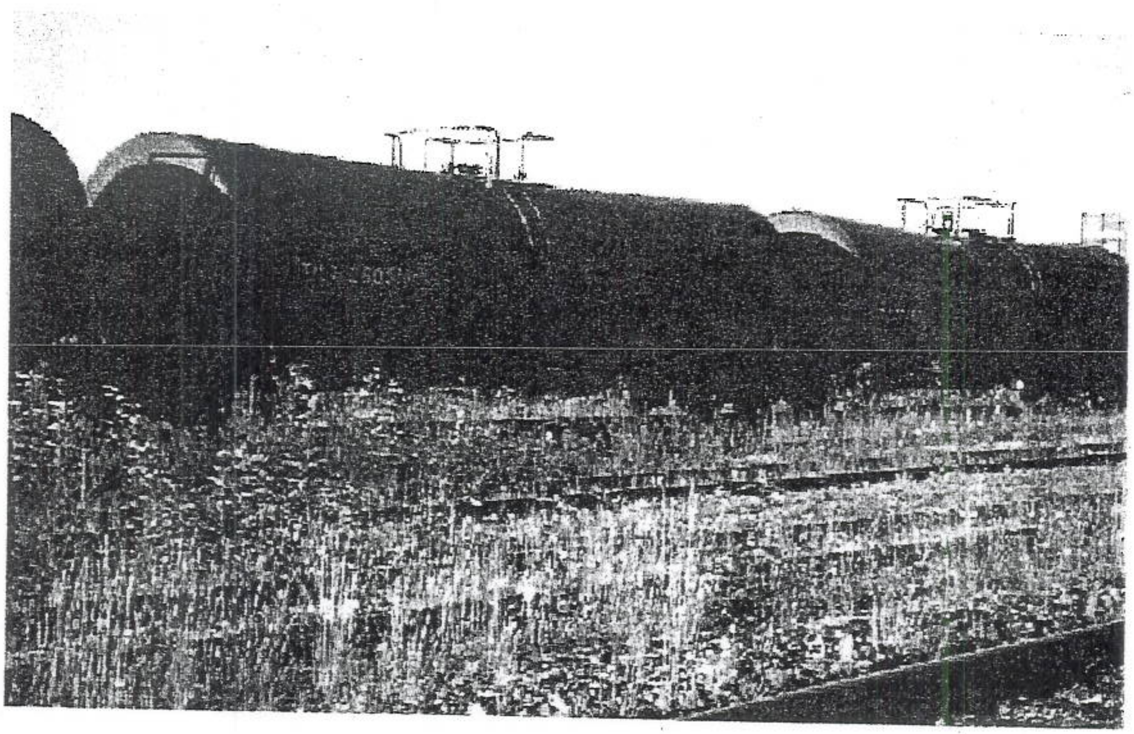
CONTROLLING UNWANTED VEGETATION THAT IMPACTS RAILROAD INFRASTRUCTURE

A Critique of the Trials of Five Potential Solutions
and
Review of Seven Other Potential Control Strategies



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INTRODUCTION

The search for an effective method to control unwanted vegetation has been an important priority for the Alaska Railroad Corporation (ARRC) for many years. Vegetation growing in track ballast, within the limits of rights-of-way and in rail yards is a safety hazard and a destructive agent of railroad infrastructure.

For many years the Alaska Railroad utilized chemical herbicides to reduce or retard plant growth. While many of these chemicals are still are quite effective and relatively inexpensive to apply; potential side effects and public pressure have caused the railroad to seek alternative means of vegetation control.

The restrictions associated with the use of chemicals to control vegetation are not unique to ARRC. Finding alternatives is a search that is ongoing around the world, not only for controlling unwanted vegetation on railroad properties, but along highways, ditch systems and other transportation infrastructures where operating costs and safety are adversely affected by unwanted plant life.

Since 1990, the ARRC has evaluated non-herbicidal solutions to the problem of vegetation control. The railroad has enlisted the help of consultants, contractors, other railroads and staff to address the search for a cost effective and environmentally friendly system to accomplish vegetation control.

The methods investigated over the past several years have involved the use of steam, hot water, open flame and hand labor, as well as mechanical systems such as the use of the railroad's modified ballast regulator to kill, remove, and retard growth of plants.

