of Trustees of the Joseph William Gottstein Memorial Trust Fund as a Gottstein Fellow, for receipt of a grant to assist with travel and general living expenses expected to be incurred during such a study tour. The Forestry Commission of New South Wales, with whom the Author is employed, granted study leave for a period of six months to allow participation in the program. Both the Forest Services involved in the study tour program also assisted greatly with the provision of accommodation and travel arrangements etc.

In all, the tour involved two weeks short of six months travel, between 29 March and 17 September 1990. The first six weeks were spent as a guest of the Alberta Forest Service, Canada, and the latter four months spent as a working member of the Lassen Hotshots fire crew of the USDA Forest Service. Due to the time of year being spring in Canada, it was possible to actively participate in some of the pre-fire season training courses given to forest officers of the AFS that would carry out positions of responsibility during the fire season, including supervising crews, equipment or fire incident managers. Spending four months, including late spring and summer in northern United States enabled the Author to participate in both the pre-season training courses for a US Forest Service Hotshot hand crew and to observe fire suppression techniques applied at first hand. This included both personnel and hardware resource management at both large fire events in two different states and smaller fire events in California.

SECTION 2: SCOPE OF THE REPORT.

This report covers a description of training courses in which the Author participated with the Alberta Forest Service, Canada as well as some other aspects of fire suppression management (including fire crew training) within Alberta and British Columbia. Several opportunities to discuss the use of fire retardant chemicals are made, involving both longer term ammonium salt based retardants, foaming agents, and the methods of application.

Also within the scope of this report are the pre-fire season training courses conducted by the officers of the USDA Forest Service Lassen Hotshots. A discussion of other Large Fire organisation considerations and fire management planning observed as part of the study tour is made. This includes such factors as training facilities for permanent forest service staff, resource dispatch organisation, co-operative fire fighting and fuels management.

The feasibility of introducing certain aspects of fire suppression and management into Australian fire management practices is discussed.

SECTION 3: WILDLAND FIRE MANAGEMENT IN ALBERTA, CANADA

3.1 INTRODUCTION

Alberta is the second most south western province of Canada, neighbouring the province of British Columbia. The south western corner of the province is marked by the Canadian Rocky mountain range, however the remainder of the province is essentially flat, undulating topography. Approximately two thirds of the province is covered in native vegetation comprised of spruce, pine and poplar forests. This resource is essentially in the northern part of the province and is in many areas remote and without roading. Responsibility for protecting this resource rests with the Alberta Forest Service.

Due to near total commitment of the timber resource to various forest industries (both pulp and sawlog), a great deal of importance is placed on rapid and effective fire suppression operations. The forest protection section of the organisation is structured with a core of permanent staff, supplemented during the fire season with 'seasonal fire fighting staff'. Many of these seasonal crews are formed from groups of native Indians. At any one time, up to 5000 natives are listed as available for fire duties.

As mentioned, much of the province is without roading, and a strong emphasis on the use of helicopters to provide rapid transport for fire crews has developed. On days of very high potential fire danger, it is possible for more than 60 helicopters to be standing by at various staging camps around the province. Specialised, large air tanker bombers are used to support the ground crews. Some are capable of filling with water from the many large inland lakes, whilst flying.

The Alberta Forest Service conducts a substantial public awareness and education program. These are aimed at both school age as well as the adult population. Emphasis is placed in reaching groups living or working in areas where urban and agricultural land use meet or where agricultural land neighbours forests or prairies

A province of climatic extremes, Alberta experiences temperatures of negative 45 degrees Celsius in winter with soil moisture freezing, as do many of its waterways. The freezing conditions provide better access to the forests because of the frozen ground, and most of the logging conducted in this province is completed before the spring and summer thaw. This thaw under temperatures in the mid 30's causes a lot of swamps (muskegs) to form, making access difficult, particularly to heavy tracked equipment (eg. Dozers). Biological degradation is restricted compared to climates experienced in Australia, producing large build ups of organic material (duff) on the forest floor. Peat bog fires are common and difficult to suppress. Fire control with hand tools can sometimes mean digging down several feet through combustible duff layers, to reach mineral earth.Much of the fire management training for permanent officers of the Alberta Forest Service is conducted at the Forest Technology School, located in Hinton (Appendix 2.1). This school provides the base for the field component of the Forest Technicians Certificate, in conjunction with the Edmonton Institute of Technology. The school, with its live-in facilities provides an excellent opportunity for training personnel from all parts of the province, as well as other parts of Canada.

Training for all seasonally employed fire fighters is carried out on a district basis. The only exception are the helitack crews making use of the rappel training facility located at the school. Many of the officers conducting the training programs in the field, will have been through various training courses at Hinton.

3.2 PRE SEASON FIRE TRAINING FOR FOREST OFFICERS

The itinerary for the Canadian section of the study tour is given in Appendix 1.1.

The hierarchy of fire suppression management is well structured within the Alberta Forest Service. Personnel are qualified to fill certain roles within the organisational structure depending on their qualifications and experience. This leads to a well structured fireline organisation. As a fire increases in its requirement for resources, the qualifications and experience required to fill particular roles is increased. For example a forest officer, qualified to carry out the duties as fire boss at a fire where 25 fire fighters are involved will possibly not be permitted to act as fire boss where 250 fire fighters are involved, under normal circumstances. This means that as a fire increases in size and resource requirements, position changes and changes in responsibility between personnel may occur.

The basis for fire line organisation and organisational build up are shown in appendix 3. To qualify for higher positions of authority within the fire management hierarchy, officers are required to attend and pass examinations of certain training courses in conjunction with working experience at a given number of fires of a particular size. Courses are carried out in the non-fire season part of the year, many at the Forest Technology School located at Hinton.

3.3 FIRE TRAINING COURSES ATTENDED IN ALBERTA

3.3.1 FIRE PREVENTION 1

The Fire Prevention 1 course is designed for junior officers of the Forest Service and select members of other government bodies, who will be involved in issuing permits to agricultural settlers whose land borders or is within the area of forest protection managed by the Alberta Forest Service. Due to the limited period of time in which settlers can carry out slash pile burning and the encroachment of the farming community into the forested lands of Alberta, issuing and monitoring of fire permits is seen to be a major concern. The inclusion of members of the general public involved in these pre-suppression activities is considered important, and encouraged.

Topics discussed in this course include :

: Introduction to the Canadian Fire Weather Index System, and learning to recognise and appreciate a potentially dangerous set of weather patterns leading to increased fire danger. This can be seen to be very important from a patrolman's point of view where decisions to issue or refuse burning permits is very closely tied to current and predicted weather.

: Introductory level Fire Behaviour associated with different fuel types, topography, and, how when applied with the Fire Weather Index System, can influence a decision regarding the issuing of a fire permit.

: The format of the Pre-suppression Preparedness System (Section 5.3) employed by the Alberta Forest Service is discussed. This is centred around how Patrolman, Fire Guardians and others, with the responsibility of issuing and monitoring fire permits and burning operations, operate within the system.

: Public relations, attitudes and portraying a professional image to members of the public is discussed. Students are taught to look at a situation from the other persons view point to help understand the reasons for particular arguments and assist with discussion technique. A professional manner at all times is emphasised, to develop a good working attitude with the public. Commonly experienced conflict situations found by patrolmen are discussed with some hints on how to handle or avoid them.

: Public education and the effects of wildfires on the environment and how the public can help reduce the occurrence of wildfires, through advertising campaigns, school visits by Forest Officers and other government employees, are discussed.

: The legal aspects of issuing fire permits, including the legislation covering the protection from fire for Prairie and Forested Lands. The jurisdiction of officers within these areas is given, including the ability to refuse, cancel or place limitations within the conditions of fire permits.

3.3.2 ADVANCED FIRE BEHAVIOUR

The advanced fire behaviour course is taught to more experienced Alberta Forest Service Officers, with some positions on the course available to officers from organisations including National Parks Service and forest services from other Provinces. It is a course that is required for qualification to higher positions within the fire suppression hierarchy. For example, officers that wish to become Aerial Attack (Birddog Officers), or Fire behaviour specialists, among others, are required to complete this course as specified in the Alberta Forest Service Fireline Certification Manual.

Topics discussed in the course include :

: Introduction to Fire Science - including both the chemistry and physics involved in the processes of combustion and photosynthesis. The stages of combustion and heat of transfer are discussed, in connection with fire intensity, forward rates of spread and fire shape.

: An extensive description of the Canadian Forest Fie Danger Rating System (CFFDRS) is given, introducing the students to the different fire behaviour indices within the major fuel types used to develop the CFFDRS. Exercises are undertaken to make use of the cffdrs to calculate fire characteristics, including forward rates of spread, given sets of parameters taken from real fire events. These exercises include the use of computer based packages to assist in fire behaviour prediction.

: Fire weather and how it directly effects fire behaviour prediction are discussed. This includes a brief course on climatic change resulting from fires (increased levels of atmospheric heat and smoke), and a look at global and local climatic fluctuations and possible implications to long term fire management.

: One day is dedicated to discussing cases of extreme fire behaviour. Case studies of fires in different forest types within Canada are presented along with discussion regarding extreme fire behaviour abroad. In particular fires occurring in south eastern Australia, especially the Ash Wednesday season of 1982/83 and the Yellowstone National Park fires in the United States, October, 1988, are discussed.

: Fires leading to fatalities and the fire behaviour and fuel types that combined to produce the conditions leading to fatalities are presented. The effect of fire fighter fatigue and increased accident rates is also discussed.

3.3.3 AIR ATTACK OFFICER

Because of the extensive amounts of inaccessible forested lands within Alberta, heavy emphasis is placed on the usage of Air Tanker aircraft and Air Attack Aircraft in fire suppression operations. During a fire event, the Air Attack Officer can be expected to carry out different roles, including airspace control (air traffic management), managing various numbers of air tanker aircraft and helicopters, aerial detection and mapping of fires, and possibly overall fire boss. Much of the skills are learnt on the job, and a large amount of supervised live training is carried out before the officer is permitted to operate alone. A certain level of theory is required before people are selected for training in this field. Air Attack Officers will already possess a certain level of fire suppression experience.

Topics discussed in this course include :

: Fire reconnaissance, mapping and the use of mapping aids, including air navigation computers for air to ground navigation. Several theoretical Navigational exercises are carried out involving the survey system employed in Alberta, plotting routes from airfields to locations of fire, sources of waer for air tankers, flight times, turn around times, assigning priorities, etc.

: Aerial reconnaissance of fires, including techniques to visually estimate current and predicted fire behaviour estimating fuel types, and fire sizes from the air.

: Support to ground crews with information covering fire behaviour, fire weather weather and fuels, assist in the production of suppression strategies, and assume control of operations whilst in the air. This includes the task of assigning priorities to various operations and objectives within the fire suppression strategies.

: Limitations, characteristics and strategies of fire suppression using the different types of air tankers available in Alberta. Factors such as air speed, tank capacity, fuel consumption, loading times, air field requirements etc., are discussed.

: Use of helicopters in fire suppression, including basic safety, requirements for field operations, limitations of various helicopter types available for fire suppression within Alberta, and how to work with these machines from the air is discussed.

: Meteorology and its importance to aircraft operation. Examples of the effects of operating aircraft around large storm cells and the effects on aircraft flight characteristics when operating around large convection columns are discussed.

: Fire training simulator. Several students are placed in simulations involving multiple aircraft and sometimes multiple fires, requiring the student to make important decisions that would be expected to be made in this job during a fire event. A further discussion of simulator training is given in section 3.6. The Alberta Forest Service places a high value on the use of simulators for this type of operation. A working mock up of the air to ground communications systems used in aircraft is under construction for future students to use during simulations. The use of laser disc simulation has been found to have significant cost savings. Many hours of computerised simulation, training multiple students can be achieved for a fraction of the cost of live simulations using aircraft.

3.3.4 AIR TANKER BASE MANAGER

This course is conducted for those officers who will be involved in the daily operation of air tanker bases within Alberta.

Topics discussed in this course include the following:

: Administration associated with running an Air Tanker Base, including personnel and record management.

: Requirements for loading the different Air Tanker types used for fire suppression operations in Alberta, in particular quantities of retardant each aircaft type carries and quantities of retardant to have stored mixed. Air speed capabilities to calculate turnaround times, are also demonstrated.

: Retardant types used. Safety measures to be employed when working with retardants and foams. Different types of mixing systems and storage systems at different bases found within Alberta Control. Quality testing of retardants. (ensuring correct concentrations etc).

Operation of pumps and retardent mixing and storage equipment and the maintenance and trouble shooting associated with operation of Air Tanker Bases.

3.3.5 INITIAL ATTACK CREW LEADER

Initial Attack (IAC) Crews employed by the Alberta Forest Service during the fire season are small, mobile crews that are self contained for ground suppression activities. Crew size is not fixed, but is generally less than eight. Crews are equipped with vehicles for transportation, but regularly use helicopters to reduce response times. From all training programs and use of crew resources, this was the most similar system to those in place with fire organisations in Australia. As with many other fire crews observed during the study tour, Initial Attack crews consist of seasonal employees. Crew leaders are selected from experienced crew members, who have shown good leadership and fire fighting skills.

Topics discussed in this course include the following:

: Administrative requirements associated with management of an Initial Attack Crew; including correct use of forms and records. Effective supervision skills are discussed, emphasising teamwork and good communication. Leadership by example is emphasised regularly.

: Physical fitness is considered very important. Physical training is carried out by the class every morning. Students must reach a certain level of fitness before completion of the course or failure is the result. Initial Attack Crew leaders are expected to conduct regular physical training programs for their crews. As with the crew leaders, a minimum standard of physical fitness is expected and regular testing is normally carried out during the course of the fire season.

: Courses in fire behaviour and fire weather, at a level less intensive than the advanced fire behaviour course, are conducted. This leads to an exercise in fire assessment with a discussion on methods of initial attack reflecting fire behaviour assessments.

: Training in bush skills is given. Crew leaders are put through exercises in navigation and map reading, chainsaw operation and petrol powered pump operation. Falling and cross cutting exercises using chainsaws and training exercises to minimise set up and pump operation are regularly carried out by Initial Attack Crews during the fire seasons to maintain proficiency.

: Aircraft used in fire suppression operations, the different types and their capabilities are discussed. Because of regular contact with helicopters, the initial attack crews are expected to conduct exercises in the field to maintain the crew awareness of safety requirements as well as efficient load and dispatch techniques. I.A. crew leaders are taught the methods for calculating helicopter load limits (for different temperatures and altitudes) and how to load and work safely within those limits. This is an important aspect to consider with great variations in altitude that a crew could be expected to encounter whilst fire fighting in Alberta.

: Fire simulator training. Students are run through a series of simulations requiring them to assess a fire's behaviour and determine suppression strategies based on available resources. These simulations are designed to accurately represent tasks that are carried out by Initial Attack Crew Leaders upon their arrival at a fire.

3.4 FURTHER FIRE MANAGEMENT COURSES CONDUCTED BY THE ALBERTA FOREST SERVICE

Other courses for fire suppression personnel are conducted at the Forest Technology School at Hinton at different times of the year. These include:

: Helitack - trained personnel in rappel techniques from helicopters are trained in fire assessment in the same way as I.A. crew leaders. Much emphasis is placed on the assessment of whether or not follow up support will be required.

Helitack crews all meet at Hinton for pre season selection and training. These are the only seasonally employed crews to undergo training at Hinton. A permanent rappel training facility has been constructed to train crews before moving to standby locations in the field (figure 1).

Very high physical standards are demanded of new recruits. Regular culling of candidates takes place based primarily on fitness criteria during the initial two weeks of training. New recruits are required to complete a minimum of 100 rappels from the tower,(which is set up to permit operations to take place at different elevations up to 75 feet) before being permitted to complete a 'live' rappel from a helicopter. During the fire season, crew members are required to complete a minimum of five rappels per week to maintain currency.

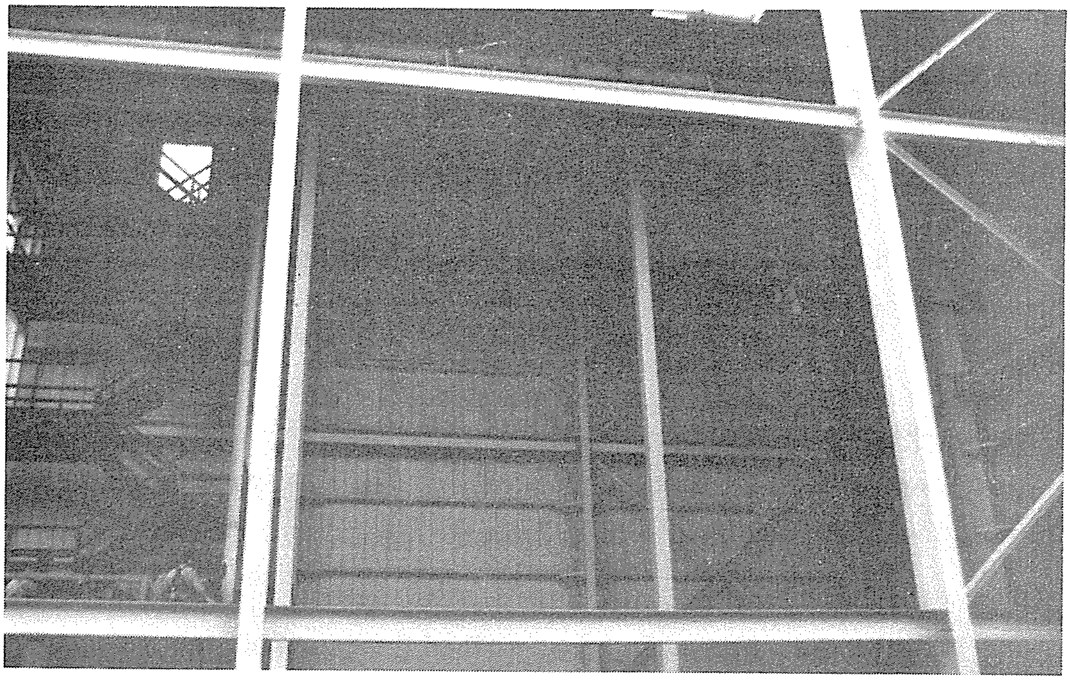

Figure 1: Helicopter Rappel training, Hinton, Alberta.

: Cat Boss (Dozer Boss) - personnel trained to carry out effective dozer operations during fire suppression. Students can expect to be placed in charge of up to 3 machines and are trained in the use of tractors for the construction of different products e.g. Helipads, safety zones, fire lines, camp sites etc.

: Crew Boss - training to certify personnel to manage up to 21 people on the fireline. This course includes topics of basic fire behaviour and weather, crew supervision, management and safety on the fireline, aircraft involved in fire suppression and methods of attack.

: Dispatcher - to prepare duty officers for tasks including development of presuppression preparedness strategies based on current and predicted weather and fire behaviour and available resources. Ground to air communications and effective use of aerial suppression techniques are discussed.

: Division Level Fire Suppression - for staff who will be responsible for management of sections of a fireline where these will be between 76 and 225 basic level fire fighters. Fire suppression tactics and fire management are closely scrutinised. Training involving simulations is included.

: Fire Prevention II - for personnel involved in the production of fire prevention plans for district and forest areas.

: Industry crew boss - designed for staff from private forest, oil and gas industries as well as staff from Parks Services to manage non-forest service crews of up to 25 persons in fire suppression operations.

: Prescribed Burning - Use of prescribed fire in habitat and fuels management.

: Sector Level Fire Suppression - for staff who will be responsible for management of sections of a fireline with up to 75 basic personnel.

: Time Officer - for personnel who will be responsible for carrying out administrative duties on fires of Division size (between 76 and 225 basic level fire fighters).

3.5 APPLICATIONS FOR AUSTRALIAN FIRE SUPPRESSION ORGANISATIONS

Although at the time of writing there are few structured courses that fire fighters, particularly supervisory staff, in Australia, are required to attend before carrying out particular duties at a fire, it is considered that there is scope for the introduction of topics similar to some already mentioned above to improve the skills of those involved in fire suppression.

3.5.1 FIRE PREVENTION 1 (ISSUING FIRE PERMITS)

Although not faced with the same amount of forested country bordering agricultural land, or the amount of remote area not accessed by roads, it is considered that a basic course for those people involved in the issuing of fire permits would be very beneficial. In Australia, fire permits are generally handled by representatives from shire councils, volunteer bushfire brigade captains, or officers of forestry services. Although there are exceptions, many of these officials are probably not aware of all laws governing the use of fire, or the legal responsibility within each state regarding the issuing and monitoring of fire permits. It is also likely that many Shire Council employees and possibly volunteer fire brigade personnel have had little or no formal training in fire behaviour, and the influences of weather upon fire behaviour, relying mainly upon personal experience, and perhaps the advice of others.

