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John J. Garland

The three most expensive wildland fire suppression seasons have occurred since 2000, each exceeding $1 billion. Many problems and issues have been highlighted including the grounding of the federal air tanker fleet, training problems with private contractors, overspending, poor management strategies, negative public perceptions, and the inability to utilize the safest and most efficient suppression resources available.

Technology used by today's loggers has revolutionized many aspects of forest operations. The equipment available can safely and efficiently move earth, cut trees, remove dangerous fuels, and reduce the hazardous exposure to people. Because many of these tasks overlap those of wildland fire suppression, it is logical to incorporate these machines into firefighting.

Private landowners are already required by law to fight fires in the state of Oregon, and the suppression systems employed may be successfully applied on larger federal fires. The biggest factor for investigating the potentials of logging machinery is safety, especially the protection that machine cabs offer. In areas where vegetation and terrain are favorable to the use of equipment, there is no reason to endanger firefighters by assigning tasks that can be performed more safely and more efficiently by logging equipment.

This paper covers the use of forest technologies in wildland firefighting. Safety regulations, training concerns, and equipment issues—including an engineering stability analysis of equipment modified with water tanks. Also covered are attempts to improve wildland firefighting in the region through the founding of the Pacific Northwest Wildfire Equipment Group (PNWEG). Conclusions and recommendations based on the research are offered.

Loggers and Logging Equipment for Wildland Fire Suppression

by

Christopher Bielecki

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Christopher S. Bielecki, Author

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  Obie offered research ideas and cooperation from the start of the project. He also provided insight on his work done with the Northern Rockies Coordinating Group (NRCG). Obie created opportunities allowing the author to attend workshops and demonstrations offered in Montana.

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  Scott provided extensive interview time and continued to participate in the research project by sharing ideas and updates. He volunteered to fly out from Montana twice to address the importance of logging technologies in wildland firefighting. His efforts aided improvements in the Pacific Northwest.

- *Mr. Lee Miller, President, Miller Timber Services*

  Lee was monumental in providing the author's required fire refresher training 2003 and 2004. He created the opportunity for the author to work on wildfires observing new equipment. Lee also contributed to the improvement of wildland firefighting in the Pacific Northwest.

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- *Dr. John Garland, Graduate Advisor*

  John's dedication and encouragement have earned the author's utmost respect and appreciation. The research delved into new areas and was at times both exciting and frustrating. It could not have been completed without John's contributions and efforts.

CONTRIBUTION OF AUTHORS

Dr. John Garland co-authored *Loggers and Logging Equipment to Fight Wildland Fires: Issues and Opportunities in Oregon, USA* as well as *Incorporating Technology: Advancing Wildland Firefighting with Logging Machinery*. Dr. Garland assisted in preparing the *Questions Regarding Forest Machinery used in Wildland Fire Suppression*.

Dr. Robert Rummer and Dr. John Garland contributed writing to *Issues of Using Modified Logging Machinery to Fight Wildfires*.

Mr. Lee Miller and Dr. John Garland contributed writing to *Saving Western Forests with Better Wildland Firefighting* as well as the *Pacific Northwest Wildfire Equipment Group Action Planning Report*.

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CHAPTER ONE: INTRODUCTION

Problem Statement

Wildfires in the western United States have become major issues in the last decade. Suppression costs have risen dramatically and resulted in the three most expensive suppression seasons ever in 2000, 2002, and 2003. The management tactics of public agencies are under scrutiny from media and taxpayers—fueled from images of giant fire camps serving gourmet meals to firefighters leaving camp after breakfast and returning before dark. In addition, fuels built up from over fifty years of intense suppression add to the number of catastrophic fires burning every summer and fall.

The need for new tools and technology for fire suppression services has never been greater. Hand built firelines and dozer lines are simply not sufficient to stop raging crown fires. Another valuable wildland firefighting tool—the air tanker, has been the source of major controversy. Multiple fatal accidents involving World War II era planes grounded the federal fleet prior to the 2004 season. These problems highlight the need for change in a wildfire suppression system that has advanced little over the last 50 years.

Meanwhile, logging equipment offers much potential for wildland fire suppression. The mobile machinery was designed to work in the woods running over rough terrain while handling earth and timber. Loggers are skilled in woods work and commonly perform many tasks that directly relate to firefighting (e.g. digging line, moving debris, etc.). Logging crews in Oregon are required to have training in wildland firefighting (**OR-OSHA, 2003**), and many have actual firefighting experience.

It is logical for the logging workforce and their technology to be used in fire suppression. However, many issues and obstacles exist limiting the use of these resources. Traditions in the fire community are at stake and many stereotypes must be broken. Improvements in utilizing available local resources are needed by the fire management agencies. On the other hand, private contractors require more knowledge regarding coordination under the incident command structure and fire behavior. Based on the level of firefighting they will be required to perform, the private contractors may need improvements in training to meet the requirements of the firefighting management agencies.

One of the important characteristics of the logging workforce is the proximity to wildfires (see Figure 8). Large wildfires in the western United States often involve forested areas where logging crews are nearby. Although not all of the firefighting systems used by private landowners are applicable to public agency wildfires, many of the tools can provide needed assistance. Suppression and clean-up of fires on logging operations and private land often occur immediately.

Focus Points

To help identify the issues, the following focus areas have been identified:

- Safety regulations for workers
- Training schemes for both private contractors and agency firefighters
- Equipment issues related to wildland firefighting

Safety Regulations

At the heart of the project is the revision of the Oregon Occupational Health and Safety Administration safety regulations pertaining to wildland firefighting (**OR-OSHA, 2003**). These regulations provide the minimum required training levels for all Forest Activities workers. Safety regulations are especially important in Oregon. The state requires all logging crews to assist in fires occurring on their timber harvesting operation (**Oregon Revised Statutes, 2001**).

Professional firefighters require additional training to fight fires safely with available resources. The professional firefighters include private contractors and agency personnel involved with wildland fire suppression on a full-time basis. To incorporate logging machinery into wildland fire suppression, these workers must learn how to coordinate with the equipment. Education needs to include the capabilities and applications of available firefighting tools. Only when agency firefighters are familiar with the resources encountered can suppression be safe and efficient.

Training Schemes

Training is essential for the safety of firefighters. From a broad perspective, the training problem is clearly defined. Private contractors are often skilled in the use of machinery in rough terrain, have woods savvy, possess skills needed in firefighting, and are located in proximity to wildfires. Yet the private contractors usually receive minimal fire training and often have little education or experience in fire behavior. Contractors also lack experience in coordinating under the Incident Command System (ICS) used by agencies and mobilizing to work alongside 20-person handcrews and other traditional resources.

Firefighting agencies including the Forest Service, Bureau of Land Management, US Fish & Wildlife Service, National Park Service, and state agencies represent the other half of the training dilemma. These firefighters commonly have extensive training in fire behavior, ICS procedures, and have experience with large complex fires. However, a decrease in timber management personnel and timber sale administrators plays a role in the agencies' lack of experience dealing with current forest operations technologies. Now that logging tools can perform a variety of firefighting tasks quickly, safely, and efficiently the firefighting agencies need to adapt if these tools will be used to their full potential.

Equipment

New equipment developments have revolutionized many aspects of forestry, but not necessarily firefighting. When the terrain and availability are suitable, logging machines can perform certain fire tasks safely and efficiently. Machines including earthmovers and timber tools are scattered throughout the western US and available for wildland firefighting. In addition, new modified water carriers provide large amounts of water (from 200-3000 gallons) to remote wildfires. These machines can knock down spot fires and dig line while also serving as off-road fire engines and water tenders.

Issues and Obstacles

The major issues revolve around the adaptation of new technologies. Wildland firefighting has deep traditions. A sense of competition is sometimes found for new equipment among professional firefighters. In Oregon and elsewhere, hundreds of private 20-person handcrews are hesitant to embrace logging equipment because they feel their jobs are at stake. These issues need to be dealt with by focusing on the coordination of existing resources with new tools—not the replacement or competitive aspects.

Another major issue is the regional difference in knowledge and perception. Region 1 of the USDA Forest Service (Northern Rockies) has embraced the new technology and properly used the best available resources. During the 2000 fire season the Northern Rockies were devastated by multiple large fires burning simultaneously. A "call for help" was put out by the fire agencies, and hundreds of loggers, construction workers, and landowners offered equipment and workers to stop the surrounding blazes. The gathered equipment covered a broad spectrum in quality, design, and capability. The 2000 fire situation prompted the Northern Rockies Coordinating Group (NRCG) to make assessments to improve the utilization of the equipment and "weed out" those pieces that are unsafe or incapable **(Kuehn, 2003)**. At this point in time, Region 1 is a leader in recognizing and working to utilize the potentials of logging equipment for wildfires.

Organization of the Paper

This report gathers many individual pieces of information to present a complete summary of the research project. Each chapter represents a segment of research and contains specifically related manuscripts. References used in manuscripts are summarized immediately following each article. References in **bold font** designate those specific to the overall report. They are listed in the document's References section (see "References" in the Table of Contents).

Chapter Two: Safety Regulations

Chapter Two introduces the reader to the safety regulations pertaining to wildland firefighting, including state and federal codes. In addition, the chapter summarizes the changes made to the Oregon Occupational Safety and Health Administration Forest Activities Code pertaining to wildland firefighting and prescribed burning. The author served on the advisory sub-committee focused on revising the wildland firefighting portion of the state Forest Activities Code.

Chapter Three: Training

The training segment begins with a summary of training regimes for the different levels of firefighting. The chapter also covers the author's experiences attending various training programs covering the use of logging equipment in wildland firefighting. These opportunities include the equipment inspection workshops and live machine demonstrations held by the Northern Rockies Coordinating Group (NRCG).

Chapter Four: Equipment

Chapter Four introduces various types of equipment available for fire suppression. The potentials for each type of machine are summarized here as well as the author's observations of machines on wildfires. The chapter leads into the work done to learn more about logging equipment from machinery experts including the Society of Automotive Engineers (SAE) Forest Machinery sub-committee. Results are summarized in the manuscript *Issues of Using Modified Logging Machinery to Fight Wildfires*, based on the input received from machinery representatives as well as contractors and firefighters.

Chapter Five: Stability of Modified Machines

Building from the equipment chapter, Chapter Five specializes in analyzing logging machines modified with water tanks. These machines perform differently when transporting a load of logs versus carrying a load of water. A computer program designed by the author to determine the stability of modified machines is described along with results.

Chapter Six: Advancement of Wildland Fire Suppression Efficiency in the Pacific Northwest

During the course of the research it became apparent that Region 6 (Washington and Oregon) of the United States Forest Service was not using logging machinery to the full potential for wildfire suppression. The Pacific Northwest Wildfire Equipment Group (PNWEG) was formed to work on improving equipment use and educating firefighters in the region. Along with the efforts of the PNWEG, Chapter Six includes the manuscript Incorporating Technology: Advancing Wildland Firefighting with Logging Machinery. The chapter concludes with a list of presentations and audiences addressed throughout the research project in attempts to distribute knowledge and educate forestry professionals about the potentials of logging equipment.

Chapter Seven: Recommendations

Chapter Seven includes the author's recommendations for enhancing wildland fire suppression management. Based on two years of research, these recommendations focus on the Pacific Northwest and include reference to successful training programs currently offered in other areas.

Chapter Eight: Conclusions

Major conclusions and observations are summarized here. This chapter will briefly summarize information presented in previous chapters and offer additional thoughts from the author based on his experiences throughout this research project.

<u>Introduction to Manuscript One</u>

The following paper describes the overall approach to the project including objectives for this research effort scoping out the topic. It was presented at the *7th International Wildland Firefighting Safety Summit* held in Toronto, Ontario, Canada in November 2003. This outreach was offered in the form of a paper and accompanying presentation to the wildland firefighting community.

Loggers and Logging Equipment to Fight Wildland Fires: Issues and Opportunities in Oregon

Christopher Bielecki & Dr. John Garland, PE

Presented at the 7th Annual International Wildland Firefighting Safety Summit

Introduction/Objectives

Recent fire seasons have been devastating with lives lost and millions of acres burned in Oregon alone. Contract loggers often have a strategic proximity to aid in initial attack. Research efforts to explore these possibilities in Oregon are addressing safety regulations pertaining to workers, developments in logging machinery to fight fire, and training concerns. The current fire situation throughout the western U.S. continues to make this line of research important for the firefighting community.

Since 1988, the Oregon Occupational Safety and Health Administration (OR-OSHA) safety code has specifically addressed the wildland firefighter as an employee of a firm operating within Oregon. While responding to fires on logging operations, employees are of course employed by contractors or the landowner. When fires on private land become state responsibility, firefighters are considered employees of the Oregon Department of Forestry. While fighting fires on federal lands in Oregon, the Interagency Fire Command Structure uses contractors who have employees covered under OR-OSHA codes.

While the federal safety code still relies on the general duty clause and other safety standards, OR-OSHA regulations covers thousands of Forest Activities workers, including hundreds of private and agency firefighting crews. An industry-based safety code review committee is currently updating the proposed regulations to include new machinery applications and other fire activity code issues.

Logging uses advanced technology to make forest operations more efficient and some of these innovations are finding a role in firefighting as part of the process. For example, felling machines are used in place of timber fallers, and hydraulic excavators are used to move timber and vegetation along with bulldozers to build firelines. Forwarders are now equipped with auxiliary tanks to make large quantities of water available in difficult terrain for hose lays, with additional foaming devices and water cannons. Likewise, skidders have tanks attached and become "skidgines" on the firelines. The objectives for research are to:

- Document the applications and uses of modified logging equipment used in firefighting

- Provide knowledge of equipment use to agencies and firefighters including slope stability issues and potential applications for timber types
- Interact with machine manufacturers through the Society of Automotive Engineers (SAE) Forest Machinery Subcommittee to gain their views on use of equipment in firefighting
- Assess policies for using logging crews and equipment on fires, especially regarding training for initial and extended attack
- Provide input to the OR-OSHA for rule development concerning wildland firefighting.

Approach

We are collecting information on the use of modified logging equipment used for firefighting on public and private lands to assess problems and opportunities. With such adaptations like auxiliary water tanks on forwarders, engineering analyses and stability models are needed to determine safe limits of machinery use on difficult terrain. The OR-OSHA committee and the SAE Forest Machinery Subcommittee are reviewing guidelines for these new technologies, and a survey is planned for the Subcommittee. Another critical issue is the training and structure of fire suppression management and the incorporation of loggers. While loggers have valuable skills in timber falling and machine operation, they may have minimal knowledge of fire behavior or fire organization for suppression. What steps are needed for a logging crew adjacent to a lightning strike to take action and extinguish the fire? How would such attacks integrate with the coordination of the responding agencies and the transition to an extended attack scenario? A review of needed training, personal protective equipment, and coordination among organizations is underway to see how such a process could work. We expect to summarize our findings in a report to the U.S. Forest Service who is providing funding for the project and to publish the results.

Results and Discussion

Because Oregon loggers are required by law to make a "reasonable effort" to suppress fires resulting from their operations, they take firefighting seriously. For example, "skidgines" follow tracked hot saw machines during operations to immediately suppress fires caused by track or saw sparks. Various forwarder tank designs have been successfully used on wildland fires, but there is little knowledge among the fire command structure how such equipment can be employed. Other modified logging equipment may not be recognized as well.

Mobility and stability models at Oregon State and Auburn University show the effects of slope, auxiliary tank placement, and machine design for fire operations. Safe operating procedures can be developed from the basic information. Results from the survey of SAE Forest Machinery Subcommittee should be available later this year.

The new OR-OSHA Division 7 Forest Activities Code becomes effective December 1, 2003 and includes provisions covering employers and employees engaged in wildland fire fighting. Some fire contractors were surprised to learn that they are responsible for all of the provisions of Division 7 safety codes unless exempted. Provisions covering fire training for logging crews are at present unchanged, but other provisions, such as machine guarding requirement and operating conditions, will be applicable.

The training for wildland firefighting in Div. 7 consists of a one-day (typically video based) training on general fire behavior and control, personal protective equipment, tools and equipment, laws and regulations, and communications/lines of authority. Some logging contractors provide additional training beyond that required by OR-OSHA and may include week long courses. However, most logging contractors do not provide the training needed to meet the Federal Interagency firefighting contract in full unless they are also engaged in agency contract fire suppression.

The OR-OSHA Fire Subcommittee is still meeting to address potential rule changes regarding wildland firefighting. Once rules are considered by the full OR-OSHA Committee, they must be submitted to public hearings, testimony and final rule-making.

Conclusion

Our research is still ongoing but some preliminary findings are noteworthy. Anecdotal evidence suggests modified logging equipment can make successful contributions to firefighting ranging from mechanized felling, water delivery, fireline construction and direct suppression. The "Proteus" is the most recognized example of such equipment. However, fire managers need much more information and experience with modified logging equipment to effectively dispatch and utilize it.

Because of contract provisions regarding personal protective gear, heavy equipment approvals, and training requirements, it is often difficult for logging crews to continue firefighting after an agency responds to the incident—especially on federal lands. Meeting the OR-OSHA Div. 7 Code requirements does not qualify logging contractors for fire suppression on federal agency fire incidents. Conversely, not all fire contractors may be meeting the full OR-OSHA Forest Activities Code requirements at present.

Modifying logging equipment for firefighting without taking into account design conditions of machine stability could lead to hazardous operations. Sticking a tank on a skidding machine without considering overall machine stability would not be recommended. Machine manufacturers may have something to say about the uses of machines they designed for uses other than firefighting. As large fires persist in the west, fire suppression is continually changing. The potential for using logging personnel and equipment to fight wildland fires is an important firefighting option.

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CHAPTER TWO: SAFETY REGULATIONS

Introduction to Safety

Safety is at the heart of this research project. Logging and firefighting are dangerous; accidents and fatalities occur every year. Many safety regulations and policies cover wildland fire suppression. Safety regulations and policies are provided by federal and state agencies, private companies, and various contracts. Therefore, it is important for loggers involved with wildland firefighting to understand which rules, regulations, and policies are applicable and at what times.

Requirements of safety influence what tactics are employed and what resources are utilized on a wildland fire. Many arguments for and against the use of logging equipment in fire situations revolve around safety. When fire managers are not familiar with a piece of machinery, the safest may be to simply not use it. There is no easy explanation for endangering a machine operator and nearby ground crews when managers are unfamiliar with the equipment technology.

Knowledge about machinery is the first step in realizing that logging equipment can perform many tasks and actually reduce the dangers to hand crews. In many situations, the ground crews can be better utilized elsewhere on the fire. A strong example is felling hazard trees (Figures 1 & 2).

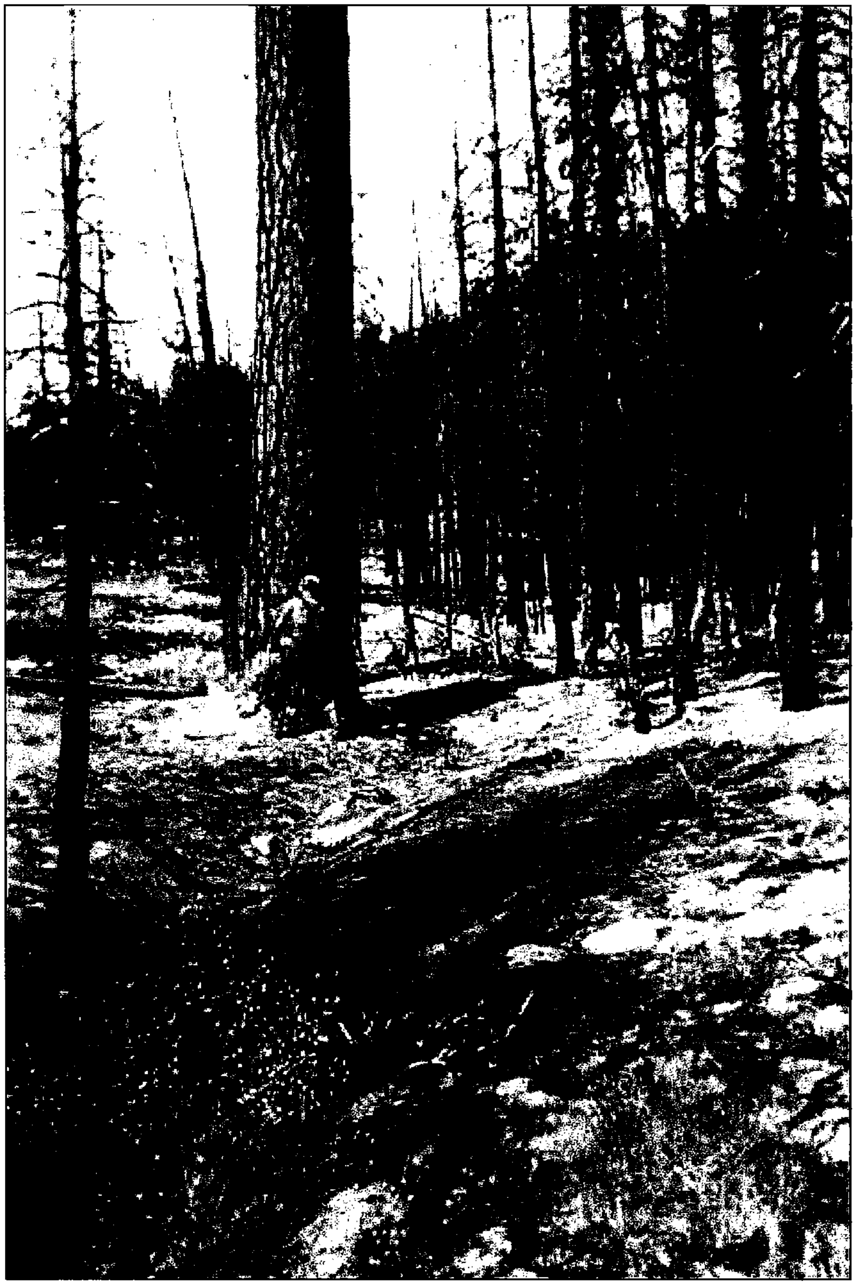

Figure 1: Manual feller working on a burned hazard tree. Considering the personal protective equipment used here, the exposure to hazards is significant.

Figure 2: Tracked log-skidder using the blade to push over a hazard tree burned off at the base. The operator exposure to hazards is minimized by the cab features—including Falling-Object Protection (FOPS) and Roll-over Protection (ROPS).

Federal Occupational Safety and Health Administration (Fed OSHA)

Fed OSHA does not specifically cover wildland firefighting. Rather, all federal firefighters fall under the general duty clause. OR-OSHA states:

> (a) Each employer –
>
> > (1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;
> > (2) shall comply with occupational safety and health standards promulgated under this Act.

> (b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct. **(OSHA, 2004)**

Because of the general coverage of this regulation, any accident resulting in injury or death might be determined to be in violation of the general duty clause. To supplement the general duty clause, Fed OSHA also relies on the policies of the individual government agencies. For example, after several firefighters died on the Thirty-Mile Fire in Washington during the 2001 season, Fed OSHA cited the US Forest Service for violating their own Fire Orders **(US Forest Service, 2004)**.

Oregon Occupational Safety and Health Administration

The state of Oregon specifically addresses wildland firefighting in the Oregon Occupational Safety and Health Administration (OR-OSHA) safety code **(OR-OSHA, 2003)**. These regulations can be found in the Division 7 Forest Activities Code, specifically in Sub-Division N, Fire Protection/Suppression and Prescribed Burning section.

All employees of a firm in the state of Oregon participating in wildland firefighting must receive the minimum safety training. To provide more adequate coverage to Oregon workers, a technical advisory sub-committee was appointed in late 2002 to revise the state wildland firefighting regulations. The author participated in the sub-committee for the duration of the research project. The main goals for the review are:

- To make rules more clear and concise for users
- Update rules to include current technology
- Eliminate outdated/obsolete rules
- Provide uniformity between Division 7 (Forest Activities Code) and other rules
- Address areas not currently addressed

The sub-committee has not yet completed the revision process. However, the major changes made to this point in time can be discussed. A full draft of proposed changes can be found in Appendix X.

OR-OSHA Wildland Firefighting Safety Regulations: Summary of Changes

Simplifications

The proposed firefighting regulations eliminate the current code designation of firefighting levels and applicable training. All personnel participating in wildland firefighting will be required to maintain a minimum level of training titled Basic Wildland Fire Safety Training. The full curriculum for training can be found in the proposed changes in Appendix X.

The proposed code also combines the Head Protection and Protective Clothing sections into a new, complete Personal Protective Equipment section.

Additions

One of the first changes readers will notice in the proposed code is the new Scope section. This section explains the purpose of the minimum wildland firefighting safety regulations and specifies that the minimum firefighting regulations do not limit the use of other applicable safety and health rules contained in agency contracts or other arrangements.

Training regulations were added that require an annual firefighting refresher training each spring. Under the current code a forest activities workers (e.g., loggers, timber cruisers) engaged in wildland firefighting could feasibly receive fire training only once during their career. The annual refresher will not be required to be as in depth as the initial training, but rather be "relevant to the fire suppression activities to which workers may be assigned" (Appendix X).

A new segment for definitions is also included. There are two purposes definitions: to make the new code clear to readers, and to remain uniform with the other areas of the Forest Activities Code. The new code will define terms such as wildland fire suppression, prescribed burning, direct supervision, fire watchman, and so forth.

The machine operation section was expanded from the current wording to address new modified logging machinery used in wildland firefighting. The current code states that:

> Machines (tractors, skidders, excavators) used for fire trail construction or firefighting, may be operated on slopes in excess of 50% provided measures are taken to assure the stability of the machine by:
>
> (a) Using the blade, or
> (b) Tying to stumps, anchors, or other machines, or
> (c) Excavation to limit the effective slope under the machine. etc.
>
> **(OR-OSHA, 2003)**

The addition proposed involves the new line (d) which states: "Limiting the operating range of movement and/or the loading to maintain stability". The sub-committee felt that this addition would provide for a minimum level of safety for those working with machines with supplementary water tanks and other modifications.

Proposed Rule Change Procedure

Once the sub-committee agrees on the new Subdivision N, it will be passed to the full committee assigned to revise the entire Division 7 code. Upon its approval, the proposed changes will go for a period of public review. Agency approval after the public review stage will result in the establishment of the updated code. The implementation date will be preceded by an education period where OR-OSHA and

Associated Oregon Loggers (AOL) work to teach those involved with Forest Activities in Oregon about the new changes and understand their interpretation.

CHAPTER 3: TRAINING

Training is essential for safe and efficient utilization of firefighting equipment including logging machinery. Chapter Three begins with a summary of the current training required for various levels of firefighting. For a thorough overview of this subject see Appendix IX. The chapter also provides an introduction to two successful types of training developed by the Northern Rockies Coordinating Group (NRCG) in Montana. The NRCG training programs have potential to be adopted in other areas including the Pacific Northwest.

Current Training Provisions for the Levels of Firefighters in Oregon

Professional Firefighters

The professional firefighters in Oregon include agency firefighters and private contractors with crews. Oregon is unique in that it has more private 20-person handcrews than any other state (around 300 in 2004). They are required by contract to receive a level of training equal to state and federal agency firefighters. Commonly this training program is a week-long (40 hour) fire school that covers fire behavior, firefighting tactics, use of hand tools, coordination under the Incident Command System (ICS), building fireline and deploying fire shelters. Professional firefighters are also required to wear Nomex™ and carry fire shelters.

Another major portion of professional firefighter training covers the rules of engagement. These rules are an ever-expanding reference that includes many orders, rules and situations to pay attention to when fighting fire. Most of the rules of engagement were created after fatal accidents so the lessons learned can be employed to save lives in the future based on responsive actions. The following are examples of the rules of engagement:

- 10 Standard Fire Orders
- 18 Watch Out Situations
- Downhill line construction checklist
- Wildland Urban Watch Outs
- LCES Checklist
- Look Up, Look Down, Look Around
- Tactical Watchouts

Forest Activities Workers

The forest activity worker represents a professional forestry worker such as timber cruiser, logger, or tree planter. This group includes logging equipment operators. In Oregon, if these workers "may be called upon to do fire suppression", they must receive the proper training within a certain time of hire. Oregon also requires landowners and logging contractors to provide a reasonable effort to suppress wildfires started on their operation or property **(ORS 477)**. Oregon Revised Statute 477.066 specifically states:

> **Duty of owner and operator to abate fire; abatement by authorities.** (1) Each owner and operator of forestland on which a fire exists or from which it may have spread, notwithstanding the origin or subsequent spread thereof, shall immediately proceed to control and extinguish such fire when its existence comes to the knowledge of the owner or operator, without awaiting instructions from the forester, and shall continue until the fire is extinguished.

To prepare forestry workers, a minimum level of fire safety training is provided. Often a 1-hour video with handouts is used. After training, workers with the proper safety gear can fight fire on the job.

Many employers go beyond the basic training required by OR-OSHA when they have specialized firefighting equipment on site. Specialized equipment can include water tanks, water trucks, pumps, hoses, hand tools, radios, and emergency phones/radios. Many crews spend time learning to use their firefighting equipment. Most companies write up a safety procedure to follow in the event of a fire.

Pick-Ups

Pick-ups, otherwise known as emergency hires or administratively determined (AD) employees, represent another level of firefighters. This designation applies to a rancher who owns a bulldozer needed at a nearby fire, or a neighbor with hand tools ready to help. With no training whatsoever, agency fire managers can utilize these resources for the first shift (often a 12 or 24 hour period depending on the individual agency policy). The fire assignment is restricted to situations where the pick-up firefighter works directly with trained firefighters. In Oregon, after this first shift, the agency must provide basic fire training and provide appropriate safety gear if the worker is to continue on the fire.

Two Successful Training Strategies for Adapting to New Equipment Technologies

During the course of the project the author had the opportunity to participate in two important training sessions with the Northern Rockies Coordinating Group (NRCG) in Missoula, Montana. The first was a weeklong Equipment Inspectors Workshop. The second was a two-day Big Iron Demonstration that featured one half-day of classroom discussion and a full day of equipment observation. Both of these programs offered valuable information to public agency personnel involved with firefighting. The benefits from these preparatory sessions provided for enhanced fire suppression efficiency in Montana and could be applicable in other regions as well.

Equipment Inspectors Workshop

In the spring of 2004, the NRCG held three weeklong training sessions for those inspecting firefighting equipment for the upcoming season. This training was held because the duties of the fire equipment inspectors have increased with the variety of equipment used on wildland fires. In addition, the increase in private contractors created a need for improved inspections of equipment in conformity with agency regulations.