For the most part, these methods have proven to be expensive and not completely effective. Manipulating the soil, whether by hand or machine, scalding the above ground portions of plants with hot water or steam, or causing light surface burning have had little or no long lasting effect on unwanted plants and in some cases have increased plant growth despite the appearance of mortality right after a particular treatment.

This report reviews recent efforts by ARRC to find a technique that is effective in controlling undesirable plant growth. This report summarizes the results of trials which were sponsored by the railroad in an effort to find a control method. In addition, the report reviews and critiques methods which have been tried by other railroads looking to solve the same problem.

ANALYSIS

The Problem

For the most part railroads are built on soil, rock and stone that to one degree or another supports plant life. There are thousands of plant species, each adapted to some range of environmental conditions that will invade and colonize, through species succession, within the growing habitats of a railroad.

The railroad ballast prism, because it consists of rock over soil, is an inviting target for pioneer, "light loving" plants, that if left undisturbed (whether annuals or perennials) will regenerate themselves by root expansion, seeds, or ground layering. If left unchecked, these pioneer plants will convert relatively sterile ballast to soil through decomposition of organic matter and breakdown of ballast rock, providing a growing site for more plant species with the eventual result being a complex plant community.

Railroad operators, knowing these facts, have attempted to control this natural propensity for growth, because the presence of unwanted vegetation creates safety hazards and destroys the track infrastructure itself as it gradually weakens the integrity of the ballast. Safety hazards include fire, obstruction to good visibility, interference with personnel movement alongside the track and interference to moving and stationary equipment, including track, switches, and signals.

Efforts to Find a Solution

In 1988, the Alaska Railroad Corporation retained the University of Alaska Fairbanks, Institute of Northern Engineering, to conduct in-depth research into vegetation management within the ARRC track infrastructure.

Conducted over a two-year period, this work analyzed the effectiveness of seven separate treatments at four sites along the track system.

The sites were generally representative of the bio-geographic zones on which the track system is built. The treatments included herbicide application, hand weeding, hand cutting, multiple hand cutting, ballast regulation and re-ballasting.

The recommendations made following the research called for an integrated approach and encouraged ARRC to continue to look for new alternatives to control unwanted vegetation.

In 1993, the railroad tried hand clearing and grubbing. The work was performed by inmates from the Department of Corrections. Also in 1993, the railroad tried live steam as a control method utilizing a Canadian Pacific Railroad steam system at selected sites between Seward and Girdwood, and along the Palmer Branch Line.

In 1998, the ARRC continued the search for solutions to the problems of vegetation control. The railroad solicited proposals from qualified contractors, retaining three contractors to demonstrate three different control methodologies.

Trials of Potential Solutions

The following are the summarized results of trials of vegetation control approaches tested by the ARRC in the past five years. The methods used may be divided into two classes: mechanical and "energy/chemical reaction".

The mechanical methods of control include both hand labor and heavy equipment. Hand labor can be used both along the track and in adjacent areas, and is transportable either by road or on track to the treatment area. Up to this point, the use of mechanical equipment has been confined to on track transport. ARRC has made minor modifications to its ballast regulator and has used this machine to perform some limited vegetation control along the track ballast prism.

The "energy/chemical" methods tried so far use heat, applied either through hot water or steam, or direct combustion.