3.5.2 ADVANCED FIRE BEHAVIOUR

The training involved in this course is considered to be very appropriate for training staff responsible for the supervision of crews at fires. This would mean the Forester/ Ranger/ Brigade Captain level of personnel, who could be expected to assume control of field operations at fires. Training in fire behaviour and fire weather is critical for accurate assessments of fire to be made, and promotes the employment of better "thought out" suppression strategies.

Much of the theory involved in the physics and chemistry of combustion, basic fire weather and fire behaviour is covered within the fire behaviour courses conducted as part of the Bachelor of Science (Forestry) degree. It is considered advantageous that forestry officers obtain several years fire fighting experience, before supplementing their knowledge with advanced information contained in such a course. People who assume supervisory roles at fires should possess a good knowledge of fire behaviour, and recognising different fire weather patterns. This knowledge promotes the safe operation of crews at a fire.

3.5.3 AIR ATTACK AND HELITACK

3.5.3.1 HELITACK

Several Forestry Organisations in Australia already have trained Rappel crews. Victoria and Tasmania, both states with large areas of difficult access wilderness have small numbers of trained personnel in this field. In New South Wales, both the National Parks and Wildlife Service and The Forestry Commission have crews trained to be winched into remote areas from helicopters. In most situations experienced, a trained crew, comprising one or more experienced chainsaw operators for clearing helipads will be sufficient to enable helicopters to land and bring in more resources. This becomes a problem when the surrounding vegetation is taller than the winch cable is long. Ropes used in rappelling are longer than most winch cables used in helicopter operations (up to 150 feet long compared to an average of 75 feet for light helicopters such as the Aerospatiale Squirrel). With the tall hardwood forests of Gippsland and Tasmania, there is a good use for rappel. In the smaller hardwood forests of northern Victoria, New South Wales, and much of South and Western Australia, winch operations would be adequate. It is not anticipated that the forest services and rural fire fighting organisations in those areas would consider the cost of establishing, training and maintaining such rappel crews justified.

To establish fixed tower training facilities for Rappel crews, such as Hinton, are inhibitively expensive, but do provide excellent training opportunities. The availability of helicopters for such work in this country is also considerably reduced compared to Alberta. Based on these points, along with the limited number of fires in which helitack rappel would be significantly quicker, it is considered unlikely that an expansion of rappel crews used in fire suppression in Australia will take place.

3.5.3.2 AERIAL ATTACK

The use of aircraft to provide air to ground support in fire suppression operations in Australia is well documented. Aircraft provide a good platform from where an overall picture of the fire behaviour can be gained as well as providing a position to give ground forces support. This support can be in the form of information about fire behaviour, location, size, warning of dangers,best locations to commence suppression, assistance in navigating to the fire when vegetation make visibility difficult etc.

Several of the topics discussed in the Air Attack Officers course were found to be useful for officers of the forestry services and rural fire departments, who could expect to be involved in aerial detection or airborne assistance to ground crews. Such topics as air to ground navigation, mapping fires from the air and assessing and predicting fire behaviour from the air were found to be useful and relevant.

3.5.4 INITIAL ATTACK

As mentioned, the use of initial attack crews most closely parallels the use of Rake-Hoe Crews and Helitack crews by the forestry services and rural fire organisations of Australia. Crew sizes, and the approaches to utilising these crews are similar. For example, the crews are small, mobile units that are sent in to commence initial attack, or supplement other resources. Upon arrival at the fire, the crew leader must make an assessment of the fire, and future requirements for successfully containing and suppressing the fire.

A major point to come from the training of Initial Attack Crew leaders is the level of fitness required. Crew leaders are expected to set examples of fitness levels required by the crew, and lead regular exercise sessions for the crew. It should be noted that these personnel are seasonal staff, who may not be involved in physical activities during the non-fire season, however, very high standards of fitness are required before appointment is carried out, and a high standard of fitness is to be maintained throughout the season. A set of the desired fitness standards for employment is given in Appendix 5. Australian fire organisations are encouraged to investigate fitness training further. The subject of crew fitness is one point that is paramount to both Canadian and United States fire management. Further discussion is found in section 6.4 (Physical fitness and its relation to work safety and output).

Topics covering leadership and supervision qualities, developing teamwork, and basic bush navigation skills are currently covered within the 'Field Supervisor' training programs, now common to most forest services, although often not directly in place for fire training purposes.

3.5.5 INTERAGENCY TRAINING

Although not as evident as in the United States, much effort is made to include officers from other agencies to participate in training courses conducted by the Alberta Forest Service. Unlike the Western United States, and Australia, the province of Alberta has one primary fire suppression organisation for suppressing fires on forested lands. The Forest Service invites officers from agencies who are responsible for issuing fire permits near land managed by the Forest Service, and also conducts courses or invites members of other organisations who are involved in fire suppression (For example Parks Service and other provincial forest services) to attend courses aimed at standardising training for fire fighters within the province.

Co-operative fire fighting agreements between land management agencies in Alberta and neighbouring provinces are also in place. The format of these agreements is similar to those between different states and land management organisations in Australia.

3.6 FIRE SIMULATION TRAINING

3.6.1 INTRODUCTION

To be responsible for decision making in a bushfire situation quite often requires rapid decision making skills under the pressure of loud noise, high temperatures , wind, and possibly smoke. It is difficult for normal training in a classroom situation to prepare the student for the real life event. In the past, much of the training of decision making under these conditions has had to be on the job observing experienced officers at work or by trial and error. Obviously, in some situations there is no room for error, particularly where safety is concerned. To assist in this type of training, simulation of potential events has been developed. Combinations of audio and visual stimulus, similar to those encountered on the fireline, provide conditions designed to put pressure on the student similar to real life situations.

The Alberta Forest Service uses fire simulation as an effective tool in several of its training courses. As has already been mentioned, the simulation program adds a lifelike realism to training exercises by the introduction of both audio and visual stimuli. One advantage of the simulator system is that a wide time frame on a simulated fire can be placed into a short simulator review. For example, the passage of events of an afternoon of fire behaviour may be viewed in a simulation session lasting perhaps 30 to 40 minutes. The package described below is considered the current 'state of the art' technology in this field of training. The US Forest Service is planning to introduce a simulator based on this technology in a mobile form, which can be moved between states or districts on a needs basis.

3.6.2 LASER DISK FIRE SIMULATOR.

The success of training programs with the simulator relies on two factors. Firstly, the quality and quantity of video footage of different aspects of the fire suppression operations, and, secondly, the active participation of the role players as part of a simulation. The reason that this system of training is so effective is because of simulation. The reason that this system of training is so effective is because of realistic visual stimuli. The simulator is based on video laser disc technology. Fire footage from video tapes is transferred onto laser discs. These discs are approximately 25 cm in diameter, and the images are accessed by a video laser disc player. These disc players are not available for general retail purchase but are commercially available. The referee or instuctor of a simulation session can access the images by way of keying on an IBM XT computer, requiring 286 mega-bytes of memory. Before simulation commences, the function keys on the top of the computer keyboard are assigned to either short runs of video images, or still images. The software is fitted with a buffer to store more than one series of images. For example, if a fire tower operator image is called for, there could be photos from 3 or 4 different angles, which would be accessed sequentially each time the type of image is requested. This has the effect of reducing repetition of images, increasing realism.

As mentioned, the simulator requires the participation of role players. These players communicate with a microphone/head set intercom system, adding realism to the simulation because of the comparison to radio traffic involved in fire suppression operations. Each microphone of the role players can be preprogrammed in the same manner as the function keys on the computer keyboard to access a set of images when it is keyed. For example, the tower operator mentioned could be part of the simulation as the reporting party of a lightning strike when the role player keys their microphone an appropriate image is selected by the computer and displayed. Further realism is introduced with the use of a bank of five audio tape players. These too are linked to the microphone system of each role player. By using an appropriate background noise tape, audio stimuli are introduced to the training program. The resulting effect is a training scenario which has a large degree of realism.

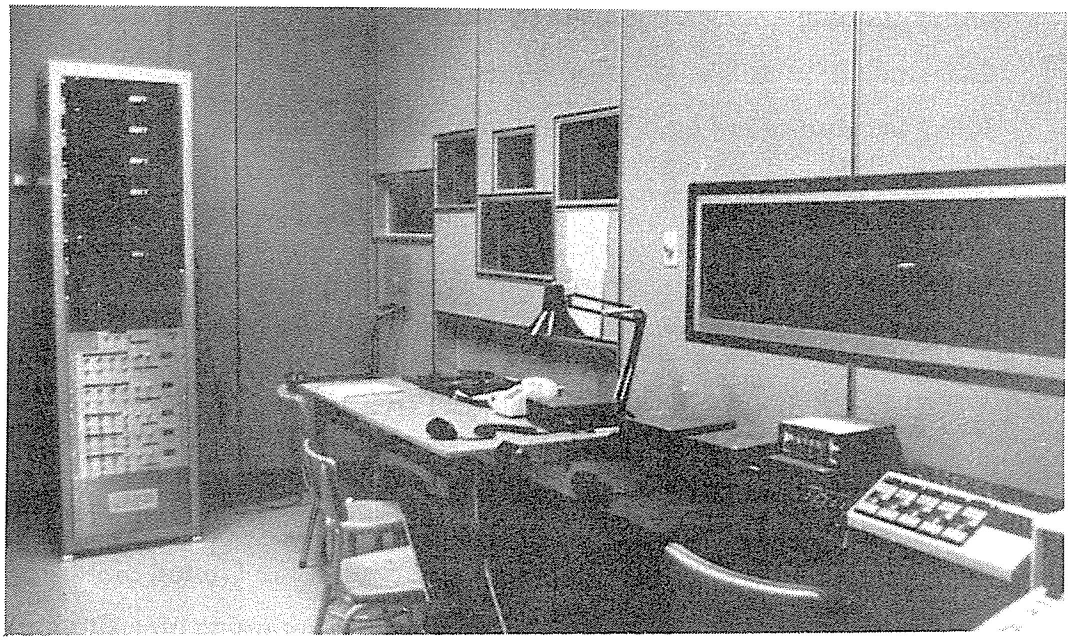

Figure 2: Hardware involved in running the Laser Disc Simulator. Bank of equipment on left includes laser disc player, audio tape players and computer - laser disc player interface. On the table are the role players intercom sets and mixing table (for controlling background noise levels).

3.6.3 STUDENT APPRECIATION OF SIMULATION EXPERIENCES

On several occasions, apprehension was witnessed from students selected for training using the simulator. The common concern was being put in the position of making decisions in front of a group of their peers, in a classroom environment which appears foreign and somewhat hostile. On each occasion the apprehension was quickly dispelled with the high levels of concentration required of the student using the simulator, and the way each simulation seems to be very realistic, and absorbs the students attention. All students that were involved in simulation program during my visit praised very highly the value of such training and expressed desire to have increased access for future training programs. Staff involved with the management of the simulator program claim that the majority of students having experienced simulation training desire increased exposure during future training courses. Discussions with staff from the simulator program claim that student retention of information can significantly increase (by as much as 30%), because of increased student interest associated with 'hands on' training (D. Quintilio pers. comm 1/).

3.6.4 AUSTRALIAN APPLICATION OF FIRE SIMULATION TRAINING.

3.6.4.1 FIELD EXERCISES SIMULATING FIRE OPERATIONS

Cost effective training for crews in fire operations may involve field simulation of fires. This method of training was also observed in the United States, where crews were put through the operation of containing and mopping up a simulated fire and spot fires as part of pre-season certification.

This method of crew training does not necessarily require the lighting of actual fires for crews to work on, but simulated fires, perhaps flagged in the bush, with different scenarios being applied to the situation by instructors aiming to teach fire line awareness. If possible, the use of hazard reduction burns or experimental burns can be made to increase the level of realism.

It is strongly recommended that the forestry services investigate the feasibility of setting up of regular fire simulation training at a district, or regional level as a part of basic and crew leader training programs. It has been found that the closer to realism that training gets, the more that participants get from it.

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3.6.4.2 VIDEO LASER DISC SIMULATOR TRAINING - AUSTRALIAN FEASIBILITY

As mentioned, one of the primary sources of limitation for the simulator is the availability of good quality, relevant video footage. It is considered that much of the footage already an disc and in use by the Alberta Forest Service is of little relevance to fire suppression training in Australia. This leaves open two avenues of obtaining fire behaviour and suppression technique footage. Firstly, it is considered probable that many of the television news services and particularly those in regional centres have stored film footage of bushfire behaviour and suppression forces in their local area. Major fire events such as Ash Wednesday in South Australia and Victoria in 1983, major fires in 1990 near Junee and the Blue Mountains in the 1970's should be available. An example is the Prime television network regional centre in Wagga Wagga, N.S.W. which shows footage of bushfire behaviour as part of the introductory film clip for the regional news broadcast of an evening. The second method of obtaining suitable footage could be to follow up the Canadian example and have a camera crew on standby to move to any large fire event that should start up. It is considered that gaining access to old news footage may provide adequate quality and quantity of footage.

The provision of role players for a simulation can come from those who are conducting the training programs, backed up with members of the training group. Using persons with fire experience, with background knowledge increases the level of realism produced with the simulator.

It is felt that the use of simulation in fire training has applications at the brigade captain/forester/crew boss/ranger level. It is a very useful training tool for any group that will be involved in making decisions on suppression strategy either on the fireline, in aircraft, or as a duty officer/dispatch in the office. By nature of the description of the types of people that this training technique is applicable to, shows that it has a lot of merit as a multi-departmental or interagency co-operative training tool.

Costs involved in establishing such a training facility would not be substantial for any forest service or fire organisation in Australia. The principal cost is the purchase of the hardware. Estimations of cost for video laser disc players are $150,000. All other computer and audio link equipment could be purchased for $20,000, depending on if a portable or permanent system is to be constructed. Initial disc formation for several training scenarios $5000. The software component has been developed by the Alberta Forest Service, who are willing to negotiate a technology transfer. Including the purchase and production of fire behaviour video footage, the cost of establishing a fully functional video disc simulator at time of writing should not exceed $185,000 to $195,000 (Austr.)

The brief length of time spent observing and working with the fire training simulator impressed the important role that such a facility could play in future training programs for Australian bushfire fighters. An opportunity exists to develop a program to promote interagency training. Multi-departmental training will assist the reduction of the barriers that can sometimes form between departments involved in fire suppression in the same area.

It is strongly recommended that potential sources of video footage of Australian fire events be investigated. Large television corporations are expected to have such footage in storage archives. If such visual material is found to be available and affordable, then the feasibility of obtaining a video laser disc playing system should be investigated. It is not known how readily available this technology is in Australia, nor the ability to convert video master images to laser disc. Officers of the Alberta Forest Service have expressed a keenness to assist in the setting up of such a facility with provision of technological advice and assistance with the provision of already developed software packages. Other equipment such as audio cassette players, mixing benches, intercom system and television projector and screen are items readily available in Australia and are not expected to provide problems for supply.

SECTION 4: USE OF FIRE RETARDANT CHEMICALS BY THE ALBERTA FOREST SERVICE

Fire crews employed by the Alberta Forest Service make use of chemicals to increase the effectiveness of water used for fire suppression. Both retardants in the form of Ammonium based salts and foaming agents are used. As part of the study tour it was possible to observe training programs being carried out for both ground and aerial applications.

4.1 GROUND BASED APPLICATIONS - FOAMING CHEMICALS

Three forms of ground application of foaming chemicals were observed in Alberta. Foams are used to both pre treat areas in the path of oncoming fire as well as direct fire suppression in various fuel types.

4.1.1 USE OF TIMBER HARVESTING MACHINERY WITH FOAMING CHEMICAL CAPACITY

The use of timber industry equipment fitted with water tanks and foam induction equipment is one approach to fire suppression used by the Alberta Forest Service. Throughout much of Alberta, harvesting is limited to a small number of months of the year. This is primarily in the winter, when the ground is frozen over and capable of supporting the weight of logging machinery and log trucks. During the summer months after the snow thaw, the ground becomes boggy and incapable of supporting the weight of heavy machinery, particularly trucks. One technique that is used for fire suppression is the fitting of a 500 litre tank to the rear of an articulated skidder (Figure 3). With this equipment is fitted a small pump motor and induction unit to draw foam concentrate from a 20 litre container. The use of an aspirating nozzle to create bubbles is made, with the operator walking through the bush following behind the skidder.

Excellent terrain access is provided by using the skidder, which has the capability of refilling its tank using suction hose and pump motor. A crew of two is required (driver plus hoseman) for efficient use of this resource. Due to low output flows, this system was not seen to be effective as a direct suppression technique, but would be excellent for mop-up operations and pre-treatment of trees with foam before the arrival of the fire front.

Although this technique has been displayed primarily as a training exercise, the foam was used successfully to treat short grass fuels, bark on trees and conifer forest litter.

Whilst skidder tractors are extensively used in Australia, both in the conifer plantation and hardwood districts, these machines are generally dedicated to logging operations in the summer, and may be difficult to acquire for fitting tanks and pumping equipment. The small Honda pump motor does not have sufficient delivery pressure to be used effectively in foam production with hoses larger than approximately 25mm diameter. This, combined with the use of a small diameter aspirating nozzle restricts the distance of the foam propulsion and reduces the quantity and expansion of the bubbles produced. Designing such a system to be rapidly mounted using grapples or winch cables would make such a concept feasible for Australia. The fuel types in which this system has been developed and used successfully (conifer plantations) are found in Australia.

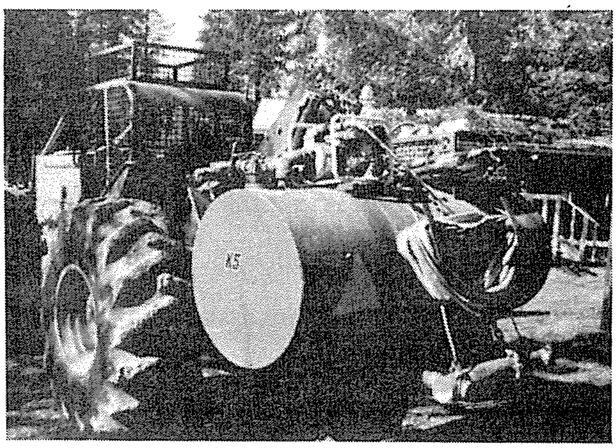

Figure 3: Skidder Tractor fitted with 500 Litre Tank and Foam Induction unit.

4.1.2 PORTABLE PUMPS WITH FOAM INDUCTION CAPACITY.

Native Indian crews, Helitack and Initial Attack crews are trained in the use of hand carried pumps for fire suppression. The main pump involved is the Wajax Mk III pump that can be carried by two people. A small inductor is used to draw foam concentrate from a container into the delivery hose and then pumped through an aspirating nozzle. The Wajax pump is more powerful than the small unit used with the skidder operation, and uses a 1 1/2 inch delivery hose in place of the 1 inch used with the skidder. This also enables the use of a larger aspirating nozzle, which, when combined with higher pump delivery pressure, creates a better quality of foam expansion. Higher pump pressures also produce a more effective propulsion distance.

The use of portable pumps in Australian fire suppression is common for refilling tanker vehicles. Organisations such as the NSW National Parks and Wildlife and Victorian Department of Conservation and the Environment use small portable pumps for direct suppression operations. To install inductors to these pumps will make the water used more effective, for a small increase in the unit weight, and is recommended for further investigation.

4.1.3 COMPRESSED AIR FOAM GENERATION EQUIPMENT

Although this type of foam generation is not used by the Alberta Forest Service, it was possible to observe the operation of a trailer mounted system at a field day at Edson Air Tanker Base (Appendix 6). This approach to foam generation is more expensive than other induction systems used for portable pumps, however does produce a high quality foam expansion, and depending upon flow rates, also produces good propulsion. Figure 4 shows the propulsion and quality of foam produced by the compressed air foam generator marketed by the Monsanto Chemical Company. As mentioned, this technique is expensive. The unit shown in figure 4 is priced at $10,000.00 (Canadian). This is a significant increase in cost to produce a higher quality of foam, but not considered to provide a positive cost benefit.

Figure 4 Fire Fighting foam produced by compressed air foam system.

4.2 AERIAL APPLICATION OF LONG TERM FIRE RETARDANTS

As Alberta has a large quantity of inaccessible terrain, a large amount of the fire suppression effort rests with the use of aircraft. Both fixed wing and helicopters are employed extensively throughout the province for crew transportation and application of fire retardants. During the severe part of the fire season, the Alberta Forest Service is capable of having sixty helicopters and sixteen large sized (tank size larger than 3000 litres) air tanker aircraft on standby.