The equipment inspectors use a single page checklist when looking at equipment, whether it is a school bus, fire engine, or feller-buncher. This fact alone leads one to believe that additional checklists are needed. This improper evaluation procedure has been recognized by the NRCG and they have provided additional checklists for some of the equipment used today—including skidgines, bulldozers, and fire engines. These can be found on the NRCG website **(NRCG, 2004)**. Since the checklists have already been created and updated, part of the workshop was spent familiarizing those in attendance with the additional lists.
A hands-on day was included—allowing those who have yet to work with hydraulic excavators, skidgines, delimbers, super-skidgines, and feller-bunchers the chance to see mechanized logging equipment first hand.

Figure 3: Fire equipment inspectors learn about feller-bunchers during a Northern Rockies Coordinating Group workshop.

Big Iron Demonstration

The Big Iron Demo was organized to provide an opportunity for observing logging equipment available for wildland firefighting and fuels reduction. The workshop targeted anyone that deals with forest and interface fuels management and wildland fire suppression. This group included silviculturalists, resource advisors, unit managers, specialists dealing with site rehabilitation or environmental protection, operation section chiefs, division/group supervisors, dozer bosses, equipment managers, incident commanders, and private consulting foresters.

The two-day workshop was the second such meeting held by the NRCG. It was intended to show how machines best work together for efficiency and meet management standards. The workshop also scheduled time for the attendees to interact with machine operators.

Figure 4: Attendees at the Big Iron Demonstration learn about hydraulic excavators.

Figure 5: Modified grapple skidder at the Big Iron Demonstration.

CHAPTER 4: EQUIPMENT

Mechanization has always been a part of forest operations, and major advancements have occurred in the last few decades. In logging operations, machines offer improvements in safety and efficiency. However, machines cannot be used in every situation. There are limits to machinery operation such as slope, vegetation type, and tree diameter. New technology allows for these limits to be extended. For example, self-leveling cabs and tracked carriers allow feller-bunchers to operate on steeper ground. Similar innovations have influenced many forest operations, and new technology is starting to be used in wildland firefighting.

The major innovation here is the modification of logging machines for fire suppression. Many types of machines have been changed to carry and deliver water. These include:

- Skidders modified with water tanks, pumps, hoses, and water cannons
- Feller-bunchers with misters to reduce sparks and debris exhaust heat
- Excavators with hoses to spray water from the boom
- Forwarders modified with water tanks up to 3000 gallons
- Bulldozers equipped with water tanks, pumps, and hoses

The modified machines come from a wide-range of designers, engineers, and budgets—resulting in a variety of capabilities and qualities. This variety is a major obstacle for a professional firefighting situation. Without a systematic way to classify and evaluate the many types of machines, fire managing agencies are unlikely to employ them. The Northern Rockies Region (Region 1) of the Forest Service has worked to classify these machines using specifications, pay rates, and checklists for evaluations. The products of the Northern Rockies Coordinating Group provide an example to other regions interested in wildland fire suppression technology **(NRCG, 2004)**.

An Example of Potential with Equipment

Logging equipment can enhance many tasks of wildland firefighting, including protecting the wildland urban interface. The Townsend Hydra-Horse (Figure 6) is a skidgine equipped with a 1500 gallon water tank, pumps, hoses, remote-controlled water cannon, and gel system for structure protection. The owner, Ed Townsend, volunteered the machine for the 2004 fire season with the Ferndale Volunteer Fire Department. Townsend and the fire department believed the machine would be useful defending multiple structures from fire in wildland-urban interface fires (**Townsend, 2003 and Kovacevic, 2004**).

This thinking is drastically different from other wildland/urban areas. In California, these fires commonly call for the placement of an urban fire engine and crew at each structure. These engines are limited to travel on roads and require wide turn-arounds and driveways. The spacing of houses and structures use many engines and crews. On the other hand, the skidgine could travel between structures, using the 4-wheel drive and substantial clearance to get where needed. Minimal preparation by the landowners would be needed around their structures.

Townsend has experience using his machine to fight fire in the crowns of trees. Using the water cannon on his machine he has knocked down flames from tree canopies. An example of the range of the cannon can be seen in Figure 6. Because many fires often have spotting in distant tree-tops, the Hydra-Horse skidgine could serve as an effective piece of equipment for defending fireline and patrolling for spot fires.

Figure 6: The Townsend Hydra-Horse, a skidgine used in Montana for wildland firefighting.

Interaction with SAE

A questionnaire was prepared in an attempt to gather information about machinery used in firefighting (Appendix I). It was distributed to the Society of Automotive Engineers Forest Machinery Sub-Committee, a group consisting of major forestry and logging equipment manufacturers. Minimal feedback was returned from the sub-committee. It was then distributed to companies and contractors involved with wildland firefighting with logging technologies.

Fire Observation

Summer 2003

To observe equipment during the summer of 2003, the author trained with Miller Timber Services and joined a nationally dispatched initial attack handcrew. Miller owned a log forwarder modified with a 2000 gallon water tank, and it was planned for the author's crew to be dispatched along with the machine when ordered. However, the machine was not ordered throughout the summer and eventually the handcrew was dispatched to California. Here the author fought fire on a number of agency managed wildfires, but not one piece of ground-based machinery was observed. See Appendix 3 for more information.

Summer 2004

During the summer of 2004 the author joined the Forest Service as an Engineering Technician to observe firefighting machinery. A full twelve-hour day was spent observing two skidgines on the Log Springs Fire in Oregon (see Summer Observation Report #1 in Appendix 4). These machines are log skidders converted with fire engine capabilities. There were two types present: a tracked FMC machine and a rubber-tired Caterpillar skidder. Both were used in mop-up activities on the fire.

Each machine had a skilled operator, supplying water quickly and efficiently at the request of the coordinating hand crews. This eliminated the need for the crew members to carry individual forty pound (five gallon) backpack pumps commonly used during similar mop-up situations in remote areas. The operators each had hand-held radio communications and were also able to communicate to the adjacent firefighters with hand signals. Because the noise of the machine often drowned out the operator radio, the hand signals were significant.

The tracked skidgine was also used to push over a hung-up danger tree. The tree had previously burned out at the base and fell into another tree, creating a hang-up. The sawyer assigned to this division assessed the situation and then called the skidgine operator. The machine used the blade to push the tree down, eliminating the need for a person to perform the task manually with a chainsaw.

Introduction to Manuscript Two

The following paper entitled "Issues of Using Modified Logging Machinery to Fight Wildfires" is largely based on the responses provided to the questionnaire. It was submitted to the *International Journal of Wildland Fire* in November 2004 and is currently in the peer review process.

ISSUES OF USING MODIFIED LOGGING MACHINERY TO FIGHT WILDFIRES

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Each year wildfires continue to burn valuable land and resources while threatening people and structures. Trends in the United States show increasing land burned and increasing suppression costs during recent years (*Figure 5*).

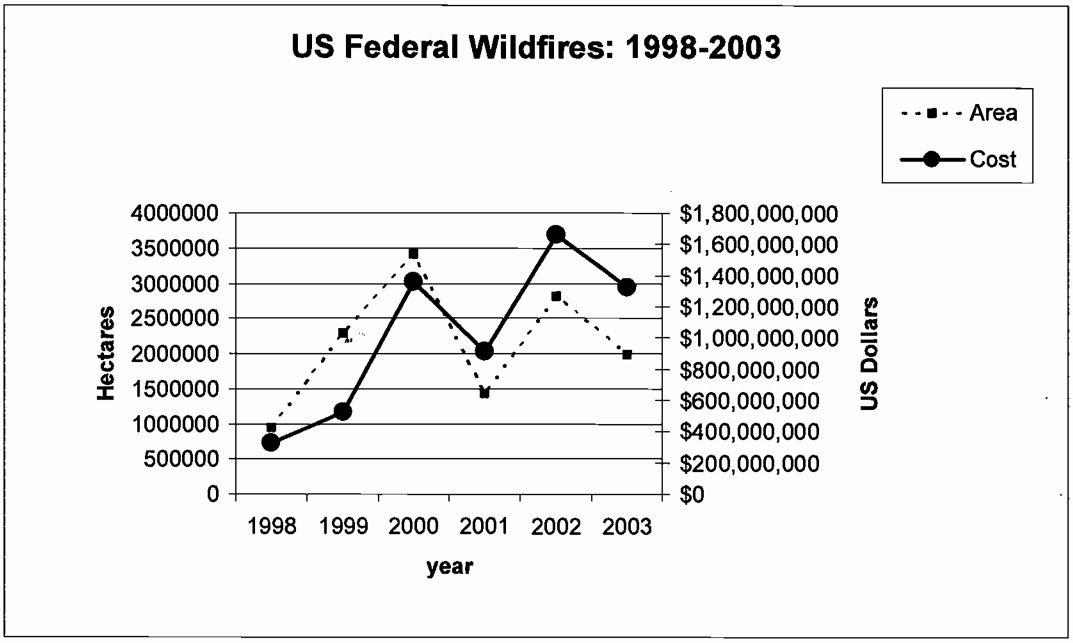

Figure 7: US Wildfire Costs and Area Burned 1998-2003 (NIFC, 2004).

To make progress on these catastrophic events, new tools are in demand throughout forested areas. Non-traditional firefighting systems involving logging machines are currently used to fight fires in western North America—demonstrating the potential to revolutionize wildland firefighting. Modern machines can supplement crews and traditional resources by quickly and effectively building fireline, creating wide fuel breaks, assisting mop-up activities, and rehabilitating areas after these suppression actions. When considering their proximity to wildfires (*Figure 6*), private forestry contractors offer a needed source of firefighters and technology. However, many issues exist regarding the use of these people and their machines. Furthermore, these issues often create obstacles to using the safest and most efficient resources available.

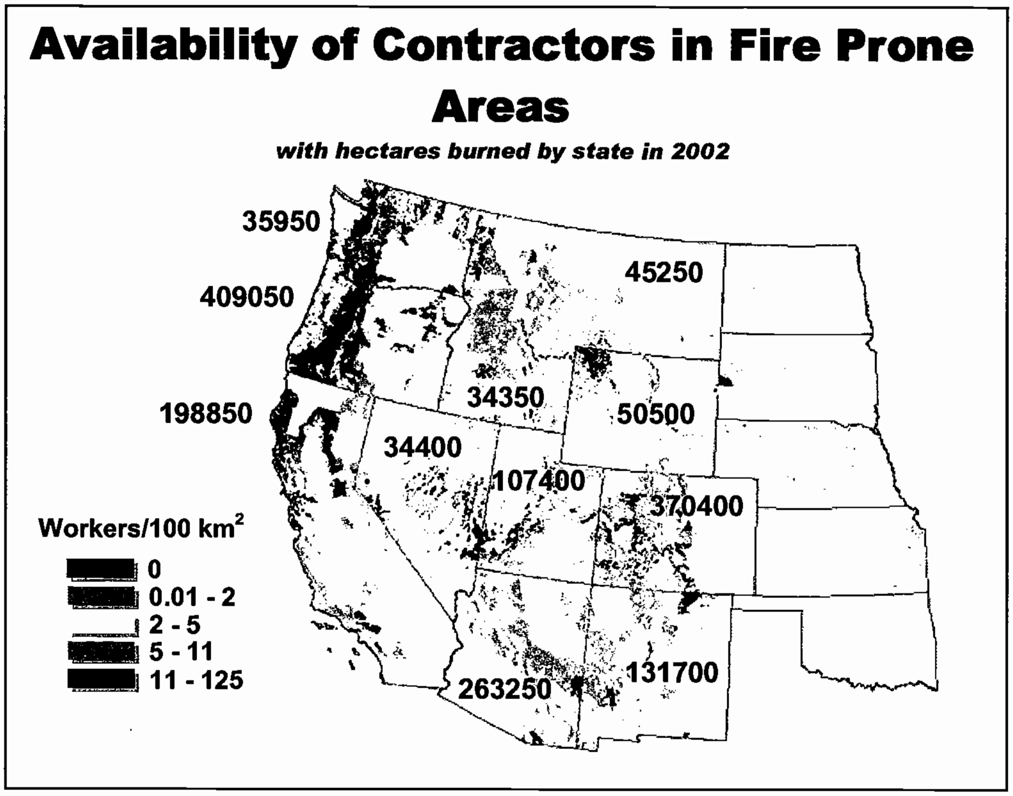

Figure 8: Location of forestry contractors in fire prone areas of the western United States (US Forest Service, 2003 and NIFC, 2003).

In addition, the mobility of firefighters nationally and internationally makes it important to learn about the use of modified logging equipment to fight wildland fires.

> *In 2002, fire resources were hard pressed and worldwide resources were employed. By early July, 28,000 firefighters and support personnel were assigned to fire suppression activities, which is the maximum number of civilian resources available. Later in the month a battalion of about 600 Army troops were activated for fire suppression efforts. An additional 950 Canadian, New Zealand and Australian firefighters then joined in the effort* (NIFC, 2003).

What Are the Issues?

Although the use of logging machinery has seen an increase since the 2000 fire season, the concepts are not new. A 1986 study in the Lolo National Forest concluded that a *skidgine*—a log skidder modified with pumps, tanks and hoses for fire suppression—"promises to provide a safe, cost-effective suppression tool for the future" (Roose, 1987). Work has continued in the Northern Rockies area (Region 1 of the US Forest Service) utilizing logging technologies for fire suppression and addressing many issues including equipment classification, specifications, and inspections in addition to contracting and business concerns.

Important issues involve agency use of privately owned firefighting equipment, deployment, utilization, and operator training. This paper focuses on the actual machinery and equipment. Ideally, once specifics on the equipment are resolved, additional issues can be managed.

Where Do the Machines Come From?

There are few machine manufacturers producing and advertising machines specifically for wildland firefighting. However, many types of machinery have been used for firefighting, coming from a variety of suppliers. The base manufacturers originally provide the machines to the loggers and the firefighting contractors. When modifications take place, engineers sometimes play a role, although most inventions have been put together with simple strategies in the local machine shops of the contractors. The fire equipment aftermarket industry also plays a role by providing accessories and attachments for firefighting and fuels reduction.

Where Can We Find More Information on the Machines?

The first point of inquiry was the Society of Automotive Engineers (SAE) Forest Machinery sub-committee. A series of questions covering various issues of equipment use in wildland firefighting was given to this international group comprised of major equipment manufacturers and machinery experts (Bielecki and Garland, 2003). To generate additional information, the series of questions was also given to companies involved with designing, contracting, and operating equipment for wildland firefighting.

What Kinds of Machines are Used?

Machines such as bulldozers, tractors, and fire plows have been traditionally used for fire suppression. Recently, additional standard earthmoving machines including excavators and graders have been used without modifications to scratch fireline, repair rough access roads, and rehabilitate sites after suppression activities. Standard timber tools such as feller-bunchers, harvesters, skidders, loaders, and forwarders have created wide firelines in heavy timber and removed the cut fuels. In addition, masticators and mulchers equipped with aftermarket cutting tools for brush and small fuels have created firebreaks and firelines in thick brush.

Figure 9: Excavator available for wildland firefighting and rehabilitation.

“Modified” machines can perform earthmoving and timber-handling tasks plus carry water and reduce fuels for firebreaks. Modified machines can be further sub-classified as “permanent”—those that have tanks welded on to the frame and accessories used only for fire purposes. Other machines are “convertible” and can change from a logging setup to a firefighting setup with removable tanks and attachments. The equipment modified to carry water, including skidgines, super-skidgines/forwarders, tracked-suppression vehicles, and pumper-cats, can carry up to 11350 liters (3000 gallons). The adaptability of these base machines has advanced harvest operations, and the multiple functions of the equipment add to the flexibility required of today’s successful contractors.

Figure 10: Modified skidder engaged in mop-up activities.

What Machines are Acceptable?

It is important for machines to be acceptable on a number of levels. Standards need to reflect environmental, safety, and operational concerns. Equipment inspections are used to verify the quality of firefighting resources, ensuring the necessary concerns are met and that the expected machine is provided to the fire organization. The inspection process must be consistent and reliable; yet, inspections currently vary significantly by region and agency.

Most wildland fire equipment must meet the provisions of the OF-296 checklist. This one-page document covers all firefighting equipment, ranging from busses to feller-bunchers (US General Services Administration, 2000). To enhance the inspection process, some regions have prepared supplemental checklists (Northern Rockies Coordinating Group, 2004). For example, the Northern Rockies Region has established its own classifications and specifications for each equipment type to produce a more thorough inspection process for their needs compared to other regions.

Figure 11: Agency fire equipment inspectors learning about feller-bunchers in Montana.

Inspection timing and schedules also vary by region. Some areas sign up equipment resources before the fire season and perform inspections at this time. Other areas do not inspect the equipment until it is delivered to the fire. An important benefit to the pre-season inspection is the time allowed to bring the machines into compliance. Inspection in a non-emergency situation is likely to be more effective without the urgency of a burning fire.

Working in Proximity to Heat, Smoke, and Dust

These new firefighting machines represent a broad variety of approaches—it is rare to see two machines with the same design. Thus, each machine will have different parts and attachments exposed to the extreme heat of a wildfire. Some further modifications can protect the machine, and more importantly the operator, from the heat. Operator safety is a primary concern. New enclosed, environmental cabs offer increased safety in hot situations and reduce exposure to smoke and dust. However, some operators prefer to work in an open cab so that they can "feel the heat" and determine if the situation is safe. Fire screens and curtains are also available, and are required by the California Department of Forestry and Fire Protection (CDF) on fire ready bulldozers (CDF, 2004).

Burnover situations are a critical concern when machines work on wildfires. Although fire curtains can block some of the radiant heat, most operators agree that the machine should be abandoned in the case of an impending burnover. Flammable fluids under pressure, exposed hoses and fuel lines, and other burnable parts could create a major problem. It may be too dangerous for an operator to simply "ride it out".

There are useful procedures that can be followed prior to a burnover situation. Given ample warning, some machines can construct safety zones, or enhance a fire shelter deployment site for the operator and adjacent hand crews. The difference between a safety zone and a deployment site must be recognized! The safety zone offers a safe location for the machine and personnel to position themselves without use of the individual fire shelters. Deployment sites must not have a machine anywhere close as it is a major hazard to those taking refuge in fire shelters.

Retardant foam, machine extinguishers, and sprinkler systems can give the machine a better chance of lasting through a burnover. The effectiveness of these tools for machine burnovers remains untested and varies tremendously depending on their design and the amount of water or chemicals available.

Rubber tires are another concern. The value of 121 degrees Centigrade (250 degrees Fahrenheit) is a guideline for an upper operational temperature. At higher temperatures the rubber in forestry tires begins to degrade, reverting back to constituent components. At 316 degrees Centigrade (600 degrees Fahrenheit), rubber reverts quite rapidly and can ignite. With sustained or higher temperatures, the rubber in the bars or treads may break off or chunk away. The most common heat buildup comes from sustained high speeds of approximately 32 kilometers per hour (20 miles per hour) on a hard surface. Tire temperatures are also increased by heavy loads. Moving at a high rate of speed for 30 minutes can overheat the bars and result in damage to the tires (Miller, 2004). We do not know what surface temperatures are encountered in wildfires, nor do we know how long tires are exposed to the temperatures. Certainly, if surface temperatures are too hot for humans on foot, machine travel may not be acceptable.

There may be a number of ways to deal with the effect of heat on woodland tires. The means will vary with equipment capabilities, e.g. water/foam on board, electronics available, etc. These may include:

- Thermal imaging to detect hot spots outside the machine in the direction of travel
- Use of chains/tracks to protect tires
- Filling tires with water to improve heat transfer
- Inflating tires with nitrogen to reduce pressure loss and the possibility of internal ignition
- Wetting areas of machine activity or travel
- Using a water-bath (mud puddle?) to cool the tires or an on-board sprinkler system

- Teamwork with handcrews using their judgment as heat indicators

Other options may develop with more experience using woodland tires in the heat of wildfires.

To further protect the machine from heat, some possible solutions currently used by the steel industry have merit for trials within the firefighting industry. Metal heat shields are used to block some of the heat exposure to vulnerable parts of the machine. Insulating wraps and metal flex-pipe can protect the hydraulic and fuel lines. Hydraulic fluid that is non-flammable is now available for situations where leaking fluid may be exposed to flames (Beschem, 2004).

Heat, smoke, and dust can also affect machine performance through air intake to the engine. To improve the situation, air filter pre-cleaners reduce the amount of debris to air intake. Reversible fans are also available to blow out debris clogging up the engine cooling system. Machines without reversible fans will need more frequent manual cleaning of screens and filters. The higher temperatures and lower oxygen levels accompanying wildfire conditions will also affect gasoline and diesel engines. Both suffer from power losses, and gasoline engines can have difficulty starting in these conditions (Carter and Milton, 1994).

Operator Guidelines

Most logging equipment manufacturers do not recognize firefighting as an approved use, so it will unlikely be addressed in operators' manuals. However, related information is likely to be included, for example, working in proximity to people on the ground or lifting limits associated with boom configurations. Machines with fast-moving, rotating parts such as feller-bunchers should have easy-to-read warning signs advising a safe working distance, as well as a section in the operators' manual. It is critical for the operators of machines used for mop-up to recognize the hazards of working in close proximity to hand crews and to take the necessary precautions. Operator manuals commonly cover the hazards and signals when reversing the machine. Machine operators and hand crews should have a coordination briefing before working together.

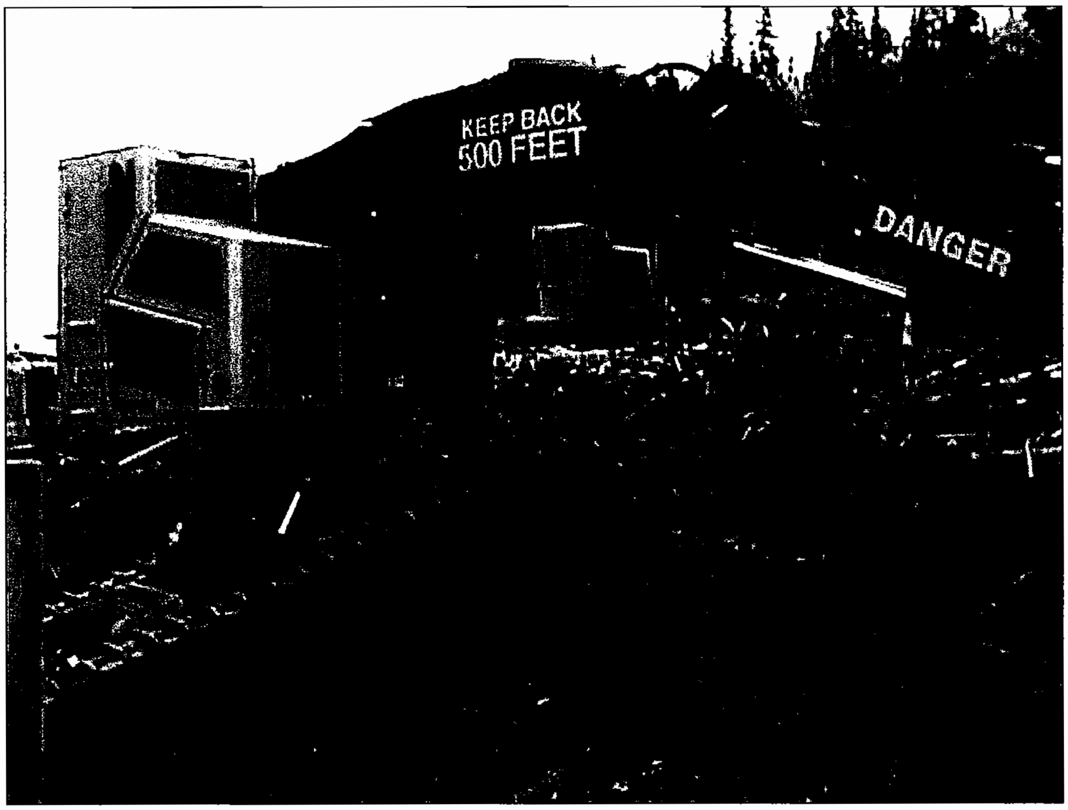

Figure 12: Warning signs found on equipment.

Slope guidelines are also important, especially when the machine is modified with large capacity water tanks. The weight and movement of the fluid will react much differently than a load of logs! The Northern Rockies Coordinating Group requires an engineer to certify machine designs involving supplementary water tanks (NRCG, 2004). In addition, a program is in development at Oregon State University's Forest Engineering Department to assess the static stability of modified logging machines (Bielecki, 2004).

Safety Regulations

Employees in the United States have safety and health protection provided by laws and regulations of the 1970 Occupational Safety and Health Act (US Department of Labor, OSHA, 2004) at the federal level. About half the states have individually approved state plans to comply with federal guidelines and about half a dozen western states have specific coverage of logging operations. At present there are no federal safety regulations for wildland firefighting and the general duty requirement to provide a safe workplace for employees is used for reference. In addition, the federal Occupational Safety and Health Administration has invoked the Ten Standard Fire Orders and Eighteen Watch Out Situations in reviews of wildland fire accidents and fatalities. Such fire training documents are not "regulatory" language" in that they do not restrict or proscribe specific employer obligations and may overlap and conflict in specific situations. In states with logging coverage, wildland firefighting is treated in various ways.

The Oregon Occupational Safety and Health Administration (OR-OSHA) Forest Activities code addresses wildland firefighting (currently in review) and includes a segment on machinery use (OR-OSHA, 2003). OR-OSHA requires a certain level of operator protection (guarding to protect against hazards) as well as indicates operating limits for the machine. These regulations are applicable to all employees of a firm in the state of Oregon and are often used as a reference in other areas. When machines are modified, extra hazards need to be mitigated by the employer based on the changes made to the machine. For example, adding a four thousand liter water tank on a skidder should indicate a lower slope operating range. Training and safety management is also proscribed by the Oregon rules.

Warranties, Liability, and Insurance

A majority of base-machine manufacturers currently do not address wildland firefighting as an acceptable use of their equipment. The main reason is to avoid the liability of advertising a machine built for firefighting. Therefore, it is unlikely that most warranties will cover damage occurring on a wildfire. This risk needs to be recognized by the machine owner. Certain firefighting tactics complicate this scenario—such as indirect attack and construction of fuel breaks. These tasks usually involve working at a substantial distance from the fire and can be quite similar to a typical logging operation. If the machine were used as it was purposely designed by the original manufacturer, it would likely be covered by warranty in this situation.

Equipment insurance is another important issue. In Oregon, loggers are required to provide "reasonable effort" to suppress fires occurring on the operation (Oregon Legislative Assembly, 2001). Because of this requirement, typical contractor insurance covers wildland firefighting under the General Liability Clause. It is up to the individual insurance provider to decide whether or not to identify firefighting as an exposure.

Future Potentials and Research

The design and construction of logging equipment is costly. Wildland firefighting is still a limited use of logging machines and major base machine manufacturers will not likely address fire suppression anytime soon. One manufacturer estimates that seven machines must be sold to simply break even with the design and production costs. However, a growing number of companies are involved with aftermarket attachments and the number of contractors with machines available for firefighting continues to increase.

To help document the issues and define the problem, the Forest Engineering Department at Oregon State University (OSU) is conducting research on various issues. One important area involves the stability of modified machines when operating on steep slopes. Accidents involving machines modified with water tanks have been documented, and knowledge gained from this research should provide for safer work environments in the future. OSU also helped with founding the Pacific Northwest Wildfire Equipment Group (PNWEG) to enhance coordination and communication in the firefighting community so that the safest and most efficient equipment will be used. Future research should help document the efficiencies and production rates of using modified logging equipment to fight wildland fires.

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CHAPTER 5: STABILITY OF MODIFIED MACHINES

Need for Investigation

Modified logging machines are perhaps the most "eye-catching" of the equipment used in wildland firefighting. Because log loads influence machine performance differently than water loads, there is a need for analyzing the capabilities of the modified machines. Accidents have been documented with these machines, such as those using the configuration found in Figure 13 **(FERIC, 2003)**.

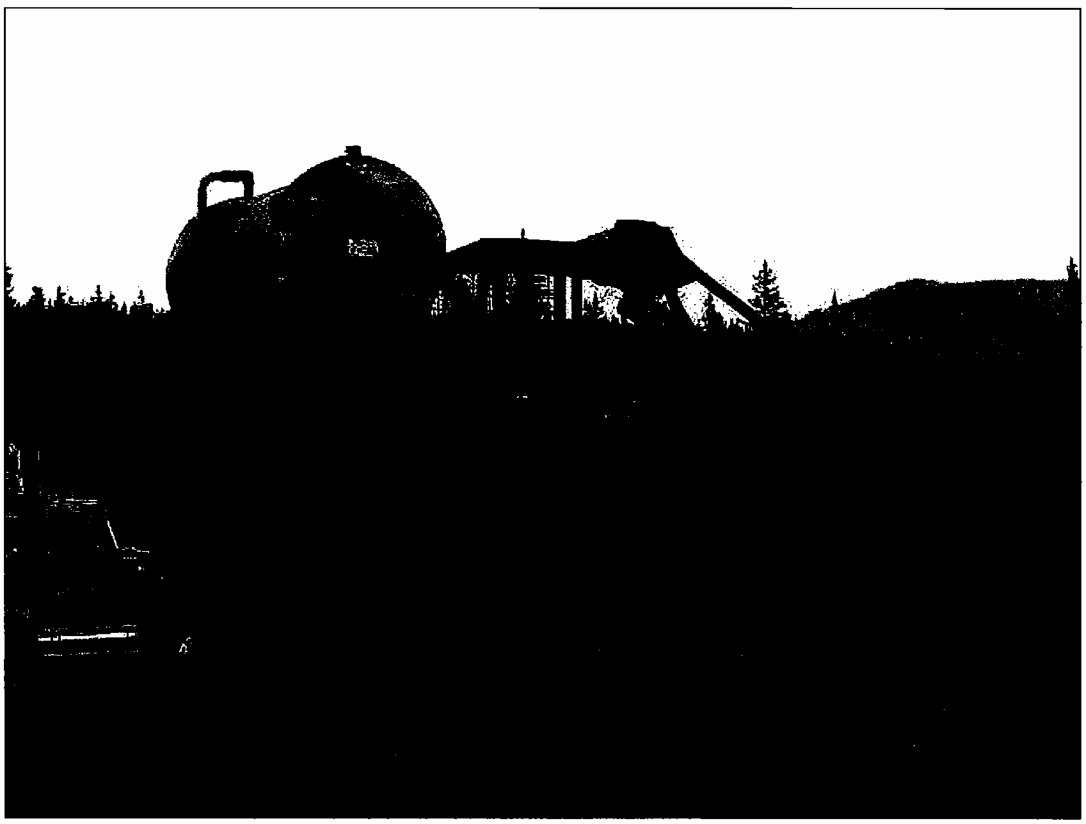

Figure 13: Skidgine involved in rollover accident (photo courtesy of the Forest Engineering Research Institute of Canada).