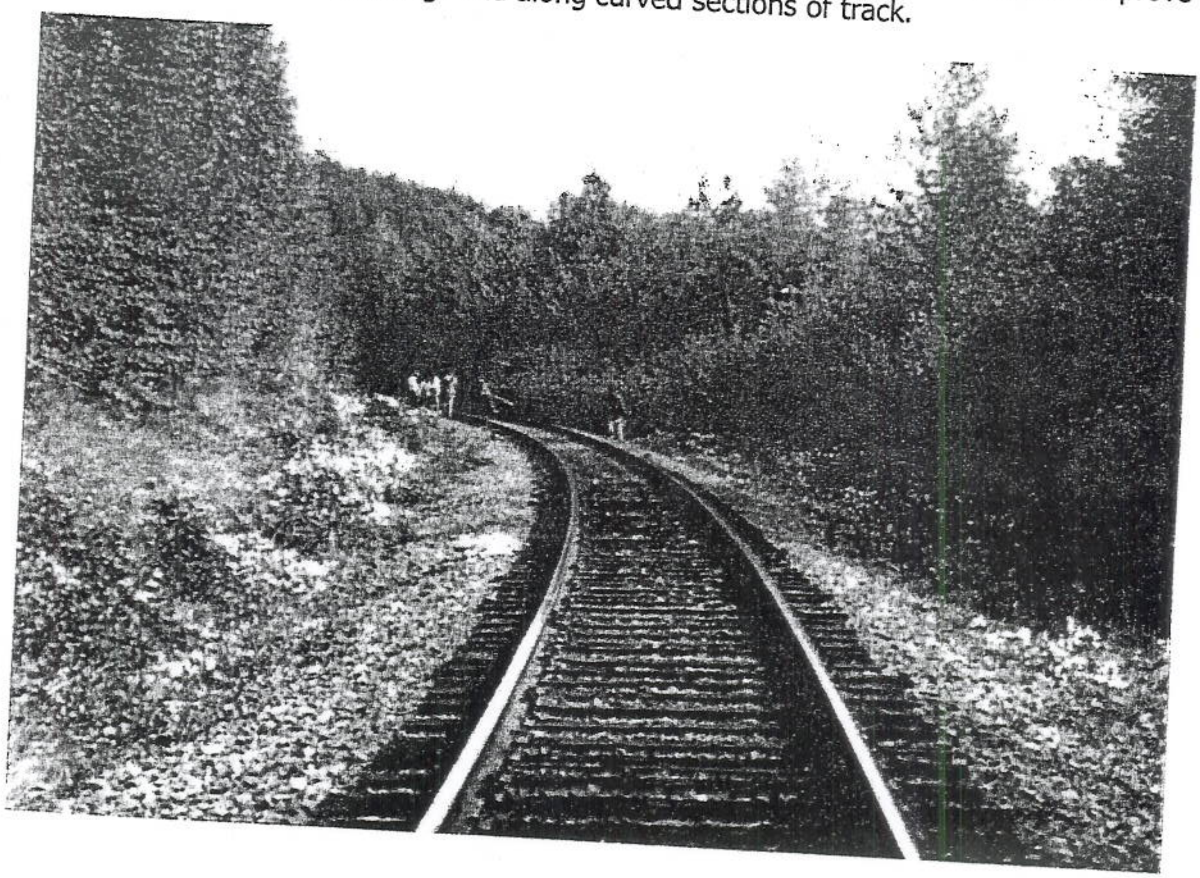
For the reasons noted none of the trials has demonstrated a control system which is entirely adequate. While each trial demonstrated a method of killing unwanted vegetation, it appears that none of these systems provided a broad spectrum, thorough, and long lasting result.

Hand Labor

Grubbing, cutting, raking and pulling by hand, with only the aid of simple tools (shovel, scythe, pulaski, rake, wheelbarrow, etc.) is the most time consuming, labor intensive method of removing weeds and woody plants from the railroad right-of-way, including the track ballast. Although the efficiency of hand labor is improved when powered hand tools (brush cutters, chain saws, etc.) are utilized, many times because of the location and tenacious nature of vegetation; for example, vegetation growth between ties, powered hand tools are not useable.

Summary of Activities Performed to Date

In 1993, the Alaska Railroad Corporation utilized State of Alaska Correctional Facility Inmate Labor to clear selected areas. The emphasis of this work was to improve sight distance at road crossings and along curved sections of track.



Analysis of the Effectiveness of Hand Labor

Cutting and grubbing vegetation, whether woody or succulent, is a labor intensive and slow process. To have a long-term effect, the work must be conducted during each growing season to stay ahead of the emergent plant growth of each new year. If a plant is just topped, particularly in the use of woody stem perennials (for example alder or aspen) the root system left behind will just send up new growth (suckers) and several stems will result where one was removed. Further, any vegetative material left behind, unless the plant cell structure is totally destroyed, may simply send down adventitious roots starting the plant life cycle all over again. Pulled plants may provide seed for new plants. In addition, plant material, if pulled or cut and left, will decompose and provide nutrients for subsequent plants and become part of the soil matrix creating an improved microsite for more species of plants. However, hand labor, when performed thoroughly, is a long lasting method of control.