As found in the United States, the large, ex-military aircraft are more readily available for conversion to this type of work. Unless the Australian Federal Government assists with the provision of similar aircraft, perhaps for example the Grumman Tracker aircraft, mothballed following the sale of the HMAS Melbourne or unused C-130 Hercules Transports, then the large scale use of this type of aircraft in fire suppression is unlikely.

4.2.1 FIXED WING AIRCRAFT - RETARDANT APPLICATION

All fixed wing aircraft contracted to the Alberta Forest Service are set up to utilise fire retardants. The primary aim of the use of aircraft with retardant carrying capability is initial attack on small fires. By doing this, the fire can be slowed up sufficiently to permit ground crews to properly contain the fire.

Air Tanker Bases are located throughout the province (Appendix 6). Not all are occupied with aircraft during the fire season, with air tanker groups moving within the province on a needs basis. Most bases are equipped with storage, mixing and pumping facilities for retardant, with a crew to manage the running of the base. Alberta maintains up to 16 aircraft on standby during the summer, divided up into tanker groups of one, two or three aircraft. The retardant carrying capacity of each aircraft type is varied, but is between 3,500 and 11,360 litres.

4.2.2 FIXED WING AIRCRAFT - FOAM APPLICATION

The Canadair CL-215 is the main system used to aerially apply foam chemicals. This aircraft has the capability to skim lakes for refilling purposes. Within the aircraft is a foam concentrate tank, from which the aircrew can inject varied volumes of foam into the water bay, changing foam concentrations to suit vegetation types. This system of foam generation is used in close proximity to the fire line as a direct retarding agent. Because of large quantities of foam being laid down each pass, an effective fire retardant blanket is produced. One limiting factor of this system is that if a large concentration of foam concentrate is employed, then it is possible that foam reserves may run out before fuel supplies, requiring the aircraft to either have to return to base for more concentrate or drop only water.

4.2.3 HELICOPTER - FOAM APPLICATION

As in Australia, different types of water carrying systems are used with helicopters. Both buckets and belly tanks are used. To increase the effectiveness of the water for fire fighting, foam concentrate is injected into the water, and when the water is released, the action of the air moving over the liquid causes bubbles to form. A blanket of foam bubbles is laid down along the fire edge, which can be regulated by changing the airspeed of the helicopter when dropping.

These injection units do not add significant weight to the helicopter, and do not restrict the quantity of water that they can carry.

Appendix 4 shows the typical set up of foam injection units for bucket systems in light helicopters.

Most water delivery systems employed on helicopters in Australia are either direct use of Canadian systems or modifications of them. The introduction of foam injection into buckets and belly tanks has been found to not significantly effect the water carrying capacity of the helicopter, and does provide a positive increase in the effectiveness of this operation. Several helicopters used for fire suppression in Victoria are currently fitted with such foam injectors. It is recommended that those organisations employing helicopters for fire suppression operations investigate the introduction of foam injection into their machines.

SECTION 5: OTHER ASPECTS OF FIRE MANAGEMENT PRACTICES OBSERVED IN ALBERTA

Other aspects of fire management were also observed as part of the study tour within Alberta. Most items observed were components of the pre-suppression planning programs.

5.1 LIGHTNING DETECTION SYSTEMS

An efficient lightning detection system is in place in all Forest Headquarters within the province. This system, similar to one in place in Eastern Australia shows on a map overlay within the computer program display the locations of lightning strikes as they occur, and is a significant aid in allocating resources for both detection and initial attack.

As mentioned, this aid is already available in Australia. One example of such a system is used by the Electricity Commission of NSW. Because of the resistance to fire of much of the native vegetation of Australia, there is not such a high priority in knowing the exact location of each lightning strike, although the use of such an aid would be useful in guiding spotter aircraft to potential fire sites. The forestry services with substantial capital investments in fire sensitive species such as conifer plantations may justify the expense of setting up such a system, but it is not expected that a broad scale implementation will take place

5.2 INTELLIGENT FIRE MANAGEMENT INFORMATION SYSTEM (IFMIS)

IFMIS is a computer based package designed to assist the forest officer responsible for planning resource movements etc in decision making. The system is based on a geographic information system (GIS) linked with a powerful data base. Graphical displays of the forest or region, incorporated with a data base storing information of fuel types, levels of curing, weather, crew location and size, can be used to show relative fire danger in any given area and provide options for crew and other fire suppression resource movements.

It is planned to establish IFMIS in all Forest Headquarters in Alberta, as funding permits. The dissemination of the relevant fire management information can then be passed to District level staff as needed.

All Australian forestry and fire organisations that possess computer systems with data base and geographic information systems have the capability to produce a system similar to IFMIS. It is considered that this approach may be too specialised for some Australian organisationss, particularly the volunteer fire fighter network, who change locations to fight fires rather than be on standby for potential fires. The forestry services, however, move crews around based on potential fire danger, and can use such a system to show the potential fire hazard within the state, possibly helping with decision making on inter regional crew movements.

5.3 PRE-SUPPRESSION PREPAREDNESS SYSTEM (PPS)

All of Alberta is involved in the pre-suppression preparedness system. Sections 5.1 and 5.2 deal with items that directly link with the PPS program. The concept was established after the bad fire season of 1982, and was developed around the following key points:

1. Recognising key factors from the Fire Weather Index system that indicate potentially severe fire behaviour in different areas of the province.

2. Distinguishing of main fuel types in the province, their distribution, crown fire potential and resistance to control of fire.

3. Determination of acceptable initial attack times as related to potential fire behaviour within the recognised fuel types.

4. Identification of predetermined strategic initial attack centres that provide optimum coverage of forested areas, depending on current fire danger, values at risk, standby 'Manup' levels

5. Identification of areas of high value or high protection priority

6. Initial attack resources must be in place and in sufficient quantities, based on predicted fire danger levels, in order to reduce assembly and dispatch times, and increasing initial attack effectiveness

7. The economics of the system is to make use of some of the funding that would normally be expended on large fire suppression, for up front pre-suppression. Investment is made in the form of pre-suppression in order to reduce the cost and impact of campaign fires.

Forestry services in Australia have fire contingency plans, which include many of the aspects of the pre suppresion preparedness system. Topics such as fuels management, cooperative fire fighting agreements, protection priority classification etc are included in fire management plans of forestry services and other land management organisations.

SECTION 6: FIRE STUDY TOUR OF THE UNITED STATES OF AMERICA

The section of the study tour located in the United States was primarily aimed at investigating fire crew training techniques and the management of these human resources in fire suppression operations. The Author was a working member of a United States Department of Agriculture (USDA) Forest Service Hot Shot fire crew for the duration of the late spring and most of the summer.

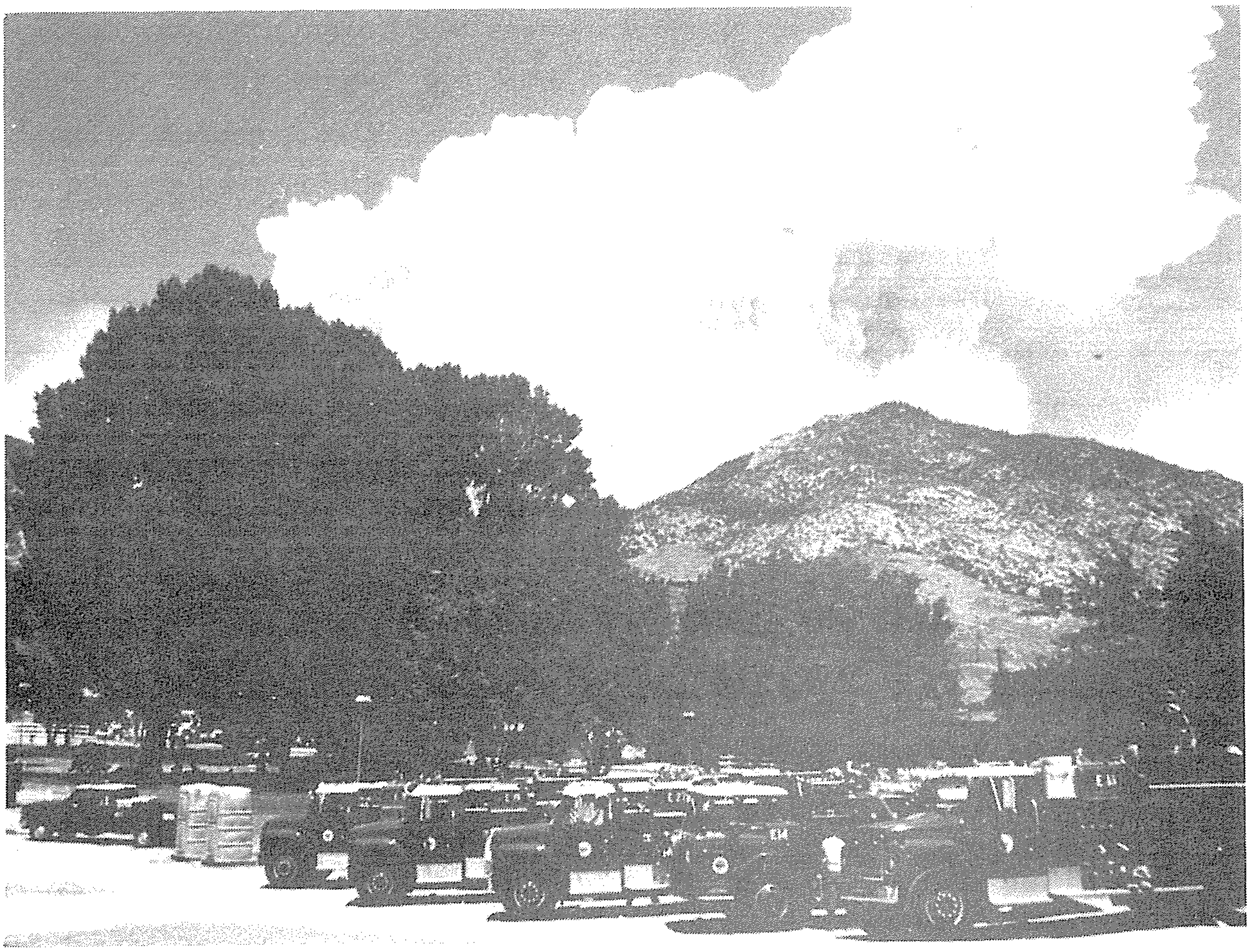

Figure 5: Smoke column rising behind Fire Engines, Stormy Complex Fire, Kernville, Southern California. August 1990.

6.1 INTRODUCTION

The majority of all forest operations in the United States are carried out by federal rather than state based forest services. Several states also have a state forest service to assist with fire suppression and forestry duties. The majority of wildland fire suppression is, however the reponsibility of the US Department of Agriculture, Forest Service. Other government organisations such as the Federal Bureau of land Management also participate in fire management. In the State of California, the California Department of Forestry are also heavily involved in fire suppression operations.

All departments participate in cooperative fire fighting agreements. To manage this, a uniform training program has been developed so that officers from the different organisations can fill different roles at a fire, independent of the overall land management authority in charge of the area. This incident command system has developed to the extent that people from all over the country and different organisations can form together as a working management team at a fire.

Fire crews are classified according to qualifications. Type 1 fire crews have high levels of fitness and supervision, and are used for more arduous, dangerous tasks. Crews such as the Smoke Jumpers, Hotshots, Rapitack and some of the minimum security prison inmate crews in California are qualified as type 1. Type 2 crews are generally used for less arduous, and certainly less dangerous tasks, particularly mop up. Student crews and some native crews and other inmate crews are qualified only for type 2 duties.

All people, including the inmate crews are paid for their services at fires. This is one major difference with fire suppression operations in Australia. There are no unpaid volunteer fire fighters in America. Based on this fact, and the possibility that there could be more than 1000 people involved in the suppression of a fire (depending on size) for periods of several weeks, fire suppression is a very expensive component of the USDA Forest Service budget.

6.2 USDA FOREST SERVICE HOTSHOT CREW

6.2.1 INTRODUCTION

A USDA Forest Service Hot Shot fire crew is recognised as a mobile, well trained, and independent crew for wildland fire suppression. Crews are comprised of a minimum of 17 people, but generally 20 persons, with no more than two persons with less than one season of fire fighting experience. The majority of the members of each crew are seasonal employees, engaged for the duration of the fire season, and led by a small core of permanent Forest Service staff. For example, the Lassen Hotshots in 1990 have three permanent forest service employees, and 17 seasonally employed fire fighters. A Hotshot crew is self sufficient in providing tools, communications equipment and transportation, work together as a team on a daily basis and have a permanent supervising superintendent assigned to them. Hotshot crews are a national and interagency resource, and are expected to operate anywhere in the United States or elsewhere, regardless of events taking place within their own base district should they be dispatched away.

The USDA Forest Service maintains 51 Hotshot Crews, and with several other local government and federal government departments (e.g. Kern County, Bureau of Land Management and Bureau of Indian Affairs) providing others, the total number of Interagency Hotshot crews is approximately 56 (However this figure changes regularly). If the total number of personnel involved in Hotshot crew operations is compared with the overall number of personnel involved in wildland fire suppression in the United States, this figure represents approximately one percent of the overall number.

Seventeen Hotshot crews are stationed in California, with seven based in the north. These crews are controlled by North Zone Dispatch facility located in Redding (Appendix 2). The days worked by crews are staggered so that a maximum number of crews are working seven days a week. Effectively, the crews are on permanent standby, being prepared for dispatch twenty four hours a day seven days a week.

Duration away from home whilst on fire assignment is not restricted. It is not uncommon for crews to be involved in tours of four to five weeks duration during the peak part of the season. For example, the Lassen Hotshots were away for forty two days consecutively during the Yellowstone National Park fires of 1988, before being relieved. During the 1990 fire season several crews from California were dispatched to Alaska for five weeks.

As discussed in section 6.4, physical fitness is considered paramount in the management of Hotshot fire crews. The physical qualifications to obtain an Incident Qualification Card or 'Red Card' as a member of a Hotshot crew are described as 'arduous'. To test aerobic fitness, the indicator used to determine fitness qualifications, each crew member is required to pass a step test (section 6.4). To promote physical fitness, regular physical training programs are carried out whilst not on fire assignment. These programs are designed to increase both aerobic capacity and muscular strength and stamina. At various periods throughout the fire season, testing may be carried out to gauge improvement in crew member fitness. If any crew members are found to be unsuitable in fitness standard, they may be layed off based on safety grounds.

Physical fitness becomes an important consideration when looking at the lengths of shift sometimes carried out by Hotshot crews. Shifts worked are generally much longer than are carried out by professional crews in Australia. Several fires attended during the 1990 fire season included shifts of more than 30 hours duration. These shift lengths include transportation time to the fire, and actual fire fighting operations.

All members of a Hotshot crew are required to complete what is known as the Basic 32 Course. In Susanville, the base of the Lassen Hotshots, this course is conducted at the local college, and is divided into two primary sections :

1. Basic Fire Fighter Training and
2. Introduction to Fire Behaviour.

The subjects taught as part of this course are repeated during the initial two weeks of the fire season as part of the Hotshot training program (Section 6.3).

Figure 6: The Lassen Hotshots, 1990. Savage Fire, Mariposa, Central California, September, 1990.

6.3 BREAKDOWN OF PRE-SEASON TRAINING COURSES CONDUCTED BY LASSEN HOTSHOTS

A two week period at the start of the season is allocated for crew training. In past years where bad fire seasons had commenced early, or perhaps the crew had formed later in the year, it was not always possible to finish the training program. For the 1990 fire season, the weather did not produce an early start and it was possible to complete all of the training program uninterrupted. The following represents the subjects presented and length of time involved in training for two weeks:

1. Orientation and Policy: 8 hours. Crew members are taken through the different paper work involved in signing on to a fire crew for the summer. The different members of the crew are introduced and their backgrounds discussed. An initial crew order is presented, including the breakdown of the crew into a tool order , squads and lightning strike teams. Tool order represents the position of each member of the crew along the line when constructing fire line. Each member of the crew is assigned a particular tool (Figure 9) and the respective position of that tool. The most common tool order is given in Appendix 10. Crews are also broken down into squads and lightning strike teams for work on small spot fires or lightning strikes. Each squad or lightning team is self contained with at least one of each type of hand tool, and supervisor. The distribution of chainsaw fuel and oil containers within the crew are also allocated. Each member of the crew carries a minimum of one litre of chainsaw fuel, and approximately half of the crew also carry chain oil.

2. Physical Training

   Between 1 and 1 1/2 hours on a daily basis. This training is continued throughout the fire season whilst the crew is in station. Training includes exercises to improve aerobic capacity, including running and jumping jacks, exercises to improve muscular strength and endurance including situps, push-ups, abdominal crunches, chinups and bar dips. Stretching to reduce likelihood of muscle damage during exercises and improving flexibility is also carried out. Crew members must be of a certain fitness level before being appointed. The aerobic capacity of each crew member is tested using the step test (6.4) at the start of the season. As mentioned it is possible that people can be laid off from the crew on safety grounds if they show that they are unable to reach a certain fitness standard.

3. Basic equipment - 2 Hours

Setting up web gear (fireline packs), ensuring each crew member is issued with the correct equipment (safety equipment, headlamp, fire shelter, clothing, hard hat, safety glasses, earplugs etc) also the setting up of Red Bags (Fire Bag) with personal equipment (sleeping bag, tent, spare fire fighting and civilian clothing, toiletries etc.). Carry out weight manifesting for each crew member for air transport purposes.

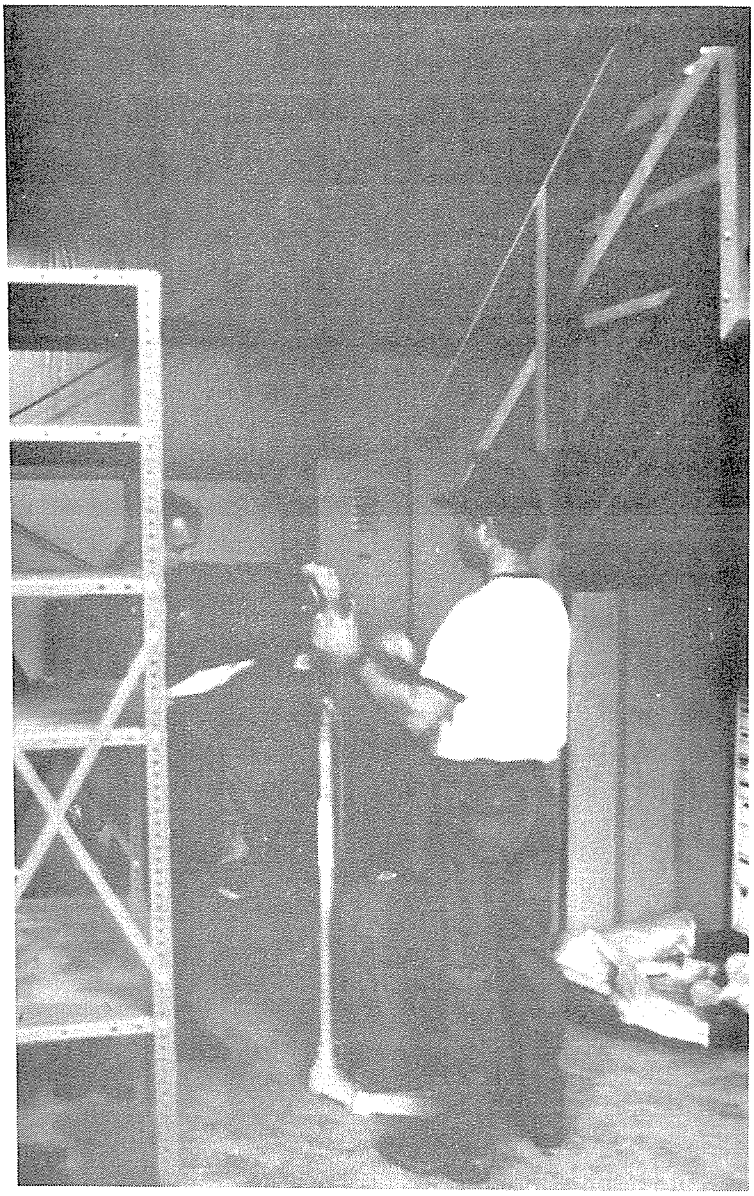

Figure 7: Crew Member conducting weight manifest of fire equipment.