Although few identical machines exist, many modifications to carry water utilize the rectangular box shaped-tank design (Figure 14). In addition, the rubber-tired log skidder is commonly used as a base carrier for the "skidgine". To better understand the limits of modified logging equipment for firefighting, the author developed a computer program that analyzes static stability of modified machines.

Figure 14: Rubber-tired log skidders modified with rectangular water tanks.

Computer Static Stability Analysis Program

It is important for the analysis to incorporate various tank fill levels. Machines used in firefighting are often subject to tank conditions ranging from full to empty during transportation for filling and refilling. During actual firefighting the machines are usually at less than full capacity, and that situation is when the machine is subject to shifting water based on the steepness of terrain (slope). **Hunter (1986)** determined that

> *the fluid will find its own level in the lower part of the tank, unless the tank is completely full. This results in a movement of the center of gravity of the fluid within the tank, which may have a large influence on the stability.*

Figure 15: Modified log skidder working on a side-slope.

In addition to fill level, vehicle position is also critical. Traversing side-slopes (Figure 15) and climbing steep adverse grades while loaded (Figure 16) can create potentially dangerous situations where rollovers can occur.

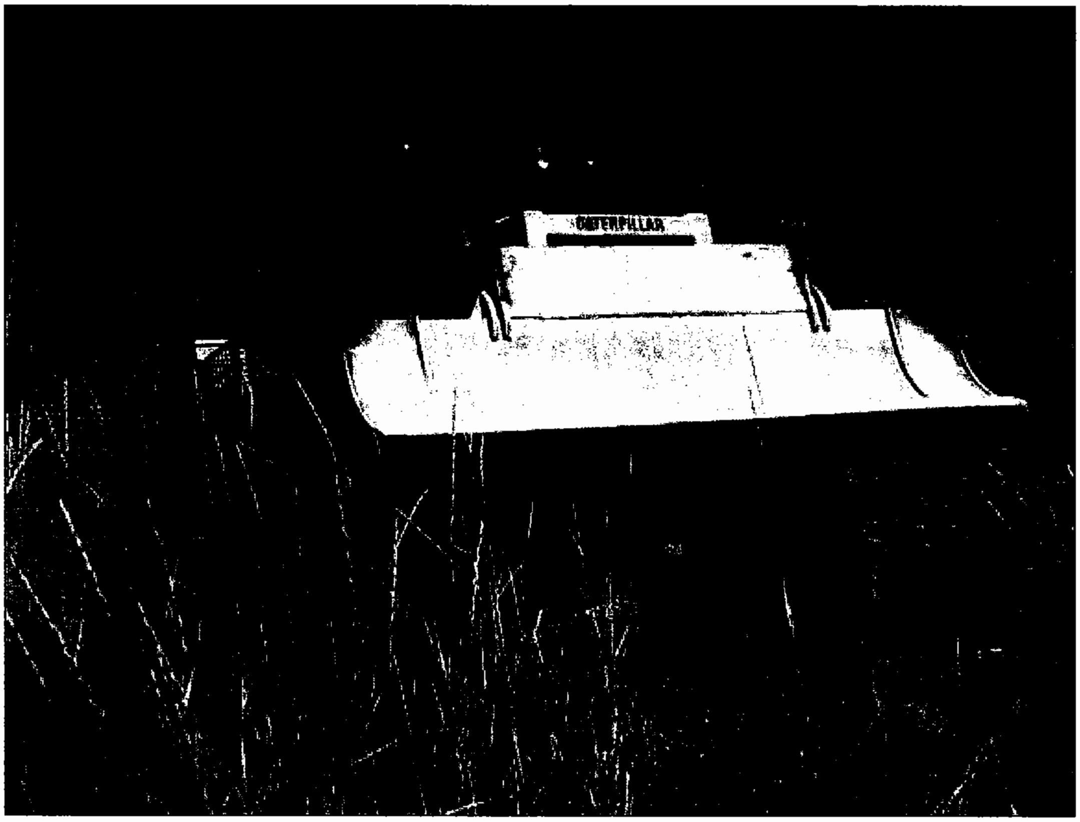

Figure 16: Loaded skidgine operating on an adverse grade.

The “Stability Determinator” program is designed with two separate interfaces based on the scenario the user wishes to analyze: side-slope or adverse slope (see Figure 17 and Figure 18).

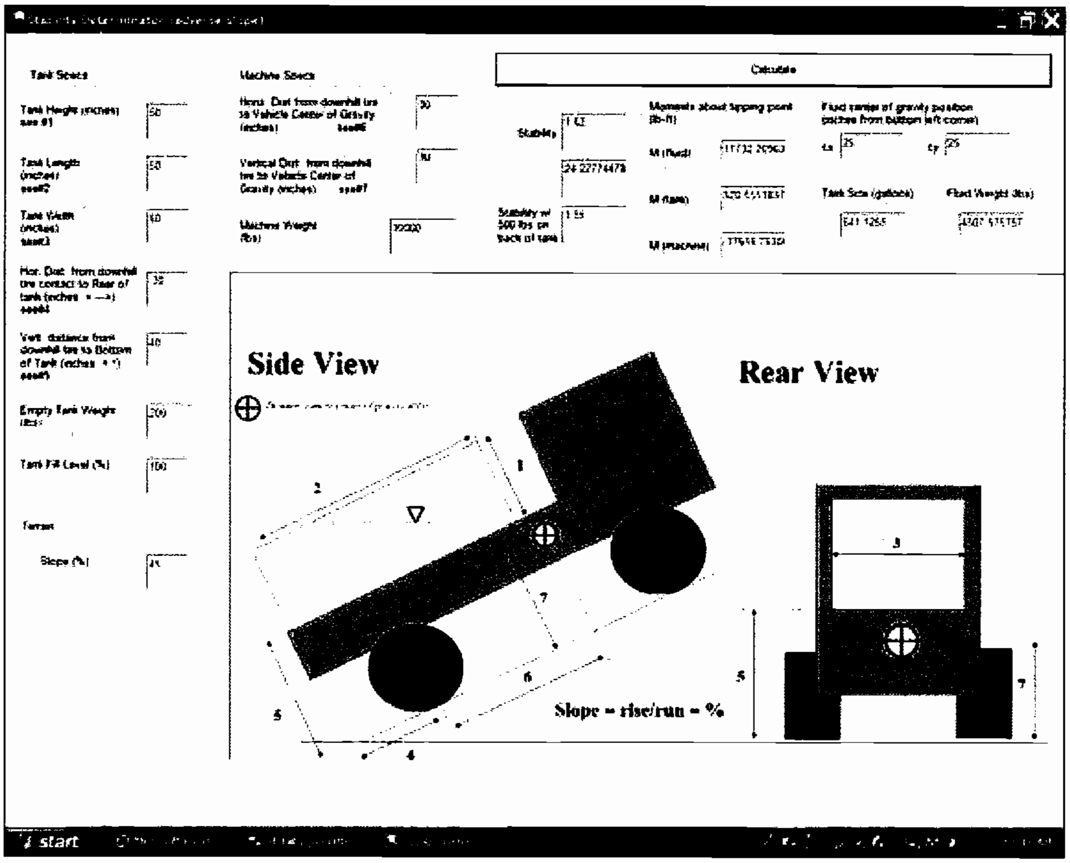

Figure 17: User interface for analysis of machines operating on adverse slopes.

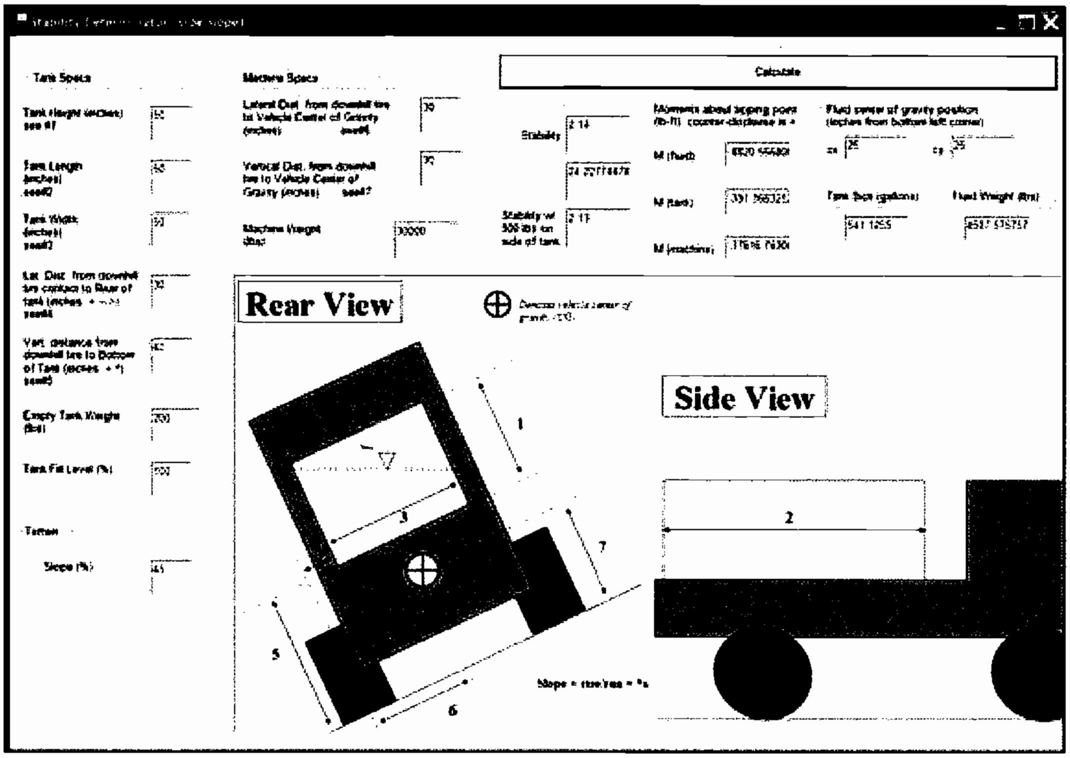

Figure 18: User interface for analysis of machines operating on side-slopes.

<u>Assumptions</u>

A number of assumptions were made to allow for the analysis. The program is designed to determine the static stability of a four-wheeled vehicle without articulation in the following conditions:

- Moving directly across a side-slope or moving straight up an adverse slope
- Supplemented with a rectangular box-shaped water tank
- At static conditions (constant velocity and slope)
    - Forces generated through sloshing of water are not considered
    - Acceleration forces on both the machine and water tank are not considered

- The thickness of tank walls or baffle locations, if any, are not considered (however the weight of the tank itself is included)
- The normal force acting on the uphill tire(s) is assumed to be zero (this is equal to the force at the point of rollover)
- The machine is not articulated
- The tipping point is located at the center of the tire. Machines with wide tires or tires embedded in soil would be treated differently.

Methodology

To evaluate the machine and tank static stability, the program requires a number of user inputs. These are based on the actual measurements of the machine and the slope of the terrain. Inputs include tank size, tank position, fill level, slope of the terrain (%), machine weight, and center of gravity location of the machine. Once the inputs are entered, the program goes through the determination process. Figure 19 is a flowchart of the model.

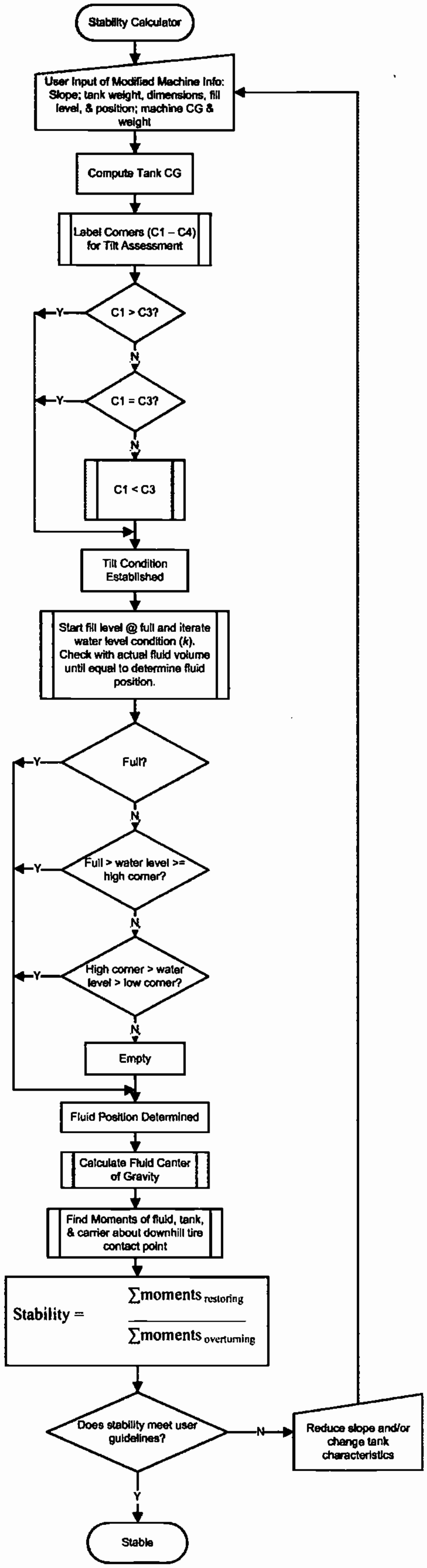

Figure 19: Flowchart for Stability Determinator program.

Program Concepts

To simplify the static stability calculation process, the tank is visualized two-dimensionally by the program. In a side-slope situation, the tank will be viewed from the rear. In an adverse slope situation, it is viewed from the side. Based on this rectangle, each corner is assigned a number beginning from the top left and moving counter-clockwise. One of three tank conditions is then determined according to the heights of the corners (Figure 20).

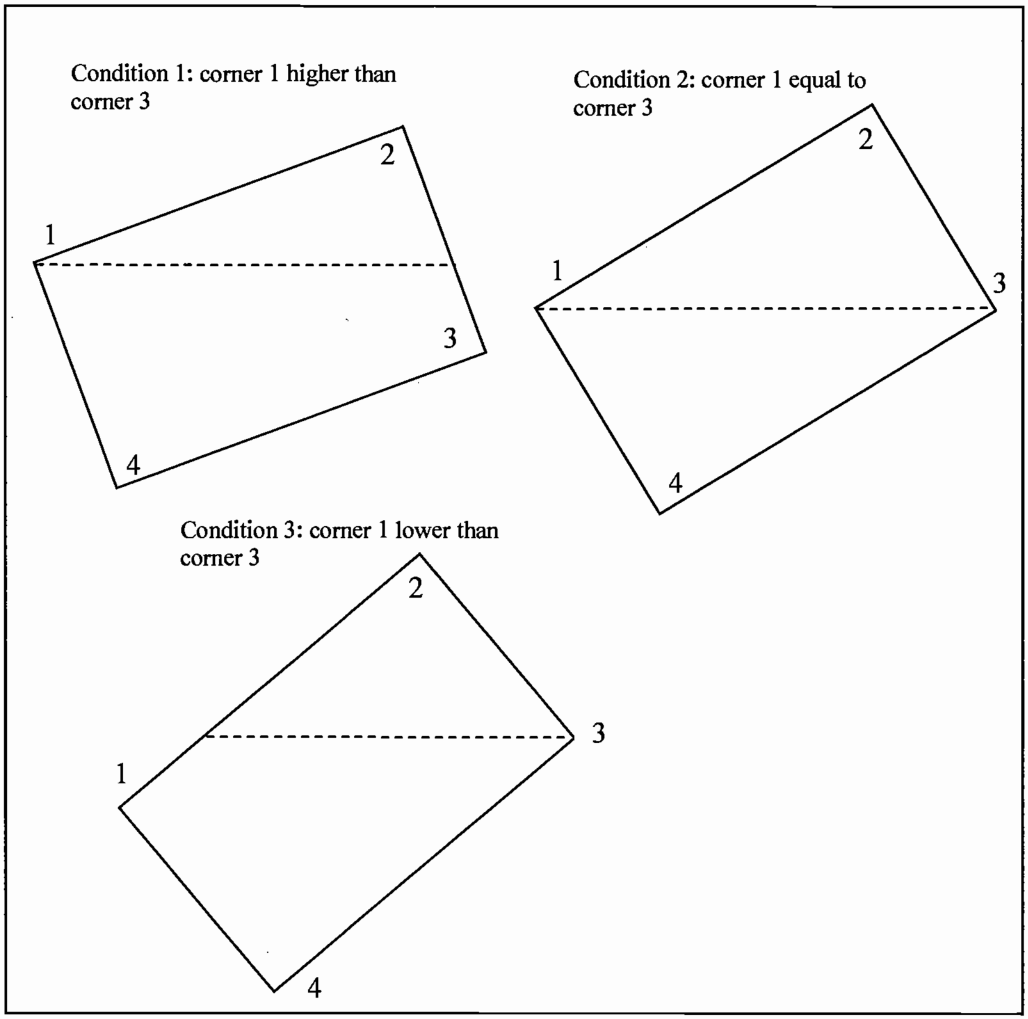

Figure 20: Conditions of water tank based on dimensions and slope of terrain.

Once the tank condition is determined, the program determines the position of the water surface. This process is based on the cross-sectional area of the tank and fluid. Given the fill level of the tank (user input), the cross-sectional area of fluid and open space can be found on side-slopes and adverse-slopes. Using the variable k to represent the distance from the top corner to the water surface, the iterations begin at k_0 and increase until the true water position is found at k_i (Figure 21). The cross sectional area with height k is checked against the true area of the unfilled tank area until they are equal. At this point the water surface is known and the fluid center of gravity can be determined.

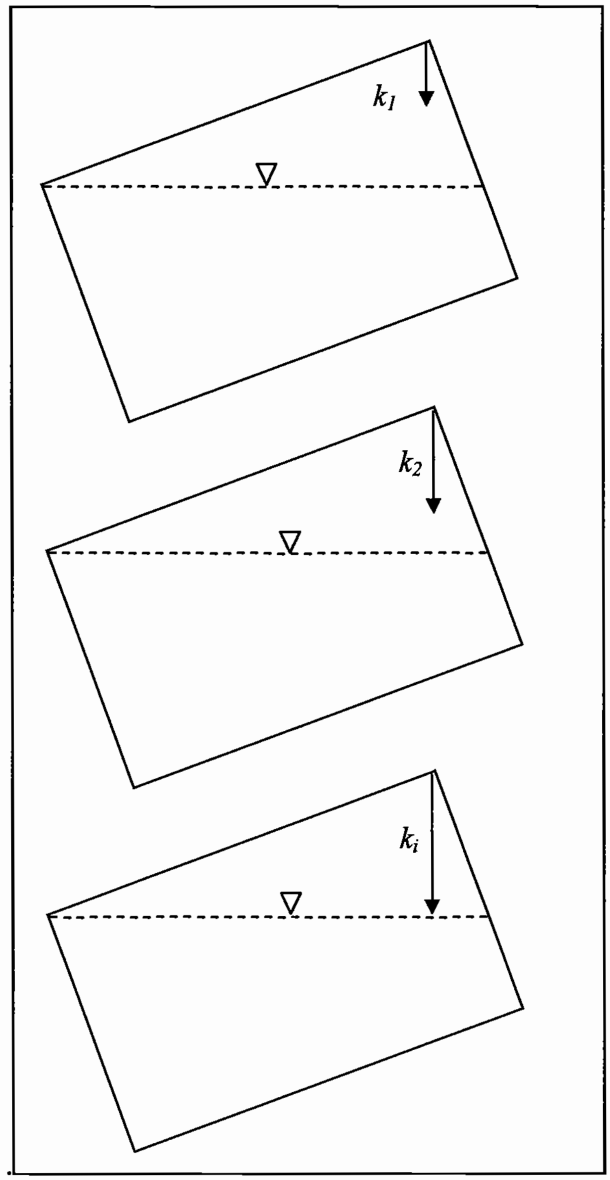

Figure 21: Determination of water surface level.

Fluid Center of Gravity

There are a limited number of shapes the water can form within the tank. This shape must be determined before additional calculations can be made (Figure 22).

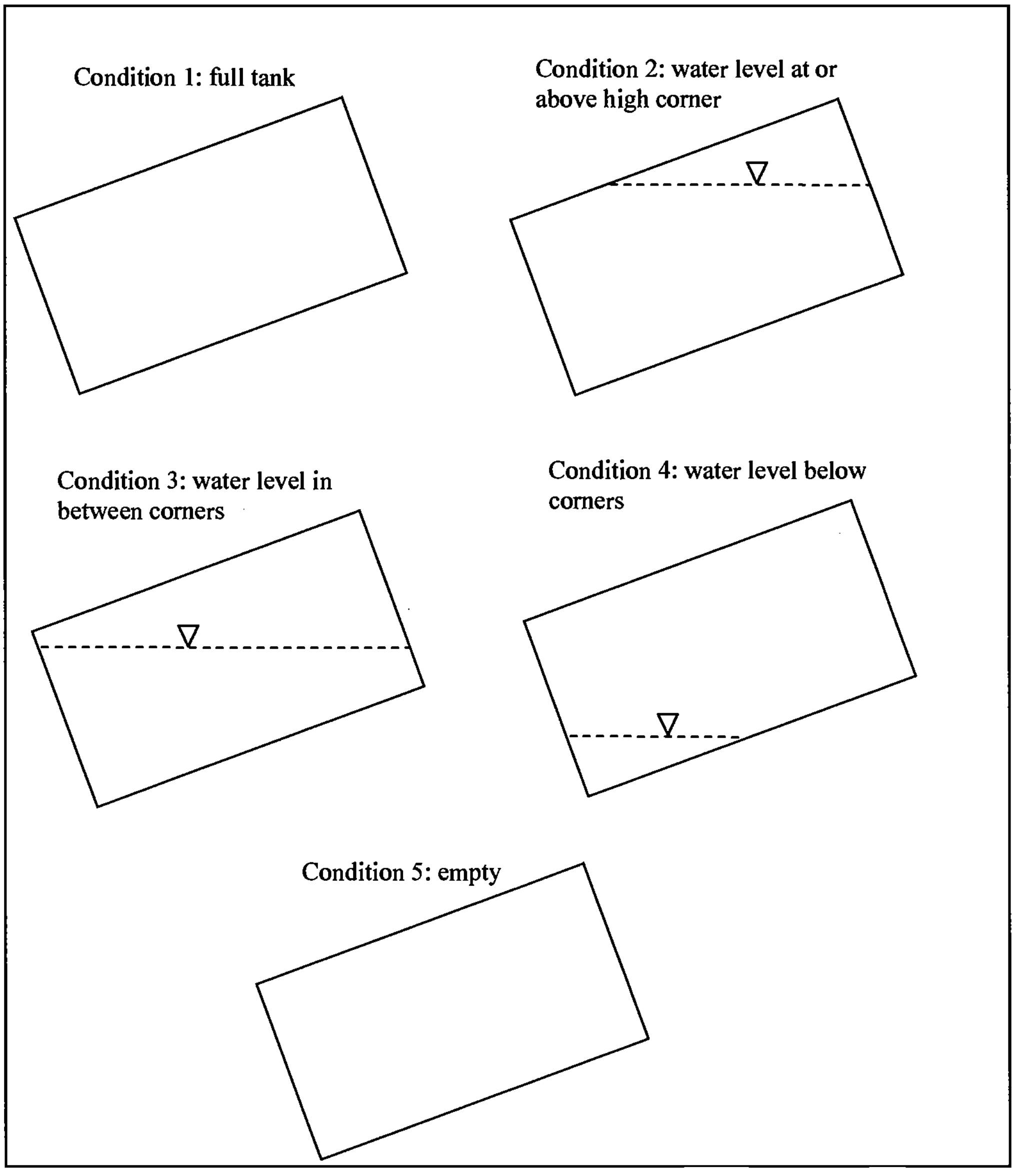

Figure 22: Possible water level conditions found with inclined, rectangular shaped tanks.

After the water shape condition is determined, the centroid can be found. The centroid marks the location of the water center of gravity. This value is used to calculate the moments used in the static stability formulation. This program defines stability as the ratio of the restoring moments to the overturning moments:

$$static\_stability = \frac{\sum moments_{restoring}}{\sum moments_{overturning}}$$

Based on this definition, a value of one or more is deemed statically stable, and anything less than one is deemed statically unstable. Users may consider static stability at values greater than one to account for:

- acceleration
- sloshing of the water (in less than full tanks)
- sudden movements from rough terrain

To make this number more valuable to the user, an additional output is generated. This involves placing a five hundred pound weight at the downhill edge of the water tank. Five hundred pounds can represent the weight of pumps and hoses or two firefighters with gear. If this additional weight is enough to drop the static stability below the user defined limit, then the machine is likely operating on too steep of a slope. In this situation the operator should restrict operation to lesser slopes and/or limit the load weight.

Sample Results

FERIC Skidgine Accident

The first configuration tested modeled conditions similar but not exactly like the machine involved in the rollover accident (Figure 13). The accident occurred when the machine was fully loaded (100% fill level) on a slope of approximately 34% (FERIC, 2003). To model similar conditions, the following specifications were assigned:

Table 1: Machine specifications assigned to model the stability of skidgine involved in accident.

Tank Height (inches)	50
Tank Length (inches)	50
Tank Width (inches)	70
Lateral Distance from downhill tire contact to rear of tank (in)	-12
Vertical distance from downhill tire contact to bottom of tank (in)	80
Empty tank weight (lbs)	500
Tank fill level (%)	100
Slope (%)	10 to 95
Lateral Distance from downhill tire contact to vehicle center of gravity (in)	40
Vertical distance from downhill tire contact to vehicle center of gravity (in)	60
Machine weight (lbs)	27000

The accident occurred when the machine was climbing an adverse slope. To investigate other possibilities, the side-slope was also analyzed here. The static stability results are graphed in Figure 23. Based on the results, the machine had a static stability of approximately 1.5 prior to the accident. It is notable that the side-slope static stability is close to that of the adverse slope static stability, perhaps due to the machine configuration (with the tank mounted high above the rear axle).

Because the model identifies the machine statically stable at a slope of 34%, there were other factors involved in the accident. The actual vehicle was not in a static condition; rather, it was accelerating downhill after a series of failures involving the engine and brake system. These dynamic factors are not addressed by the Stability Determinator program and should lead the user to use a higher static stability limit when testing configurations. In this case a static stability of 2 would have limited the operating slope to less than 30%. This would be where the red line crosses the static stability value of two in Figure 23.

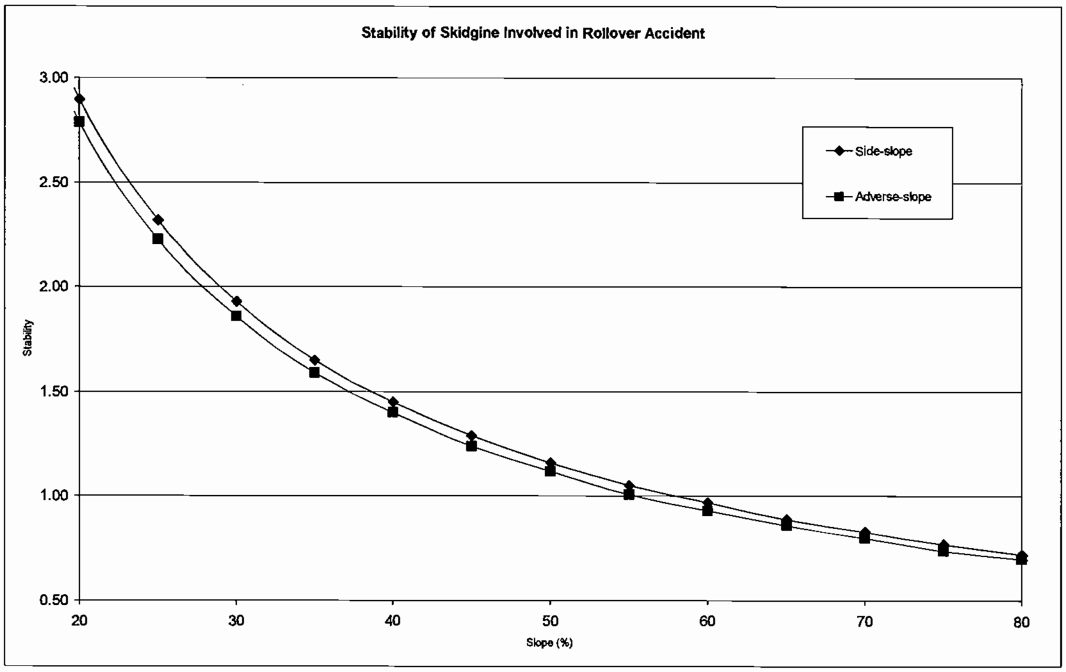

Figure 23: Static stability test results of machine involved in rollover accident.

Testing a Second Skidgine Configuration

Another common skidgine configuration was tested using the static stability model at various slopes. Full, half-full, and no tank configurations were analyzed. The full tank in this scenario has a capacity of 1500 gallons. Because the machine information was readily available a Franklin Q90 skidder was used as the base carrier **(Franklin,**

2004). User inputs for this skidder and water tank configuration can be found in Table 2.

Table 2: Machine specifications used in stability analysis.

Tank Height (inches)	60
Tank Length (inches)	72
Tank Width (inches)	80
Lateral Distance from downhill tire contact to rear of tank (in)	5
Vertical distance from downhill tire contact to bottom of tank (in)	70
Empty tank weight (lbs)	500
Tank fill level (%)	100, 50
Slope (%)	10 to 95
Lateral Distance from downhill tire contact to vehicle center of gravity (in)	45
Vertical distance from downhill tire contact to vehicle center of gravity (in)	60
Machine weight (lbs)	38000

The results of this test can be seen in Figure 24. These results are significantly different from those displayed in Figure 23. Here the side-slope is the obvious limiting condition. Although the water tank on the second machine is twice the size of that in the accident skidgine, the machine is more statically stable due to the design configuration. Similar to the results found in this example, side-slope is often the limiting condition for non-modified machines.

Additional trials were modeled with this skidgine configuration using three different tank situations: full, half, and absent. Here the absence of the water tank is used to represent the non-modified skidder. The next graph (Figure 25) shows the static stability of modified machines to be less than the static stability of unmodified machines (without water tanks). In this configuration the modified machine is less statically stable than the unmodified machine. Therefore, machine operators should operate modified machines on lesser slopes than those traversed when operating non-modified machines.