Summary: SDOC

Trial date	July, August, and September, 1993
Miles of applications (total)	29
Main line	24
Sidings	1
Yards	4
Materials used	Hand tools
Days in service	49
Average production per day	.6 mile
Total cost	$120,500
Average cost per mile treated	$4155
Effectiveness on target plants	Excellent
Penetration	Very good
Overall impact	Nearly complete kill of annuals and heavy kill of brush and tree species by actual removal of plant
Impact on regeneration	Significant mortality on next season's emergent annual vegetation
Problems	Slow, expensive on a per mile basis, labor intensive
Advantages	Thorough and relatively long lasting when compared to other types of treatment. Coverage includes entire ballast prism and adjacent trackside areas

Steam

The steam approach to vegetation control utilizes water that has been vaporized under either high temperature or reduced pressure conditions.

Summary of Activities Performed to Date

In 1993, the Alaska Railroad Corporation conducted vegetation control trials using a two phase steam generating system owned by CP Rail of Canada. This system consisted of an oil-fired boiler housed in a rail car and an attached vegetation management car that further heated the steam to 200 degrees Celsius (twice the temperature required to vaporize water at sea-level pressure) in a non-pressurized post-heater. The high temperature steam was then distributed through a piping and nozzle system under the car and to wings that could be adjusted to match the ballast profile. The CP Rail steam system was actually a multi-car work train, consisting of an engine, fuel cars, water cars, the steam-generating car, the vegetation management car, and a caboose.

Analysis of the Effectiveness of Steam

The CP Rail steam system reportedly killed only the above the surface portion of some targeted plants.

Steam system appears to have little impact on the root systems of plants. After the trials, many plants with still-functioning root systems responded with new growth. In fact, because of the low soil temperatures along many segments of the ARRC system, the application of steam appears to stimulate plant growth in some vegetative zones along the ARRC system.

Summary: CP Rail

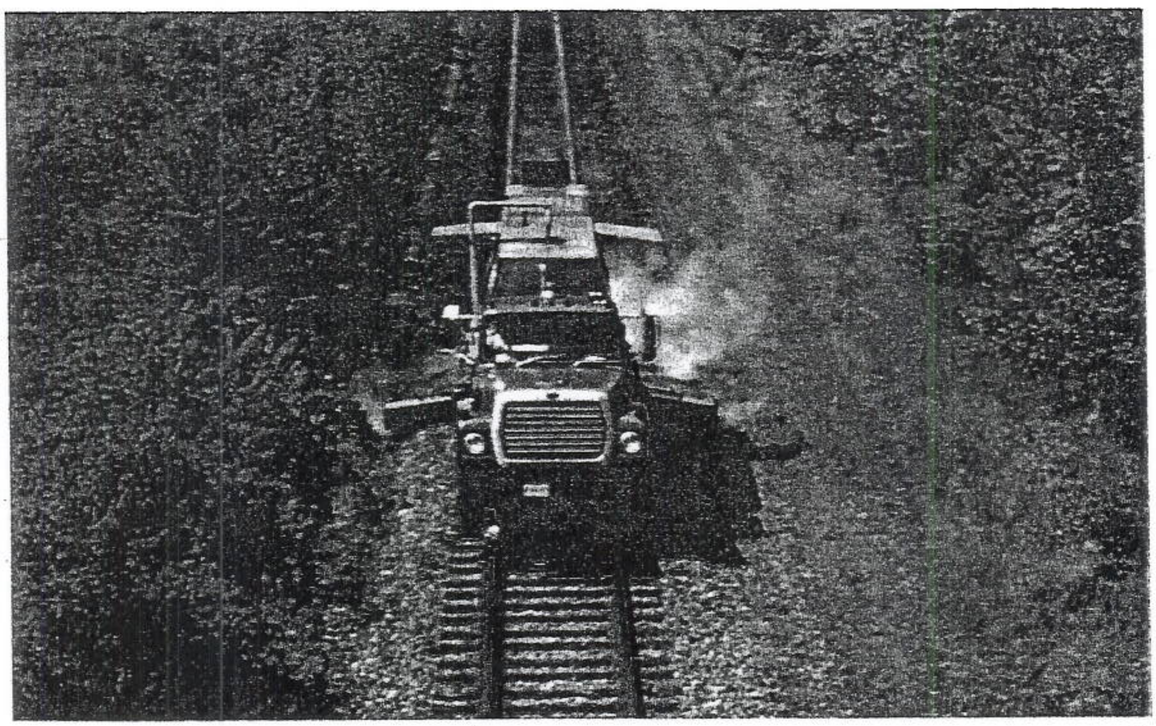
Trial date	July and August 1993
Miles of applications (total)	114
Main line	
Sidings	
Yards	
Materials used	Water, diesel
Days in service	14
Average production per day	8.78 miles
Total cost	$112,000
Average cost per mile treated	$1,000 (approximately)
Effectiveness on target plants	Fair to good
Penetration	Good
Impact on regeneration	Limited impact through mortality of structurally weaker species
Overall impact	Four weeks of dieback, major impact on leafy vegetation and grasses
Problems	Equipment intensive, highly specialized system, no longer in service in CPRR system
Advantages	Moderately effective in "killing back" plants along ballast prism