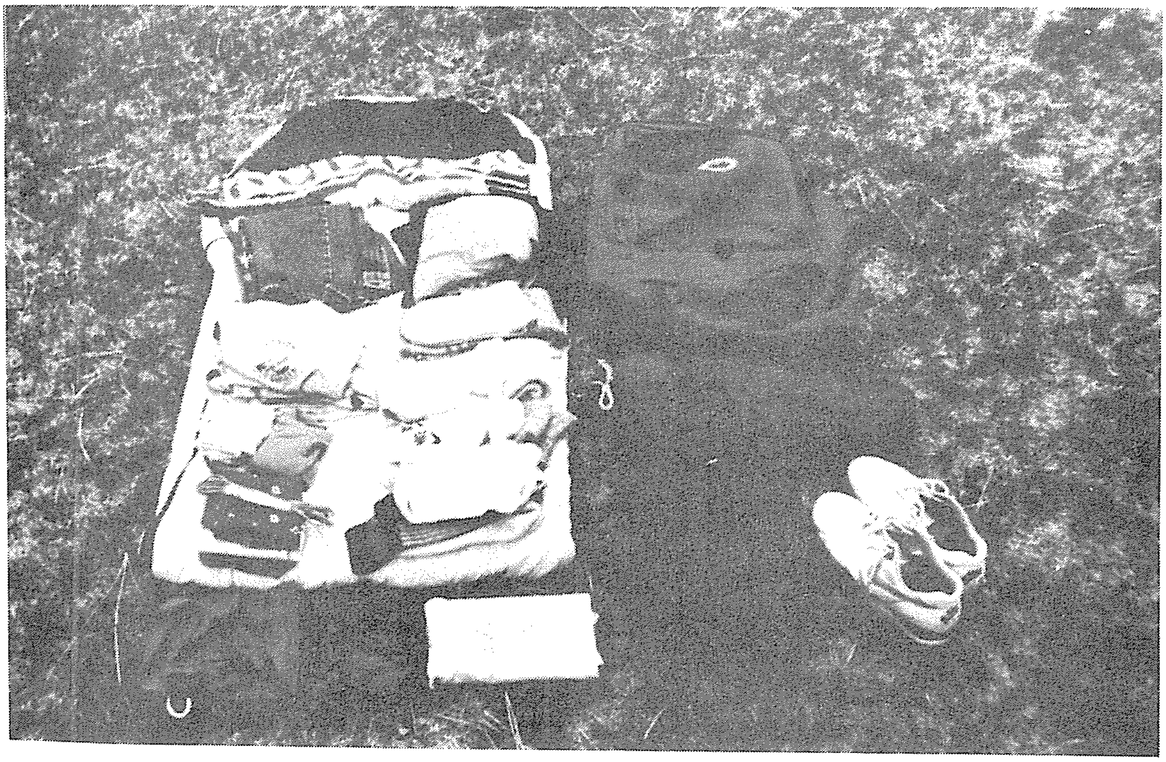

Figure 8: Contents of Red Bag (Fire Bag): Spare Clothes, Sleeping Bag, Tent, Toiletries.

4. Fire Shelters - 4 Hours

   Crew members are required to be able to deploy their personal fire shelters within 30 seconds of instructions for deployment being given. Practice is carried out to ensure that this level is reached by all crew members.

5. Hand Tools (Use and Maintenance): 4 Hours. Within the Hotshot organisation, all hand tools are sharpened by hand using ten inch mill bastard files. All members of the crew are trained to sharpen each of the tools used by the crew in fire suppression operations. These tools include: Shovel, rakehoe (McLeod Tool), Pulaski (small mattock) and speciality combination tools (Figure 9) The purpose and correct method of use for each type of hand tool for different fuel types is discussed and demonstrated, along with the correct method for carrying each tool in the field and storage in vehicles and aircraft.

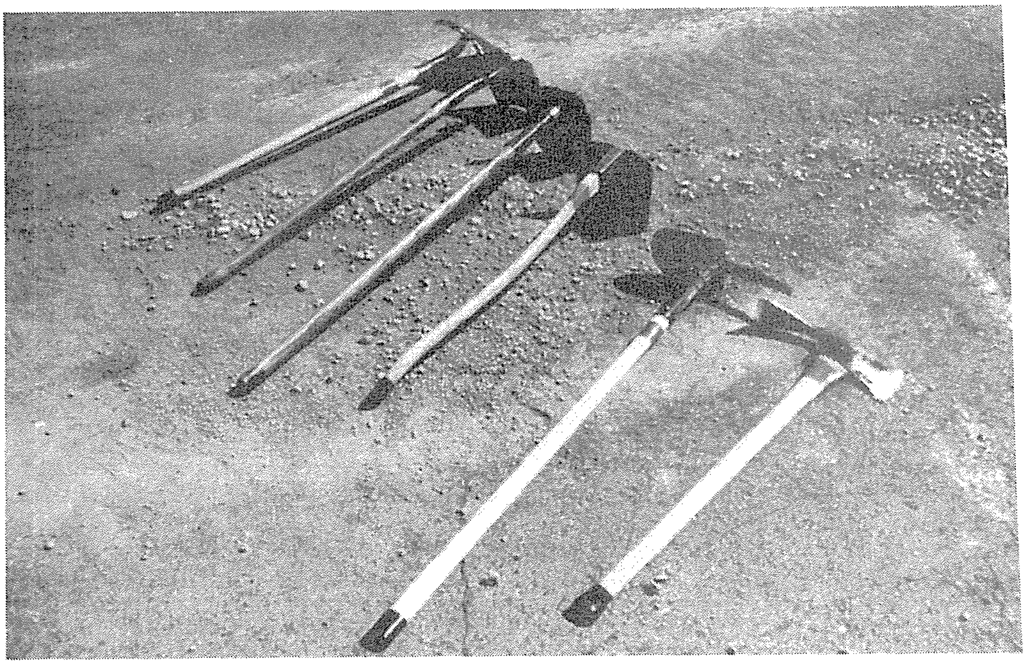

Figure 9: Hand Tools used by Fire Crews in the United States. (Left to Right) Shovel, four combination tools, Pulaski.

6. Line Construction: 8 Hours. The use of different sized control lines depending on fuel type and fire behaviour is discussed. The rationale behind selecting a line of a certain width is covered, including the syntax used to describe construction of control lines. For example, a handline described as six and three is actually a chainsaw cut through the undergrowth of six feet wide and the scrape down to bare mineral soil is to be three feet wide. This size of line construction is the standard used for most fuel types in California, and is the assumed standard of line construction unless otherwise specified.

Practice sessions constructing hand lines are carried out at a nearby logging coupe. Here the crew are taught how to share the workload evenly between crew members, as well as acceptable quality of the line construction. Terms such as 'Hit And Lick',and 'Mode One' are taught. Hit and Lick occurs when the crew putting in hand line only hits the ground with their tool every one or two steps, and is an effective way to put in hand line in light fuel types, at high speed. Mode one is the term used to described emergency line construction where a crew is trying to cover as much ground as possible in a short period of time. This technique is especially useful in combating small spot fires.

Figure 10: Lassen Hotshots hand line construction training session on Mount Antelope, Northern California, May 1990.

7. Fire Assessment - 2 Hours

Crew members are taught to size up a fire on initial approach, making estimations of predicted and current fire behaviour (for example directions of forward spread, spotting potential etc.). A discussion of recommended methods of initial attack using available crew resources is carried out. Crew safety and effective crew placement are also discussed.

8. Chain Saw Course - 16 Hours

It is desirable to have all members of a Hotshot crew certified to operate chainsaws on the fire line. Depending upon competence using the saw and theory qualifications each crew member is certified to fall trees up to a certain diameter at breast height. A one day theory course is conducted, discussing safe operating procedures of saws in the field, and saw maintenance. This is concluded with a written exam. Crew members are taught to pull down a chainsaw and check or replace components in the engine of the different types of saw used by the crew. Each member of the crew is certified in the field by a qualified instructor after completing a falling and cross cutting exercise on a tree of the appropriate diameter class.

The diameter classes for fallers are as follows:

a) Trees less than eight inches in diameter
b) Trees less than twenty four inches in diameter
c) Fully qualified faller - unlimited diameter constraints.

Each crew member is issued with a falling qualification card which, like the 'Red Card' should be carried at all times on fire operations.

9. Firing Equipment: 2 Hours. Crew members are introduced to the different types of equipment they may use in burning operations. Such equipment includes: Drip torch, Fusee, Very Pistol, Burnol Canisters and other forms of explosive devices. Crew are trained in safe techniques to use incendiary devices including correct ratios for mixing drip torch fuel and ignition techniques for different fuel types and topography.

10. Equal Employment Opportunity, 'Shades of Grey': 4 Hours. All members of the crew are required to view a training video based on sexual discrimination in the workplace, and participate in a discussion aimed to eliminate or reduce problems. A film discussing hygienic requirements of both males and females discussing commonly experienced medical problems found at fires is also presented.

11. Helicopter and Air Procedures: 2 Hours. Basic safety whilst operating around helicopters and fixed wing aircraft are discussed. Crew are presented with a pair of Nomex flight gloves which are to be worn whilst in helicopters. Other requirements for personal safety are discussed including doing up the top button of the Nomex fire shirt, collar bent upwards, safety glasses and earplugs in place.

Correct lay out for helipads constructed in the field are discussed, including size, location, and how to incorporate weather conditions such as wind in the lay out of the helipad. Basic hand signals to assist the pilot in manoeuvring within tight areas are also presented.

The layout of Northzone dispatch centre located at Redding airport is discussed. Procedures to be employed when arriving at Northzone, including unloading of vehicles, loading of aircraft etc. are covered. This is important for most interstate fire assignments, when the crews are likely to be flown rather than drive. Correct loading procedures for the different types of aircraft contracted to the government for the fire season are also discussed.

Figure 11: Lassen Hotshot crew transportation using Helicopter. Stormy Complex Fire, Kernville, Southern California, August 1990. Note the use of safety clothing whilst operating around helicopters (including top button of nomex shirt done up, nomex flight gloves, safety glasses and earplugs)

12. Ten Standard Fire Fighting Orders and Eighteen situations that shout 'Watchout' - 4 Hours

The Ten standard fire fighting orders and situations that shout watchout are presented in Appendix 7. Each crew member is required to have the fire fighting orders committed to memory after developing an understanding of their meaning and relevance to fire fighters. Examples of each situation using experiences of the instructors are provided. A small card copy of each of the 10 standard fire orders and 18 watchout situations is presented to the crew and must be kept with them at all times.

13. Radio Communication - 1 Hour

Each of the different types of radio used by the crew are discussed, including basic preventative maintenance and correct use. Syntax to be used in radio work is taught (for example many words are similar to those used in aviation, such as: copy, roger, negative, affirmative etc), in conjunction with the most commonly used radio frequencies, and their functions.

14. Distance and Acreage - 2 Hours

Crew members are taught to estimate distances and areas in the field without using any measuring equipment. For example, pacing and horizontal distance and visually estimating areas of different size, based on pacing estimations are taught.

15. Mop-up - 2 Hours

Wet and Dry techniques for mop-up operations are presented, including basic safety considerations, and gridding techniques to search for heat sources and potential spot fires. Some examples of how to use each of the different hand tools for mop-up operations are also given.

16. Pumps and Hoselays - 2 Hours

The different types of hoses and fittings and their roles in different suppression operations are presented, in conjunction with the likely role of a Hotshot crew in construction, usage and breakdown of hoselays. Basic hydraulics, including pump pressure to achieve water flow up or downhill are discussed, with some theoretical exercises carried out in calculating required pump pressures to elevate water to different altitudes to achieve a given outlet pressure. Operation, maintenance and trouble shooting for a Wajax Mk III petrol powered pump is also given.

17. Fireline Safety - 2 Hours

This section of the course includes a discussion of how to care for your protective safety equipment (safety glasses, gloves etc.) and how to watch for signs of both physical and mental trouble in other members of the crew. Of particular concern to all firefighters is heat stress and how to reduce or treat it. An emphasis is also placed on keeping a knowledge of safety zone locations and escape routes and maintaining good communications with other crew members working around you. A study of the causes of some fatal accidents on fires is also presented and discussed.

18. Fire Transportation - 2 Hours

The different forms of ground transport available to crews at fires is discussed, including buses and crew carriers. Setting up the Hotshot crew carriers is finalised. This is done on a squad basis, with each member of a squad allocated a seat in the carrier, and allocated a place to store their equipment. Storage of other equipment such as ration packs, firing equipment, chainsaws and other hand tools are also shown.

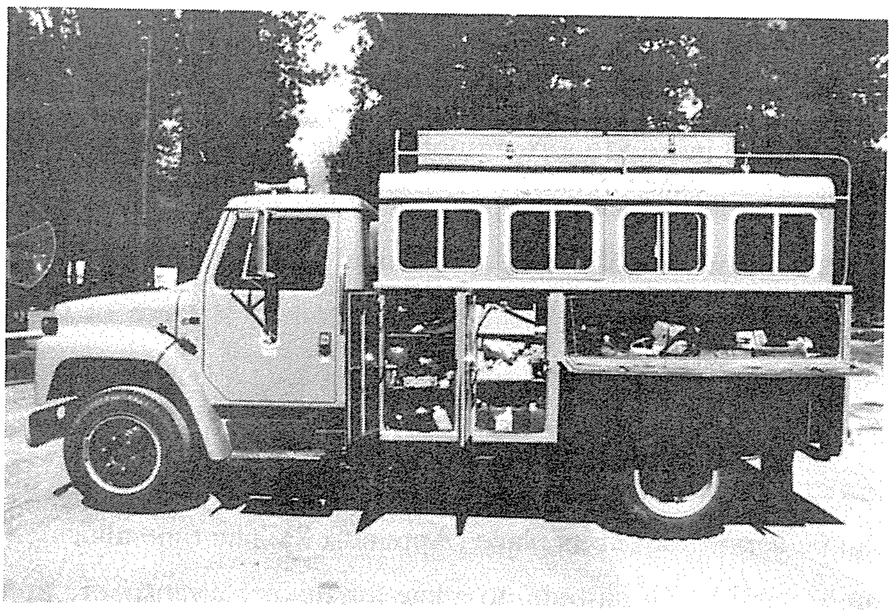

Figure 12: Lassen Hotshot Crew Transportation. The crew maintains two such vehicles.

6.4 PHYSICAL FITNESS, SAFETY AND WORK OUTPUT.

Since the mid 1960's, the USDA Forest Service has placed a strong emphasis on the physical fitness of its fire crews. Following a study of wildland fire fighters in 1965, it was concluded that the most limiting factor to a fire fighters work capacity was oxygen intake capacity or aerobic fitness. Poor fitness can lead to poor work output, injury or worse. The ability to maintain arduous fire fighting physical activity (such as hand line construction against active fire fronts) throughout a shift is dependent upon a continual supply of oxygen, and the efficient transportation of this oxygen to the muscles. In arduous situations, the drain on the body is compounded by heat, wind, altitude, and other emotional strains involving personal safety etc.

Improved physical health leads to not only increased work output, but safer fire operations, with reduced injury rates. It is widely considered that the time when most accidents occur is when fire fighters are weary, after a prolonged period of work and little sleep. Unfit workers can quickly become a hazard to not only themselves, but those working around them.

Oxygen is the most limiting factor involved in work capacity. To test the level of aerobic fitness, all fire fighters must pass a step test (Appendix 8). This involves stepping up and down from a box fifteen and a half inches high (Thirteen inches for females) in step to a metronome sounding at ninety beats per minute. At the conclusion of five minutes a pulse count is taken and placed into an equation that takes account of both body weight and age, to produce a fitness score. To be eligible to become a Hotshot crew member, a score of one or two must be achieved.

If a crew member has difficulty with the step test, then a one and a half mile run can be carried out in its place (Appendix 8). The time allocated to complete this run is varied with altitude, to allow for thinner atmosphere and reduced oxygen availability, but may be a better indicator of aerobic capacity of older persons. An interesting point in comparing the two types of aerobic test showed up at the completion of a timed 1 1/2 mile run completed by the Lassen hot shots. There were no people on the crew who completed the run in a time that achieved a physical fitness score higher than 2, yet 12 members of the crew were rated as a fitness level of 1 based on the step test results. The conditions under which the run were carried out could be part of this disparity, however, I feel it shows up a major difference in the results obtained from the two different testing systems.

It would be obvious to state that muscular strength and work capacity are directly related. A certain level of muscular strength is required to achieve different tasks in the field. Muscular endurance is required for repetition of the task or ability to carry out others.

As discussed in section 3.5.4, a set level of muscular strength and endurance must be achieved to be taken on as a crew member of initial attack crews and helitack crews in Canada. Similar standards are used in the selection procedures for Smoke Jumper and Hotshot crews.

The muscle groups that are identified for exercising are the arm and shoulders, abdomen, and legs. To strengthen these muscle groups, the following exercises are carried out on a daily basis, when not on fire assignment:

1. Pullups (Chinups)

   Each crew member must achieve at least twenty, generally carried out in repetitions or sets to build up to twenty. This exercise strengthens the arm and shoulder muscles, which are utilised in digging and scraping dirt when constructing fire line, lifting and carrying heavy loads through the bush (for example, carrying chainsaws for prolonged periods, dragging charged or wet fire hose etc), pulling heavy objects such as smouldering logs, fire hose etc.

2. Pushups
This exercise is carried out to increase arm and shoulder muscle endurance. This is considered important for such work as McLeod tool or shovel work. This exercise is generally carried out as a crew and all crew members would be expected to be able to complete a minimum of 20 - 25 push ups in one set. To supplement this exercise, the Lassen Hotshots also complete 20 Bardips. This exercise is similar to the push-up, except that the whole body is suspended by the arms on two parallel bars. Again, repetitions and sets are normally used to achieve a total of 20.

3. Situps
Abdominal muscular fitness is indirectly related to work capacity, however strong abdominal muscles are responsible for reducing lower back injuries. A study carried out in the United States has found that over 50% of people involved in hard labour complain of back problems, and that of these problems 80% are muscular in nature. Generally, 60 situps of differing types are completed in a session, commonly in sets of 15.

To supplement this exercise, many hotshot crews also complete a series of Abdominal crunches where the muscles are required to suspend the legs and the back off the ground, similar to a V-Sit, for a count of 10 seconds. 10 repetitions of these are carried out.

4. Leg muscles which are required for hiking and carrying equipment are strengthened by carrying out project work. Projects vary with the crew, however, chainsaw thinning of logging blocks, light construction work and fuels management (hazard reduction burn preparation and burning) are common. Often, much of these projects involve working in hilly terrain with logging slash on the ground, strengthening the legs due to non-uniformity of terrain (Having to climb over logs, rocks etc.) Permanent staff involved in fire suppression are paid to carry out an hour a day, three days a week training during the winter to maintain good fitness levels. This changes to an hour a day, five days a week during the summer. It is

recommended that serious consideration be given to following this example within the forestry services of Australia.

6.5 COMPARISON OF USDA FOREST SERVICE CREWS WITH FIRE CREWS IN AUSTRALIA

6.5.1 CREW SIZE

Possibly the most significant feature in the comparison of fire crews in the two countries is size. The average size of a fire crew in the forestry services in Australia is five to eight people. The minimum number for a type one hand crew working for the USDA Forest Service is seventeen, but generally twenty. Many more people can be involved in fire suppression operations in the United States than Australia. For example, a 10,000 hectare fire in southern California was attended by 1200 personnel, for a duration of 12 days. The majority of these were organised in crews of 17 to 20 persons.

6.5.2 CREW MANAGEMENT

In difficult fuel types such as shrub (similar to ti-tree) it is not uncommon for more than one crew to be involved in the line construction operation. An example observed of this type of suppression organisation included the use of six type one crews to put in a hand line of approximately two kilometers in length in very steep terrain. Due to the nature of the fuel types, this operation still required approximately twelve hours to complete. As many fires are fought in forests where conifers are the dominant fuel type, a large emphasis is placed upon the use of chainsaws to remove the lower branches from over the hand line. Depending upon the fuel characteristics, this can mean the use of up to three chainsaws with offsiders (Swampers) to clear a path for the hand tool component of the crew.

United States crews are instructed in the methods of field sharpening equipment such as hand tools. All crew members carry a file to keep the edge of their hand tool sharp. This is considered important in the fuel types often encountered, where, due to deeper duff layers, there is a need for more digging than scraping of fine fuel components to be carried out, and a sharp tool provides an advantage.

As the Hotshot crews are an interagency resource, they can be expected to travel anywhere within the United States to participate in fire suppression operations. This can involve long periods of travel before having to put in a shift at the fire. It is common for the crews to be dispatched at any hour of the night, depending upon calls for resources at fires.

The Fire Suppression budget of the USDA Forest Service is substantially larger than that of the Forestry Services of Australia. Accordingly, the crews are encouraged to work long shifts on the fire line, earning substantial overtime payments. As travel time is included in a shift, it is not unusual for a crew to conduct a thirty hour shift as the first shift on a fire. As mentioned, there are no unpaid volunteers involved in fire operations, causing the cost of fire operations to be significantly higher than Australia (cost of large numbers of Aircraft and large numbers of staff also influence this figure). For example, the total cost for a fire operation lasting 11 days, involving up to 10 aircraft during daylight hours, and a further 12 helicopters of various size, manned by 1200 personnel exceeded 9.5 million dollars.