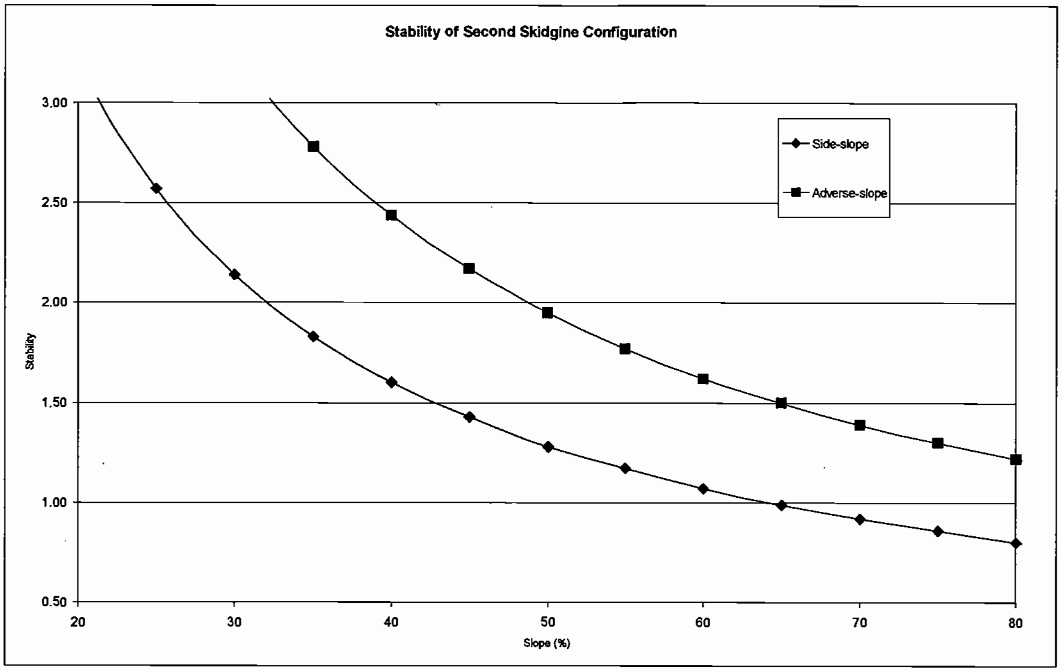

Figure 24: Static stability test results of modified Franklin skidder configuration.

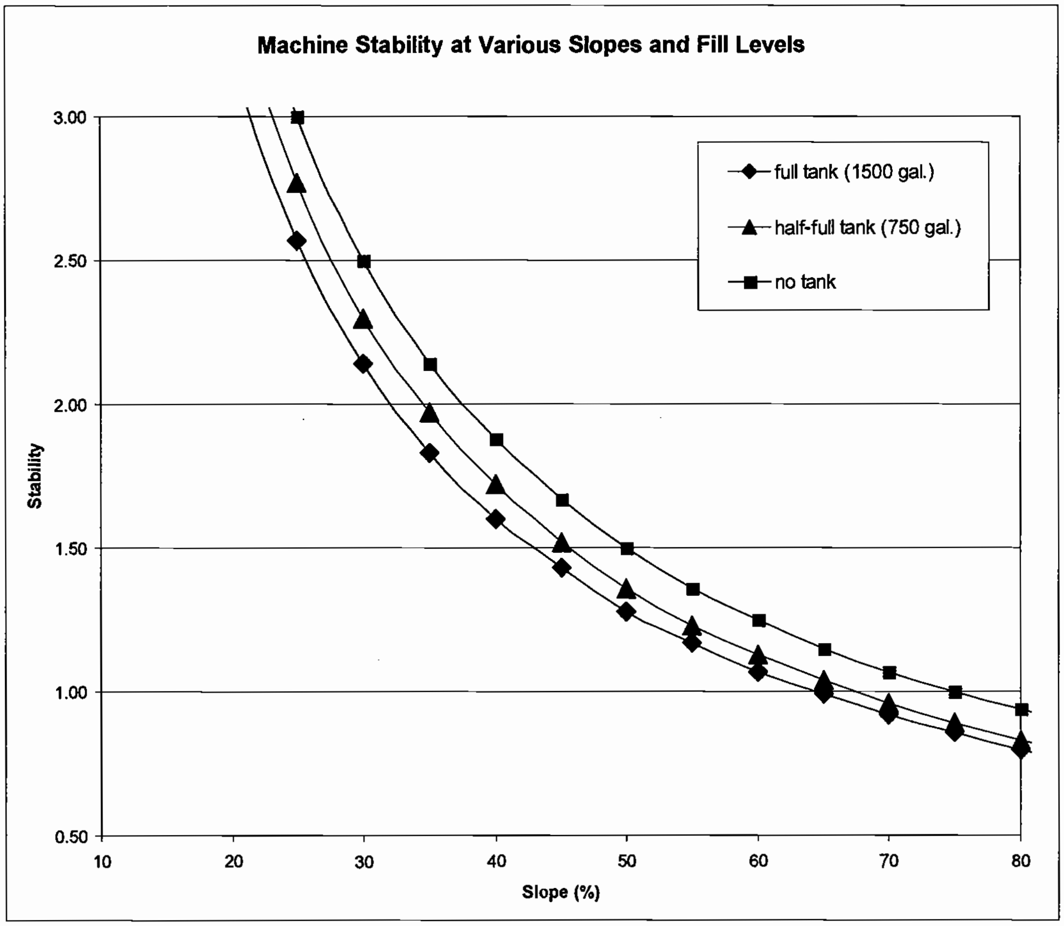

Figure 25: Side-slope static stability of standard machine and modified configurations.

The Changing Center of Gravity of the Water

The Stability Determinator program also provides results involving the fluid center of gravity. Tanks at less-than-full capacity are affected by the shifting of water according to the incline of the slope. Figure 26 shows the various locations of the water center of gravity based on the configurations in Table 2. Three fill levels were analyzed: one-quarter, half, and three-quarters. These results show that the fluid center of gravity (location of resultant force of water weight) shifts between a 10% and a 95% slope. The amount of the shift is based on the fill level, with the water in the least full tank experiencing the biggest change. The approximate shifts in the centroids were 8.2 inches, 17.4 inches, and 24.7 inches for the 75%, 50%, and 25% fill levels, respectively.

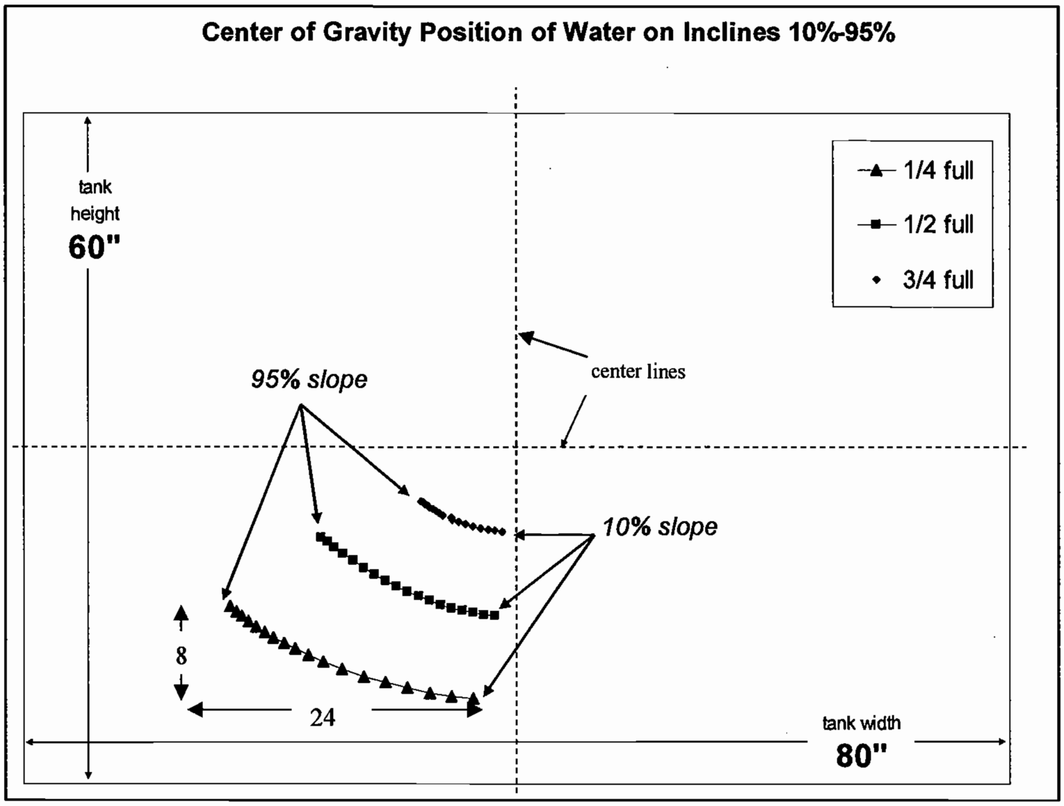

Figure 26: Water center of gravity position based on slope (cross-sectional view from rear of tank, center lines shown as dashed lines).

Discussion

A number of lessons can be learned from this modeling. Machine configurations affect their performance and slope capabilities. Also, the fluid center of gravity shifts in tanks that are less than full. Tank size, tank position, and machine weight are factors that should be considered when designing or operating a modified log skidder.

There are at least three ways to interpret and use the results obtained from the Stability Determinator:

- A larger value than one should be used to define the static stability limit accounting for the dynamic conditions that may be encountered
- The static stability value of the non-modified machine at 30% slope (OR-OSHA operating limit for skidders) might be used for the static stability limit of the modified machine
- The operating slope limit should be reduced by the difference in percent slope between modified and non-modified machine static stability at the same value. For example, Figure 25 illustrates a slope difference of five to fifteen percent when comparing standard and modified machines at equal static stabilities. This difference should be subtracted from 30% to find the new operating limit for the modified machine (without special operating conditions).

The modified skidder that was involved in the accident rolled over on a 34% slope. Even without modifications, this slope exceeds the recommended slope in Oregon's Forest Activities Safety Code. This states that:

> *Machines must not be operated on slopes in excess of the following limits unless specified by the manufacturer of the equipment.*
> *(a) Rubber-tired skidders – 30 percent*
> **(OR-OSHA, 2003)**

The tank placement was also involved in the accident. The tank limited the operator's view and required driving forward up the slope as opposed to backing up, which is a practice for machines with similar loading. The high position of the tank resulted in a static stability value of approximately 1.5. This created the dangerous situation and resulted in an accident when coupled with additional contributing factors.

The use of judgment is important when interpreting the output of the Stability Determinator. At a minimum it is recommended that a machine configuration be tested where an additional five-hundred pound weight located on the back or side of the tank is incorporated into the calculation. Operating in conditions where the stability ratio value remains above two will accommodate for the additional five-hundred pound force in the configurations tested here.

Tank size and fill level influence the shifting of the center of gravity according to the incline. With smaller tanks, this shift is less significant due to lower fluid weights. However, in a 3000 gallon tank at 25% full, a center of gravity shift of only 15 results in a moment increase of 3750 foot-pounds. This can mean the difference between stable and unstable conditions.

There are limitations to this computer program, and some have already been mentioned. It does not account for dynamic forces, i.e. acceleration and sloshing of water against tank baffles. Machine articulation is not addressed. Also, the analysis is limited to rubber-tired machines with only two axles. Last of all, only rectangular box-shaped tanks are analyzed. Further modeling efforts incorporating these factors would be useful for those involved with designing, building, and operating modified forest machines for wildland firefighting.

CHAPTER 6: ADVANCEMENT OF WILDLAND FIRE SUPPRESSION EFFICIENCY IN THE PACIFIC NORTHWEST: INSTITUTIONAL ISSUES

Rationale

After a year and a half of interaction with various individuals it was apparent that the Pacific Northwest needs improvement in the use of loggers and logging equipment for wildland fire suppression. Despite having the largest contingency of contract handcrews in the USA (approximately three-hundred in 2004), the region's fire managers are using few pieces of logging equipment on wildland fires. This contrasts with the high density of available equipment based on contractor location (Figure 8).

Founding of the Pacific Northwest Wildfire Equipment Group

Important issues identified revolved around the problems related to ordering, dispatching, assigning, inspecting and evaluating machinery on wildland fires. See Chapter Seven: Recommendations and Chapter Eight: Conclusions for further discussion of these items. To address the regional issues and attempt to make improvements the inaugural meeting of a regional equipment committee was organized. Invited individuals were involved in all aspects of firefighting. Agency fire managers and contract specialists, equipment contractors, and researchers attended.

The paper *Saving Western Forests with Better Wildland Firefighting (*Appendix V*)* accompanied the invitation. This paper illustrated what the goals of the group might be and provided the potential attendees with information to form expectations. Lee Miller, a local contractor and president of Miller Timber Services, wrote the paper with Dr. Garland and the author.

The meeting was held on July 10^{th}, 2004. Attendees came from as far as Twin Falls, Idaho, with additional representation from Washington and Oregon. The group consisted of approximately 25 people, with private contractors forming the majority of the group. The multidisciplinary group was later coined the Pacific Northwest Wildfire Equipment Group (PNWEG). An *Action Planning Report* (Appendix VI) includes the conclusions and action items determined by the group to improve firefighting in the region.

Follow-up to the PNWEG

One of the major recommendations was the need to address the equipment potentials with those directly involved with ordering and using the equipment—the Incident Management Teams. Mr. Terry Brown, United States Forest Service Regional Equipment Specialist, offered to contact teams he has interacted with and urge them to hear what the PNWEG had to say. Mr. Brown then arranged for an invitation to the October meeting of the Pacific Northwest Wildfire Coordinating Group Operations Working Team (PNWCGOWT). Unfortunately, after the September meeting the PNWCGOWT decided to cancel this presentation. The author was told the decision was based on previous bad experiences dealing with private contractors as well as a general lack of understanding regarding the situation. Jim Furlong, the PNWCGOWT representative, mentioned that private contractors were a "bunch of fire chasers" **(Furlong, 2004).**

Although Mr. Furlong was referring to this phrase in the most negative fashion, a better understanding of the circumstance is needed. Private contractors offer a service, in this situation a piece of machinery and accompanying operator for firefighting. Therefore the contractor must advertise and attempt to create business by selling resources potentially valuable in fire suppression.

Summary

The current system in the Pacific Northwest is inadequate in the ability to utilize logging equipment for wildland fire suppression. Fire management agencies cannot exclusively solve this problem. Rather, a coordinated effort is necessary for the two groups (contactors and fire managers) to work together effectively. The PNWEG was founded in attempts to address the related issues and identify necessary action items to improve firefighting with logging equipment. Although the PNWEG includes agency representatives, more outreach is needed for the group actions to be effective and for wildland firefighting in the Pacific Northwest to incorporate logging machinery. Appendix VII includes a list of presentations made to date.

Introduction to Manuscript Three

The following paper was written for and presented at the 2004 Society of American Foresters annual meeting in Edmonton, Alberta, Canada. The paper offers an introduction to the potentials of logging equipment for firefighting and identifies important issues. It also provides an explanation for the slow adoption of the technology into the realm of wildland fire suppression.

INCORPORATING TECHNOLOGY: ADVANCING WILDLAND FIREFIGHTING WITH LOGGING MACHINERY

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Presented at the Society of American Foresters Annual Convention

2004

Abstract

Catastrophic wildfires in the western United States and Canada continue to be major threats to forests and people. Logging machinery has been successfully adapted to aid wildland fire suppression, but the technologies vary greatly. The use of logging equipment to fight wildland fires involves important issues: safety regulations, training concerns, and the use of machinery. Review of safety regulations and training schemes within state and federal organizations is underway. The modified equipment in use is so novel that guidance is needed for slope stability, operational feasibility, and specifications for safety and coordination. Each season, more is learned about what the modified machines can do. However, knowledge is still needed regarding the capabilities of the modified machines to improve the efficiency of firefighting. The topic provides an interesting case-study relating to the adoption of innovation in complex organizations.

Keywords

wildland firefighting, technology, equipment

Catastrophic wildfires in the western United States and Canada continue to be major threats to valuable forests, resources, people, and infrastructure including powerlines. In some circumstances logging machinery has been successfully adapted to aid suppression activities of wildland fires, but the new technologies vary greatly. The wildland firefighting process is further complicated by the fact that public agencies commonly manage the wildfires, but rely on private contractors for supporting resources including mechanized equipment.

The use of loggers and logging equipment to fight wildland fires involves three important issues: safety regulations for machine operators and adjacent firefighters, training for the private equipment contractors and the coordinating fire management team, as well as the machinery itself. Our research addresses these concerns through the revision of Oregon's wildland firefighting safety regulations, various training workshops and demonstrations, observation of firefighting equipment working at wildfires, founding a group to improve wildland firefighting with logging equipment in the Pacific Northwest, and development of new tools to assess the stability of forest machinery modified for firefighting.

Safety and Training

The Oregon Occupational Safety and Health Administration (OR-OSHA) is currently revising the rules covering wildland firefighting. These regulations can be found in the Division 7 Forest Activities Code (OR-OSHA, 2003). Unlike Federal OSHA, the state of Oregon addresses wildland firefighting (US Department of Labor, 2004). The OR-OSHA Wildland Firefighting regulations cover machinery used in wildland fire suppression activities and provide guidance for their operation.

A review of training schemes within state and federal organizations is also underway. The modified equipment is so novel that guidance is needed for slope stability, operational feasibility, and specifications for tactics and operations. Most machine modifications are unique; therefore, providing an all encompassing set of machine requirements would be impossible. Despite obstacles, some training methods have successfully provided information on the new firefighting technologies.

To educate firefighters, the Northern Rockies Coordinating Group (NRCG) conducted three Equipment Inspection Workshops during the spring of 2004. These week-long courses allowed equipment inspectors, fire managers and contracting officers to learn proper equipment inspection procedures on a variety of fire equipment, ranging from busses and water tenders to skidgines and excavators (NRCG, 2004). The NRCG has also proposed an update to the standard "Dozer Boss" firefighter course (S-232), which is currently under review by the National Wildfire Coordinating Group (NWCG). This important step recognizes innovative wildland firefighting technology with potential for improved safety and efficiency.

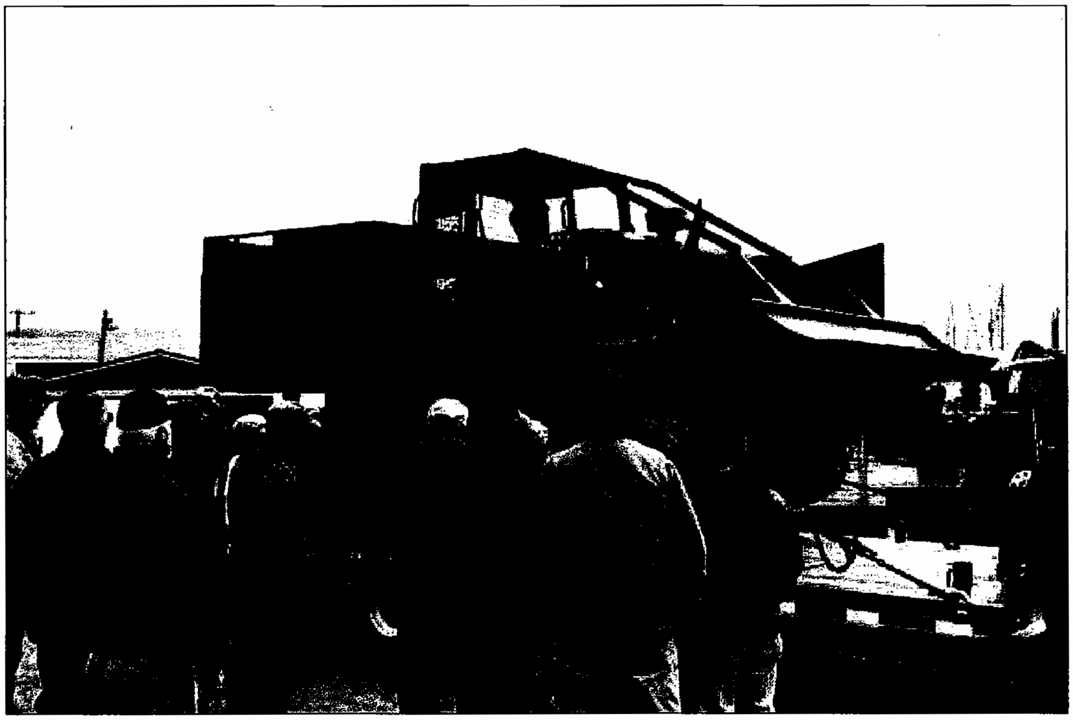

Figure 27: Fire equipment inspectors learn about tracked-suppression machinery at a 2004 workshop offered by the Northern Rockies Coordinating Group (NRCG).

Potentials

Oregon State University (OSU) research is defining the issues and problems involved with modified equipment and engaging scientists and practitioners in the fields. With each fire season, more is learned about what the modified machines can do. However, firefighting tactics are slow to evolve; fire managers still use only traditional resources (handcrews, aircraft, engines, bulldozers) on most incidents.

Mechanized equipment could revolutionize wildland firefighting. Earthmoving machines have been used successfully without modifications. Hydraulic excavators scratch firelines, swing fuels and logs, and remain available to rehabilitate after suppression. Graders quickly repair access roads and dig firelines in light fuels. Standard timber tools—including feller-bunchers and harvesters—cut trees and help create wide firelines to stop crown fires. Log loaders equipped with grapples move logs and other debris to create fireline and clear roads.

Modified machines have also supported fire suppression in the west. These include machines supplemented with accessories including water tanks, pumps, hoses, foam systems, and fuel-reduction attachments. To identify the new tools, names such as "skidgines", "superskidgines", and "pumper-cats" have been coined. While some of these new inventions are permanent modifications and committed as firefighting resources, others can be quickly adapted from a logging setup to a firefighting configuration.

Figure 28: Skidgine with remote-controlled water cannon at the 2004 Big Iron Demo in Montana.

Despite these advancements in equipment technology, more knowledge about the capabilities of the modified machines to improve the efficiency of firefighting is needed. Once the equipment is better understood, contract and dispatch issues can be addressed and resolved. The OSU research seeks to learn more about the entire process—from developing wildfire safety regulations to observing equipment in actual firefighting activities to gather productivity data. Presentations will be made to Pacific Northwest Incident Command Teams to share the results of the research and propose future studies.

Incorporation

The recognition and implementation of innovations in complex fire management organizations provides an interesting case-study. Adoptions of technology in the forestry sector, including the fire subculture, may follow processes of classical diffusion of innovation theory of Everett Rogers (1962). The classic curve of adoption of technologies follows the normal curve over time with innovators through laggards as percentages of the social system population (Figure 29).

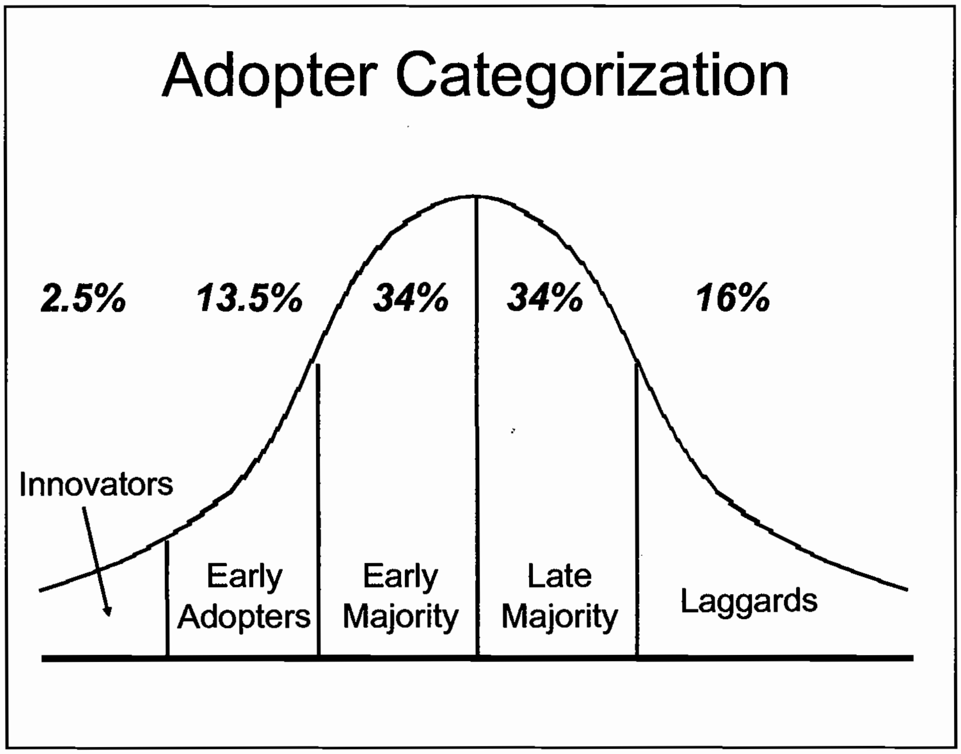

Figure 29: Categories of adopters in the diffusion of innovation theory by Everett M. Rogers.

Rogers further outlines steps in the innovation decision process to consider:

1. knowledge
2. persuasion
3. decision
4. implementation
5. confirmation

Following this process leads to the adoption of the innovation or rejection (decision not to adopt).

Within this system, examples of technology adoption have been influenced by the catastrophic nature of events. Protective apparel (Nomex®) has undergone a long period of development, testing and incorporation into the fire community. In contrast, when a new fire shelter became available, it was quickly mandated in the requirements (GSA) and standardized from the top down. Just as quickly, some models were recalled when problems arose (NIFC, 2004). Similarly, loss of firefighters' lives can quickly change firefighting strategies and tactics (SAF, 2001).

The social system of the fire suppression culture and institution has some unique factors that may tend to inhibit or accelerate the use of modified logging equipment to fight wildland fires. In Table 1 below, we outline some factors and associate them with our estimates whether they would likely increase or decrease adoption of modified logging equipment.

Table 3: Factors of wildfire suppression culture and institutions. Increasing ↑ or decreasing ↓ likely adoption of modified logging equipment to fight wildfires.

FACTOR	Increase ↑ Decrease ↓
Nationwide Incident Commanders some unfamiliar with equipment—regional variation	↓
Hierarchal organization with vertical chain of command	↓ or ↑
No permanent fire teams for full year but rather assembled for individual fires	↓
No Overhead Team Specialist for equipment as in Manual Felling	↓
Bias against equipment by Resource Protection Specialists and those favoring hand crews	↓
Entrepreneurial contractor sector with the equipment	↑
Defined & rigid training & qualifications system—need equipment in training scheme before adoption	↓
Anecdotal successes of equipment widely seen	↑
Disconnections between machine resource ordering, contracting (rates), & dispatch computer systems	↓
Variable specifications, Inspections, and Production rates for modified equipment	↓
No history of modified equipment use, little research information, few demonstrations of technology	↓
Flexibility (various functions) & Effectiveness along with cost benefits	↑

From our perspective, the use of modified logging equipment to fight wildland fires is already on the pathway of adoption of the technology. We can identify the innovators, and some of the early adopters from what has taken place within Region One of the Forest Service. The time frame to date appears to have taken about five years. It remains to be seen how the innovation diffusion curve can take place in other Forest Service Regions and how the progress will continue in Region One.

Summary

Recognition and implementation of innovations in complex fire management organizations provides an interesting case-study. Mechanized logging equipment has been used successfully in wildland firefighting. The machines are designed for forest operations and offer potential improvements in safety and efficiency for wildland firefighters. However, the incorporation of these resources into the wildland fire suppression system has been a slow process, and traditional tools such as bulldozers, engines, handcrews, airplanes, and helicopters are still prevalent. Many factors contribute to the adoption of technology, perhaps following the classical diffusion of innovation theory of Everett Rogers. Ideally, mechanized forest machinery will be considered when firefighters are looking for the safest and most efficient tools available. Logging equipment will not replace traditional tools, but when used properly in combination with long-established resources, they offer an enhanced wildland fire suppression system.

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CHAPTER 7: RECOMMENDATIONS

The following chapter is based on two years of wildland firefighting research. The author has spent time firefighting in Northern California, observing fire equipment in Oregon and Montana, conducting interviews with participants throughout the west, revising the OR-OSHA wildland firefighting safety regulations, and attending fire training workshops in Montana. The author has also worked with individuals in the Pacific Northwest to eliminate obstacles to the use of logging machinery in wildland firefighting.

Training

Training is needed before anything else can take place. Knowledge gained by designed training is the foundation for providing a safe work environment. Familiarity with firefighting technologies is the key to recognizing wildfire situations for using logging equipment. Therefore, specific training is essential for all participants and should be specific according to their expected level of firefighting.

Professional Firefighters

Basic firefighters (e.g., Firefighter II) should have knowledge of logging machinery if they are expected to work beside it. Coordination between handcrews and equipment is critical, especially in mop-up situations. Unfortunately, less experienced crews are often assigned to mop-up and are less likely to have worked with mechanized equipment previously. Therefore, a segment in the basic training of all firefighters is needed.

In addition, fire managers require more knowledge about the equipment. This involves the whole spectrum from ordering to evaluating post-assignment. At a minimum, the following courses should address logging equipment:

- Strike Team/ Task Force Leader (S-330)
- Dozer Boss (S-232)
- Suppression Tactics (S-336)
- Division/ Group Supervisor (S-339)

In addition to existing courses, the creation of a new course specific to the use of mechanized logging equipment would be invaluable. However, the changes required in the fire community to incorporate such a course are unlikely. Based on past changes made in agency firefighting, it is more likely that slight adaptation to existing procedures will take place.

Another source of information is fire researchers. Along with Oregon State University, related research is taking place at the United States Forest Service San Dimas Technology and Development Center and the Wildland Fire Operations section of the Forest Engineering Research Institute of Canada. These sources should be actively involved in providing updated materials to wildland firefighters prior to each fire season.

The demonstrations and workshops used in the Northern Rockies area also have potential in the Pacific Northwest. Hands-on field days where contractors and firefighters get together benefit both groups. Firefighters gain experience through first-hand observation of the machine types and can also witness the various applications of each machine. Equipment workshops and demonstrations provide the equipment contractors with an opportunity to share their machinery and interact with fire managers while forming relationships for future business.

Equipment Contractors

Contractors expecting to work on agency managed wildfires require meeting the requirements of the agency contract. This requirement commonly calls for a red-card, or Firefighter II level training. Because agency policies prevent agencies from training private contractors, the training must come from elsewhere. Currently, a Memorandum of Understanding allows outside companies to offer training to contractors. A sample MOU can be found at the National Wildfire Coordinating Group website: (http://www.nwcg.gov/teams/ibpwtnew/pers/1b_SampleTrainingProviderMOU.pdf). This procedure is an obstacle in the use of logging machinery for wildland fires. An improved system to coordinate training among public and private employees would eliminate the difficulties of finding a training provider and allow all firefighters to efficiently receive proper training.