6.5.3 PROTECTIVE CLOTHING AND SAFETY EQUIPMENT

6.5.3.1 PROTECTIVE APPAREL

As mentioned, all fire fighters in America are supplied with "Nomex" or "Aramid" fabric clothing. This material is similar in composition to but not as thick as racing car or pilot flight suits, and is used because of its fire resistance. Nomex material will burn in the constant presence of a high intensity flame, but will extinguish almost immediately upon removal from flame contact.

The clothing issued is in the form of long trousers and long sleeve, button up shirts. One detrimental property of nomex is a build up in radiant heat. This characteristic is in contrast to the commonly used fabrics, cotton and wool, used by fire fighters in Australia, which disperse radiant heat well. This accumulation of radiant heat has been found to be a problem in mop up operations where fire fighters come into close contact with radiant heat sources such as smouldering logs and stump holes. In the most severe cases, radiation burns can result from direct skin contact with the fabric. To prevent this occurring to the upper body, most fire fighters used in direct suppression operations (such as hand line construction against active fire fronts or use of hoses from tankers for active flame knock down etc) wear cotton tee shirts under the nomex fire shirt.

Studies conducted in Australia by Budd and others of the National Institute of Occupational Health and Safety have found that heavy clothing, often preferred by urban fire fighters, are unsuitable for bush fire fighters. The high levels of insulation prevent sufficient evapouration, with increased sweating, and increased levels of heat storage, possibly leading to heat stress and perhaps heat exhaustion. (G. Budd pers. comm. 2/). Light weight cotton clothing provides adequate protection from radiant heat, while allowing ventilation of heat built up by exertion.

From this study, plus personal experience, it is recommended that fire services in Australia pursue the increased use of cotton clothing for fire fighters. If concern is raised about flame resistance, there are varieties of clothing available with chemical treatments such as "Proban" or "Proban II" fire retardant to improve protection.

6.5.3.2 SURVIVAL SHELTERS

All staff involved in fire suppresion operations are required to be competant at deploying a fire survival shelter (Appendix 11). These units are light weight single person tents, shaped similar to an 'A frame' tent, and constructed of a thick foil

2/ G Budd is currently employed with the National Institute of Occupational Health & Safety. Much of his work has involved a study of the physiology of workers in stressful situations such as bush fire fighting.

covered paper. Tents are not fitted with floors, but rather straps at each corner of the tent for securing with hands and feet. This is necessary to hold the tent down against strong winds likely to be experienced as a fire front approaches. Reflection of a large amount of the radiant heat pulse is provided by the foil coating, and provide a pocket of relatively cool air for the occupant to breath until such time as the fire front passes and it is safe to emerge.

Each tent weighs approximately one and a half kilograms and is generally carried outside the pack, attached to the belt for easy access. For qualification as a member of a Type 1 crew, each person is required to be able to fully deploy the shelter within 30 seconds of being given the instruction to deploy.

There are several examples of failures of the survival tents. The most recent occurred during the Dude Fire, central Arizona, June 1990, when six members of one fire crew perished after deploying their shelters. In contrast to this are the numerous cases where lives have been saved by correct deployment of the shelters. Every incident where people are put in a position where shelters are deployed is fully investigated with the aim of minimising the possibility for reocurrance.

From observations made, it is considered sensible for such safety equipment to be considered for use in Australia, particularly where crews are involved in remote area fire fighting. Crews that have walked or been flown into an area, and rapid withdrawal following blow up conditions is difficult would find such shelters good back up. In most other situations, vehicles provide equal or better protection against radiation and direct flame contact, and should be treated as the primary safety area.

Improved levels of fire fighter training, increasing awareness of surroundings, potential fire behaviour and escape routes will be more beneficial to levels of crew safety than providing crews with such equipment. A concern exists that staff equipped with such safety equipment will expose themselves to increased levels of danger than they otherwise would.

6.5.3.3 SAFETY EQUIPMENT

Other safety equipment issued to all fire suppression staff includes:

LEATHER WORK GLOVES: gloves reduce the chances of injury due to splinters, burns and blisters. Any injury to the palms or fingers significantly effects the ability of a fire fighter to maintain work output. For this reason all fire fighters in the United States wear leather gloves. Many Australian fire fighters are involved in manual labour throughout the year, which toughens the skin of the hands and so reduces the chances of blistering. The risk is still present, however for injury from splinters, and burns, particularly when moving logs and sticks during mop up, or if reaching down to stop a fall in rough country. It is recommended that Australian forestry services and fire organisation consider implementing the wearing of gloves as mandatory for fire crews.

SAFETY GLASSES: or goggles are issued to all crew members for eye protection when working in shrubby vegetation types at night, when assisting the chain saw teams, for operations involving helicopters or when using digging tools where loose dirt, sticks and rocks fly around dangerously. Safety glasses are preferred for better fogging resistance, but goggles are commonly used by fire engine crews for smoke protection.

EAR PLUG: issued to all crew members for operations involving chainsaws and helicopters.

6.5.4 FEMALE FIRE FIGHTERS

The US Forest Service has in place a policy named 'Consent Decree'. This policy is designed to maintain a certain level of female, and other minority groups within all levels of the service. The effect that this has on fire crews such as Hotshot crews is that a fixed number of places on the crew must be filled by females or minorities. The 1990 Lassen Hotshots for example had three female members, six native indians and eleven white males. Other crews encountered on fires during the season also possessed female members.

Personal experience working with females in fire situations has shown that female fire fighters do not generally possess the muscular strength of males, but can possess similar aerobic capacity, leading to good endurance. Prolonged use of heavy equipment such as chain saws may lead to accelerated fatigue, and dangerous situations. If working with lighter weight hand tools such as shovels and rake-hoes, or tanker crews working with fire hose, females have shown to be an effective component of a fire fighting crew. Many females were found working as supervisors on fire tankers at fires. In this capacity, females were found to work very well.

No special physical training is conducted to increase female muscular strength whilst working with a hand crew. Females are expected to be able to complete the same number of repetitions of the different exercises carried out as part of the physical training each day. Through extra workouts conducted during spare time, evidence of significantly increased muscular strength, particularly in the arms was found.

It is considered that the number of females wanting to be employed in these tasks in America is higher than Australia. Affirmative action created by policies such as consent decree, ensures that a high number of females obtain positions. It is important to realise that employers should take each applicant on their value. Not only physical strength and stamina are required of fire fighters, but also mental ability. Where possible, the best suited person for a task should be selected.

6.6 USE OF FIRE TANKERS

6.6.1 CREW TRAINING

As with most USDA Forest Service fire crews, most tanker trucks are staffed with a small core of permanent employees with the remaining crew members made up of seasonal employees. The seasonal employees are expected to have carried out the Basic 32 course as described above. Permanent employees may be selected to attend training at the Fire Engine Academy. Crews are trained in the same subject material as carried out in four wheel drive and tanker courses conducted by the forestry services in Australia. Topics include the following:

Air Brakes, Hydraulics, Maintenance, Water Additives, Portable, Power take off and Slip-on pumps, 4WD Driving techniques, Cross country driving, and Fire Attack methods.

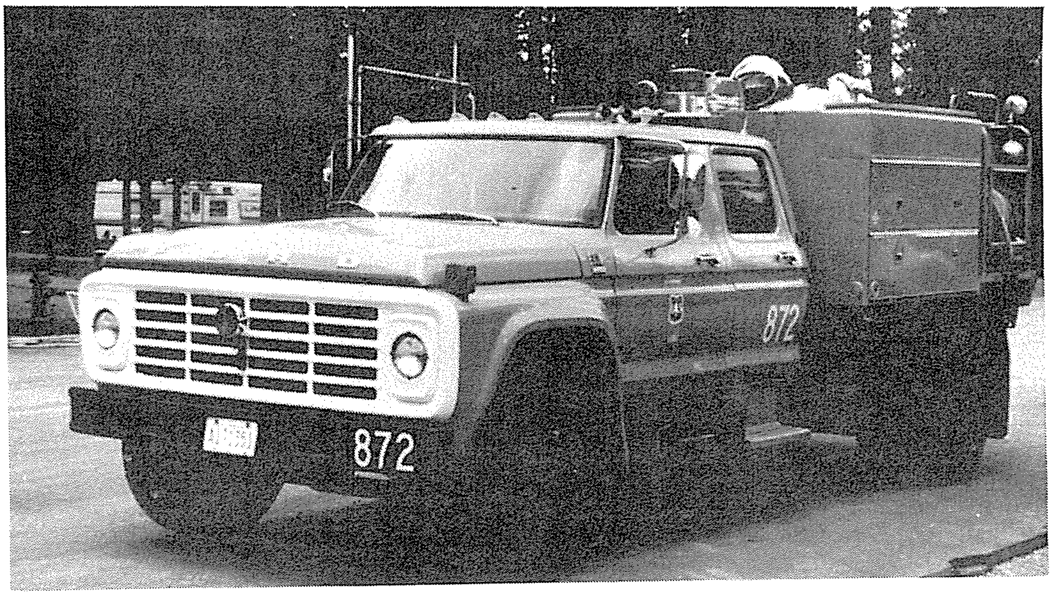

FIGURE 13: Standard sized USDA Forest Service Fire Engine. Seating Capacity 5, water capacity, 250 US Gallons.

In general, most tankers observed whilst in America do not have the tank capacity of those used by the forestry services in Australia, and many of the privately maintained units of the volunteer brigades. The largest tanker observed is fitted with a 650 US Gallon Tank. The M Series Bedford Tanker and current series ISUZU tankers hold 850 Imperial Gallons or approximately 900 US Gallons. A large amount of space on the vehicle is taken up by cabin for crew. Crews for these vehicles are five, compared to crews of three to five in Australia. There are also designated storage compartments located along the rear of the vehicle to store tools, plus spare lengths of hose and fittings. All of these items add to use up available tank space. No recommendations for modifications of existing Austaralian tanker fleets are made based on observations of Tankers in the United States.

SECTION 7: INTERAGENCY COOPERATIVE FIRE SUPPRESSION

Because of the nature of fire fighting in the United States, with several large organisations involved in land management, there is a need for cooperative fire management in both training and operational ways. For example, 1: the interagency training facilities at Boise, Idaho and Redding, California cater for the training needs of several different fire fighting organisations, and, 2: Interagency fire crews such as the Hotshots, and Smoke Jumpers, who assist in fire suppression operations anywhere within the United States. Cooperative fire suppression also takes the form of interagency dispatching facilities, who cater for resource allocation to fires occurring on land managed by different organisations.

7.1 INTERAGENCY DISPATCH FACILITIES

As part of the study tour to the United States, it was possible to tour the Susanville Interagency Fire Centre (SIFC). This facility, located in Susanville, Northern California is responsible for the resource allocation to fires within National Forest lands, California Department of Forestry management area and Bureau of Land Management areas.

7.1.1 GOALS OF AN INTERAGENCY DISPATCH FACILITY

1. To ensure maximum protection to the resources utilising the most economical method, in accordance with management plans for the various departments.

2. To gather and disseminate information which will assist field units.

3. To dispatch initial attack units using the 'closest forces concept'.

4. To manage all aircraft use, utilising only approved aircraft and pilots to ensure safe, efficient aircraft utilisation.

5. To manage Incident (Fire) Assignments.

6. To operate within the existing Cooperative Agreements with Public Agencies.

(Taken from Susanville Interagency Fire Centre, Operations Plan)

7.1.2 STAFFING AND PLANNING OF THE SUSANVILLE DISPATCH FACILITY

During work hours, it is general practice for an officer from each of the agencies represented at the facility to be available. After hours, a California Department of Forestry Dispatch Officer maintains a watch over the radio. This ensures that field stations, fire towers etc. can get information out 24 hours a day. For the members of the Lassen Hotshot crew this communication link is vital, as dispatch during the night would not be possible otherwise.

7.2 INTERAGENCY FIRE QUALIFICATION SYSTEM AND TRAINING

The Wildland Fire Qualification System has been designed to provide a resource of fire suppression personnel, to fill designated jobs at any fire in the country. The system was designed in such a way that the participating organisations were able to agree upon the training, experience and fitness levels required to qualify for each job level. This program fits within the guidelines set down for the 'Incident Command System' (ICS) which is the basic format for fire management organisation in the United States.

As with the Alberta Forest Service, personnel are able to participate in higher levels of training leading to higher levels of responsibility to be carried out at a fire.

Each organisation is responsible for ensuring that any personnel dispatched to an incident have acquired at least the minimum standard acceptable for the position.

Each organisation is responsible for certification and recertification or maintaining the currency of staff.

Appendix 9 shows a flow diagram of the qualifications required to fill the operations section of a fire organisation. Prerequisite courses and physical fitness requirements are also shown.

Within the working hierarchy of most fire organisations in Australia, a less formal system is in place. Based, almost exclusively on experience, Foresters, Foremen, Brigade Captains etc. assume roles of responsibility. These levels of responsibility, with regard to the overall scale of the fire change with the size of the fire and the number of personnel involved. Although it is strongly recommended that an increase in the level of training be carried out for all staff, including professionals, it is recognised that it is difficult to try and develop a training program as rigid in its structure as the ICS system, incorporating all organisations involved in bushfire suppression. Using such a system, with certification to each level of responsibility will help ensure that well qualified staff are involved in fire management operations and will help officers from different organisations work together with more confidence in the ability of others.

SECTION 8: FIRE RETARDANT EVALUATION IN THE UNITED STATES

Extensive use is made of retardant chemicals by the fire fighting organisations in the United States. Although most of the technological advances have been made in the area of aerial application of retardants, there are examples of foaming chemicals being employed using fire engine trucks. This is mainly in the form of foaming chemicals. Foams are used for protection of buildings and trees, by pre treatment before an approaching fire front.

8.1 THE OPERATIONAL RETARDANT EVALUATION "ORE" PROGRAM

An evaluation study has been carried out, primarily to determine the required concentrations of retardant chemicals to achieve fire suppression of a given intensity fire in different fuel types, and to determine if the retardant operation is providing a positive cost benefit. The study was initiated in the 1983 fire season, and field data collection concluded in 1989.

The ORE study is based loosely on the same experimental design as the studies carried out as Project Aquarius by CSIRO in the mid 1980's. Retardant is laid down in front of an oncoming fire front, then, using an infrared detector mounted on a fixed wing aircraft, the effectiveness of the retardant in relation to the fire behaviour in different fuel types is observed and measured.

As the basis of this study is primarily the use of retardants with fixed wing aircraft, much of it is of little value to the Australian Fire Fighting Community. however, the information regarding foam injection equipment used with helicopters is applicable here. It has been found that the use of foam delivered from helicopters can provide valuable assistance when direct fire attack is being made, in close support of ground crews. One major concern of foams are that the effectiveness is dependant upon the moisture content, leading to a decline in effectiveness over time as the chemical dries up. This is not so much of a concern for long term retardants such as the Ammonium based salts.

8.2 USE OF FOAM

Extensive use of foaming chemicals is made by the fire fighting organisations of the United States. As already mentioned, the two primary methods of application are by fire tanker trucks and aerial drop from helicopter. Both of these techniques are relevant to the Australian fire scene, and are currently used by different forestry and fire fighting services.

During fire operations, some observations were made of the foam chemicals being used for pre-treatment of buildings and forested areas. This involved structures and trees being covered with foam, then being left to face the oncoming fire front. The second common technique observed in using the foaming agents was in mop-up operations. This included foaming chemicals being pumped through non-aspirating branch pipes, hence not producing a high expansion of foam bubbles.

Foams have been found to be effective in the low , open fuel types such as low shrubs, and grass lands where they can provide a smothering blanket. A higher density of foam than commonly used in Australia was used in building protection. This higher density foam has better adhesion caused by slower drainage times which allows fire fighters to treat objects with foam and safely move away before the fire front arrives.

8.3 USE OF LONG TERM RETARDANTS

Long term retardants observed during the study tour were used with aerial applications (Figure 14). Depending upon the availability of aircraft, retardant laden air tankers are dispatched as an initial attack resource. It has been shown that if a retardant line is established quickly enough, then the forward rate of spread of the fire can be reduced sufficiently to allow ground forces to get in and contain the burn (where access and transport times permit ground crews to respond quickly. This was shown to be especially effective in low canopy fuel types where good penetration of the retardant to fine fuels below was possible.

Examples of effective containment of fire before ground crews moved in was found in north eastern California, where aircraft effectively stopped two fires burning in low brush country. All that remained for the hand crews to do was mop up and put in place a small control line.

Where the intensity of a fire is in excess of what could reasonably be contained by ground crews, the use of retardant dropping aircraft was found to be much less effective due to spotting activity etc. Increased hazard to flight crews also resulted from attempting to lay down a line of retardant close to the edge of a fire that is increasing in intensity.

Figure 14: P2 Neptune Air Tanker Bomber releasing 2000 US Gallons of retardant to back up the boundary of a back burning operation. Savage Fire, near Mariposa, Central California. September 1990.

CONCLUSION

Much information has been gained in training experience and fire suppression management from this study tour. It is considered likely that in future, Australian fire services will tend to follow the lead set by similar organisations overseas in the field of fire suppression training.

It is recognised that the financial and human resource availability of the organisations observed in North America are greater than those in Australia, however this should not detract from serious efforts being made to upgrade the levels of training here.

Points that are considered important for fire services to consider are:

1. Simulation training, both with computer aided technology and simulated field exercises.

2. Crew member fitness, with the aim of significantly improving worker efficiency and reducing fatigue related injuries.

3. Crew member awareness of fire weather, fire behaviour and personal safety issues related to fire fighting.

Because of the co-operative nature of most fire fighting operations in Australia, it is considered important that these different organisations pursue training to similar levels. This should closely parallel the 'incident command system', developed by the USDA Forest Service, and adopted by fire organisations in Canada.

Australia has shown to be well advanced in the use of retardants and foam chemicals, with the exception of retardant application from aircraft, which is not considered likely to be implemented on a broad scale in this country due to establishment costs. Ground application of foams and retardants are well investigated and implemented, particularly in Victoria and Western Australia. The expected levels of development from organisations such as Victorian D C & E in this field should satisfy most Australians requirements.

Overall, this has been a worthwhile program, and should the opportunity for reciprocal tours become available, it is recommended that Australian fire services participate with similar enthusiasm displayed by North American Forestry services.

Ian Dicker
July 1991

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APPENDIX 1

APPENDIX 1.1 Itinerary of fire management activities carried out in Canada.

APPENDIX 1.2 Itinerary of fire management activities carried out in the United States of America.

APPENDIX 1.1

ITINERARY OF FIRE MANAGEMENT ACTIVITIES CARRIED OUT IN CANADA

The following represents a chronology and basic description of events that were participated in during the Canadian section of the trip. The Alberta Forest Service provided both an educational and entertaining program for six (6) weeks.

29 March	Depart Australia for Canada - arrive Edmonton. Ground transport provided to Hinton Forest Technology School (appendix two).
2-6 April	Attend Fire Prevention 1 Course, Hinton. Course designed for officers responsible for issuance of fire permits adjacent to or within Forest Protection Areas.
5 April	Attend field demonstration - use of skidder with 500 litre tank fitted with a foam induction unit and small Honda pump. Also trials of Wajax MKIII Pump and foam induction system (see appendix two). Cold Creek Ranger District.
9 April	Visit Hinton District Ranger Station - discussion with District Ranger and staff regarding fire suppression and general forestry concerns within the district.
9-10 April	Tour of fire suppression facilities, White Court Forest, Central Alberta including a visit to the forest headquarters where an introduction was given on IFMIS (Intelligent Fire Management Information System) a computer based expert geographic information system for management of fire suppression resources based on fuel and weather characteristics assisting the officer responsible for resource management to best allocate crews and equipment. The lightning detection system was also displayed in operation. Visits were arranged to the Forest Fire suppression warehouse and air tanker base, where a light weight heli-torch (Aerial incendiary system)for light weight helicopters such as a Bell206, Robinson R22 or Aerospatiale

Squirrel, was demonstrated. A visit to a local native reservation was also made for a pre-season discussion regarding numbers of crew to be hired and conditions of hire etc.

11 April One hour presentation given to air attack officer pre-season refresher course on fire behaviour and suppression operations in Australia. Attendance was also made to the Fire simulator briefings and training sessions. Hinton.

12 April Fire simulator training sessions. Hinton.

17-20 April Attend Advanced Fire Behaviour Course, Hinton.

20 April Three hour presentation given to Advanced Fire Behaviour Course, on fire behaviour, management and suppression in Australia. Much emphasis being placed on extreme fire behaviour witnessed during Ash Wednesday, 1983.

23-27 April Attend segments of Initial Attack Crew Leader, Air Tanker Base Manager, Hinton - two hour presentation given to Initial Attack Crew Leader Course on fire behaviour and fire suppression operations, particularly initial attack in Australia.

25 April Visit to Edson Air Tanker Base, inspection of retardant storage and mixing facilities, discussion of safety concerns with usage of retardants and foam concentrates. Presentation given by Monsanto representative on new mixing technology for fire retardants and foam generation equipment.

27 April Two hour presentation given to Helitack Crew Leaders and new recruits on fire behaviour and fire suppression operations in Australia.

29 April Inspection of Helitack facilities including rappel training tower, classroom and equipment - maintenance operations. Hinton.

30 April	Observation of live rappel training techniques from helicopter near Hinton.
2 May	Depart Hinton for Footner Lake Forest, Northern Alberta. Discussion with Forest Protection Officer for Footner Lake Forest regarding fire suppression and other forest protection concerns in Northern Alberta.
3 May	Visit High Level Ranger Station and Footner Lake Forest Headquarters, discussion with district and forest headquarters staff regarding fire and forest management. Observation of field staff training with four wheel drive quads and initial attack crew training with Wajax Mark III pump equipment, near High Level, Alberta.
4 May	Visit Rainbow Lake Ranger District (see appendix 2.1). Discussion with District Ranger regarding fire and forest protection management concerns, including difficulty associated with extremely limited access and remoteness.
5 May	Visit Fort Vermillian Ranger District and inspect unauthorised burning operation on nearby native reserve.
6 May	Depart High Level for Edmonton.
8-10 May	Visit Provincial Forest Fire Centre (PFFC), Edmonton. Discussion with section leaders involved in different areas of forest protection and fire suppression. Those consulted included Fire Prevention Co-ordinator, Manager of Fire Management Programs, Fire Operations Supervisor, Manager of Supplies and Services, Senior Fire Meteorologist and Manager of Air Operations.
10 May	Depart Edmonton for Vancouver.
11 May	Visit Abbotsford Air Field. Inspection of Conair and Frontier Helicopter facilities and attend opening of Abbortsford Air Tanker Base. Meeting with Monsanto Chemical Company representative and Forest Protection

Officer, discussion fire suppression topics, including feasibility of current retardant technology being suitable for Australian conditions.

APPENDIX 1.2

Itinerary of fire management activities carried out in the United States.

The following represents the chronology of fire management activities carried out whilst a guest of the USDA Forest Service:

13 May	Arrive San Francisco from Vancouver, Canada.
14 May	Depart San Francisco for Reno, Nevada. Ground transport provided by foreman of Lassen Hotshots, to Susanville, California. Introduction to Fire Management Officer and Hotshot Crew Superintendent at Lassen National Forest, Eagle Lake Ranger District office.
18 May	Tour Susanville Interagency Dispatch Centre discussion with staff regarding capabilities of equipment and strategies behind operational plans.
20 May - 1 June	Pre fire season Hotshot crew training program.
18 - 20 June	Conduct hazard reduction burn within Lassen Volcanic National Park. Fire management activities observed include: hand ignition planning, utilising hand carried drip torches, usage of hand crews for securing control lines and mop-up procedures.
26 June - 2 July	Attend "Dude Fire", near Payson, Arizona, within the Tonto, Coconino and Apache Sitgreaves National Forests. Fire management activities included: extensive burning operations to secure control lines, particularly at night. Construction of hand line in difficult terrain in the dark, mop-up operations in daylight and dark hours, use of fire camps for crew support

(including transport,catering and equipment supply management). Final fire size approximately 10,000 hectares.

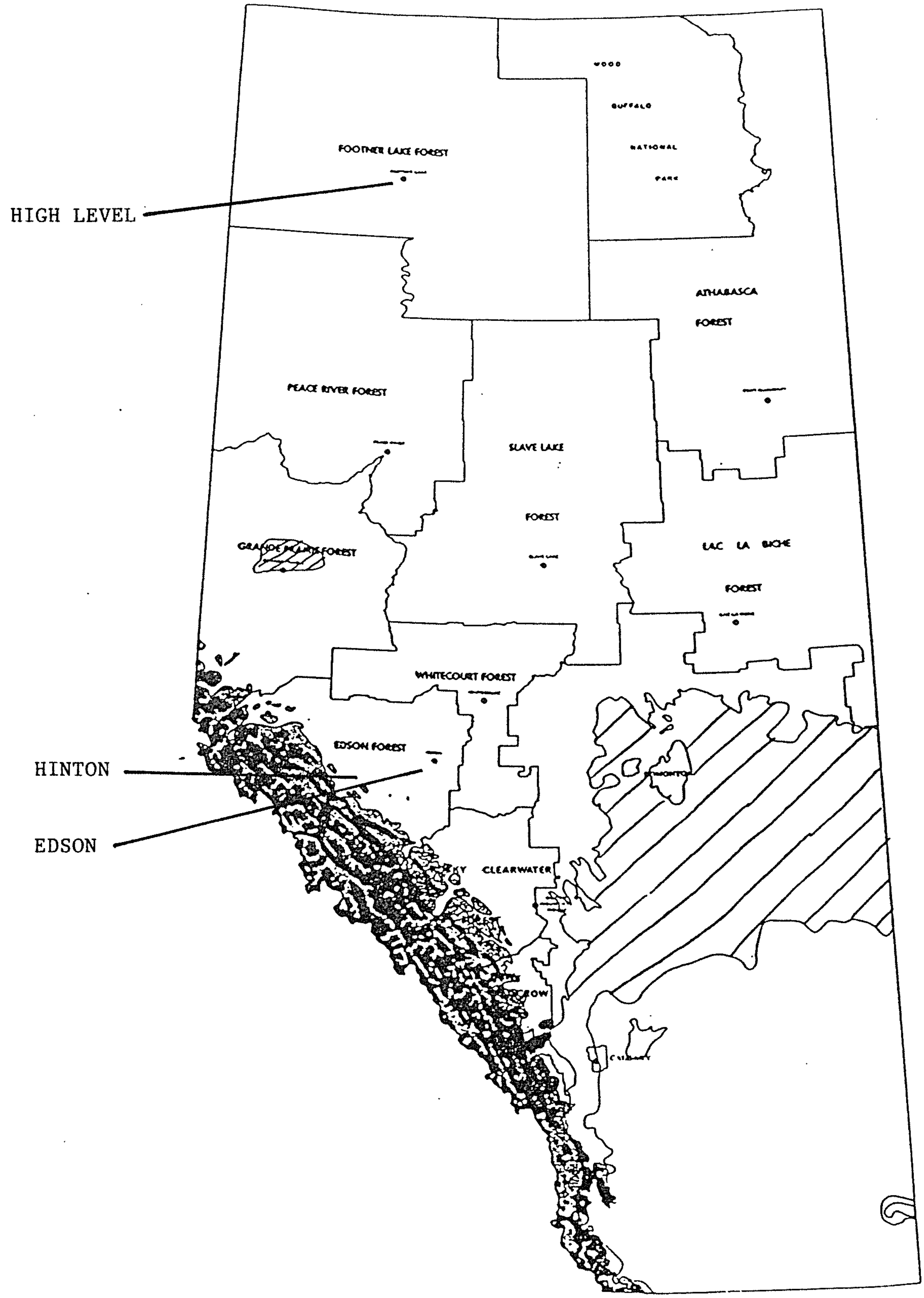
3-7 July	Attend "Stago Fire", on the Fort Apache Indian Reservation, Arizona. Fire management activities included: construction of handline in steep and rocky terrain in the dark, and night mop-up operations. Final fire size approximately 1,200 hectares.
14-15 July	Conduct mop-up - "Chilcoot Fire", Plumas National Forest, Northern California. Final fire size 2 hectares.
18 July	Conduct mop-up - "Potato Fire", Plumas National Forest, near Portola, Northern California. Fire management operations included: night burning operations in shrub fuel types, night mop-up, Helibase management and fire camp management. Final fire size approximately 700 hectares.
2 August	Conduct mop-up - "Rice Fire", Lassen National Forest, near Chester, Northern California. Final fire size approximately 5 hectares.
5-17 August	Attend "Stormy Complex Fire", Sequoia National Forest, near Kernville, Southern California. Fire management activities included: construction of handline in step terrain and difficult fuel types at night (including the value of chainsaw crews in the construction of handline in heavy shrub fuel types), bull dozer operations both during the day and at night, especially for construction of control line and structure protection, air tanker operations and usage of helicopters for dropping water - retardant and evacuation. Controlled burning operations in difficult fuel types, medical evacuation from fire areas, cold trailing line construction techniques, mop-up during both daylight and night, large fire management (including fire camp facilities, catering facilities etc) and structure protection.

28 August	Tour of North Zone Dispatch Facilities, located at Redding, California, including discussion with USDA Forest Service Training Manager re: training of different fire fighting agencies, tour of air tanker facilities, Smoke Jumper Base (including training facilities), and discuss with the Eagle Lake Ranger District Fire Management Officer, in detail issues of fire management both at a district and state level and for the United State in general.
30 August - 3 September	Attend "Savage Fire", Sierra National Forest, near Mariposa, Central California. Fire management activities included: hand line construction in steep terrain, and difficult fuel types. Hand ignition methods (including small explosive devices), aerial ignition methods (particularly the heli-torch), use of aircraft for dropping water and retardant (both fixed wing and rotor wing) used to back up hand constructed control lines, use of helicopters for aerial based fire management.
9 September	Conclude tour with Lassen Hotshots.
15 September	Depart United States for Australia.
17 September	Arrive Sydney - conclusion of tour.

APPENDIX 2

APPENDIX 2.1 Locality Map, Alberta, Canada.

APPENDIX 2.2 Locality Map, Western United States of America.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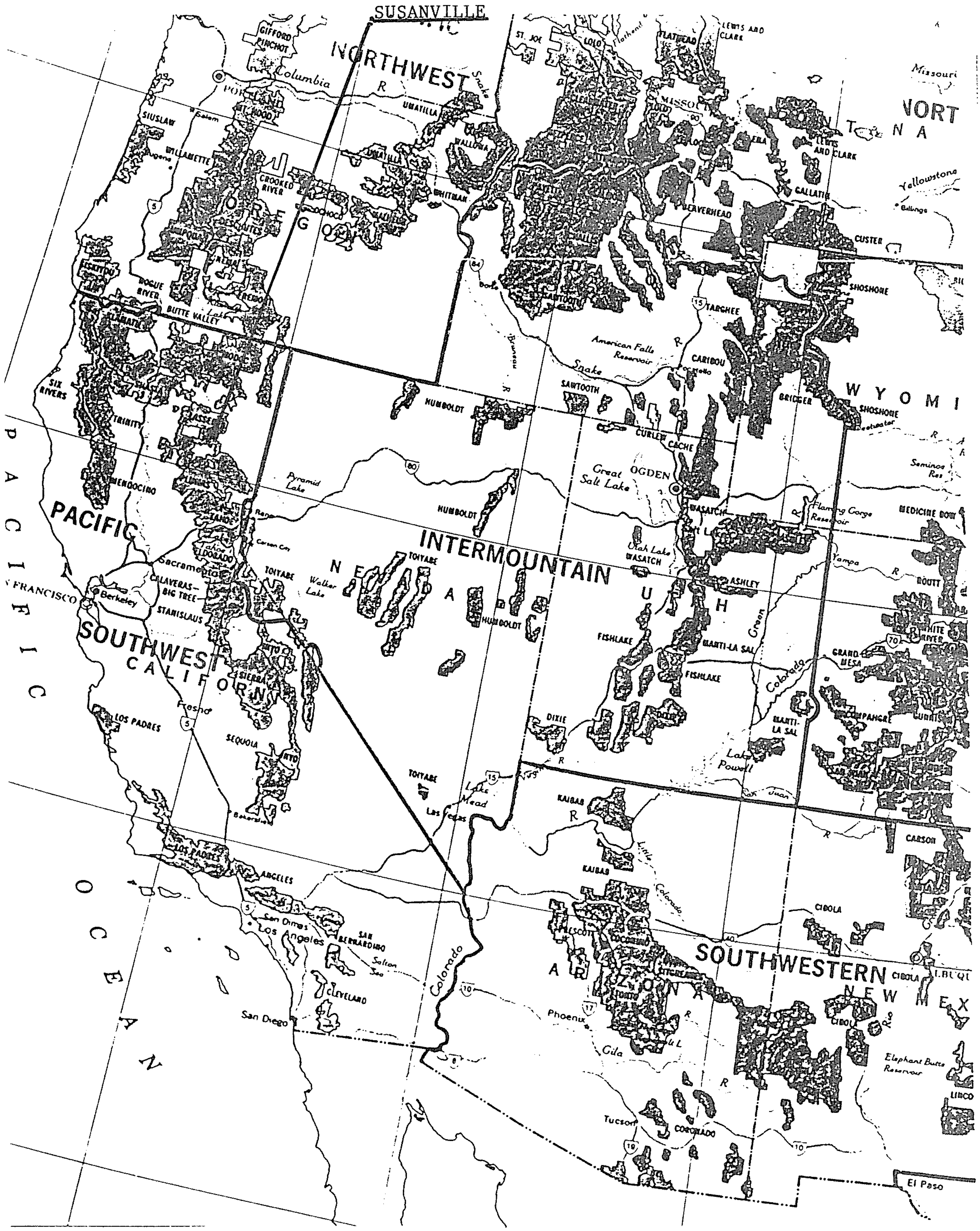
CLEARWATER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INTERMOUNTAIN
PACIFIC
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UTAH
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NEW MEX
WYOMI
PACIFIC OCEAN
Columbia R
Snake R
Great Salt Lake
OGDEN
Lake Mead
Las Vegas
Lake Powell
Colorado
Gila
Phoenix
Tucson
San Diego
Los Angeles
Fresno
Sacramento
Berkeley
Carson City
Pyramid Lake
Walker Lake
Salton Sea
El Paso
Yellowstone
Missouri
American Falls Reservoir
Flaming Gorge Reservoir
Elephant Butte Reservoir
HUMBOLDT
TOIYABE
FISHLAKE
DIXIE
MANTI-LA SAL
WASATCH
ASHLEY
CACHE
CARIBOU
TARGHEE
SAWTOOTH
BRIDGER
SHOSHONE
CUSTER
GALLATIN
BEAVERHEAD
LEWIS AND CLARK
FLATHEAD
LOLO
ST. JOE
UMATILLA
WALLOWA
WHITMAN
GIFFORD PINCHOT
SIUSLAW
WILLAMETTE
CROOKED RIVER
ROGUE RIVER
BUTTE VALLEY
SIX RIVERS
TRINITY
MENDOCINO
CALAVERAS-BIG TREE
STANISLAUS
SIERRA
SEQUOIA
LOS PADRES
ANGELES
SAN BERNARDINO
CLEVELAND
KAIBAB
CORONADO
CIBOLA
CARSON
GRAND MESA
MEDICINE BOW
ROUTT
UNCOMPAHGRE
LINCO

PAYSON

APPENDIX 3

APPENDIX 3.1 Fireline organisation, Alberta Forest Service

APPENDIX 3.2 Organisational build-up, Alberta Forest Service

BASICS OF THE FIRELINE ORGANIZATION

Organizational Premises

The Alberta Forest Service Fireline Organization is based on the following organizational premises:

(i) A basic Squad should consist of seven Firefighters and one Straw Boss while a basic Crew shall be composed of twenty-one Firefighters, three Straw Bosses and one Crew Boss.

(ii) No Straw Boss should supervise more than seven Firefighters.

(iii) No Crew Boss should supervise more than three Squads.

(iv) No Sector Boss should supervise more than three Crews.

(v). No Division Boss should supervise more than three Sectors.

Organizational Buildup

The organizational buildup of the Fireline Organization consists of four separate stages according to manning levels:

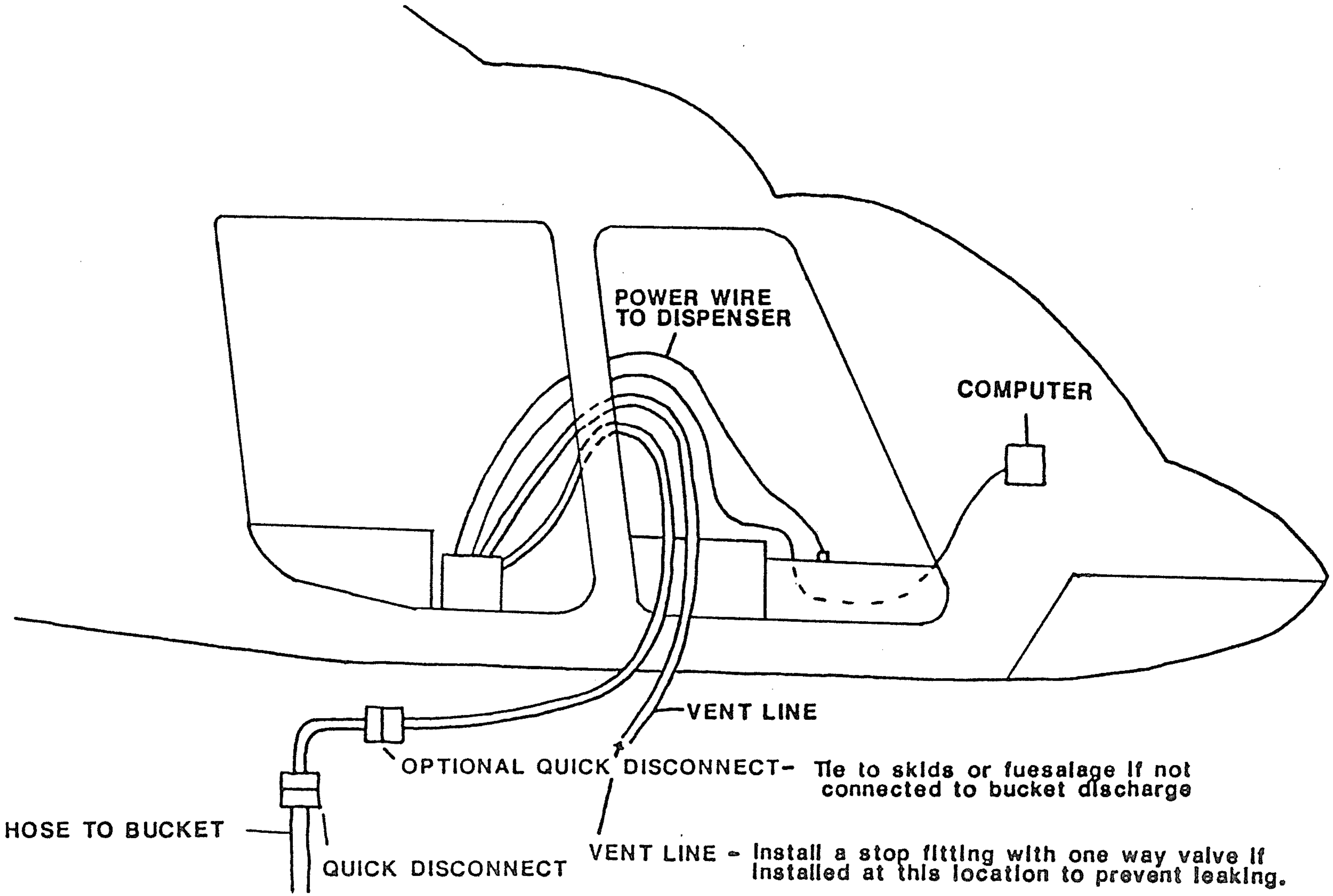
I	Crew Fire	-	1 to 25 basic personnel
II	Sector Fire	-	26 to 75 basic personnel
III	Division Fire	-	76 to 225 basic personnel
IV	Zone Fire	-	226 to 675 basic personnel

APPENDIX 4

Typical set-up for foam injection unit for light Helicopter Bucket Systems.

FOAM INJECTOR INSTALLATION

Manufactured by Chemonics



APPENDIX 5

Fitness levels for initial attack crews, Alberta Forest Service.

Physical Fitness

All IAC members must be in good physical condition, able to sustain hard work and participate in a physical fitness program with an objective to maintain the following standards:

2.5 km run in 11 minutes or less

12 chin-ups in 1 minute or less

35 push-ups in 1 minute or less

40 sit-ups in 60 seconds or less (hand touching only side of head or ears, not behind head; knees bent with no weight or support to feet; elbows must touch knees. Do not bounce off the floor. If heel of foot leaves ground that sit-up is not counted and an extra sit-up is required to achieve the 40/minute standard.