In Oregon, logging contractors currently receive a forty-five minute fire safety video to meet the requirements of the OR-OSHA Wildland Firefighting regulations. This training can be adequate for forest activities workers involved with minimal firefighting. For those expecting to spend more time in firefighting tasks, additional preparation is necessary. At a minimum, these workers should become familiar with firefighting equipment, fire behavior, and coordination under the Incident Command System

Hiring

Fire management agencies hire firefighting equipment only when needed in Oregon. This procedure results in a delay when firefighters need a machine resource on an incident. To avoid a delay in mobilization, agencies in other areas hire equipment before the season. The United States Forest Service in Region 1 (Northern Rockies) signs up equipment during pre-season hiring. Pre-season hiring allows all of the paperwork to be prepared prior to the emergency situation and provides for an effective mobilization when the resource is actually needed. However, pre-season hiring can be more expensive when equipment is signed up and then not used.

The hiring process usually is accompanied by an equipment inspection. The inspection is meant to eliminate unsafe and poor-quality equipment from being assigned to wildfires. Currently, equipment inspectors use the OF-296 form. The OF-296 form is a single-sheet checklist used on all types of firefighting equipment, including buses, vehicles, water trucks, fire engines, and logging equipment. The form is not adequate for proper inspection of logging machinery.

The Northern Rockies Coordinating Group (NRCG) has created additional checklists for logging equipment and these checklists should also be used in the Pacific Northwest. In addition to the checklist, the personnel inspecting the equipment need to have a working knowledge of different types of equipment used in firefighting. Improved inspections will provide safe machinery for use on wildfires.

Dispatch and Ordering

The Resource Ordering and Status System (ROSS) is currently used by agencies to dispatch available fire resources. The ROSS system is not compatible with the Emergency Equipment Rental Agreement (EERA), the common method of hiring contractor equipment in the United States. ROSS requires that the equipment entered into the EERA database be re-entered into the ROSS system manually. This delay results in a lack of identification of available equipment through the ROSS system. These databases need to correspond for efficient ordering to take place.

The dispatch and ordering process can also be enhanced with the use of photographs. Photos would help to eliminate the ordering of unwanted machinery. During a fire in the Southwest, a fire manager requested a feller-buncher. The manager was seeking a tracked, self-leveling machine with a hot saw capable of felling large timber on slopes. A small, three-wheeled shear machine was ordered instead and transported from the southeastern United States. This machine was not adequate for the fire circumstances and was not used. However, the managing agency paid to have the machine mobilized and de-mobilized. In this case, more specific instructions were needed from fire managers to dispatchers than to simply “order a feller-buncher” **(Kuehn, 2003).**

Utilization

Improvements in utilization will come from enhanced training and available knowledge about firefighting machinery. Machine capabilities and limitations need to be recognized. Machinery information can be provided through new research. In addition to learning about new equipment, analysis of traditional firefighting systems will help to identify what tasks can be improved with new technology.

Future Research Needs

Research can help provide a working knowledge of firefighting tools. Areas involving logging equipment that need new and updated information include productivity of modified machines, tools to make comparisons to other equipment, and methods to evaluate operator and machine performance.

Machine Inventory

New machine innovations and combinations are constructed every year. Fire managers need access to a thorough inventory in order to keep up to date on the various types of equipment available for firefighting. A color-catalog would be useful to explain the technologies to firefighters unfamiliar with the equipment. A catalog would be helpful in fire courses. It would also serve personnel involved with dispatching equipment. Identifying and requesting a machine from a catalog with photographs will reduce the delays and inefficiencies caused from ordering improper equipment.

Machine Capabilities

A catalog of firefighting equipment would benefit from information covering machine capabilities and applicable firefighting tactics. One recommended format is a matrix that lists resources and applications. A developed matrix would allow firefighters to quickly determine a machine to fit the management goals for the incident. A sample format for this matrix can be found in Table 4.

Table 4: Sample matrix of fire equipment capabilities.

Machine Type:	rubber-tired skidgine	rubber-tired super-skidgine	tracked harvester	tracked feller-buncher
Firefighting Task				
dry fireline	x		x	x
wet fireline	x	x		
defending line/patrol	x			
water delivery: 500+ gallons	x	x		
water delivery: 1500+ gallons		x		
water cannon	x	x		
tree felling			x	x
swing fuels			x	x
mop-up	x	x		
rehabilitation				
Side-slope limit	**25%**	**20%**	**30%**	**30%**
Adverse slope limit	**30%**	**25%**	**40%**	**50%**
Vegetation Limit			**30"**	**32"**
Horsepower	**120**	**140**	**150**	**150**

As included in Table 4, it would be helpful for the matrix to include slope consideration. Slope limits were investigated in Chapter 5; however, additional analyses are needed. Modified machines with three or more axles and tracked carriers have yet to be researched. Tests are also needed that consider acceleration, multiple tank designs, sloshing, gradeability, and baffle designs.

Production Rates

Studies of production rates for logging machines are needed to properly assign equipment on wildfires. The productivity measurements should cover each applicable function of the machine, including water delivery rates for modified machines and fireline construction rates for modified and non-modified equipment. Water delivery should be determined in units that incorporate volume, distance, and time such as gallons/hour/mile. Fireline construction cab be broken into two types: timber/fuels removal and earthmoving. Traditional resources measure construction rates in distance per unit of time. Because logging machines can create firelines much wider than traditional tools, the new measurements should note the fireline width. Fireline rates should be classified as x feet of fireline at width y over time z.

Observation and testing of machines in fire suppression situations can be difficult. To generate as much information as possible at one time, researchers should utilize the equipment demonstrations where multiple machines, contractors, and operators attend. The NRCG Big Iron Demo is one such event. A test course would provide for water delivery machines to be measured. In addition, fuels management projects can be accomplished as timber and fuels reduction machines are measured for productivity.

Comparisons and Evaluation

Methodology is needed to compare traditional firefighting equipment to logging systems. When production rates of logging equipment in fire suppression applications have been obtained, an analysis of the production efficiency could be performed. An example of this method can be found in Appendix VIII, *Fireline Production Efficiency Analysis using Data Envelope Analysis*. Making comparisons is essential to efficiently assigning the available resources on a wildland fire.

Operator qualifications and certifications also need to be evaluated. Many inexperienced entrepreneurs are purchasing retired logging equipment and competing with experienced contractors for firefighting opportunities. Fire managers usually have little information to base decisions on except their past experiences with the individuals. Logging industry programs for continuing education and certification have potential applications within firefighting and need to be investigated further.

Review of Administrative Functions

Dispatching systems and hiring procedures used by fire managing agencies need to be addressed through additional research. It has been determined that the Resource Ordering and Status System (ROSS) and the Emergency Equipment Rental Agreement (EERA) used by the United States Forest Service are not compatible. Either an entirely new system or modifications are needed to provide these functions.

Cost and Economic Analysis

Various economic studies are needed to improve the process of using logging equipment for wildland firefighting. A study comparing the costs and benefits of the use of new forest technologies in fire suppression would be useful. How does a machine with a cost of $1500 per day compare in production with a contract handcrew running $6000 per day? Another comparison should be made that provides an efficient method for determining machine pay rates. Some current pay rates for specific machines are so outrageous that firefighters are hesitant to use that machine as well as similar machines that may be much cheaper. Pay rates need to genuinely reflect the machine value and capabilities.

Training Strategies

Specifics for using and evaluating logging equipment need to be incorporated into training regimes. Fire managers, machine operators, and equipment inspectors need to understand machine guidelines and requirements for fire suppression. During firefighting situations now, the operators commonly have to explain what the machine can accomplish to the fire managers. An improved training regime prior to fire season would help managers form better expectations when firefighting with logging machinery.

Modifications to agency fire references are also needed to incorporate logging machines. Documents such as the Fireline Handbook and Incident Response Pocket Guide can easily be supplemented with descriptions, specifications, applications, and evaluation tools for various types of forest machinery. Participation on the national level would assist this process. Groups such as the National Wildfire Coordinating Group were created to address these issues and need to become more involved in the reality of fire suppression in the western United States.

Future Organizational Directions

The Pacific Northwest requires a coordinated effort for improving the use of logging machines on wildland fires. The effort should involve fire managing agencies as well as private contractors. To work towards improvement, the PNWEG was created. Additional agency representation, acceptance, and coordination are necessary for the goals of the PNWEG to be met and for wildland firefighting to utilize forest operations technology.

CHAPTER 8: CONCLUSIONS

Mechanized logging equipment has been used successfully in wildland fire suppression in western North America. Machines designed to improve forest operations offer potential improvements in safety and efficiency for wildland firefighters. However, the incorporation of these resources into the wildland fire suppression system has been a slow process. Traditional tools such as bulldozers, engines, handcrews, airplanes, and helicopters are still most commonly used.

Mechanized forest machinery should be considered when firefighters are looking for the safest and most efficient tools available. Logging equipment will not replace traditional tools, but when used properly in combination with long-established resources, mechanized logging tools offer an enhanced wildland fire suppression system.

Potentials

Non-modified logging equipment is built to work in the woods on rough terrain while moving earth, falling trees, and removing vegetation. These tasks are similar to those in fire suppression. Hydraulic excavators can dig fireline, swing fuels, and remain available for rehabilitation after suppression. Feller-bunchers and harvesters can build a wide fireline to stop crown fires and can effectively eliminate danger trees. Skidders and loaders can remove hazardous fuel loads from the forest and perhaps deliver a product to help recover some of the suppression costs.

Modified equipment may function like standard logging tools in addition to delivering water to the fire. Log skidders, forwarders, or tracked vehicles can be modified with water tanks to serve as off-road fire engines. These mobile machines can put out spot fires, build wet-line, knock down flames in tree crowns, and coordinate with handcrews in mop-up activities. Tanks up to 3000 gallons can be placed on log forwarders, creating super-skidgines. Super-skidgines can serve as off-road water tenders delivering water to remote areas of the fire. In addition, some super-skidgines can be refilled with helicopter water buckets.

Safety

In order to address new technologies in wildland firefighting, the author participated in the OR-OSHA Wildland Firefighting review sub-committee from January, 2003 until December, 2004. The rules were revised to simplify the requirements for those working in wildland fire suppression in Oregon. Suggested changes made to the code include added training requirements and machinery use guidelines. The proposed changes will soon be passed on to the full Division 7 Forest Activities review committee and to public hearings.

Training

Successful training regimes were observed in Montana. The sessions were organized by the Northern Rockies Coordinating Group (NRCG). To enhance evaluations on upcoming fires, equipment inspectors learned about logging equipment. In addition, the Big Iron Demonstration provided an opportunity for forestry professionals to learn about available firefighting equipment and interact with machine operators. These training methods have potential in the Pacific Northwest.

Machine Modifications

Adding a water tank to a logging machine affects the performance and capability of the equipment. Rubber-tired machines supplemented with tanks can be analyzed using the Stability Determinator program. The program accounts for the fluid shift in a partially filled water tank and measures the static stability. Analyses determined that supplementary water tanks influence the stability of forest machinery. To reduce the danger of overturning, modified firefighting equipment should reduce the operating slopes according to the load and operator ability.

Recommendations

Wildfire suppression in the Pacific Northwest can benefit from logging machinery. Modified log skidders were used successfully on the Log Springs Fire in Oregon during the 2004 fire season. To better utilize these machines in the future, government fire management agencies and private equipment contractors must work together. The important areas of training, ordering, evaluating, and utilizing must be addressed to incorporate logging tools into a fire suppression system with strong traditions.

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Dr. Robert Rummer
Forest Operations Research Unit
Southern Research Station, US Forest Service
Auburn, Alabama

Dr. Rummer offered a Cooperative Research Grant for the research project. In addition, Dr. Rummer provided the author with employment during the summer of 2004 as an Engineering Technician with the United States Forest Service. This arrangement allowed fire research work on agency managed wildfires.

Cooperators:

Mr. Lee Miller
Miller Timber Services

Mr. Miller provided the author with the opportunity to work with his modified log forwarder in a wildland fire situation during the 2003 fire season. Training was provided in the form of an 8-hour refresher course and pack-test. Miller Timber Services also provided the author with firefighting equipment and a position on a nationally dispatched 20-person initial attack hand crew.

Mr. Miller co-founded the Pacific Northwest Wildfire Equipment Coordinating Group (PNWEG) with Dr. Garland and the author. The initial meeting was held in Bend, Oregon during the summer of 2004 and was based on the paper entitled *Saving Western Forests with Better Wildland Firefighting*—authored by the three founders.

To assist preparation for equipment observation, Mr. Miller again provided the annual training for the author during the spring of 2004. The training allowed the author to remain “line qualified” for the upcoming fire season.

Mr. Pat Mulligan

The author originally contacted Mr. Mulligan to hold an interview discussing his experience operating as a contract firefighter using FMC skidders. During the interview he shared many related documents. The information Mr. Mulligan provided was very helpful and illustrated how he and his co-workers were working on related issues twenty-five years prior.

After the interview Mr. Mulligan also offered to provide a full set of fire safety clothing (Nomex). This included shirt, pants, and neck shroud.

Mr. Obie O’Brien

As the Logging Engineer for Region 1 of the Forest Service, Mr. O’Brien not only served as the author’s primary contact with the Northern Rockies Coordinating Group (NRCG) in Montana, but also sat on the graduate committee as an honorary member. Mr. O’Brien’s expertise was helpful during the author’s attempts to get out on wildfires and observe equipment. He was also helpful in establishing many important contacts.

Northern Rockies Coordinating Group (NRCG)

The NRCG was helpful in assisting the observation of training techniques used in the Northern Rockies area. The members, particularly Mr. Kevin Erickson, Fire

Equipment Specialist, and Mr. Scott Kuehn, Private Industry Liaison, welcomed the author (as a graduate student) and offered full privileges to participate in their workshops and demonstrations.

Mr. Kuehn also provided the author with an extensive interview covering his experiences as a forester with Plum Creek Timber as a representative of private industry liaison and equipment expert on the NRCG. Mr. Kuehn visited Oregon twice to address the Pacific Northwest Wildfire Equipment Group and also to speak at Oregon State University about equipment used for wildland firefighting.

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APPENDICES

Appendix I: Questions regarding Forest Machinery used in Wildland Fire Suppression

The following questionnaire is part of a research project on The *Use of Loggers and Logging Equipment to Fight Wildland Fires*. Chris Bielecki, a Master's student in Forest Engineering, is conducting the study. The overall goal of the Oregon State University project is to improve the efficiency of fire suppression. Various equipment and skills utilized in the logging industry have important potentials for firefighting, and your expert advice will greatly aid the equipment research efforts.

All individual answers will be kept confidential, and an aggregate summary will be compiled. No firms will be identified. Your time is greatly appreciated, and a copy of the summary will be made available to the SAE subcommittee.

Please respond by **December 31st, 2003** using email, fax, or surface mail to:

Chris Bielecki (chris.bielecki@oregonstate.edu)
Forest Engineering Department
Oregon State University
215 Peavy Hall, Corvallis, OR 97331-5706
Phone: (541) 737-4952, Fax: (541) 737-4316

Respond in the space following each question, and take as much room as needed. If the question does not apply to your firm's products, type **na** (not applicable). If you cannot respond to the question directly, we ask that you forward it to someone else in your firm who can provide a response. Multiple responses from each firm are encouraged.

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1. Should equipment being used in close proximity to flames and heat require special protection so that the engine does not take in superheated air or burning material?

2. Do you have any knowledge regarding fire resistant air filters in forest machinery?

3. How much heat can regular tire tread on logging equipment withstand from adjacent flames? What tire manufacturer supplies your firm?

4. Does your equipment have enclosed cabs that protect the operator from dust and smoke?

5. Would your equipment provide a safe working environment to the operator in a burn-over situation? Should any additional features be required, such as pull down fire screens to reflect the intense heat? Do you have other ideas regarding burn-over protection for the operator? If so, where can additional information be obtained?

6. Are there any negative effects to the operator involving either interior or exterior automatic fire extinguishing systems?

7. What direction do you provide in the operators' manuals regarding working in proximity to personnel on the ground? Does this cover working with firefighters?

8. Would the use of your product in wildland fire suppression result in a loss of warranty coverage? Are there any warranty voids that would occur when using adapted machinery? For example: mounting a 500-2500 gallon water tank on the machine.

9. The new Division 7 Oregon Occupational Health and Safety Administration Forest Activities Code states that forest machinery used in fire suppression can exceed the 50% slope limit with precautionary measures (using the blade; tying to stumps, anchors, or other machines; or excavation to limit the effective slope under the machine).
Do your product specifications offer any slope limits or guidance about machine operation? Do you think this OR-OSHA regulation should be made more specific?

10. Is your firm interested in providing equipment or attachments for wildland fire suppression? Are there any other studies taking place in your line of products with relation to firefighting?

11. Do you have any information you would like shared with the Oregon Occupational Safety and Health Administration Forest Activities safety code review fire sub-committee regarding equipment use in wildland firefighting?

12. Please provide any other sources of information (such as technical manuals, other knowledgeable contacts, international standards, etc.).

Thanks again,

Chris Bielecki, Graduate Student
email: chris.bielecki@oregonstate.edu

Dr. John Garland, PE, Professor
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Appendix II: Summary of Responses from Questionnaire

	Question:	No	Yes	NA	Other	Other	Other	Other	Other	Other
1	Should equipment being used in close proximity to flames and heat require special protection so that the engine does not take in superheated air or burning material?		V	|||	this is an idea with merit and could be added to a machine with a pump or pressure system to provide a small sprinkler system under the hood and around the air intake and around the fuel system	We designer/engineers rarely see what actually occurs when the machinery is exposed to the heat generated in a wildland fire.	Modifications such as artificial aspirations for engines, or Kevlar, Nomex, fire retardant materials could be employed, but are not readily available from O.E.M. Typically, if conditions are too "hot", we should not be there.	Steel lines can be used for hydraulic and fuel lines. There would be some flexibility/bending issues.	Any forest machine is not designed to be close enough to a fire to take in superheated air or burning material. Ideally, when heavy machinery is used to fight a forest fire, the equipment is used in an unburned area to create fireline by pushing combustible materials away down to bare soil. Thus, when the fire burns to the fireline the mobile equipment is working far enough away to not be exposed to the advancing fire. To work any closer puts the equipment and the operator at risk. Just as no operator is immune from the effects of exposure to superheated air, neither is a machine. No forest is worth that risk.	
					Operating in 120° F is common, but our machines can't get enough cooling to work in superheated conditions. Side-by-side coolers is advantageous to eliminate heat transfer from one to another--so that each sees the same temps. Screens are used to trap materials and when operating with a lot of debris--especially in the southeastern US--there is a one-hour time limit on operation. Every hour the fans must be reversed to blow out the material. During a recent barn fire, machines 200' away had paint damage and plastic parts such as light covers were ruined.			this is an operator issue before an engine problem	precleaners and reversible fans prevent taking embers into the chassis. We didn't do anything remarkably different, just maintained well. There is a point which is getting too close and affecting the aspiration.	

Question:	Answer:								
	No	*Yes*	*NA*	*Other*	*Other*	*Other*	*Other*	*Other*	*Other*
2 Do you have any knowledge regarding fire resistant air filters in forest machinery?	VI		I	there are some special air filters used in steel mills which may help	Donaldson air filters may be working on this. (www.donaldson.com)	air filters designed specifically for extreme "unnatural" conditions are not available for machinery by application. Certain manufacturers of such items may be able to help in this area, but for loggers to be able to purchase at this time would be a monumental task. Not entirely impossible.			
				Mere ignition of a paper filter inside the air intake will generally not cause a fire on the machine. If the filter begins to burn and enough smoke is ingested into the engine, the engine may die, but there is generally no place for the fire to go outside of the steel filter housing. Even if the filter was fire resistant, the dust collected by the filter is not fire resistant. I would not be as concerned about drawing burning materials into the air intake as I would be having flames and heat close enough to ignite other combustibles in the engine compartment...what machine doesn't have some oil or grease or other fuel residue in the engine compartment?					

	Question:	Answer:								
		No	*Yes*	*NA*	*Other*	*Other*	*Other*	*Other*	*Other*	*Other*
3	How much heat can regular tire tread on logging equipment withstand from adjacent flames?			IV	if exposed to direct flame, most tires will burn and support combustion	It would be hard to determine tire tread damage. If you stop in the fire where the heat is over 500 degrees the tire will start to burn. If the machine is moving the fire will go out. It is my opinion that staying in an area where the heat is over 250 on the ground for a long period of time; i.e., 30 minutes or so will damage the tires. It is a must that when we park and start pumping water on the fire that we cool the area under the machine and tires first. In the nine fires that we have been on this has not been a problem.				Normally we will never have subject ourselves to be in direct flame. We have never experienced tire separation due to heat in many years of "mop-up" conditions.
					It depends. The tread can certainly withstand more heat than the sidewall. Exposure to heat against the sidewall may lead to increased tire pressure and blowout before the tire catches fire. If the tire is heated until it begins to smoke, then the tire is beginning to gasify and flaming combustion will soon follow.		Once the tires start to burn there are concerns with many other parts including hoses. Stelco (Steel Company of Canada) uses rubber-tired front-end loaders.	a fair amount if of short duration--it isn't easy to ignite a tire	I've only see tires burned on abandoned vehicles.	best answered by tire manufacturers
	What tire manufacturer supplies your firm?			II	Gibbelin & Michelin			Firestone & Nokia		

	Question:	Answer: No	Yes	NA	Other	Other	Other	Other	Other	Other
4	Does your equipment have enclosed cabs that protect the operator from dust and smoke?	III	III	II	Our machines do not have enclosed cabs at this time but are well guarded. Working in close proximity with ground crews the open cabs are better. If the machine is moving and running down the road in the dust, the enclosed cab would be nice.		Fully-enclosed cabs with air conditioners.	the equipment I evaluate has both enclosed and open cabs depending on age and manufacturer	We wanted the crew and lead operator have a good understanding of what situations they're in. This tended to guide decisions and tactics. We had 1-2 additional people on the working platform. Safety first, production second.	Some models have sealed, pressurized cabs, but smoke can enter through ventilation.
					I know of no filter system for portable equipment that is capable of providing such protection for prolonged periods. Typically, the best protection is to stay out of the smoke or to wear a personal self-contained breathing apparatus. Of course, if the smoke is so thick so that you can't see, then how do you operate the equipment safely?			All of our machinery has enclosed cabs, air conditioned, filtered air intake into the cab. This is designed by O.E.M. for dust no necessarily for smoke filtration. Proper "pressurization" of cabs reduce smoke tremendously.		Yes to dust protection. We follow ISO and SAE air quality standards for enclosed cabs used for earthmoving.
5	Would your equipment provide a safe working environment to the operator in a burn-over situation?	VI		I	In an extreme burnover, there would be no way one would survive on the machine.	At this point, NO logging machinery should be considered as safe environment for operators in fire situations. Compared to ground personnel it is much safer, if capabilities are totally understood by Federal and logging personnel.			We build our cabs using 3/4" Lexan on the front window and have tested projectiles to determine this.	This is truly a life or death situation that is best to plan for by staying a safe distance away from the fire.
					Big polycarbonate windows are used for high visibility. These range from 3/4" to over 11/4". Saw teeth are usually the factor for window thickness, but the Lexan melts in hot conditions.			Radiant heat alone would kill the operator and crew. Our burnover plan would be: leave the machine running, turn on the monitor and try to cool the area as much as possible with water, and have the crew set-up shelters on the ground.		

Question:	Answer:								
	No	*Yes*	*NA*	*Other*	*Other*	*Other*	*Other*	*Other*	*Other*
Should any additional features be required, such as pull down fire screens to reflect the intense heat?		II	I	Pull down screens would help but there should also be protection for fuel systems and a means to keep the operators' compartment cool. The best protection is to not put an operator in the situation for exposure to overturn. Follow the basic Watch Out Situations and Fire Orders!		There are, I understand, fire screens which can be fitted to the machines but I do not think one could buy a system to bolt on to a specific machine.	External thermometers easily read from the cab could be useful.		
				Pull down screen are a minimum requirement. The operator can possibly use the new portable fire shelters inside the already screened vehicle.		The operator needs a safety cocoon.	An enhanced protection capability is necessary.		
Do you have other ideas regarding burn-over protection for the operator?			II	special precautions should be taken as deemed necessary by the manufacturer and the user	One thought would be to doze as large an area as time would allow and use the USFS fire shelter for protection. If time would allow we would always try to get to a black area where burning had already taken place.		Many safety improvements in fire situations could be employed and should be researched.	Neither hydraulic oil nor diesel fuel are highly flammable. They don't burn with ferocity.	It makes more sense for an operator to abandon the machine and to deploy a fire shelter on bare soil.
If so, where can additional information be obtained?			I						

	Question:	Answer:								
		No	*Yes*	*NA*	*Other*	*Other*	*Other*	*Other*	*Other*	*Other*
6	Are there any negative effects to the operator involving either interior or exterior automatic fire extinguishing systems?	||	V	|	depends on the type of fire suppression system used	cab interior fire suppression would suffocate	there should be no problems with any of the new systems, either with the machines or operators	A negative effect would be the inhalation of fire suppression chemicals or gasses or depletion of oxygen.	Automatic systems provided by manufacturers are usually Class "A" or Class "B" dry chemical. This system normally is built to extinguish exterior compartments only. Interior extinguishing of this type would result in a no air situation for the operator, therefore not practical.	
					Don't breathe the powder! Get out of the cab before actuating the portable fire extinguisher or the fixed fire suppression system.	Dry chemical powders are poison, but water is good! Usually the systems are directed into the engine compartment only--activated by heat sensors. Cabs can fill with smoke quickly.	Halon is bad news if inhaled. The fire caddy is just coming out with a new machine system that is water based. This system will run for 30 minutes.	The systems are directed into the engine compartment and tub area, so the operator would have time to get out and get to an area of clean air.	Our systems cover only the outside of the cab. The operator would be ok. The extinguisher systems seldom eliminates the fire entirely--usually it's the operator w/ handheld system who eliminates it. Insurance rates influence the use of these systems.	

	Question:	Answer: No	Yes	NA	Other	Other	Other	Other	Other	Other
7	What direction do you provide in the operators' manuals regarding working in proximity to personnel on the ground?			||	ground personnel should be out of the swing radius or operating envelope of the machine	We require people to stay back 200' from an operating machine. This includes firefighters. In the event of a fire we expect the machine to be shut-down and abandoned.	We try to emphasize this area at all times with a short talk to each crew leader or whole crew about staying clear of the machine and trees or logs the machine may kick up. We also sound our horn before any move forward or back and we ask that the crew stay to the rear of the machine when we are moving on the fireline.		All of our service & operators manuals cover details of working conditions with ground personnel, when they are in their natural "logging" environment.	All machines say "Stay Back 300 Feet".
					Forest fire suppression generally has three phases: air phase utilizes aircraft to drop suppressant from above; ground heavy equipment works in advance of ground crews to create fireline in heavy timber; ground crews using water hoses or hand tools to clear a fireline. The overall task of extinguishment is a symphony of multi-tasking, but rarely are the ground crews working side-by-side with the ground machines.			The operator must be watching what is around the machine. There are lots of warning signs. Debris can be thrown 300-400'.	This has not yet been done in our organization.	We would have briefings and talk about how to operate before hand. We still had a situation where an engine came in right behind us, but luckily our crew communicated to avoid backing over this engine.
	Does this cover working with firefighters?	|		|		Most of these are able to relate to ground personnel or "firefighters". They do not go into specifics that may be encountered on fire operations.				

#	Question:	No	Yes	NA	Other	Other	Other	Other	Other	Other
8	Would the use of your product in wildland fire suppression result in a loss of warranty coverage? Are there any warranty voids that would occur when using adapted machinery? For example: mounting a 500-2500 gallon water tank on the machine.	I	I	III	warranty would be void if not pre-approved	Our warranty does not cover use of a machine for purposes other than the design intention.	I think if push came to shove any machine used in wildfire suppression is going to have a hard time getting any warranty and if the machine was altered in any way there would be non warranty.	I have not checked with the manufacturers for warranty coverage of the machine after installation of a tank.	Warranty coverage is definitely a questionable area because of subjecting a machine to an environment not originally intended for such machinery. After modifications, warranties are more than likely VOID. I have talked with other O.E.M. vendors about tank sizes, etc. They should never exceed engineering for machinery designed to carry specific load. Data not available from O.E.M. as to different capabilities.	
					Our warranties currently don't cover firefighting. The operator should watch the heat gauge. We experience more problems from cold temps in Canada. Heat thins the oil while cold conditions restrict oil flow and harden metals.		Changes must be factory approved.	Our carriers were designed to log aggressively. Firefighting was much easier on the machine, so there shouldn't be any conflict with the warranty. Another issue is the insurance coverage. As far as liability goes, the larger companies probably don't want to address firefighting because it isn't that big--basically a waste of time.		Warranty coverage would be zip. A purpose built machine is needed for adding water tanks--obviously the bigger the better.

	Question:	Answer: No	Yes	NA	Other	Other	Other	Other	Other	Other
9	The new Division 7 Oregon Occupational Health and Safety Administration Forest Activities Code states that forest machinery used in fire suppression can exceed the 50% slope limit with precautionary measures (using the blade; tying to stumps, anchors, or other machines; or excavation to limit the effective slope under the machine). Do your product specifications offer any slope limits or guidance about machine operation? Do you think this OR-OSHA regulation should be made more specific?		||	||	the limitation is based on the engine oil sump grade capability limitations, not the machine ability to travel on steep grades	The Oregon code sounds good to me. This has been a problem area for all manufacturers for some time. It is a bit of a judgment call as to slope and gradeability of a machine. Anything more than 50% needs to be approached with caution and with an experienced operator. The type of soil has almost as much to do with what can be done safely as the slope. I don't think this is an area where being more specific would help.		Our equipment has been tested and approved to 60%.	It is oversimplified. What about operating and interacting with other resources?	We issue standards for our feller-bunchers and follow other manufacturers specs for carriers (i.e.. Delimbers should follow excavator's recommendations)
					Some of our machinery (feller-bunchers, skidders, forwarders) do give some suggested slope limit capabilities. These will never be inclusive and positive limitations by them as their competitors will simply list higher limits. The OSHA regulation needs to define "precautionary measures" to understandable reasoning for the limitations. There is positively no substitute for experience in this area.		We provide general warnings out of the operators' manuals.	I limit my evaluations to a 35% side slope as per verbal comments made by a manufacturer. (Under very rare conditions will a machine only be operated on flat surfaces.) For liability reasons a limit should be placed on the machines and on evaluations. Machines will encounter situations every day that can result in a rollover. The operators must assume a portion of the machine operation responsibility. The fireline supervisors must also be aware of the capabilities of the machines and not put them in situations that could result in a rollover. The fireline supervisors should also direct or warn the operators of dangerous situations.		Our machines are not used on slopes. The specifics should be left up to engineering analysis.

	Question:	No	Yes	NA	Other	Other	Other	Other	Other	Other
10	Is your firm interested in providing equipment or attachments for wildland fire suppression?	I	III	I	We may be interested in building up equipment for fire suppression at some time in the future. There are other ideas being looked at by one of the fire departments in the area but it pertains more to organization rather than equipment.			Yes to both. We have developed and built many specialty wildland suppression machines and are currently working on several to date. We believe "Big Iron" (logging machinery) definitely has a huge future in current and future firefighting practices.		
					As I do not directly produce equipment, this question does not directly apply.	It is better to focus on prevention than suppression.	We're willing to talk about it. Firefighting machines are not currently part of our program--we need more contacts and experiences.			
	Are there any other studies taking place in your line of products with relation to firefighting?	II	I	II	FERIC recognizes the trend towards mechanized firefighting.	I am interested in the design and development of machinery and firefighting equipment. I design, develop, and manufacture prototypes for others that are interested in equipment production.			Our main concern is who will own the mechanized firefighting equipment. The design is not paid for until 7 machines are sold.	
11	Do you have any information you would like shared with the Oregon Occupational Safety and Health Administration Forest Activities safety code review fire sub-committee regarding equipment use in wildland firefighting?	II		II	The main thing I would like to say to anyone regarding equipment use in this area is to remember the idea is to put the wet stuff on the red stuff as safely and efficiently as possible. The machines need to undergo better inspections; not only as to the safety of the unit but also as to their efficiency on the fire. The inspectors need better training. It may help of the inspectors had more training on the fire system; i.e., pumps, reels, fitting foam systems, etc., which should be tested during the inspections. We receive training on fire safety every season but we receive no training on how to best use the machines before fire season starts. Fire bosses are trained to fight fires but they are not trained on what the different types of equipment are capable of or not capable of doing.					

Appendix III: Summer 2003 Firefighting Experiences

During the two weeks of September 2nd through the 12th, I worked with a Miller Timber Services private firefighting crew. The crew is a Type II I-A (initial attack), and is typed based on a standard list used by all agencies. This is the highest level that contract crews have been typed as, based upon my knowledge. The crew was working under one of Miller's 2 national contracts, meaning that we can be dispatched nationwide. The usual procedure is to travel to a bunkhouse located outside of Spokane, WA. From here the crew resides off-duty until being dispatched. I was told that the average wait is approximately 1 day.

The original purpose for my training with the company was to have the opportunity to work alongside and observe a prototype forwarder modified with a 2000 gallon water tank. Miller had used a similar piece of equipment during the previous summer for mop-up and water delivery in an Oregon fire. This year the owner decided to invest in and construct a larger specialty water tank that can be mounted on the machine.

Unfortunately, the timing did not work out for my project. Mr. Miller had a difficult time "selling" the product to the appropriate agencies—especially the USFS on the B&B complex fire near Sisters. Because it is obvious to most experienced firefighters that the machine has potential, mainly due to providing an all-terrain large capacity water transport vehicle, the difficulties experienced by Miller Timber Services illustrates the need for fire operations research.

The following observations were gathered during the time I spent with the crew. We were dispatched to Humboldt County, CA, where we worked on four separate fires. Three occurred on Forest Service land, and were therefore also handled by a Forest Service management team. The size of these lightning strikes varied. Included were: a 15 acre roadside blaze, an 8 acre hillside blaze about a ½ mile walk from the road, and a single-tree incident. Our crew performed initial attack on the 2 larger blazes (Rabbit and Bluejay incidents), both times cutting fireline around the fire until "tying in" with another crew working from the opposite flank. Both of these involved nightshifts and were 5 hours and 26 hours in length, respectively. On the single-tree Mendocino Fire, we performed mop-up with a contract engine crew serving as Incident Commander (IC). This mop-up was handled in a thorough 7 hour shift.

Issues:

dispatch process

The crew was dispatched from approximately Spokane, WA the morning of September 2nd. The destination was Yreka, CA. Since the crew was still located in Philomath at the time, we performed yard work around the shop and adjacent residence until the approximate time that we would be passing back through the area. This was around 1500. We arrived in Yreka late that evening (2200?) and checked into a hotel. The next morning the crew checked in with the Yreka Forest Service Ranger Station at 0700 where an inspection was performed on three private contract crews: Miller, Greyback, and Ferguson.

- all three companies had 3 matching vehicles
- Greyback and Ferguson had miniature versions of crew buggies that carried around 10-12 people. Miller used a van.
- Greyback and Miller had dress codes (Nomex pants, tucked-in company tee-shirt, no crooked baseball caps), while Ferguson did not appear to

management

We spent time at two separate fire camps. The first, located near Ruth Lake was managed by the USFS. At the maximum there were approximately 15-20 crews assigned to the complex. Some of these arrived, worked a shift of mop-up, and were demobilized (released). I assume that these were Type II or Type III crews. Our crew was one of the first to arrive and one of the last to leave. The first three days saw three shifts working on the blazes. At this point another four days were spent "staging", or waiting on duty and prepared to leave within three minutes if necessary. After the fourth day of this process the crew was demobilized and sent to check in with the CDF to work on another complex that was ignited from the same storm series.

From the start the use of our crew at the state managed incident was sparse. After sorting out the confusion of where our crew and 4 other crews needed to check in, we arrived at High Rock conservation camp, outside of Weott, for the evening. Here the crews were fed and given orders to travel back to Honeydew in the morning for assignment. No time was actually spent fighting fires directly. Rather, our crew spent two days working to support a major burnout operation on the Honeydew Fire, up to 17,000 acres based on the spread of the blaze west towards the Pacific Ocean. I found this odd since the fire had consumed only 200-300 acres at the time of our arrival.

During the three days that we were assigned to this fire, there were no ground crews placed on the actual fire. I estimated that there were 10-15 CDF Department of Corrections crews, 3 private hand crews, 2 CDF hand crews, and another USFS hot-shot crew. The only direct fire suppression taking place involved 4-6 helicopters dumping water on the blaze during the daylight hours. From my viewpoint, this did little to stop the fire—especially because there were no hand crews working to direct and accompany the air crews.

After our three days, it was obvious that the burnout was not going to take place. All private hand crews were demobilized. I believe that this decision was partially due to the proximity of adjacent landowners and structures. However, the fire has grown to cover most of the burnout area at this time and over 24 million dollars have been spent on the Honeydew and Canoe fire complex.

resources (type and utilization of)

There were some major differences initially observed between the different contract crews. The most obvious of these had to do with appearance. Some crews were well outfitted with matching vehicles and comfortable accommodations for occupants. Other crews seemed to be crammed into 2 personal vehicles, usually with a company sticker or emblem. Since there would be little room for all the appropriate gear, I assumed that these were Type III crews, who are required to have less experience and resources (such as radios, tools, saws and sawyers). Because of this, they are unable to be broken up and utilized as squads.

In addition, a variety of other crews were seen on the fires, including: federal, state, and private engine crews, federal, state, private, and convict hand crews, helitack crews, air tankers, helicopters (I assume state and private), air attack, Incident Management Teams, contract falling crews, water tenders, caterers, shower and laundry services, etc. In addition, the California Conservation Corps provided trash maintenance and logistical services at the fire camps.

Appendix IV: Summer 2004 Firefighting Equipment Observation Report #1

Fire:	Log Springs Fire
Observation Date:	8/3/04
Location:	Warm Springs Indian Reservation, Oregon
Size:	13,539 acres (as of 8/5/04)
Terrain:	Standing timber with heavy dead and downed fuels; also grasslands and juniper woodland

Two skidgines (log skidders modified with water tank, pumps, hoses, & nozzles) were employed by the fire. I spent one-half day observing each as they performed mop-up activities. The first machine was an FMC Soft Track with a 1500 gallon water tank. It was equipped with a Compressed Air Foam System (CAFS), remote control water cannon, rear vision camera for backing up, and rear spray heads. The company, *Soft Track Attack Inc.*, is based in Montana and has 2 machines staged in Terrebonne, Oregon. The machine was assigned to a single division of the fire and coordinated with multiple hand crews to provide water for hot spots and smoldering stumps in relatively flat, rocky terrain with widely-spaced juniper and pine. It was also used to push over a hazard tree—one that had been burned out at the base and was hung up in an adjacent tree. This alternative reduced the risk from using a hand-faller.

Tracked skidgine pushing over a hazard tree.

During earlier stages of the fire, the machine constructed 6 miles of fireline, brushed non-maintained roads, and patrolled existing fireline at night.

A converted Caterpillar 518 skidder was also observed while performing mop-up on a separate division of the fire. It worked in hilly terrain with dense pine, coordinating with a hand crew and providing water from a 1000 gallon tank. With articulation the operator was able to work on steep terrain (~25%) and maneuver through tight spaces.

Rubber-tired skidgine performing mop-up activities while parked on side slope.

While parked the machine used a widened 2-way blade to provide for extra stability. This machine was also used to build a turnarounds, move rocks, and chase spot-fires while patrolling the fireline. The company, *GL Ervin*, is from Prineville, Oregon.

Both machines received positive responses from ground crews directly working with them as well as the Incident Command Team managing the fire.

Appendix V: Saving Western Forests with Better Wildland Firefighting

Chris Bielecki [1]

Dr. John Garland, PE [1]

Lee Miller [2]

[1] *Forest Engineering Department, Oregon State University, Corvallis, Oregon*

[2] *Miller Timber Services, Philomath, Oregon*

Pacific Northwest Wildfire Coordinating Group

Oregon State University has been researching ways to improve wildland fire suppression with loggers and logging equipment. At the forefront are new developments in forest machinery offering potential applications for wildland firefighting. Innovations have already been used successfully on some western fires. However, the opportunities and technologies are overlooked in various regions. We hope to share information and collect ideas for future improvements.

Early wildfire suppression with effective tools is essential to reduce the catastrophic fires of recent years. Logging crews are often working in proximity to fires on adjacent lands, and can quickly respond. In addition, logging crews in Oregon must be equipped to fight fires occurring on their operations. This experience along with logging skills useful in wildland firefighting offers valuable resources for fire managers. Many fires have been suppressed safely and efficiently on private lands, and more help is certainly needed on public lands. Potentials can be realized with a combined research, development, and implementation strategy involving interested agencies, institutions, firms, and individuals. The time for action is now!

Premises

1.) The need for loggers and logging equipment is readily apparent. The nature and extent of modern wildfires are expected to continue. In the last 5 years alone, millions of acres of forest land have been burned, thousands of homes destroyed, and dozens of people killed by wildfire. Forest conditions continue to contribute to large fires and imperil lives and property.

2.) There is a need for new technologies to fight wildfires, and advanced logging equipment can be used for wildfire suppression. Standard and modified machinery is useful for fireline construction, hazard tree felling, initial attack, water delivery, mop-up, rehabilitation, and other tasks.

3.) There is a capacity in the western logging sector to fight wildfires. Loggers often suppress wildfires on private lands, and in the past, were a major resource with their equipment to fight wildfires on public lands. A labor force of more than 25,000 loggers could be tapped for the western states to suppress wildfires.

4.) Government agencies who manage the wildfires on public lands are not likely to invest in logging machines strictly for firefighting. Some logging machines used or modified for fire fighting may cost over $400,000. Therefore, more coordination is needed between the public and private participants.

5.) There are significant safety benefits from using mechanized equipment requiring fewer operators for the high exposure tasks and to complement firefighting personnel on the ground with hand tools.

6.) The western regions are moving to use equipment already but without much systematic study, evaluation, and guidance. Montana and Idaho have used logging resources more than most areas, and other states are now learning about the techniques and results.

Desired Outcomes

There have been anecdotal successes! In Region 1, The Big Iron Initiative developed by the Northern Rockies Coordinating Group (NRCG) has provided for effective use of logging equipment in creating large-scale firelines, in direct attack of wildfires, and for mop-up with modified machinery. These tools have unquestionably helped suppress the large fires of recent years.

Effective wildfire suppression needs an integrated fire suppression system that incorporates logging equipment with hand crews, aircraft, and other traditional resources—including the use of fire itself. The equipment will fill an important need with new tools, but not before institutional barriers involving deployment, tactics, and strategic fire operations are addressed. The capital investment of the logging sector in machine capacity can be used by firefighting agencies to more quickly suppress wildfires through the use of new equipment technologies.

Research Needs

Past Research

Research at Oregon State University (OSU) is underway on the use of loggers and logging equipment to fight wildland fires. OSU is defining the problem through identification of pertinent issues, and the major topics include training, policy, and equipment. The project involves reviewing the Oregon Occupational Health and Safety Administration (OR-OSHA) Forest Activities code that covers wildland firefighting. In addition, interviews with experienced operators and individuals working on the advancement of logging machinery for fire suppression are generating new knowledge. The opportunities for machines have produced many innovations—both good and bad. More research is needed to utilize safe designs while eliminating unsafe and ineffective equipment solutions. One example of screening unsafe designs is a Region 1 policy requiring engineering analyses for machines retrofitted with water tanks. OSU will further document machine applications through fireline observations of new equipment during the 2004 fire season.

Future Research

Additional research and development are needed along with a systematic sharing of information to fire managers and equipment operators. These include research into

1.) Tactical and strategic uses for firefighting with new equipment and loggers on wildland fires.

2.) Formation of an effective dispatch system to match machines and operators with fire suppression needs and operations including building knowledge and experience of equipment operations within the Incident Command System.

3.) Stability and gradeability of modified machinery as well as safe operational guidelines for machine use and inspection procedures.

4.) Production rates for fireline construction, water delivery, and other fire operations (e.g. snag falling) performed with logging equipment.

5.) Training system development for fire managers and logging personnel to address specifics for using and evaluating logging resources and equipment.

6.) Modifications to agency guidelines and references (i.e. Incident Response Pocket Guide, Fireline Handbook) to include Equipment Applications.

7.) Develop institutional structure to continue improvements on a national level, perhaps through the National Wildfire Coordinating Group (NWCG).

<u>Recommendations/Actions Needed</u>

For the immediate future, these actions can be taken to enhance the use of loggers and logging equipment on wildfires:

1.) Convene a regional users group of interested representatives from agencies and industry. Region 6 can benefit immediately from this action as Region 1 has already successfully conducted equipment workshops and demonstrations.

2.) Assess machinery classification by relevant criteria, e.g. tank size, horsepower, excavator size, felling attachment(s), etc. for applications in firefighting.

3.) Consider machinery pay rates for fire suppression as a function of capacity and equipment purchase prices.

4.) Improve operator qualifications and certification by suggested interim guidance.

5.) Review of the dispatch system and inspection processes for equipment used in wildland firefighting. For example—would the use of visual images be helpful to fire managers when ordering equipment?

6.) Improve the OR-OSHA Safety code related to wildland firefighting.

7.) Develop workshops and demonstrations for operators and agencies in Regions 5 and 6 to gain better understanding of potentials.

8.) For those involved: gain a better understanding of how the complex wildland fire suppression functions.

9.) Implement the results of research on the use of logging equipment and operators in wildland fire suppression.

For Immediate Action

We propose a meeting of those interested in advancing the use of loggers and logging equipment to fight wildland fires. We expect to further develop ideas that will change how modified logging equipment and crews will be used in fire operations. If you are interested in such a meeting, please contact:

During business hours:
541-737-4952
Forest Engineering Department
Oregon State University
215 Peavy Hall
Corvallis, OR 97331

Evenings:

Mr. Chris Bielecki	541-738-0470
Dr. John Garland	541-754-9080
Mr. Lee Miller	541-929-2840
--or--	541-453-5051

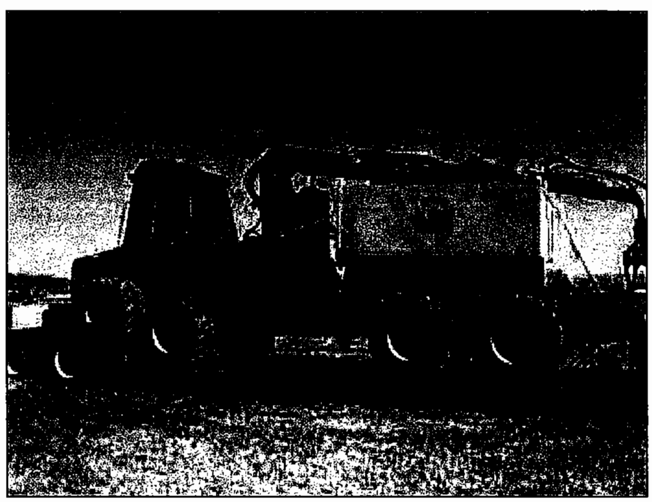

Figure 30: Modified log forwarder able to carry 2000 gallons of water on rough terrain for wildland fire suppression.

Appendix VI: Pacific Northwest Wildfire Equipment Group Action Planning Report

July 10th 2004 meeting

Submitted by

Chris Bielecki & Dr. John Garland

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Corvallis, Oregon

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Lee Miller

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Dear Cooperator:

Please find enclosed the Pacific Northwest Wildfire Equipment Group ACTION PLANNING REPORT from the July 10th 2004 meeting in Bend. Please review report and let me know if something important was missed or should be added.

Note in the Action Items that we will hold another group meeting of the Pacific Northwest Wildfire Equipment Group (as we have termed our ad hoc group) in October/November. In addition, Lee Miller, John Garland, and Chris Bielecki are scheduled to meet w/ the Pacific Northwest Wildfire Coordinating Group Operations Working Team on October 21st to share your views on the important topic of improving wildland fire suppression with logging machinery.

Please share this report with others who might be interested and let us know if you have names that should be put on the list for the fall meeting.

In addition, please keep in touch with Chris and let him know when you know of logging machinery being dispatched to wildfires.

Sincerely,

/s/ Chris Bielecki

Christopher Bielecki

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On Saturday July 10th a group of more than twenty loggers, firefighters, government personnel, and researchers met in Bend to discuss improving wildland firefighting with loggers and logging machinery. The Washington Contract Loggers Association and operators from Washington and Idaho also participated. Equipment for fighting wildfires is part of a research project underway by Dr. John Garland and Chris Bielecki at OSU's Forest Engineering Department. AOL member Lee Miller also helped organize the event. The meeting was designed to help understand machinery potentials; how to get equipment listed, dispatched and used on a fire; and what improvements in Region 6 can be made for equipment use.

The need for new resources for firefighting is apparent because wildfires on public land are becoming more costly and damaging, using only traditional fire suppression resources such as handcrews, engines, and dozers. While there is no need to replace these tools, industrial machinery can complement the current system and should be considered by fire operations managers selecting the safest and most efficient firefighting tools available.

The morning session included presentations, opening with Dr. Garland giving a motivational speech about the use of logging equipment in wildland firefighting—addressing what a small group of committed people can accomplish. Scott Kuehn, Senior Forester for Plum Creek Timber Co. in Montana and Private Industry Liaison for the Northern Rockies Coordinating Group (NRCG), shared his valuable experiences working to improve firefighting with equipment in the Northern Rockies area.

Terry Brown, Region 6 Contract Operations Specialist for the Bureau of Land Management and US Forest Service spoke about the agencies' use of logging equipment and covered important topics of equipment specifications, training, pay rates, procurement, marketing, and dispatching. Lee Miller, owner of Miller Timber Services in Philomath, shared his decades of experience in logging and contract firefighting. Lee also shared information about the National Wildfire Suppression Association (NWSA), a national firefighting association, from his role on the executive committee. The final presentation from Chris Bielecki, an Engineering Technician with the US Forest Service Forest Operations Research Unit and graduate student at Oregon State University's Forest Engineering Department, provided early results and future plans for the research project on "The Use of Loggers and Logging Equipment for Wildland Firefighting".

The afternoon session involved a lively group discussion covering issues, background and experience, research needs, opportunities, and necessary action items to make improvements in firefighting in the region.

ISSUES

The agencies' use of Emergency Equipment Rental Agreements (EERAs) came up throughout the meeting. EERAs are the way government signs up firefighting machinery. In Region 6 there are no current funds to perform pre-season inspections; therefore, EERAs are often written when the machine is requested and signed up at the fire. Another issue with this system is the time delay: it can take 3 days to dispatch one of these machines. There are also discrepancies in the Resource Ordering and Status System (ROSS) used by the government for dispatching. Machines already signed up with EERAs need to be reentered into the ROSS system because of incompatible databases. Who is responsible for this process?

Machine costing and pay rates were an important topic. One of the major dilemmas is that most agencies and regions estimate differently—resulting in many complaints and pay rate differentials. The California Department of Forestry (CDF) uses the industry standard rates for machines; however, CDF is not a big user of modified logging equipment other than bulldozers. The work/rest ratio, shift length, and "Best Value" contracting concepts also influence machine rates.

Another important issue surfaced about the use of equipment for fire rehabilitation. Often the Burned Area Emergency Rehabilitation (BAER) teams follow local and regional specifications with lower standards—not the equipment inspections standards of firefighting equipment. At a minimum the result is two classes of machines—commonly with major differences in environmental maintenance and operating conditions.

Agencies lack familiarity with the actual environmental impacts of equipment use, and this affects deployment. Although machinery has long been used and studied with the impacts documented in other forest operations, agencies continue to have misperceptions about damage and often hesitate to use available resources. Many similar issues highlight the need for continued education about the machinery. Also, protection efforts of saving special resources are questionable if the resources and the entire forest around it are killed or destroyed by a raging firestorm. Is 0% machine compaction and 100% resource mortality better than a small amount of compaction and little mortality?

Many issues surfaced on the lack of deployment of machinery, including needed information about applications and capabilities. One equipment operator was discouraged from innovation because he was told the agency wanted a simple machine not one with "bells and whistles". When machines are used, the system for maintaining evaluations and performance ratings is not adequate. This lack of information is a major barrier in the use of the safest and most efficient resources available. Besides the equipment operators it is unclear who else keeps track of the written evaluations following their use on a wildfire. We need more discussion and sharing of experiences within the firefighting community after logging equipment is used.

The hesitancy of Deschutes National Forest Fire Managers to use logging equipment on recent fires was brought out as well. This resistance illustrates many things—including lack of education about machine applications, misperceptions, and a barrier to selecting the safest and most efficient tool for wildland firefighting.

BACKGROUND & EXPERIENCE

The role of the Fire Contract Officer (CO) was heavily discussed at the meeting because they interact with contractors. Although they "buy" equipment for the customers (agency fire managers, operations personnel, strike team leaders, task force leaders, incident commanders, etc.), they are not technical experts. Many equipment owners approach the CO to promote their machine, but this information needs to reach those actually using and ordering the equipment. The Northern Rockies Coordinating Group created a new full-time Forest Service position in 2004 to address equipment contracting and operator training. The requirement for Water Tender operators to be trained at the *Engine Boss* level in Montana was also discussed. Work to establish equipment pay-rates, specifications, and classifications on a national level is also being discussed.

RESEARCH NEEDS

Research is needed on many of the questions, recommendations, and opportunities for industrial machinery in fighting wildfires. At the heart of this is the idea of using the "Right tool for the right job". More information is needed on machine use and production in many tasks—for example, the wildland/urban interface wildfire suppression, fuels treatments, and constructing fuels breaks and firelines. Fire managers need to understand the productivity of equipment. Even a rough estimate—such as the rates currently used by firefighters for hand and dozer line construction would be a great asset on the fireline.

Production rates would aid in the establishment of fair and reasonable reimbursement rates. Additional machine information on slope capabilities, water tank design and capacity, certification approaches, performance in vegetation types, and useful attachments is also needed. Chris Bielecki hopes to begin this procedure during 2004, although more research will be needed.

To further help those on the fireline with dispatching, potential database systems need examination. This review should involve how to incorporate EERAs into the ROSS system so necessary information about a machine and contractor only has to be entered once. Also needed within the fire agency is a more efficient dispatch system and method for information transfer between the agency departments: fire operations, contracting, and dispatching. Documentation of the costs for adding pre-season equipment inspection and the resulting cost-savings later at the fire needs to be established.

A system of better reimbursement rates is needed from improved machine assessment techniques. The old rule of thumb for rates of 1% of equipment cost per day may be no longer applicable—especially when considering new forwarders, airplanes, and helicopters. Age and capacity of the machine are also factors when establishing a fair pay rate.

The best way to address unknown elements of machines for firefighting needs to be examined. A study of the effects of firefighting with machinery should be conducted—including the environmental impacts of inaction versus actually stopping the fire. The cost savings of using logging machinery needs to documented. This was highlighted by Montana's Lincoln Fire in 2003. Fire management was unable to obtain the standard aerial resources and handcrews, forcing them to use the available resources of logging machines. This resulted in a cost savings estimated at $400,000 to $600,000 per day, but all contributing factors are not clear ("Gov Report Shows Some Cost Cutting", Eve Byron, Helena Independent Record, 12/14/03).

Operator assessment is a topic for research to separate inexperienced equipment operators from those with experience both on machines and fire operations.

OPPORTUNITIES

Many suggestions were made during the meeting to provide some temporary or permanent improvements. The idea of having a separate agency or board perform the machine rating, inspections, and costing was mentioned. In Montana, Idaho, and Wyoming a governor appointed board is proposed to focus on some of the machine issues. Independent boards could help develop criteria for a "best value" contract.

To address the issue of operator efficiency and experience, one suggestion was to make preference for logging operators who have been recognized by accredited logger training programs. This has been successful in the logging industry, and with some changes, could provide a way identify machine contractors for firefighting.

The need to pass along knowledge and share the capabilities of what logging machines can do is critical. Many meetings involving agency fire management teams were mentioned. These included Type I and II IC Team Meetings, an annual interagency

IC team meeting in WA, Pacific Northwest Wildfire Coordinating Group (PNWCG) meetings, and Fire & Aviation team meetings.

Other suggested methods of education included a web-page, static and live equipment demonstrations, and equipment inspection workshops to teach firefighters about the potential uses of logging machines. It is important for these types of events to involve the on-the-ground fire staff from National Forests, BLM Districts, State Agencies, and other operations personnel.

Opportunities for funding are a concern and research and educational tools need to be useful (educational videos can cost $1000/minute). Research money is possibly available from the government agencies—including through San Dimas Technology and Development Center (SDTDC). The successful "Big Iron Demo" held in Montana during the Spring of 2004 was funded and supported by the Bureau of Indian Affairs (BIA), Montana Department of Natural Resources, and the Montana Logging Association.

As far as the Equipment Users Group, there are various directions to focus. The group can possibly become a sub-committee of NWSA, AOL, or remain independent. It will be important for the group to deal with the agencies through a representative as fire managers will respond more positively to a single speaker versus a group of speakers. The group discussed the structure of a proposed "Pacific Northwest Wildfire Equipment Group" or PNWEG to continue for another meeting in the Fall of 2004. In the meantime, Garland and Bielecki will continue to identify organizations and individuals to participate in the Fall meeting.

The final opportunity is the idea of political involvement. While some feel that "from the top down" is the best way to make change, others feel that this will miss some key players. However, it should be noted that some "key players" were invited to the meeting and did not respond.

ACTIONS

As a result of the July 10th meeting, Terry Brown was able to schedule a presentation on logging machinery at the PNWCG Operations Working Team meeting this October. In addition, John Flannigan is going to look into opportunities to speak with Oregon's Type II Team meetings.

Research is continuing with Chris Bielecki spending the 2004 fire season observing equipment in use on wildfires. Chris wants the group to keep in touch as to their dispatches this summer. If Chris can document the machines in use and what the equipment can do, this knowledge can be shared widely. Chris will soon be graduating and looking for further opportunities to continue working on wildland firefighting equipment.

John Garland will provide access to a video and written materials on soil impacts to share research that has already been completed in the area of machinery use and the environment. The video is useful to fire operations and resources personnel lacking information about forest machinery impacts.

Garland and Bielecki will look into possibilities of affiliating with other organizations for the next meeting this fall. They will also look into a static/ live fire equipment demonstration of industrial equipment for suppression and fuels treatments. They will see what is involved with putting up a web site for communications on equipment for wildland firefighting. And they will look at the political support that may be needed to make progress in the area without leaving out "key players" from the process.

Follow-up is needed on potential sources of funding including the Forest Protection Associations, SFA grants, Oregon Forest Resources Institute (OFRI) and other opportunities related to fuels reduction.

This summary report is also an action item and a way of continuing to involve and work with people concerned with improving wildland firefighting. Attached to this report is a list of people who attended the meeting so that we can all stay in touch.

CONCLUSION

The meeting was a success—concerned people came from Oregon, Washington, and Idaho to work on improving the use of machinery for wildland firefighting and to discuss future actions. Many more individuals and companies have a stake in this issue, so additional participation is encouraged. **The next meeting for the Pacific Northwest Wildfire Equipment Group is scheduled for the Fall of this year.** Hopefully more contractors, firefighters, and agency personnel involved with fire operations, contracting, and dispatching can attend and build from new experiences during the 2004 fire season.

Please contact Chris Bielecki for additional papers and to be added to the Equipment Group contact list:

Chris Bielecki

Cell: 541-829-9617
Office: 541-737-4952
Fax: 541-737-4316
Email: chris.bielecki@oregonstate.edu

Appendix VII: Presentations Given on the Topic of Logging Equipment used in Wildland Fire Suppression

Event (Audience Size)

Firefighting with Loggers (20)
2003 presentation at Forest Engineering graduate seminar. March 2003.

Loggers and Logging Equipment to Fight Wildland Fires: Issues and Opportunities in Oregon, USA (120)
Presented at the 7th Annual International Wildland Firefighting Safety Summit in Toronto, ON, Canada on Nov. 18th, 2003

Modification of Logging Machines for Wildland Fire Suppression: Applications and Slope Stability (20)
2004 presentation at the Forest Engineering graduate seminar. January 2004.

New Technologies in Wildland Firefighting (45)
Invited to Reno, NV to conduct 2 one-hour workshops at the National Wildfire Suppression Association (NWSA) annual meeting. February 18th, 2004.

Use of Modern Harvesting Equipment for Wildland Fire Suppression: It's Not Just Dozers Anymore! (30)
Special Seminar by Scott Kuehn, Plum Creek Timber. February 25th, 2004.

Logging Equipment used in Wildland Firefighting (25)
Presented at the 2004 Council on Forest Engineering (COFE) conference in Hot Springs, AR on April 29th, 2004.