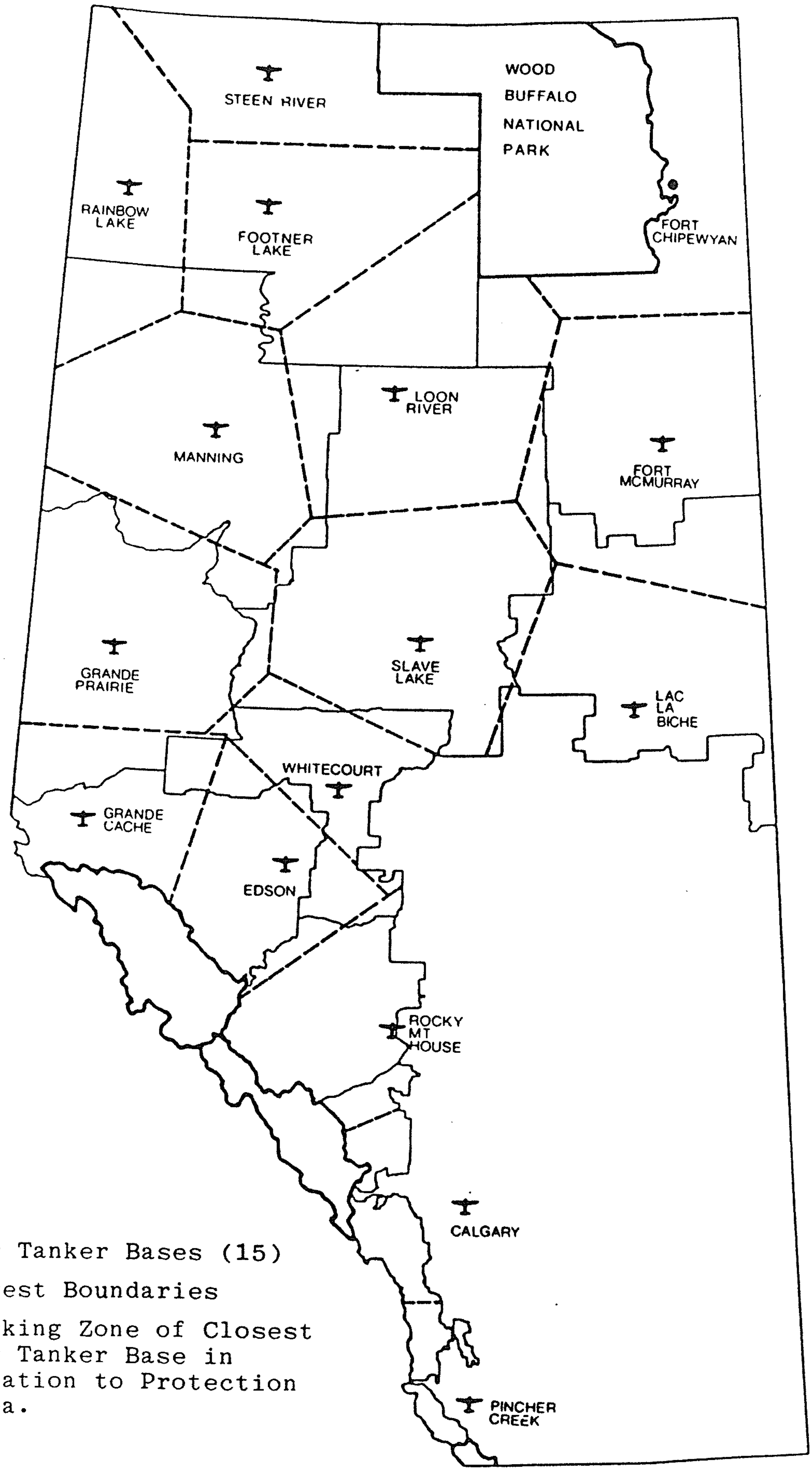
Each member must be tested at the beginning of the season and at least once a month thereafter. The physical fitness record form must be completed for each member.

All members of the crew should be familiar with the "Alberta Forest Service Fitness Program For Initial Attack Forest Firefighters." This paper can be used as a guideline to set up a physical fitness program for each crew. Whatever the program is, each member should participate with a positive attitude to achieve the set standards.

APPENDIX 6

Locality Map, Air Tanker Bases, Alberta, Canada.

ALBERTA AIRTANKER BASES



LEGEND

- Air Tanker Bases (15)
- Forest Boundaries
- Working Zone of Closest Air Tanker Base in Relation to Protection Area.

APPENDIX 7

APPENDIX 7.1 Ten standard fire orders.

APPENDIX 7.2 Eighteen (18) situations that shout "Watchout".

STANDARD FIRE ORDERS

F FIGHT FIRE AGGRESSIVELY BUT PROVIDE FOR *SAFETY FIRST.*

I INITIATE ALL ACTION BASED ON CURRENT AND EXPECTED *FIRE BEHAVIOR.*

R RECOGNIZE CURRENT *WEATHER CONDITIONS* AND OBTAIN FORECASTS.

E ENSURE *INSTRUCTIONS* ARE GIVEN AND UNDERSTOOD.

O OBTAIN CURRENT INFORMATION ON *FIRE STATUS.*

R REMAIN IN *COMMUNICATION* WITH CREW MEMBERS, YOUR SUPERVISOR, AND ADJOINING FORCES.

D DETERMINE *SAFETY ZONES* AND *ESCAPE ROUTES.*

E ESTABLISH *LOOKOUTS* IN POTENTIALLY HAZARDOUS SITUATIONS.

R RETAIN *CONTROL* AT ALL TIMES.

S STAY *ALERT,* KEEP *CALM, THINK* CLEARLY, *ACT* DECISIVELY.

WATCH OUT SITUATIONS
(SURVIVAL CHECKLIST)

- ☐ 1. FIRE NOT SCOUTED AND SIZED UP
- ☐ 2. IN COUNTRY NOT SEEN IN DAYLIGHT
- ☐ 3. SAFETY ZONES AND ESCAPE ROUTES NOT IDENTIFIED
- ☐ 4. UNFAMILIAR WITH WEATHER AND LOCAL FACTORS INFLUENCING FIRE BEHAVIOR
- ☐ 5. UNINFORMED ON STRATEGY, TACTICS AND HAZARDS
- ☐ 6. INSTRUCTIONS AND ASSIGNMENTS NOT CLEAR
- ☐ 7. NO COMMUNICATION LINK WITH CREW MEMBERS/SUPERVISOR
- ☐ 8. CONSTRUCTING FIRELINE WITHOUT SAFE ANCHOR POINT
- ☐ 9. BUILDING FIRELINE DOWNHILL WITH FIRE BELOW
- ☐ 10. ATTEMPTING FRONTAL ASSAULT ON FIRE
- ☐ 11. UNBURNED FUEL BETWEEN YOU AND THE FIRE
- ☐ 12. CANNOT SEE MAIN FIRE, NOT IN CONTACT WITH ANYONE WHO CAN
- ☐ 13. ON A HILLSIDE WHERE ROLLING MATERIAL CAN IGNITE FUEL BELOW
- ☐ 14. WEATHER IS GETTING HOTTER AND DRIER
- ☐ 15. WIND INCREASES AND/OR CHANGES DIRECTION
- ☐ 16. GETTING FREQUENT SPOT FIRES ACROSS LINE
- ☐ 17. TERRAIN AND FUELS MAKE ESCAPE TO SAFETY ZONES DIFFICULT
- ☐ 18. TAKING A NAP NEAR THE FIRELINE

APPENDIX 8

USDA Forest Service step test fitness appraisal.

Aerobic Fitness Tests

(Maximum amount of oxygen that a worker can take in, transport, and use in the muscles.)

CONTENTS

RATIONALE

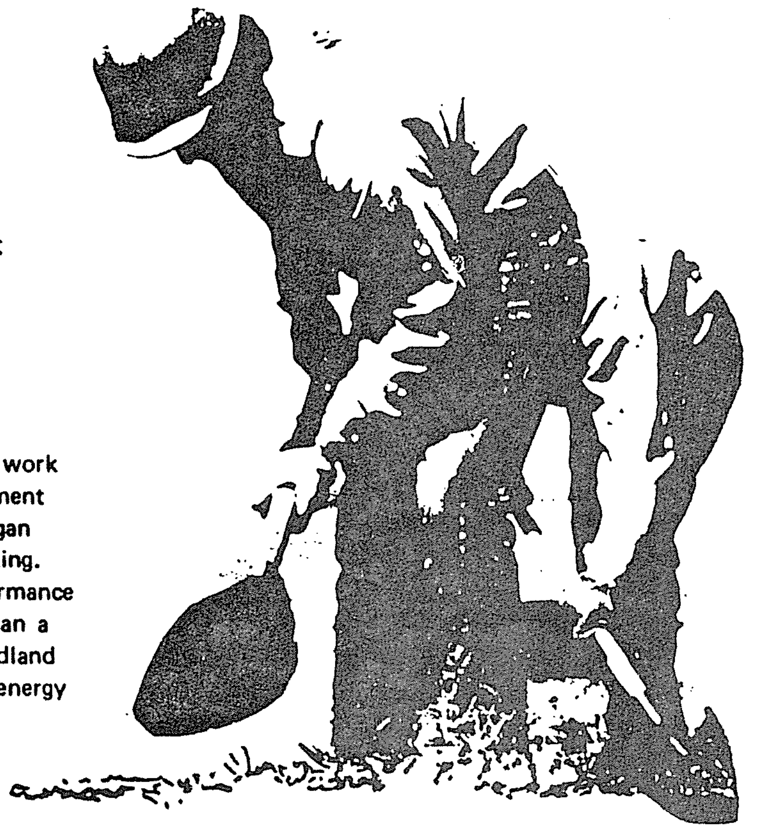
What Determines Work Capacity?

In 1965, with the help of specialists in work physiology, the USDA Forest Service Equipment Development Center at Missoula, Mont., began developing a test to assess fitness for firefighting. Dr. Brian Sharkey, director of the Human Performance Laboratory at the University of Montana, began a systematic analysis of the tasks involved in wildland firefighting. Field and laboratory studies of the energy metabolism, cardiac cost, and heat stress of fireline construction were conducted, along with an extensive review of the work physiology literature. We concluded that the single most important factor limiting a firefighter's work capacity is the oxygen intake capacity – the ability to take in, transport, and use oxygen in the active muscles. This ability is called the *aerobic capacity.*

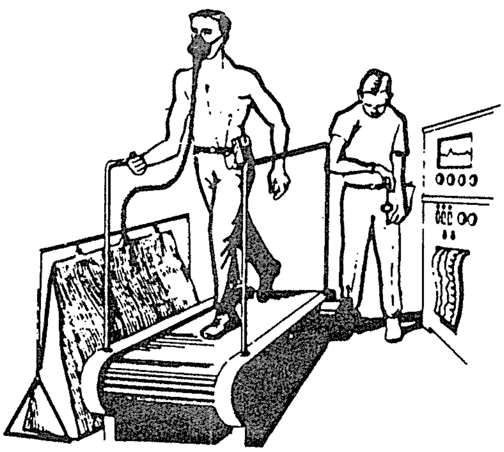
Aerobic Capacity

Take in O_2 <------>	Respiration
Transport O_2 <------>	Blood, Heart, Circulation
Use O_2 <------>	Enzymes in Working Muscles

The ability to continue arduous physical tasks throughout the working day depends on a continual supply of oxygen. This oxygen intake capability, or aerobic capacity, is best measured on a laboratory treadmill. The rate and grade of the treadmill can be increased until the subject reaches his highest level of



oxygen intake. But this procedure is both costly and time consuming. We needed a simple, inexpensive, job-related test to *predict* aerobic capacity. The test had to be valid, reliable, and objective. Moreover, to insure worker health and safety, the test could not tax older or less fit individuals.



How was the Test Developed?

Running tests were considered too strenuous for general use. Treadmill and laboratory bicycle tests were too expensive. A step test seemed the ideal way to standardize the workload. Earlier forms of step tests, such as the Harvard Step Test (20-inch bench at 30 steps/min.), were found to be too strenuous. A sub-maximal step test designed to predict the aerobic capacity was first proposed by Swedish medical physiologists, P.O. and Irma Astrand, in 1954. This test involved 5 minutes of bench stepping at a rate of 22.5 times per minute on a 15-¾-inch bench for men and a 13-inch bench for women. The pulse rate during exercise was used to predict the aerobic capacity.

Field trials of this procedure in 1965 indicated employees would accept a test of this nature. The trials pointed out the need to use a post-exercise pulse count instead of the exercise pulse. Data collected on Forest Service personnel were used to modify the scoring, and a simplified slide-rule scoring calculator was devised and tested.

Additional laboratory studies were conducted at the University of Montana Human Performance Laboratory and at other laboratories throughout the world to establish test validity and reliability. When compared with actual measures of the maximal oxygen intake, the step test was found to be a valid predictor. Test reliability was confirmed in test-retest situations.

In 1968 data were collected to adapt the test for women. More recently the data have been converted to the metric system.

This development work has been reported at research meetings and in international research journals, and the concept has been adopted by several organizations and foreign countries to evaluate fitness. The Forest Service test was administered to selected individuals in the NASA space program, and NASA officials reported close correlation with data gathered in more elaborate laboratory tests.

In the 1973-74 fire seasons, the California Region used the test to help improve health, safety, and production on the fireline. In 1975 the Civil Service Commission approved Servicewide use of the test by the Forest Service and cooperating agencies.

THE STEP TEST

Administration

The test administrator should be well versed in the test procedures and purposes, and with the material contained in the booklet *Fitness and Work Capacity*. For accuracy and standardization, specific individuals should be trained to conduct all tests. When possible, Emergency Medical Technicians (EMT's) should administer the tests because they are trained in correct procedures for pulse counting. They also are familiar with the signs and symptoms of physical stress and are prepared to respond to a wide range of emergency situations.

The test administrator should be trained and certified in first aid procedures. In the remote possibility that an emergency may arise during or after the test, the administrator should provide immediate aid and execute a *planned* program for medical followup.

The test administrator should play a positive, supportive role, never a negative or threatening one.

1. **Screen each subject before testing.** Question subject to determine history of: chest pain, shortness of breath, general state of health, drug usage, and work capacity. *Do not test* if individual reports heart, circulatory, respiratory, or other problems that have required medical attention; hypertension; acute infectious disease; fever. *Do not test* if individual is under medication or suspected of using drugs. Neuromuscular or skeletal disorders (e.g., bad knee) do not necessarily preclude testing.

2. **Inform subject and obtain consent.** Discuss the nature and purpose of the fitness test, and inform the subject that the test is moderately strenuous, but no more so than the job itself. Indicate that the test can be stopped at any time should there be discomfort or symptoms of stress. Answer any questions asked.

Obtain verbal and/or written consent that the individual understands the nature and purpose of the test, and willingly consents to participate.

3. **Demonstrate test procedures** (see following section)

4. **Administer test**

5. **Watch for symptoms of distress.** These include:

Dizziness or near fainting

Chest, arm, or throat pain

Unusual fatigue

Intolerable pain in legs

Staggering or unsteadiness

Mental confusion

Excessive pallor

Rapid distressful breathing

Nausea

Encourage the subject to stop when laboring unnecessarily.

6. **Post-test observation.** When the test is completed and the pulse rate recorded, encourage the subject to walk to hasten recovery. Observe older individuals and those who experience difficulty with the test for at least 5 minutes or until recovery seems complete. A check of the pulse rate will indicate the state of recovery.

Environment

Administer the test in a quiet room, free of onlookers. Clicking typewriters and other distracting noises can upset subject's rhythm and interfere with the post-test pulse count. The room should be at a comfortable temperature (68°F). *Do not test* when room temperature exceeds 75°F. If the subject doesn't achieve the desired fitness score, he or she should be given the opportunity to retake the test.

Altitude

Since the first few days of exposure to altitude above 5,000 feet affects the heart rate, a test administered at this time could underestimate a subject's fitness. For that reason we recommend:

- Test at lower altitudes,

  or

- Administer step test *after* 3-week period of acclimatization to altitudes above 5,000 feet.

Individuals acclimated to moderate altitudes will have normal heart rate responses to submaximal workloads such as the step test.

Equipment

For accurate predictions, the test equipment should meet the specifications indicated. The bench must be exactly 15-¾ inches high for men and 13 inches high for women.

The metronome must be set at 90 beats per minute and checked for accuracy before and during each test (count 22.5 beats for 15 seconds). Also check recordings of metronome beats; when battery-operated recorders run down, the tape runs slower.

Giving the Test

1. If possible, test in the morning at least 2 hours after breakfast. Do not test after exercise or on the day after very hard work. Subjects should not drink coffee or smoke for 2 hours before testing and should have no drugs for at least 12 hours. If you suspect drug use, *do not test* (consult physician if necessary).

2. Allow 5 to 10 minutes of complete rest before beginning test. During the rest period inquire about general health, inform subject about the test, and obtain subject's consent.

3. You may want to take the subject's resting pulse as a check of general health; allow additional rest if pulse is elevated well above normal resting values.

4. Demonstrate the test; indicate the need to STAND ERECT on the bench. Illustrate how the lead leg may be changed by marking time and stepping with the opposite leg. Subject should not change lead leg more than once per minute.

5. Inform subject he may stop at any time during the test. Start the metronome and begin the test.

6. Inform subject as each minute passes. Remind subject that lead leg may be changed. If subject seems to be distressed, suggest stopping. Never exhort the subject to finish.

7. If subject cannot keep pace with the metronome, stop and retest after several weeks of fitness training. Stop the test when symptoms of physical distress become obvious.

8. After *5* minutes of exercise, stop the metronome and have the subject sit down, relax, and breathe normally. *Do not* record data if subject holds breath.

9. Count pulse at wrist or throat for *exactly* 15 seconds, starting *exactly* 15 seconds after test ends. When taking pulse at throat simply lay fingers along side of throat and maintain gentle contact.

Test Scoring

To find subject's fitness score, enter body weight on the front of the calculator and read the fitness score from the column opposite the post-exercise pulse count. This score is entered on the back of the calculator. Age-adjusted score is found opposite subject's nearest age. The score tells the fitness category for sustained hard work.

Retest

If the subject doesn't achieve the desired fitness score, the test can be retaken. Anxiety can adversely affect test scores. Usually, two tests provide high reliability and excellent prediction of aerobic capacity. Give retests at least 1 day later.

If after five tries the subject's test score does not meet the fitness level required for his or her job, there are some options: One is to train for 6 to 8 weeks and retest.* Another is to take the 1-½-mile run test.

If the subject is over 35 years old, the fitness score can be computed with a stress electrocardiogram (ECG). If the score is still below the subject's objective, and doctor approval is obtained, the employee can begin a 6 to 8 week aerobic training program, then retake the step test or attempt the 1-½-mile run.

For subjects 35 or under, the run can be attempted without doctor approval. The run is a maximal test and is not recommended for the unfit. If the subject has been inactive, precede the test with 6 to 8 weeks of aerobic training.

*Aerobic training information can be found in the booklet *Fitness and Work Capacity*.

Medical Considerations

Over 35 years of age. Regardless of health status, it is advisable that anyone over 35 have a medical evaluation (including an ECG-monitored exercise test) before a *major increase* in exercise habits. The 1-½-mile run or assignment to a fire position would constitute a major increase in exercise habits for an inactive person.

Those over 35 years of age who are regularly engaged in vigorous physical training programs would not require the exercise ECG, unless of course the individual is concerned about his health.

*Exercise ECG.** The exercise ECG should be administered as part of a medical evaluation during a graded exercise test. The preferred ergometer is the motor-driven treadmill. The Master's Test protocol is *not* acceptable. When possible, the test should be continued to an endpoint determined by personal discomfort or severe fatigue observed by the physician or technician.

The medical evaluation test should be conducted shortly before the intended increase in physical activity.

Peak heart rates. The test should *not* be terminated at the peak heart rate (90 percent of predicted maximal heart rate). One purpose of the exercise ECG is to determine the individual's functional capacity (maximal work capacity). Since there is considerable variability in maximal heart rates, terminating the ECG at a peak heart rate may not provide enough information on the capacity for sustained arduous work.

Functional capacity. The functional capacity should be reported in writing by the doctor and submitted to the test administrator. This capacity can be expressed in metabolic equivalents or *METS* (work metabolic rate/resting metabolic rate) or in predicted or actual (if measured) oxygen intake values (ml/kg/min). A functional capacity of *12.8 METS* is equivalent to an oxygen intake (fitness) score of *45* ml/kg/min. An individual with a functional capacity below *12.8 METS* lacks the fitness for sustained arduous work on the fireline. The functional capacity can be determined as the final workload on the treadmill and converted to *METS* via the accompanying charts.

The MET is a multiple of the resting metabolic rate. If the resting rate is 3.5 ml/kg/min, a rate of 35 ml/kg/min = 10 METS (35 ÷ 3.5 = 10.0).