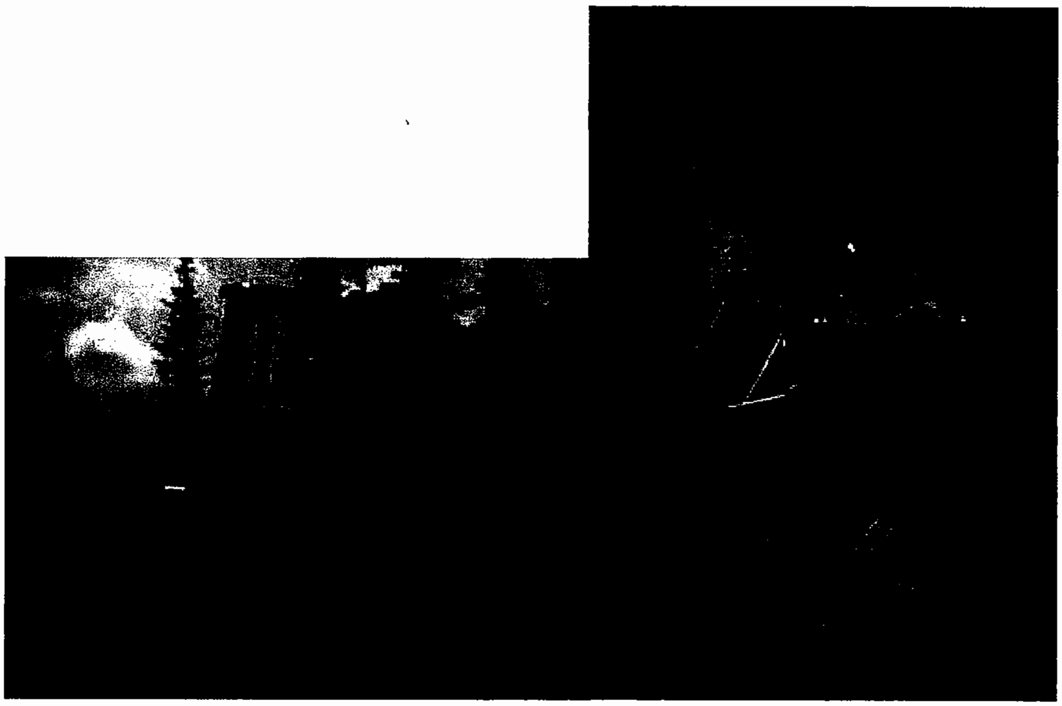
Research summary: Loggers and Logging Equipment to Fight Wildland Fires (10)
Presented to OR-OSHA Wildland Firefighting review sub-committee on May 12th, 2004.

Firefighting with Logging Equipment (80)
Presented at the Oregon Department of Forestry annual Cascade District Operators' Dinner. June, 2004.

Improving Wildland Firefighting with Logging Equipment (25)
1st meeting of the Pacific Northwest Wildfire Equipment Group. Bend, OR. July 10, 2004.

Incorporating Technology: Advancing Wildland Firefighting with Logging Machinery (100)
Presentation at the Society of American Foresters Convention in Edmonton, Alberta, Canada. October 2004.

Appendix VIII: Fireline Production Efficiency Analysis using Data Envelope Analysis



Chris Bielecki

ECON 563

March 16th, 2004

Professor: Shawna Grosskopf

Introduction

Forest management is becoming more and more complex with the incorporation of additional research and goals every year. In addition, past experience and procedure greatly influence what is currently being worked on. The current wildland firefighting situation in the western US (especially in the Pacific Northwest) illustrates this point.

At least in part due to past suppression tactics, devastating wildfires continue to threaten lives and developments each year. As the situation has developed—especially in the last ten years, many needs have been brought to the forefront of forest management. These include a need for more advanced tools to battle catastrophic fires.

Before improvements can be made, areas in need of improvement must be identified. This project looks to determine fireline production efficiency with an economic tool called Data Envelope Analysis (DEA). In this analysis, the efficiencies of fireline production with various resources in different California wildland locations will be determined. Ideally, this information can then be used to identify inefficient situations where technological advancements would best be used.

Literature Review

The literature review illustrated the need for suppression improvement and also provided some ideas leading to the model used later in the analysis stage. Six documents have been reviewed for relevance to fire suppression economics. A brief description follows.

Part One: The Need for Improvement

The use of Economic Efficiency to analyze fire suppression was suggested in one article. Anderson (1984) defines efficiency as:

$$Min: \sum \text{(fire program costs + net value change)}$$

This definition incorporates both costs and benefits of the work performed, where "net value change" is the change (usually negative) in value of land and property affected by the wildfire. Another article, Benetton et. al. (1998) estimated the benefit to cost ratio of bushfire suppression in Australia to be a staggering 24:1. This number provides a strong argument for the importance of suppression. In addition, the assets protected by the bushfires were likely underestimated, since avoided damage is difficult to measure.

Harrison (1984) extends upon the efficiency measure used by Anderson, breaking fire program costs into pre- and post-fire costs:

$$Min: \sum \text{(presuppression costs + suppression costs + resource value loss)}$$

Using historical records to estimate fire effects and an analysis of 39 organizational groups in charge of 877 million acres, Harrison concludes that non-budget increasing program changes can improve efficiency.

The Forestry Source (2004) summarizes a US Forest Service study linking wildfire suppression costs with severity of fire seasons. "Forest Service suppression expenditures are closely related to total area burned, and area burned is largely a function of weather." This contrasts with political concern over the rising costs of battling wildfires and criticism of agency budget development. "Cutting expenses could lead to significant cost savings if lawmakers develop the 'political will' to let fire managers use all options available to them". This brings policy-created obstacles to the forefront of the problem, in addition to the actual suppression procedures. Either way, the extreme fire weather of recent years is another reason to investigate new technologies.

Ingalsbee (2000) urges forest conservationists to become involved with federal fire and fuels management. He identifies problems related to the Federal Wildland Fire Management Policy, including soaring fire suppression expenditures, inefficient large fire suppression spectacles, and the costly commercialization of fire suppression. "On average, approximately 94% of the total burned acreage every year comes from just 2% of all fires, and in turn, these 2% of all fires account for over 97% of the total nationwide suppression expenditures" (Petrich, 1999).

Part Two: Potential Variables for Modeling Fire Suppression Efficiency

Mentioned variables which represented potential inputs for the model included land management objectives, topography, access, weather, fire occurrence, fire spread, fuels, initial action, extended action, detection, management scenarios, presuppression, and suppression costs. Considered outputs involved change in affected resources, risk based on probability, societal viewpoints, damage to forests, agricultural production, capital and conservation assets, water quality, and tourism that would have likely occurred,

Data

Source

Lee et. al. (1993) provides the fireline production data. This information is based on expert opinions from wildland firefighting supervisors in California. There are 2600 sets of estimates put together from the opinions of 173 people, covering 173 different areas. These estimates will serve as the Decision Making Units, or "DMU"s in the analysis. In addition, the information is broken down into types of attack—such as large bulldozers, small bulldozers, 5-person engine handline construction, etc.

Observations

Each expert was brought out to a wildland area and surveyed. They were asked to estimate the most likely, minimum and maximum time that it would take to cut a specified length of fireline in that area using various resources. These resources correspond to the resources serving as "inputs" in the efficiency analysis. Each resource was typed[1] from 1-3. They are as follows:

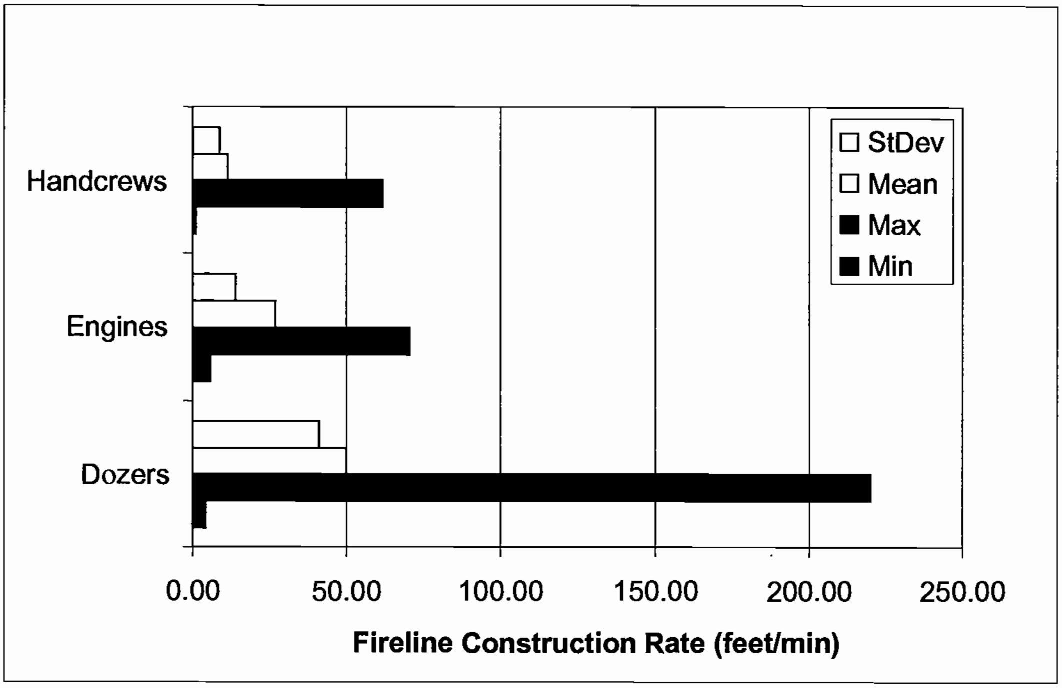
- Bulldozers (D) tracked earth-moving machine with blade accompanied by an operator
- Engine (E) fire truck with water tank accompanied by crew of 3-5 people
- Handcrew (H) crew of 13-20 people (including supervisors) that specializes in manual fireline construction

The three estimated times (most likely, min., max.) were combined to form the average time in minutes. The average rate (expresses in feet/min) is simply this

[1] Type codes are based on the Incident Command System (ICS) classification. This considers things like experience, training, and size (i.e., # of people, capacity, and horsepower).

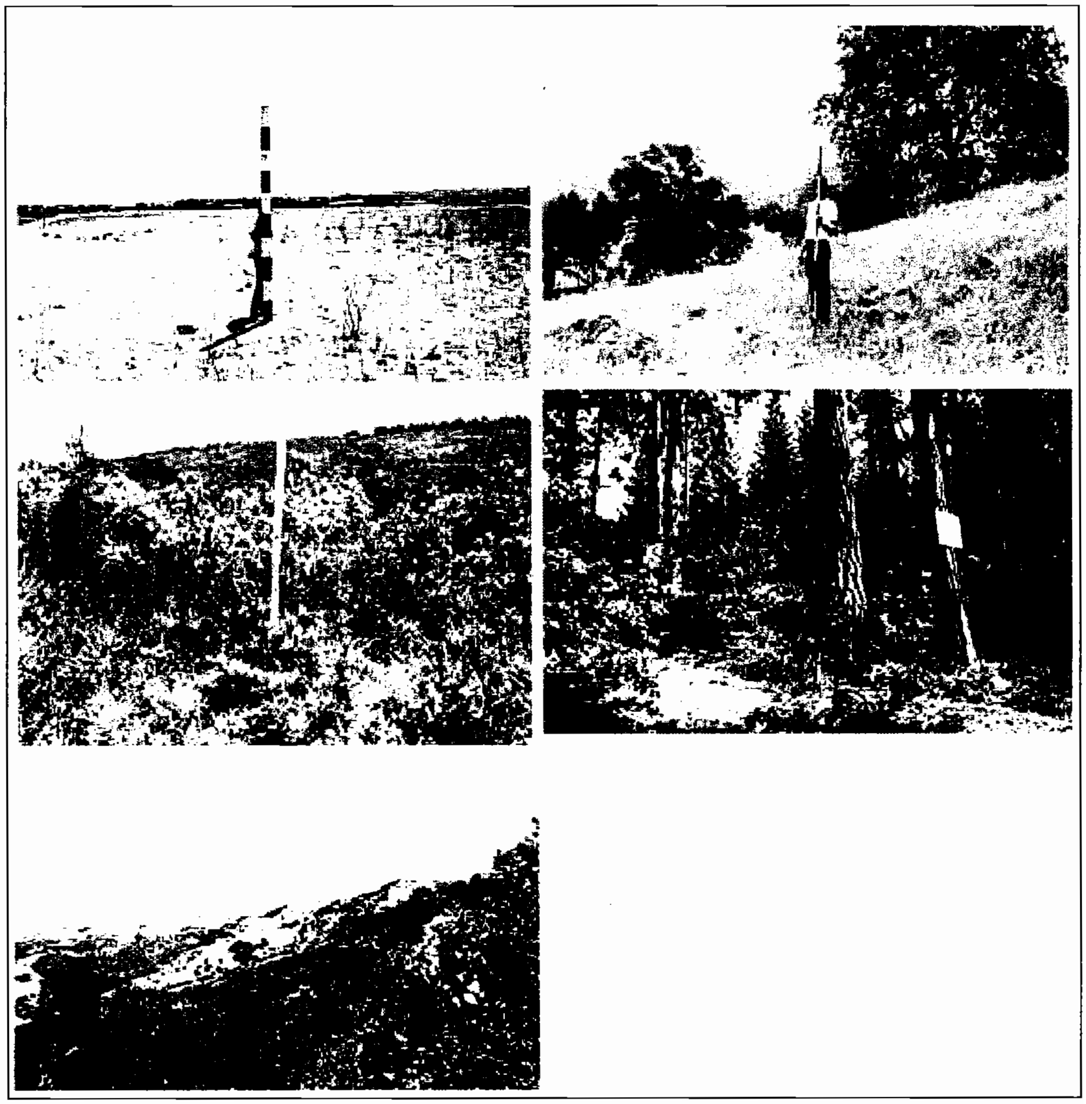
average time divided by the distance. Display 1 provides a summary of the data used in the analysis, according to resource type.

Display 1: Fireline production data summary by resource type.

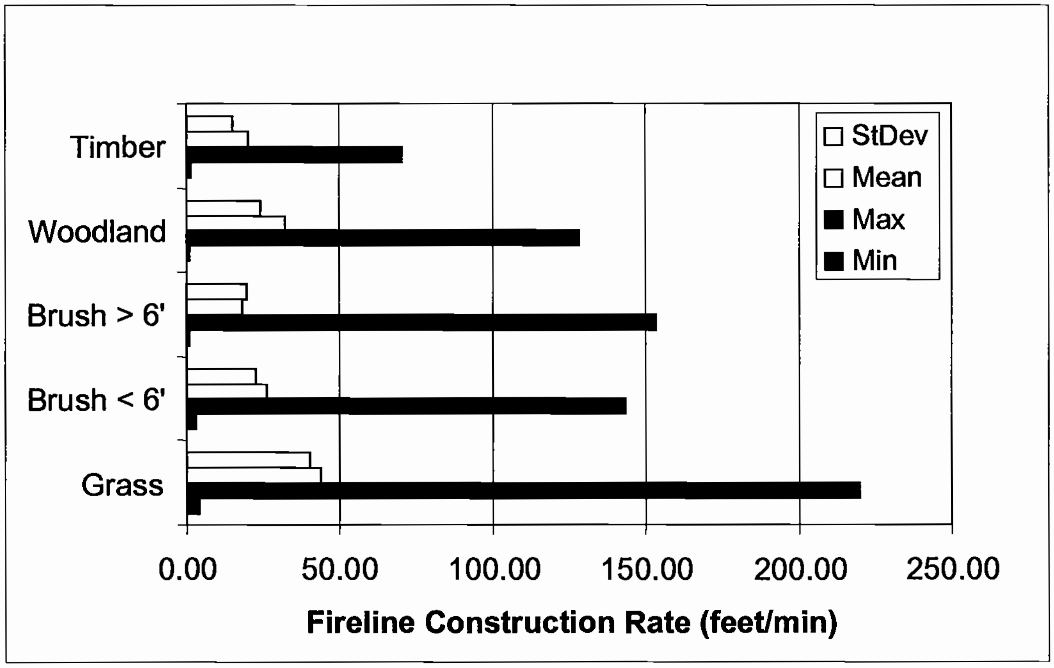


To incorporate vegetation into the analysis, the vegetation for each estimate was determined. Each estimate was further classified into one of five vegetation types (grass, brush < 6 , brush > 6 , woodland, and timber). These vegetation types are illustrated in Figure 1. The data is reorganized according to vegetation in Display 2.

Figure 1: Vegetation Types used in the DEA analysis. Clockwise from top-left, with veg. type in parentheses:
grass (1), woodland (4), timber (5), brush > 6 (3), brush < 6 (2).



Display 2: Fireline production data according to vegetation.



Methodology

Model

The DEA analysis requires selection of inputs and outputs. Considering information from the literature as well as availability in the data set, two model options were considered for analysis—input and output-based technical efficiency models. The input-based model was chosen because it is based on minimizing fireline construction time, and has an independent output variable. Table 1 documents the variables used in the analysis.

Table 1: Variables to be used in efficiency analysis.

	units	analysis variable
outputs		
Fireline (length)	feet	y_1
inputs		
dozer type1	# tools	x_1
dozer type2	# tools	x_2
dozer type3	# tools	x_3
dozer (all)	# tools	x_4
engine type1	# tools	x_5
engine type2	# tools	x_6
engine type3	# tools	x_7
engine (all)	# tools	x_8
Labor	# people	x_9
vegetation	class	x_{10}
fireline construction time	minutes	x_{11}

The analysis determines areas where fireline production time is inefficient in comparison to the best practice frontier. In addition, the analysis will include analyzing efficiency with and without a subvector. Using a subvector means that all input variables are locked except the fireline construction time. Based on these results, the potentials for maximum efficiency in lacking areas can be estimated taking the multiple of the actual time with the efficiency measure. For example, if observation has a fireline construction time of 22 minutes for a length of 500 feet, an efficiency measure of .76 would mean that the potential based on the best practice frontier is:

$$22.0 \text{ minutes} * 0.76 = 16.72 \text{ minutes}$$

Handcrews will serve as a reference in the input data, since they represent the simplest form of fireline construction (by hand). Handcrews will be used as inputs with the L value (labor) being the number of personnel on the crew. Personnel requiring additional tools (e.g., dozer operators need a dozer, engine crews need an engine) will add that tool as another input resource variable. Only handline and hoselay tactics have been analyzed, with mobile attack estimates being omitted from the analysis.

In addition, Variable Returns to Scale (VRS) will be utilized, since there is a non-linear relationship of efficiencies based on the number of bulldozers, engines, or handcrews used in each situation. Technology can be found in Display 3.

Display 3: Technology used in the DEA model

Model: Farrell's Input Based Technical Efficiency

F_i = minimum fireline construction time

LP:

$F_i\,(y^k, x^k \mid V,S) = \min\{\, \lambda : \lambda x^k \in L(y) \,\}$

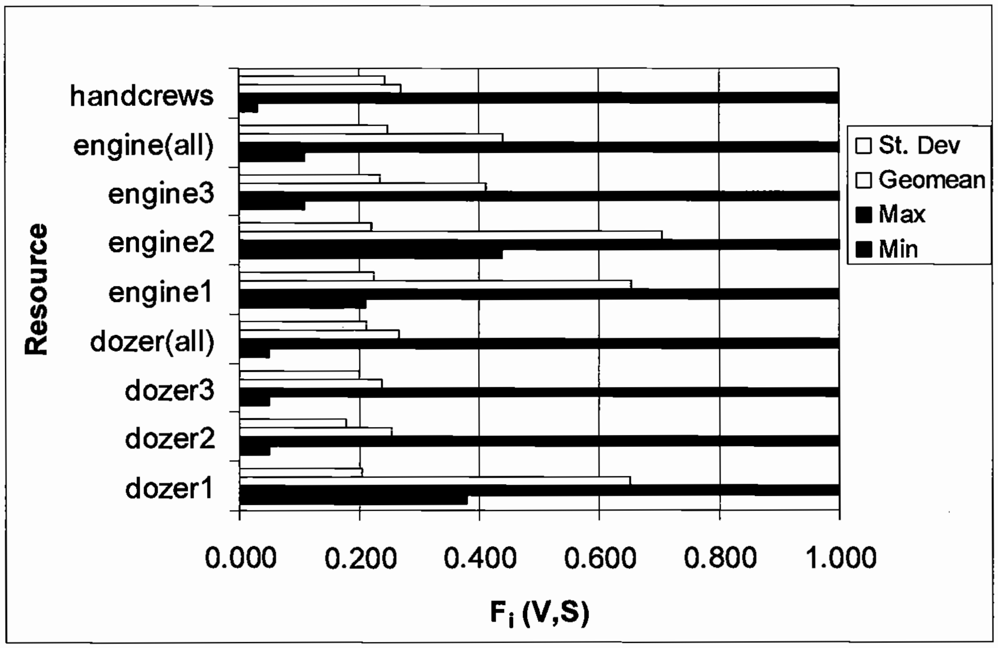
Subject to

Constraint:	Note:
$\sum z^k y^k 1 >= y_1$	1 output variable (M=1)
$\sum z^k x^k_n <= x_n$	8 input variables (N=8)
$\sum z_k >= 0$	intensity
$\sum z_k = 1$	VRS

Results

The first trial involved the use of the construction time subvector. Efficiencies were averaged by resource type. Display 4 provides the results of this analysis.

Display 4: Farrell's Input Technical Efficiency for each resource type, with construction time used as subvector.

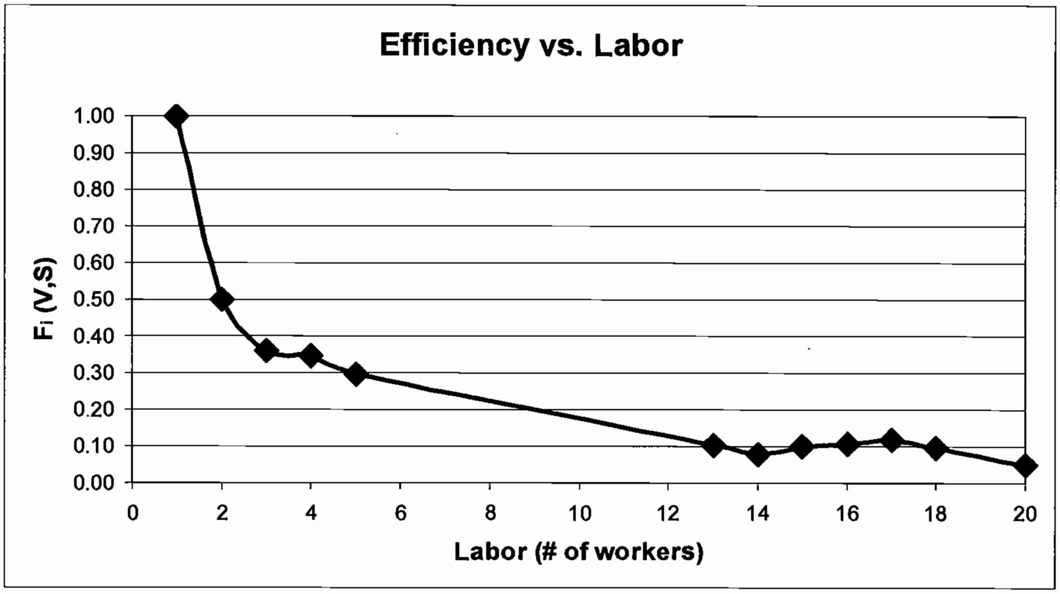


Based on the results from the analysis, medium engines (engine2) have the highest efficiency, followed by large engines (engine1) and large bulldozers (dozer1). The medium engines are more likely to have less labor than the larger engines—likely contributing to a slightly higher overall efficiency score.

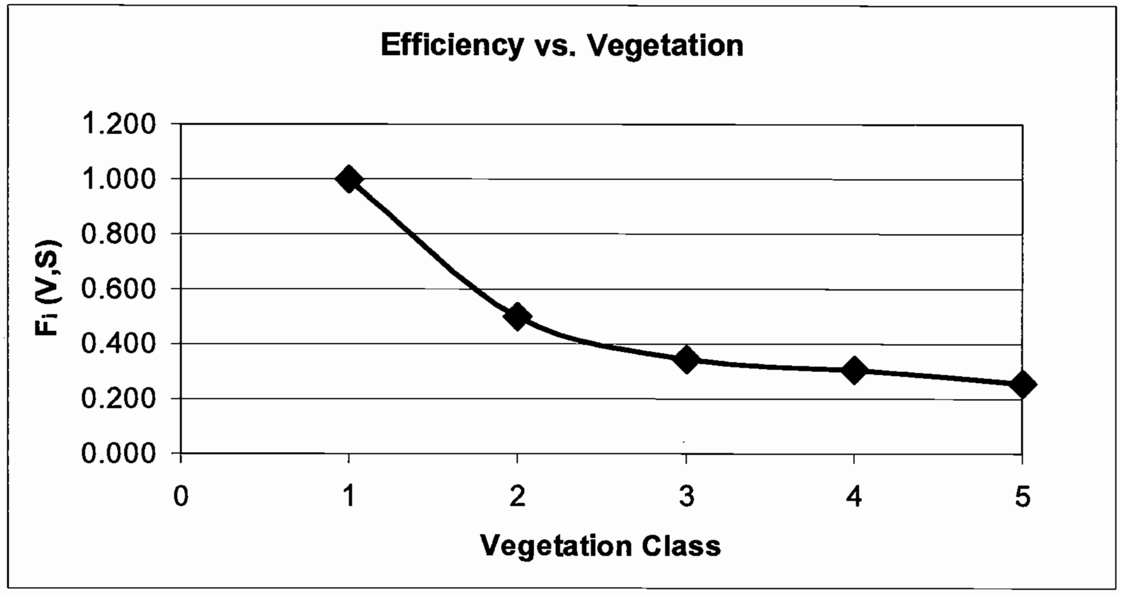
Standard deviations in efficiencies were roughly equal for each resource type (~ 0.2), and each type had at least one observation on the best practice frontier (max = 1.0). According to this information, the situations involving the resources with the lowest mean efficiencies would be targets for improvement.

To further investigate what could be causing the results found in Display 4, two alternate analyses were performed with simple models. These incorporated the construction time as an input variable and fireline length as an output variable. One model featured the addition of vegetation as the second input, and the other added labor. The results can be seen in Display 5 and 6.

Display 5: Results based on Farrell's Input Technical Efficiency, with all input variables adjustable. This analysis used a simple model with only 2 input variables and 1 output variable.



Display 6: Results based on Farrell's Input Technical Efficiency, with all input variables adjustable. This analysis used a simple model with only 2 input variables and 1 output variable.



These graphs show that there is a relationship between vegetation type/ labor and the technical efficiency measure. According to these results, areas that can be focused on for improvement would involve situations with a large amount of workers and/or heavily brushed locations, woodlands, and timbered areas.

Conclusions

Using an input-based model of Farrell's Technical Efficiency, fireline production rates in California were analyzed. Medium sized wildland fire engines had the highest measure of efficiency (geometric mean = 0.705). The second highest efficiency was found in the medium sized bulldozers (geometric mean = 0.653). These values represent the factor that when multiplied by the time required to build a certain length of fireline will produce the best possible time—located the best practice frontier.

Since costs are major issues with wildfire suppression, further analysis is recommended with an additional input variable of cost. Using DEA analysis, it would be possible to determine recommended pay rates for each resource type based on the overall technical efficiency.

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Appendix IX: A Closer Look at Oregon Wildland Fire Suppression Policies Regarding Command and Training

Chris Bielecki
FE 560
3/19/03

Abstract

This paper reviews the development of the Incident Command System. A brief analysis of Forest Service, other federal agency, and Oregon fire training standards is included. A discussion of fire suppression policy concludes the article.

Introduction

The firefighting process is very complicated. Along with simply eliminating the flames, objectives such as interagency cooperation, logistics, jurisdictional understanding, and communications standards must be met. At the heart of this are the command and training structures adopted by various organizations playing a role in fire suppression. A fundamental understanding of these concepts is essential when attempting to solve some of the current wildland fire problems here in the Pacific Northwest.

Part One: Command

Development

Throughout history, large-scale plan implementation has always had to deal with the difficulty of arranging a structure so as to divide and organize tasks in an efficient manner. The more people you have, the faster you would expect to accomplish a certain task; however, this is often not the case. Multiple people can result in a more chaotic situation, and this has often resulted in inefficiency—to say the least. Add different employers to a situation and different levels of skill and the task becomes even more complex. Yet one of the major things that a human being excels at is being able to learn and adapt from previous experiences.

Incident Command System

In the early 1970 s, this messy situation reached a peak. Various problems including different radio frequencies, misunderstood objectives, and lack of information along with a need for cooperation among various agencies led to higher demand of a standardized system. Recognizing the growing complexity of fire suppression management, a team called FIRESCOPE (Firefighting Resources of California Organized for Potential Emergencies) -- composed of agency representatives on the federal, state, and local level -- developed the Incident Command System (ICS). The ICS was based on two major needs: efficiency (especially when dealing with costs) and flexibility (it must function for myriad situations, big and small).

The ICS has evolved since its beginning. In 1980 the National Interagency Incident Management System (NIIMS) was formed to deal specifically with the ICS. It has since gained popularity, and is now endorsed by a number of organizations, some even outside the wildland firefighting realm. Some examples include:

- Federal Emergency Management Agency (FEMA)
- The National Fire Protection Association (NFPA)

- The US Coast Guard
- The National Wildfire Coordinating Group (NWCG)

This system is now widely recognized, and has approached the goal of being the one system that is used universally, making it a truly standardized system.

The National Interagency Incident Management System has expanded upon the ICS to include the following:

- Incident Command System (ICS)
- Training
- Qualification and certification
- Publications management
- Supporting technology

A portion of the Qualifications handbook PMS 310-1, discussed in more detail below, is designated to the structure of the ICS. All wildland firefighting organizations with the potential of working in a multi-agency or multi-employer fire incident will benefit from an understanding of the ICS. In addition, inter-agency incident management teams are built and trained to aid in the management of the larger incident types. These incident teams range from Type1 to Type 5, based on the complexity levels of the suppression capabilities (Type 1 being the largest incident, Type 5 the smallest).

Part Two: Training

<u>All Federal Agencies</u>

Many agencies include firefighting capability as part of their overall objective. It is important to note that since they are federal employees, they are obligated under the Federal OSHA (Occupational Safety and Health Act). Federal OSHA covers all employees in the United States--including all federal wildland firefighters. However, since there is no specific section in the code designated for the category of wildland firefighter, the General Duty clause takes over. This is stated below:

(a) Each employer --

> **(1)** shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;
>
> **(2)** shall comply with occupational safety and health standards promulgated under this Act.

(b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.

Forest Service Crew Types

There are currently three levels of firefighters trained in the US Forest Service. These levels are based on the NWCG Minimum Crew Standards for Mobilization. Included in Appendix 2 is a chart describing these levels. Important to note are the main differences related to available resources, production levels, and the ability to be broken up into squads.

Type I crews mainly consist of Hotshot and Smokejumper crews, who specialize in large fires as well as remote location fires. Most Type II crews are composed of engine personnel as well as forest service employees whose primary duty is not firefighting. Type III crews often consist of these emergency firefighters as well as most contract handcrews falling under Forest Service jurisdiction.

Policies/Qualifications

The National Wildfire Coordinating Group (NWCG) sets minimum training and fitness level standards under the Incident Qualification Certification System, in addition to producing the standard book--all Federal Agencies have agreed on the Wildland Fire Qualification Guide (PMS 310-1) for use as minimum standards. This book is essential material whenever an organization or agency sends personnel outside their jurisdiction.

In addition to the PMS 310-1, the Forest Service has adopted the Fire and Aviation Qualifications handbook (FSH 5109-17). This document was released after the fatal Thirty-Mile Fire of 2001 and builds upon the minimum standards set by the PMS 310-1.

Other Federal Agencies (including BLM, BIA, NF&WS, NPS)

The other Federal agencies use the Minimum Crew Standards for Mobilization as well when training and developing their fire crews. All other agencies train firefighters based on the policies in the PMS 310-1 qualifications handbook. This is accepted as the agency standard.

Oregon Department of Forestry (ODF)

ODF uses the same qualifications as the other federal agencies, including the firefighter types as well as the PMS 310-1 qualifications handbook. In addition ODF also must comply with the Oregon OSHA minimum requirements for wildland firefighters. The Oregon OSHA Forest Activities Code (Division 7) expands upon the Federal OSHA regulations in that it contains a specific section pertaining to wildland firefighting with regard to multiple levels of firefighting qualifications.

Professional Firefighters/ Contractors

Most of the current contracting crews are listed as Type III. However, some crew are achieving the Type I status with fulfillment of the standards set by NWCG. Contractors currently must comply with the contract supplies through the Oregon Department of Forestry. This is a standard in the Pacific Northwest, and includes training requirements such as the PMS 310-1. In addition to this the Forest Service has its own separate contract agreements through the NIFC. At this point I am researching the coverages of each contract.

There were approximately 250 contract 20-person fire crews in Oregon last year. This is the highest number by far of any state, and was the majority of the 280 contract crews available in Region 6 last year.

Non-firefighters/Emergency Workers

The Oregon OSHA is currently in the process of expanding the requirements for non-firefighting professionals in the Division 7 Forest Activities Code. This group includes loggers and other skilled woods workers who may be required to aid in wildland fire suppression. At this time, all forest activities workers must meet minimum fire training requirements as stated in the code within 60 days. These requirements are included in Appendix 3. Due to the growing number of forest activities workers being used to fight fires, a sub-committee has been formed to expand on the safety code with including considerations to training requirements, personal protective equipment (PPE), and machinery used on the fireline (including gradeability issues).

Future

Non-professional firefighters form a broad group. They mainly consist of forest activities workers whose main job duties do not include firefighting. Some recent issues involving wildfire responsibility and spread across ownership boundaries have illustrated the need for skilled forest activities workers. Additionally, some firefighters are being obtained through the use of temporary agencies to fill gaps in contract crews and efforts must be made to ensure the proper training of these individuals.

Part Three: Fire Suppression Policy Process

Many expert groups participate in the policy processes previously mentioned. Some of these include the National Wildfire Coordinating Group (NWCG), The National Fire Protection Agency (NFPA), and The Society of Automotive Engineers (SAE). Composed of representatives from various agency fire fighting organizations, the NWCG provides a formalized system to agree upon standards of training, equipment, qualifications, and other operational functions. Both the NFPA and the SAE conduct research and provide suggestions. These suggestions then become policy when Federal and state agencies adopt them.

Sadly, many new policies are formed in the brink of disaster. The Thirty-Mile Hazard Abatement Plan (HAP) was developed after the fatal Thirty-Mile Fire in Washington during the 2001 fire season, in which four firefighters died. These new guidelines are reflected in the current FSH 5109-17 handbook.

Another example of this trend occurred after the 2000 fire season, in which over 8 million acres with suppression costs totaling at more than $1.3 billion. President Clinton requested the National Fire Plan (NFP) after the devastating fire season. The document, intended to provide for ecosystem health in fire-adapted areas, had five key elements:

- Firefighting
- Rehabilitation and restoration
- Hazardous fuel reduction
- Community assistance
- Accountability

The document was seen as broad; however, the US Forest Service and the Bureau of Land Management developed specific targets based on the NFP. In the Pacific Northwest, the 2001 fire season saw more than 1100 new firefighters and more than 300 contracts worth approximately $20 million as a direct result of the NFP. Also stressed in the document was coordination, having a direct effect in the western states.

Congress called for the Secretaries of Agriculture and Interior to work with the Western Governor's Association, the National Association of State Foresters, the National Association of Counties, and the Intertribal Timber Council.

Conclusion

Fire suppression and the policies governing are constantly changing. I was once told that each of the ten standard fire orders originated as a result of a tragedy, so it comes as no surprise to me that the overall fire suppression policy process also follows this trend. Yet we must realize that in an inherently dangerous occupation it is nearly impossible to eliminate accidents entirely. The current training methods and command structures reflect a century of experience, and prove again and again to have the intended flexibility. The 2000 and 2002 fire seasons saw some of the greatest devastation in history; yet as science continues to provide more technology we can expect to see more advanced equipment on the fireline—such as logging equipment with modifications.

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Incident Command System

http://www.fema.gov/graphics/rrr/conplan/fig1.gif

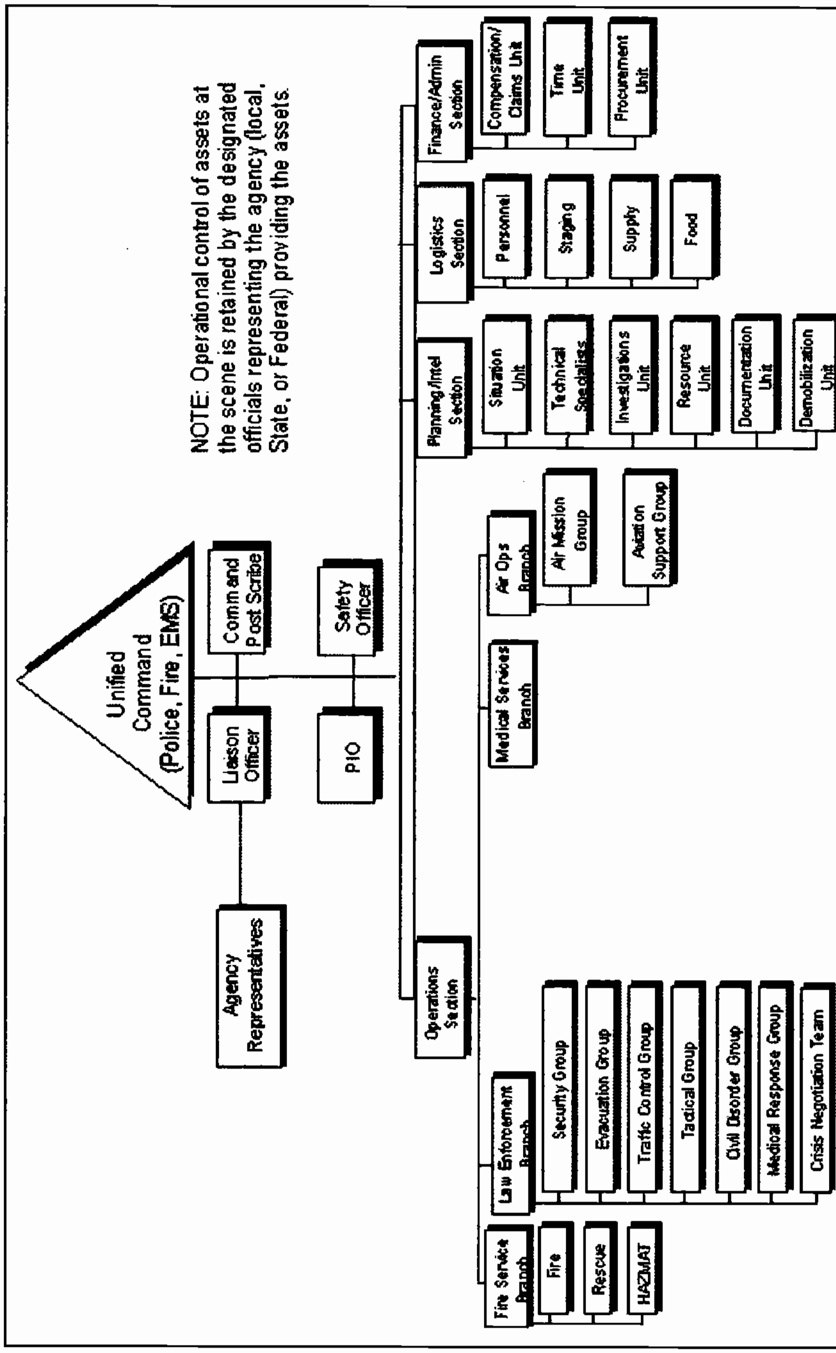

Figure 1 – Incident Command System / Unified Command

Standards adopted by the National Wildfire Coordinating Group

MINIMUM CREW STANDARDS FOR MOBILIZATION
Effective January 1, 2003

Minimum Standards	Type I	Type 2 with IA Capability	Type 2	Type 3
Fireline Capability	Initial attack/can be broken up into squads, fireline construction, complex firing operations (backfire)	Initial attack/can be broken up into squads, fireline construction, firing to include burnout	Initial attack, fireline construction, firing to include burnout	Fireline construction, Fireline improvement, mo up and rehab
Crew Size	18-20	18-20	18-20	18-20
Leadership Qualifications	Permanent Supervision Superintendent: TFLD, ICT4 Ass't. Supt.: STCR, ICT4 3 Squad Bosses: CRWB(T), ICT5	CRWB and 3 ICT5	CRWB and 3 FFT1	CRWB and 3 FFT1
Experience	80% 1 season or more	60% 1 season or more	40% 1 season or more	20% 1 season or more
Full-Time Organized Crew	Yes	No	No	No
Communications	5 programmable radios	4 programmable radios	4 programmable radios	4 programmable radios
Sawyers	3 agency qualified	3 agency qualified	0	0
Training	80 hours annual training	Basic firefighter training and/or annual firefighter safety refresher	Basic firefighter training and/or annual firefighter safety refresher	Basic firefighter training and/or annual firefighter safety refresher
Fitness	Arduous	Arduous	Arduous	Arduous
Logistics	Self-sufficient	Not self-sufficient	Not self-sufficient	Not self-sufficient
Maximum Weight	5,100 lbs.	5,100 lbs.	5,100 lbs.	5,100 lbs.
Dispatch Availability	1 hour	Variable	Variable	Variable
Production Factor	1.0	0.8	0.8	N/A
Transportation	Own transportation	Transportation needed	Transportation needed	Transportation needed
Tools & Equipment	Fully equipped	Not equipped	Not equipped	Not equipped
Personal Gear	Arrives with: crew first aid kit, personal first aid kit, headlamp, 1 qt. canteen, web gear, sleeping bag	Arrives with: crew first aid kit, personal first aid kit, headlamp, 1 qt. canteen, web gear, sleeping bag	Arrives with: crew first aid kit, personal first aid kit, headlamp, 1 qt. canteen, web gear, sleeping bag	Arrives with: crew first aic kit, personal first aid kit, headlamp, 1 qt. canteen, w gear, sleeping bag
PPE	Arrives with: hard hat, fire resistant shirt/ pants, 8@ leather boots, leather gloves, fire shelter, hearing/ eye protection	Arrives with: hard hat, fire resistant shirt/ pants, 8@ leather boots, leather gloves, fire shelter, hearing/ eye protection	Arrives with: hard hat, fire resistant shirt/ pants, 8@ leather boots, leather gloves, fire shelter, hearing/ eye protection	Arrives with: hard hat, fire resistant shirt/ pants, 8@ leather boots, leather glov fire shelter, hearing/ eye protection

Fire Training requirements for forest activities workers as included in the 2002 OR-OSHA code.

OAR 437 Division 7, Forest Activities
Basic Fire Control Training for Loggers
Appendix 7-C

BASIC FIRE CONTROL TRAINING FOR LOGGING CREWS

COURSE OUTLINE

BLOCK 1: INTRODUCTION

1. Fire Protection System in Oregon
2. Need for This Training Course
3. Summary

BLOCK 2: BASIC FIRE BEHAVIOR

1. How a Fire Burns
2. How a Fire Spreads
3. The Fire Environment
4. Summary

BLOCK 3: BASIC FIRE CONTROL

1. Pre-planning for an Operation Fire
2. Size-up
3. Control
4. Use of Water
5. Mop-up
6. Safety

BLOCK 4: INDUSTRIAL FIRE PREVENTION STATUTES AND RULES

NOTE: An example of training in Basic Fire Control for Logging Crews is published by the Oregon Department of Forestry.

Appendix X: Proposed Changes to the OR-OSHA Forest Activities Wildland Firefighting Code

Division 7 Wildland Fire Suppression, Prescribed Burning And Prescribed Fire
January 6, 2005 Pre-Meeting Draft
12-14-04 # 1

437-007-1300 Purpose of Rules.

437-007-1300(1) The purpose of this section is to provide minimum safety and health requirements for all public and private employers engaged in wildland fire prevention, **suppression, prescribed burning, or prescribed fire which include** activities such as, but not limited to:

Fire line construction
Engine (fire truck) operation
Dozer, skidgine and pumper-cat operation
Snag felling
Fire watchers
Forest patrols
Forest security
Aircraft operation
Slash burning
Mop-up
Laying hose lines
Tending dip-tanks
Handling, mixing and applying fire suppression chemicals

~~(2) These rules do not limit the use of other applicable safety and health rules.~~

437-007-1303 Application of Rules.

437-007-1303(1) Except as otherwise specified, these rules apply to all personnel engaged in wildland fire suppression, **prescribed burning or prescribed fire** activities-where there is potential for exposure to wildland fire hazards such as, but not limited to:

Falling snags
Blowup
Flash-over
Flare-up
Fire storm
Fire whirl
Crowning
Entrapment
Radiant burns
Heat exhaustion
Heat stroke
Burning embers
Smoke inhalation

(2) These rules do not limit the use of other applicable safety and health rules.

(3) These rules do not apply to personnel assigned to wildland fire suppression support activities such as fire camp support positions, which will not expose them to wildland fire hazards.

Define Fire camp – A geographical site(s), within the general incident area, separate from the incident base, equipped and staffed to provide sleeping, food, water and sanitary services to incident personnel.

Define Incident – An occurrence, either human-caused or natural phenomena, that requires action or support by emergency service personnel to prevent or minimize loss of life or damage to property and/or natural resources.

437-007-1305 General Requirements.

437-007-1305(1) Tactical and command fire suppression communications must be adequate to provide a clear line of communication to all affected personnel.

(2) When employees are required to handle, mix and/or apply ~~fire suppression~~ **hazardous** chemicals, the employer must develop, implement and maintain a written hazard communication program meeting the requirements of Division 2, Subdivision 2/Z, Toxic and Hazardous Substances, 1910.1200, Hazard Communication.

Define hazardous chemical - Any chemical which is a physical hazard or health hazard. 1910.1200

(3) During the initial attack, vehicles parked on and along any roadway must utilize emergency flashing lights to warn traffic when warning signs are not displayed and/or flaggers are not controlling traffic ~~onsite.~~

Define initial attack - The actions taken by the first resources to arrive at a wildfire to protect lives and property, and prevent further extension of the fire.

437-007-1310 Personnel Assignments.

437-007-1310(1) The employer and/or their authorized representative must take into account the physical capability of each employee to perform assigned duties:

(a) Prior to job assignment, and

(b) While the employee performs those duties.

(2) **The employer and/or their authorized representative must not assign duties to an employee with a physical or medical condition (known to the employer) which would significantly impair the employee's ability to perform assigned duties.**

(3) Personnel performing wildland fire suppression, **prescribed burning or prescribed fire** activities except as provided for in paragraphs (4) and (5) of this section, must:

(a) Work in teams of two or more, and

(b) Be positioned so they are close enough to render assistance to one another in case of an emergency.

EXCEPTION: lighting isolated piles

(4) Single employee assignments such as watchers, security and forest patrol personnel may **begin** to **contain,** control **or** extinguish a fire upon discovery only when:

(a) They have first reported the fire, described their intended fire suppression activities, and agreed on a checking system as required by 437-007-0210, and

(b) The fire can be confined, contained, controlled or extinguished by means such as using hand tools, fire extinguisher, backpack pump, fire truck, **machinery** or pre-set hose lay, and

(c) There is an escape route to a safety zone that will not be cut off if the fire increases in size or changes direction.

(5) A competent person must assure that watchers, security and forest patrol personnel, and other single employee assignment personnel who are expected to perform fire suppression activities:

(a) Have received Basic Wildland Fire Safety Training, and

(b) Are qualified in the operation of assigned fire suppression machines, equipment and use of fire fighting tools, and

(c) Are advised of the requirements of 437-007-1310(4)(b) & (c) and other conditions (known by the employer) which could affect the extent of their fire suppression activities, and

(d) Are physically capable of performing probable fire suppression activities as required by 437-007-13**10**(1) & (2).

437-007-1315 Personal Protective Equipment.

437-007-1315(1) Personnel performing wildland fire suppression, **prescribed burning, prescribed fire** activities must wear:

(a) Pants and long-sleeve shirt made of cotton, wool, denim or other fire resistant materials.

(A) Clothing made from common permanent-press materials and synthetic fiber that melts when exposed to flame or heat must not be worn.

(B) When "special protective clothing" made of aramid or other fire resistant materials is required **by the employer**, it must be provided at no cost to the personnel.

NOTE: The employer is not required to provide the minimum basic clothing listed in OAR 437-007-1315(1)(a).

(b) Footwear that:

(A) Covers and provides protection and support for the foot and ankle, such as heavy duty leather lace-up boots with an 8-inch high top.

(B) Provides for secure footing and traction for the assigned task.

NOTE: Caulked boots may be required for some fire suppression, prescribed or prescribed fire burn duties.

(C) Is fire and melt resistant.

(D) Is made of cut resistant materials when operating chain saws.

NOTE: The employer is not required to provide the minimum basic footwear listed in OAR 437-007-**1315**(1)(b)(A) – (D).

(c) Head protection in accordance with the requirement of OAR 437-007-0305(1) and (2).

(A) When wearing hard hats around helicopters, the hats must be secured by a chin strap.

NOTE: To reduce the possibility of blowing objects when working around helicopters, hard hats need not be worn when a competent person has determined there is no danger from falling or flying objects.

(d) **Upper body cover and/or hard hats of a high-visibility color in accordance with the requirement of OAR 437-007-0310.**

(e) Eye and face protection in accordance with the requirements of OAR 437-007-0315.

(f) Hand protection in accordance with the requirements of OAR 437-007-0320(1) and (2).

(g) Leg protection in accordance with the requirements of OAR 437-007-0325 when operating chain saws.

(h) Hearing protection in accordance with the requirements of OAR 437-007-0335.

437-007-1320 Training.

437-007-1320(1) The employer and/or their authorized representative must assure that all personnel who may be called upon to do wildland fire suppression, **prescribed burning or prescribed fire activities** receive Basic Wildland Fire Safety Training as follows:

(a) Once a year, between January 1 and the legal declaration of fire season, for personnel who are currently employed at the time training is presented.

NOTE 1: Personnel who have previously received Basic Wildland Fire Safety Training need only receive refresher training on those portions of the curriculum that are relevant to the fire suppression activities to which they may be assigned.

NOTE 2: Basic Wildland Fire Safety Training is not required for personnel who are assigned to fire support positions that will not expose them to the fire hazards.

(b) **Newly hired and/or reassigned personnel** who have not received **Basic Wildland Fire Safety Training** must be trained **within 17 days** of being assigned or dispatched to wildland fire suppression, prescribed burning, prescribed fire or related activities. **In the interim, they may perform wildland fire suppression,** prescribed burning, prescribed fire or related **activities provided they work under the direct supervision of a competent person who** must::

(A) Inform or brief personnel about the escape route(s), safety zone(s), anticipated fire activity, and what to do if they get separated from the competent person.

(B) Provide continuous on-the-job fire safety training, and

(C) **Supervise no more than 5 untrained personnel.**

NOTE: When an untrained runner is in route, direct supervision may be achieved by radio contact, provided there is a competent person providing direct supervision at both the pick-up and drop-off points.

(2) **Basic Wildland Fire Safety Training must:**

(a) Be presented by a qualified person, and

(b) **Provide instruction on** the training curriculum outline in Appendix 7-C, and

(c) Be Presented in a language and manner that the employee(s) is able to understand.

(3) The employer must keep a written record of Basic Wildland Fire Safety Training for each employee.

(4) Personnel who are issued fire shelters must receive instructions prior to issue from a qualified person on:

(a) How to inspect and care for the shelter, and

(b) How, when and where to deploy the shelter, and

(c) What a person needs to do in the deployed shelter.

NOTE: When fire shelters are required, an orderly transition for employee training must be consistent with fire suppression needs and employee safety.

(5) Personnel who are issued fire shelters must receive refresher training annually.

437-007-1325 Equipment, Vehicle and Machines, General Requirements.

437-007-1325(1) Fire fighting equipment, vehicles and machines must be:

(a) Inspected for defects prior to each use.

(b) Maintained in accordance with the appropriate manufacturers' recommendations.

(2) Fire fighting equipment, vehicles and machines that are defective or damaged so as to render them hazardous to operate, must be removed from service and not returned to service until repairs are completed.

(3) A safe and adequate means of access and egress such as, steps, ladders, handholds and railings must be provided and maintained to all parts of vehicles and machines where employees must go.

(4) Machine and vehicle access must comply with the Society of Automotive Engineers' (SAE)-J185-1988 or ISO 2867:1994, Access Systems for Off-Road Machines.

(5) An effective means of communication must be established when it is necessary for personnel to communicate with the vehicle, equipment and machine operator.

(6) When military vehicles are used to transport **personnel,** they must be equipped with standard military seating, backrests and endgates.

437-007-1330 Vehicles Operation.

437-007-1330(1) The operation of vehicles must comply with the requirements of OAR 437-007-0520 through OAR 437-007-0570.

(2) All equipment hauled on a vehicle must be adequately secured when the vehicle is in motion.

(3) Vehicles must be brought to a full stop before **personnel** disembark.

437-007-1335 Machine Operation.

437-007-1335(1) When machines used for fire trail construction or fire fighting, are operated on slopes in excess of the limitations for machine operation as defined in 437-007-0935(1) and (2), a competent person must assure that measures are taken to provide stability such as:

(a) Using the blade, or

(b) Tying to stumps, anchors, or other machines, or

(c) Using materials to limit the slope under machine, or

(d) Limiting the operating range of movement and/or the machine loading to maintain stability.

(2) The machine operator and supervisor must **discuss and agree** how to safely operate on all steep slopes taking into consideration the:

(a) Experience of the operator.

(b) Limitations of the machine.

(c) The soil conditions.

(d) Direction of travel (straight up and down the slope).

(e) Hazards of turning the machine on the slope.

(f) Weather.

(g) Load size.

(h) Any other adverse condition(s),.

437-007-1340 Aircraft Operations.

437-007-1340(1) Helicopter facilities must be kept clear of unauthorized personnel, equipment, and loose objects (paper products, etc.)

(2) Personnel must not smoke within 50 feet of a helicopter, fuel storage, or fueling equipment.

(3) Unless authorized by the pilot or helicopter ground crew, personnel must stay at least:

(a) 50 feet away from small helicopters, and

(b) 100 feet away from large helicopters.

(4) A competent person must provide a detailed briefing on helicopter safety procedures to all personnel prior to loading.

(5) Personnel assigned to ride in rotary wing aircraft must:

(a) Be briefed in the correct approach, riding and off-loading procedures for the particular type of aircraft.

(b) Follow instructions of helicopter personnel at all times when around helicopter.

(c) Carry all tools horizontally at your side (not slung over your shoulder) when around helicopters.

(6) Unless told otherwise by a competent person, personnel must approach and leave the helicopter in full view of the pilot.

(7) Personnel must stay away from turning tail rotors at all times.

(8) Personnel must not stand directly beneath a hovering helicopter unless they have been trained **or are being trained** in performing sling load hookup or bucket filling operations.

Appendix 7-C Training Curriculum

Basic Wildland Fire Safety Training

BLOCK 1: FIRE PROTECTION STATUTES AND RULES

1. Fire Protection System in Oregon
2. Need for This Training Course
3. Summary

BLOCK 2: BASIC FIRE BEHAVIOR

1. How a Fire Burns
2. How a Fire Spreads
3. The Fire Environment
4. Summary

BLOCK 3: BASIC FIRE CONTROL

1. Pre-planning for an Operation Fire
2. Size-up
3. Initial Attack
4. Control
5. Mop-up

BLOCK 4: BASIC FIRELINE SAFETY

1. The 18 Watch Out Situations
2. The Ten Standard Firefighting Orders
3. LCES – A System for Operational Safety
4. Lessons Learned from prior experiences
5. Hazards associated with aerial retardant drops

Discuss removal of this section on January 6, 05

18 Watch Out Situations

~~The 18 Watch Out Situations listed below **can be used to** identify conditions that **could be hazardous to** firefighters must be alert for to assess their exposure to fire hazards~~

~~(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, supervisors.~~
~~(8) Constructing line without safe anchor point.~~
~~(9) Building fire line 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 fire line.~~

Discuss Removal of this section on January 6, 05

~~**10 Standard Fire Orders**~~

~~The 10 Standard Fire Orders are actions that **can be used to manage fire suppression activities** firefighters take to minimize the risk of injury.~~

~~(1) Keep informed on fire weather and forecast.~~
~~(2) Know what your fire is doing at all times.~~
~~(3) Base all actions on current and expected behavior of the fire.~~
~~(4) Identify escape routes and make them known.~~
~~(5) Post lookouts when there is possible danger.~~
~~(6) Be alert. Keep calm. Think clearly. Act decisively.~~
~~(7) Maintain prompt communications with your forces, your supervisor and adjoining forces.~~
~~(8) Give clear instructions and insure they are understood.~~
~~(9) Maintain control of your forces at all times.~~
~~(10) Fight fire aggressively, having provided for safety first~~

Discuss presentation of the section on January 6, 05

LCES** – (Lookouts, Communications, Escape Routes, Safety Zones)* ***A System for Operational Safety

(1) All personnel need to be informed.
(2) Update throughout the shift.
(3) Lookouts/Communications
(4) Escape Routes
(5) Safety Zones

Add New Definitions To Subsection 7N or 7A 437-007-0025

Review definition on January 6, 05

Aramid - The generic name for a high-strength, flame-resistant synthetic fabric used in the shirts and jeans of firefighters. Nomex, a brand name for aramid fabric, is the term commonly used by firefighters.

Confine a Fire - To restrict the fire within determined boundaries established either prior to the fire or during the fire.

Contain a Fire - To take suppression action, as needed, which can reasonably be expected to check the fire's spread under prevailing conditions.

Control a Fire - To complete control line around a fire, and spot fires therefrom and any interior islands to be saved; burn out any unburned area adjacent to the fire side of the control lines; and cool down all hot-spots that are immediate threats to the control line, until the lines can reasonably be expected to hold under foreseeable conditions.

Direct supervision - Supervision by a competent person who watches over and directs the work of others who are within sight and unassisted natural voice contact.

> **NOTE:** When a runner is in route, direct supervision may be achieved by radio contact, provided there is a competent person providing direct supervision at both the pick-up and drop-off points.

Entrapment - A situation where personnel are unexpectedly caught in a fire behavior-related, life-threatening position where planned escape routes or safety zones are absent, inadequate, or compromised.

Escape Route - A preplanned and understood route firefighters take to move to a safety zone or other low-risk area, such as an already burned area, previously constructed safety area, a meadow that won't burn, **manmade or** natural rocky area that is large enough to take refuge without being burned. When escape routes deviate from a defined physical path, they should be clearly marked (flagged).

Firefighter - A person who works to control and/or extinguish any wildland fire, **prescribed burn or prescribed fire.**

Frequent review or inspection - A review or inspection that is conducted at intervals which are necessary (conducted on daily to monthly intervals) to gain a desired assessment of conditions, practices, policies or procedures.

Fire Season – (1) Period(s) of the year during which wildland fires are likely to occur, spread, and affect resource values sufficient to warrant organized fire management activities. (2) A legally enacted time during which burning activities are regulated by state or local authority.

Fire shelter - A personal protection item carried by firefighters which when deployed unfolds to form a pup-tent shelter of heat reflective materials.

Flame resistance - The property of materials, or combinations of component materials, to retard ignition and restrict the spread of flame.

Forestland - Any woodland, brushland, timberland, grazing land or clearing that, during any time of the year, contains enough forest growth, slashing or vegetation to constitute, in the judgment of the forester, a fire hazard, regardless of how the land is zoned or taxed. As used in this subsection, "clearing" means any grassland, improved area, lake, meadow, mechanically or manually cleared area, road, rocky area, stream or other similar forestland opening that is surrounded by or contiguous to forestland and that has been included in areas classified as forestland under ORS 526.305 to 526.**370.**

Lookout – (1) A person designated to detect and report fires from a vantage point. (2) A location from which fires can be detected and reported. (3) A fire crew member assigned to observe the fire and warn the crew when there is danger of becoming trapped.

Periodically review or inspection - A review or inspection that is conducted at predetermined intervals (conducted on 1 to 12 months intervals).

Prescribed Burning - Controlled application of fire **ignited by management action** to wildland fuels in either their natural or modified state, under specified environmental conditions which allows the fire to be confined to a predetermined area, and produce the fire behavior and fire characteristics required to attain planned fire treatment and resource management objectives.

Prescribed Fire - Any fire **burning** under predetermined conditions to meet specific objectives related to fuels **reduction** or habitat improvement.

Protective clothing - The clothing or equipment worn to protect the head, body and extremities from chemical, physical and health hazards.

Runner - A person who performs support or service functions and assists in other than direct fire suppression activities.

Safety Zone - A preplanned area of sufficient size and suitable location that is expected to protect fire personnel from know hazards without using fire shelters.

Stability - The capacity of a machine or vehicle to return to equilibrium or to its original position after having been displaced.

Watcher/Firewatch - A competent person who visually observes all portions of the operation area on which operation activity occurred during the day, may extinguish any small fire in the operation area, in addition to summoning all necessary fire fighting assistance.

Wildland Fire - Any nonstructure fire, other than prescribed fire, that occurs in the wildland.

??? WILDLAND: An area in which development is essentially nonexistent, except for roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered. ???

??? WILDLAND FIRE: A fire occurring on wildland that is not meeting management objectives and thus requires a suppression response. ???

??? Wildland Urban Interface -The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. ???

??? ORS477.015 (1) As used in ORS 477.015 to 477.061, unless the context otherwise requires, "forestland-urban interface" means a geographic area of forestland inside a

forest protection district where there exists a concentration of structures in an urban or suburban setting. ???