METS		FITNESS SCORE
12.8	=	45 ml/kg/min
11.4	=	40 ml/kg/min
10.0	=	35 ml/kg/min

Treadmill Grade %	Walking Speed (mph) 1.7	2.0	2.5	3.0	3.4	3.5	4.0	4.2
	METS							
0.0	1.7	2.0	2.5	3.0	3.4	3.5	4.6	5.0
2.5	2.3	2.7	3.3	4.0	4.5	4.7	6.0	6.5
5.0	2.9	3.4	4.2	5.0	5.7	5.9	7.3	7.9
7.5	3.4	4.0	5.0	6.0	6.9	7.1	8.7	9.3
10.0	4.0	4.7	5.9	7.0	8.0	8.3	10.0	10.8
12.0	4.5	5.3	6.6	7.9	9.0	9.2	11.1	11.9
12.5	4.6	5.4	6.8	8.0	9.2	9.5	11.4	12.2
14.0	4.9	5.8	7.3	8.7	10	10.2	12.2	13.0
15.0	5.2	6.1	7.6	9.0	10.3	10.7	12.8	13.6
16.0	5.4	6.4	8.0	9.5	10.8	11.1	13.3	14.2
17.5	5.8	6.8	8.5	10.0	11.5	11.8	14.1	15.0
20.0	6.3	7.5	9.3	11.0	12.7	13.0	15.5	16.5

Treadmill Grade %	Running Speed (mph) 6.0	7.0	8.0	9.0
	METS			
0.0	10.0	11.5	12.8	14.2
2.5	11.4	12.7	14.1	15.4
5.0	12.7	14.0	15.4	16.7
7.5	13.9	15.3	16.6	18.0
10.0	15.2	16.5	17.9	19.3
12.5	16.5	17.8	19.2	20.5

FROM: Guidelines for Exercise Testing and Prescription, American College of Sports Medicine, Philadelphia, Lea and Febiger, 1975.

*NOTE: The exercise ECG is most often used to evaluate patients with proven or suspected coronary artery disease. The exercise ECG provides more diagnostic information than the resting ECG. However, in a group with normal coronary arteries, 8 percent may be diagnosed as abnormal or false positive in the exercise test. Moreover, the test may fail to diagnose 60 percent of those with proven disease in one coronary artery, 34 percent of those with two vessel diseases, and 24 percent of those with three vessel diseases. Thus, the exercise ECG is a useful prognostic tool, but it is not an infallible indicator of coronary artery disease.

ALTERNATIVE FITNESS TEST
(1 ½-MILE RUN)

This test is intended as an alternative for those unable to pass the step test. Previously inactive individuals should precede the test with at least 6 to 8 weeks of exercise (walk-jog-run).

Comparison With Step Test Scores

Runs lasting *12 minutes* or more are useful predictors of the maximal oxygen intake. When the 1 ½-mile run takes an individual 11 to 12 minutes or more, the results correlate highly with step test scores; that is, they both predict the aerobic capacity. But when a subject completes the run in less than 10 minutes, the relationship is less pronounced. Anaerobic or non-oxidative energy sources are used in shorter events. Moreover, basic speed contributes to 1 ½-mile-run performances.

Testing Procedure

Course should be smooth and level; measure for distance. A running track is highly desirable but not necessary. (Track should also be checked for accuracy.)

Subject should be well rested. Encourage a warmup, including flexibility or stretching exercise.

On command the subject begins running and continues to run (or walk, if necessary) the 1 ½-mile distance. Using the chart, the time of the run is converted into ml/kg/min, a fitness score that predicts oxygen intake ability.

During the run, advise the subject of distance covered and the time remaining. Call out the time as subject finishes; where some subjects may lap others, count laps for each runner.

Altitude Adjustment

For test sites at moderate altitude:

- Administer test after a 3-week acclimatization period. Use appropriate correction for sites above 5,000 feet; for example, if the 1 ½ miles were run at 5,000 feet, subtract 30 seconds from the recorded time (see altitude corrections on chart).

- If testing cannot be delayed 3 weeks, arrange to test below 5,000 feet.

Mass Testing Techniques

When testing large groups at the same time, assign nonrunners to record laps and times of those being tested. This is particularly helpful when testing on tracks where some subjects may lap others and lap counting for each runner is necessary. There should be one recorder for each runner. Times should be called out as subjects finish.

Another means of mass testing is:

The funnel method. You need stopwatch, list of runners, numbered index cards. *Timekeeper* – calls time as runners finish. *Recorder* – records time for each runner by order of finish. *Scorer* – hands a numbered index card by place to each runner as he finishes.

Names are recorded beside times when runners submit numbered index (place) cards after the run.*

Midseason Followup

The step test or 1 ½-mile-run alternative should be administered right before the fire season to insure the maintenance of fitness standards and to assess the effects of preseason conditioning.

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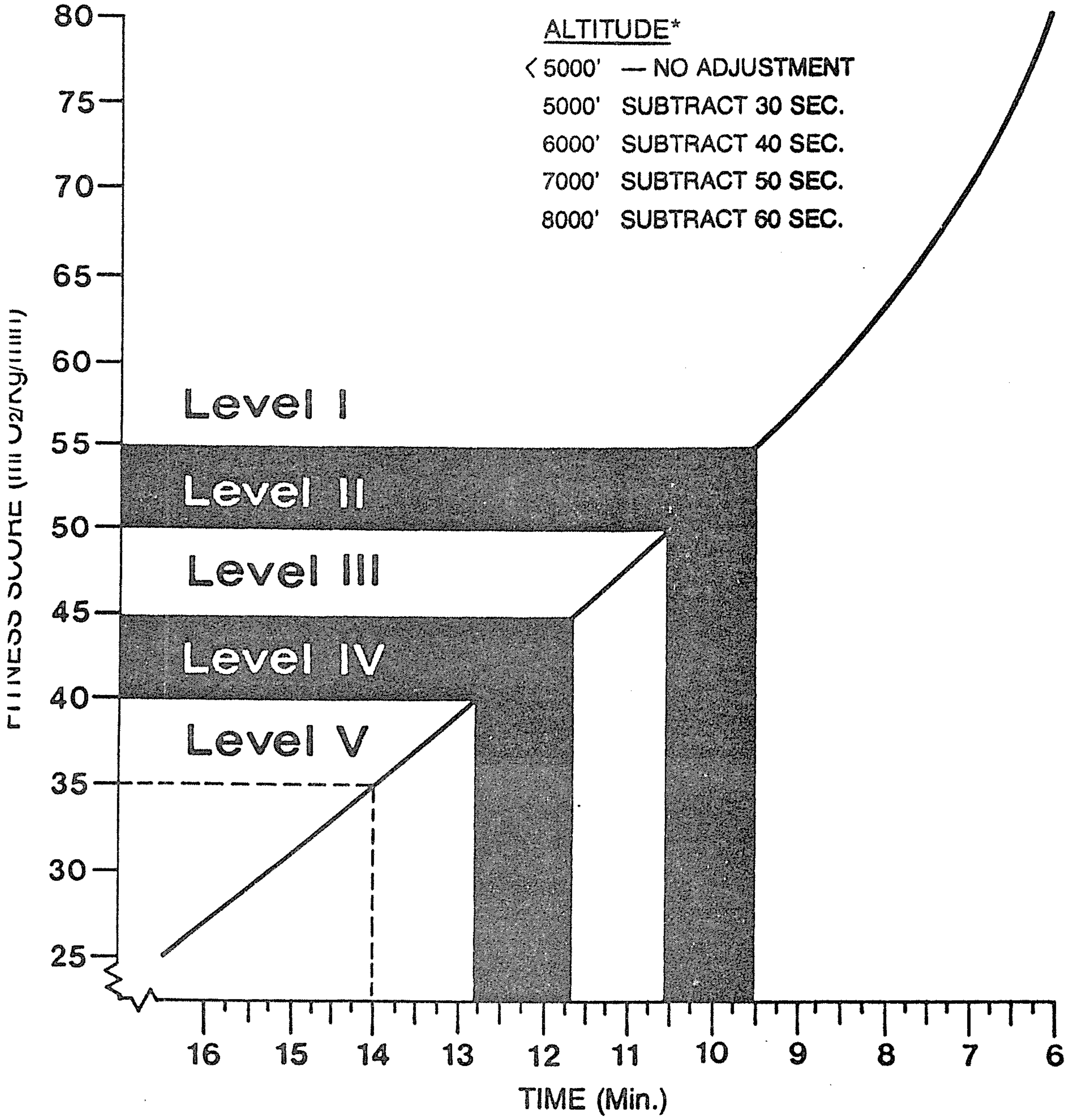
*NOTE: For very large groups the recorder can use a timing sheet with minutes and seconds preprinted. As the runners finish, the scorer touches the timer and he places a "minus" mark beside the second. A fourth official is needed to pass out index cards in the order of finish.

1.5 MILE FITNESS TEST



Rest after a light warm-up. Then run 1.5 miles over a level, measured course. Pacing and high motivation are essential for best performances. Use time for the run to predict fitness (aerobic capacity) and work capacity.

If you have been inactive, preceed the test with a six week training program (walk-jog-run). Those over 35 years of age should have a medical examination including an exercise electrocardiogram.

* FOR TEST ABOVE 5000' — TAKE TIME FOR TEST (E.G. 12:30) AND SUBTRACT 30 SEC. = 12:00. FIND FITNESS SCORE (E.G. 43).

(FROM BALKE, 1963; COOPER, 1970; DANIELS, 1972; SHARKEY, 1975)

REQUIREMENTS

The fitness standard required for sustained arduous work (*45* ml O_2 per kg of body weight per min) is based on:

1. The energy cost of using typical line building tools

pulaski	=	22.3 ml/kg/min
shovel	=	22.9 "
other tools	=	20-30 "
hiking	=	14-28 "

2. Well-trained workers cannot sustain more than 50 percent of their maximal oxygen intake for an 8-hour work shift. Many untrained and unfit individuals will sustain only 33 percent or even 25 percent.

The fitness standard was derived by doubling the average energy cost of fireline construction duties (22.5 ml/kg/min).

QUESTIONS CONCERNING THE STEP TEST

Q. Does bench height discriminate against shorter individuals?

A. Test scores are independent of height. Over half a dozen studies have shown that step test scores do *not* discriminate on the basis of height. Test scores *are* influenced by body weight – and weight *is* included in the scoring procedure.

Q. Why have different benches for men and women? Does that give women an advantage?

A. The test is *submaximal*. If women used the taller bench, it could create a maximal test for *some*. Two bench heights reflect differences in strength and aerobic capacity.

The equations used to predict aerobic capacity for men and women are based upon data collected on benches 15-¾-inches high and 13-inches high respectively. A change in bench height would necessitate collecting new data and deriving new equations for the prediction of the aerobic capacity. Use of the wrong bench invalidates test scores.

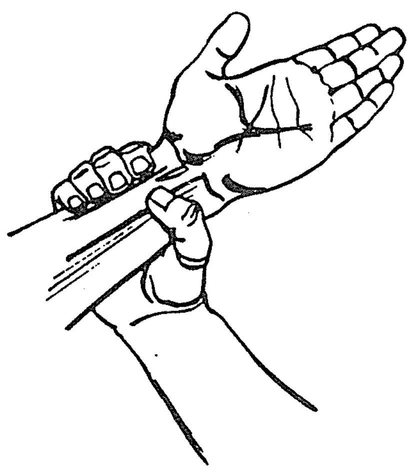
Q. Why not use the resting pulse rate in the scoring procedure?

A. There is a weak relationship between the resting pulse rate and aerobic capacity (lower resting pulse is related to higher aerobic capacity); to this extent the resting pulse is a factor in test scores. There is a *strong* relationship between the exercise pulse and aerobic capacity and between the post-exercise pulse and aerobic capacity.

Many factors can influence the resting pulse (anxiety, fever, coffee, cigarettes, previous exercise). These factors do not affect the post-exercise pulse as readily. For example, an individual may have a somewhat elevated pulse rate before the test because the test appears to be difficult. But, once the individual begins, and finds the test relatively easy, the anxiety is relieved and the pulse rate may actually decline.

Some individuals have a higher resting pulse in spite of their fitness. One man, whose resting pulse was 100, had a post-exercise pulse of 120. He scored 49 on the test.

If the subject's resting pulse seems unusually high, advise taking the test another day. If the subject's score seems low, *retest* on another day. The second or third trial provides a better estimate of aerobic fitness.



Q. Why can some people pass the test but can't do the good job on the fireline?

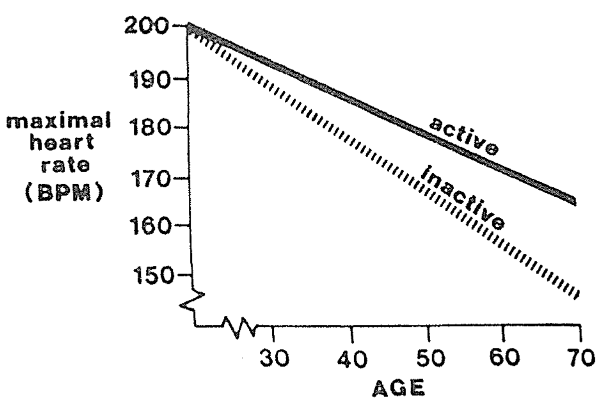
A. Other factors are involved in work capacity including:

- Muscular fitness
- Natural endowment
- Skill and experience
- Nutrition
- Acclimatization
- Intelligence
- Motivation

Some people inherit a high level of fitness. They may score well on the test even when inactive or untrained. Similarly, some inherit a lower aerobic potential. They may score lower in spite of a vigorous training schedule. However, their training will help them to work at a higher percentage of their maximal oxygen intake or aerobic capacity.

Q. Why age corrections? Don't they discriminate against older workers?

A. The maximal pulse rate declines with age, so it's necessary to adjust step test scores to avoid overestimating the fitness of older workers.



The original corrections were based on the best available information concerning the maximal pulse rate decline with age. However, in the fall of 1975 the Institute for Aerobic Research in Dallas, Tex., completed analysis of the largest study of maximal heart rates ever conducted. In a study of over 2,500 subjects with ages ranging from 11 to 79, they found that the rate of decline was less pronounced in more active individuals and more pronounced for those in low fitness categories (under 35 ml/kg/min).

The revised (spring 1976) age corrections provide a more accurate estimate of aerobic fitness for those over 30 years of age. For older workers in the low fitness categories (under 35) the age corrections remain the same.

Q. Why use a submaximal test that is complicated with pulse counts, age corrections, etc.? Why not just use the 1 ½-mile run to predict the aerobic capacity?

A. A major purpose of the test is to insure employee health and safety, as well as to meet production goals. While a simple field test such as the 1-½-mile run is fine for active young men and women, it represents an unnecessary risk for older, less fit persons. The Forest Service step test was designed to be as safe as possible for all workers, regardless of age or fitness. Maximal running tests constitute a risk to a greater percentage of those to be tested.

In the last few years the medical profession has recommended a medical examination for individuals interested in increasing their level of physical activity. A more vigorous fitness test would have to be preceded by a medical examination for all but the regularly active. So it would be financially impossible to implement a Servicewide fitness testing program. Those most in need of fitness training would be the least likely to get tested, and the health and safety goals of the program would not be met.

The 5-minute step test is the best and most accurate fitness test currently available. When research indicates a way to improve the test, to make it safer, more accurate, easier to administer or score, the improvement will be incorporated.

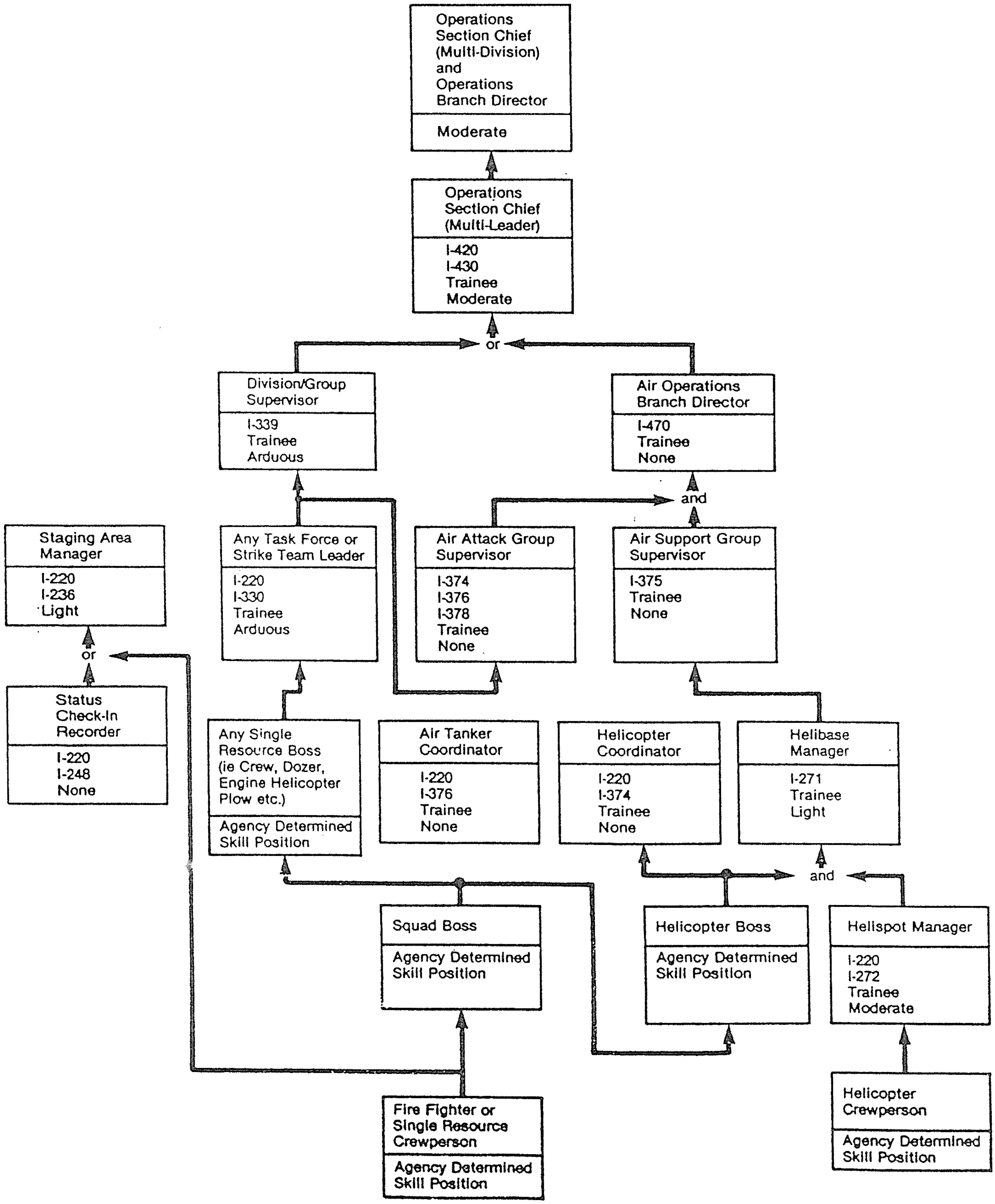
☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—796-058/96

APPENDIX 9

Flow diagram of qualification requirements for promotion within fire management ranks, USDA Forest Service.

Chart 3

Operations Section



APPENDIX 10

Standard tool order for Hotshot Fire Crew.

STANDARD TOOL ORDER

LASSEN HOTSHOTS

SUPERINTENDANT:	SURVEYING PROPOSED LINE/MONITORING FIRE BEHAVIOUR
FOREMAN:	SUPERVISE DIRECTION AND WIDTH OF LINE CONSTRUCTION.
CHAINSAW:	CLEARING LOGS/BRANCHES/SMALL TREES
SWAMPER:	CLEARING AWAY MATERIAL CUT BY CHAINSAW OPERATOR.
CHAINSAW:	
SWAMPER:	
PULASKI:	BREAK UP OF DUFF LAYERS FOR SCRAPING TOOL TO MOVE
PULASKI:	
PULASKI:	
PULASKI:	
SHOVEL:	SCRAPE AWAY BROKEN DUFF LAYERS/SPOT FIRE SUPPRESSION.
SHOVEL:	
PULASKI:	CUT TREE ROOTS AND DEEPEN LINE
COMBINATION TOOL:	FINISH SCRAPING MATERIAL TO MINERAL EARTH/WIDEN LINE
COMBINATION TOOL:	
MCCLEAD TOOL:	
PULASKI:	
SHOVEL:	
COMBINATION TOOL:	
MCCLEOD TOOL:	FINISHING TOUCHES/QUALITY CONTROL

Each member of the crew carries one litre of two stroke fuel for chainsaws. The two members of each chainsaw crew and the first four pulaski operators also carry one litre of chain oil. This will generally be adequate to maintain two saws for one shift (approximately ten hours).

APPENDIX 11

Deployment technique - survival shelters.

Your Fire Shelter