Hot Water

Hot water is water heated to an elevated temperature, but not hot enough (or at a low enough pressure) to vaporize to a gaseous state (steam).

Summary of Activities Performed to Date

Asplundh Railroad Division, a subsidiary of Asplundh Tree Services of Pennsylvania, conducted a demonstration for the Alaska Railroad Corporation in June 1998, using a hot water system called "Aquaheat". This system is mounted on a self-contained hi-rail truck. Their system consisted of a propane fired hot water heating system, spray nozzles and a fabric cover over the nozzles to keep heat on the affected ground for as long as possible.



Analysis of the Effectiveness of Hot Water

The Asplundh hot water system reportedly killed only the above the surface portion of some targeted plants. In areas of high plant density and depending on the species of plants involved, some track sections required multiple passes to effectively "knock down" the plants.

The hot water system appeared to have little impact on the root systems of plants. After the trials, many plants with still-functioning root systems responded with new growth. In fact, because of the low soil temperatures along many segments of the ARRC system, the application of hot water appears to stimulate plant growth.

Water availability was a critical factor and the equipment was out of service a great deal of the time while seeking water or filling the supply tank.

Summary: Asplundh

Trial date	June, 1998
Miles of applications (total)	42
Main line	14
Sidings	2
Yards	26
Materials used	Water, propane
Days in service	6: 6/16–20, 22
Average production per day	7 miles
Total cost	$68,600
Average cost per mile treated	$1633
Effectiveness on target plants	Fair
Penetration	Fair
Impact on regeneration	Estimated to be minimal
Overall impact	Three weeks of dieback due mostly to physical impact of hot water on foliage. Hot water may accelerate growth under some circumstances
Problems	Water intensive, great deal of lost production time searching for and filling. Narrow application width (8') with current equipment configuration
Advantages	Safe to apply

Open Flame Burning

This process uses the heat and combustion of an open flame to control vegetation. Fuel (either fuel oil or propane) is combusted to produce flames that are directed at the target vegetation. The fuel tanks and flame distribution equipment, plus water or foam to control or extinguish unwanted fire, were mounted on a hi-rail truck. The risk of escaped fire is great in any open flame system. Trackside vegetation, wood chips, railroad ties and wood bridge stringers are all potential fuels that could feed a wildfire or be damaged by out of control burning. Accordingly, flame systems are difficult to use particularly during periods of warm weather and/or low humidity. They are also less effective during wet periods.

Summary of Activities Performed to Date

In 1998, the Alaska Railroad Corporation contracted with a firm called "Tejas" from Texas to test its version of open flame burning.

Analysis of the Effectiveness of Open Flame Burning

This process resulted in limited plant mortality, affecting the above surface portion of plants in the same manner as a light ground wildfire. However, while some plant species died immediately as a result of this method (between 25 – 33% est.), an approximately equal number rebounded within a few days of treatment even after appearing scorched or lacking turgor. The other third of the treated plants lingered in a chronic condition and probably did not survive, although additional field inspections are needed for verification.

Only with a hot deep burning, intense fire that causes total mortality by heating and sterilizing the O (organic) and A (first layer) soil horizons can fire be effective as a long-term vegetation control agent. Light or partial burning may well result in increased plant propagation, as some species depend on fire to open cones or seed sacks (serotinous species) which then disburse seeds to create new individual plants. This type of burning may also select out the less fire resistant species, leaving the most fire hardy which will then require even more aggressive treatment. Also, unless the fire (or resultant heat) goes deep enough to sterilize the soil (as occasionally happens in wildfire) the "cropping" of the surface portion of the plant simply signals the root system of many species to send up new shoots. An example of this phenomenon is the use of field burning as a growth inducer in seed grass production.

Summary: Tejas

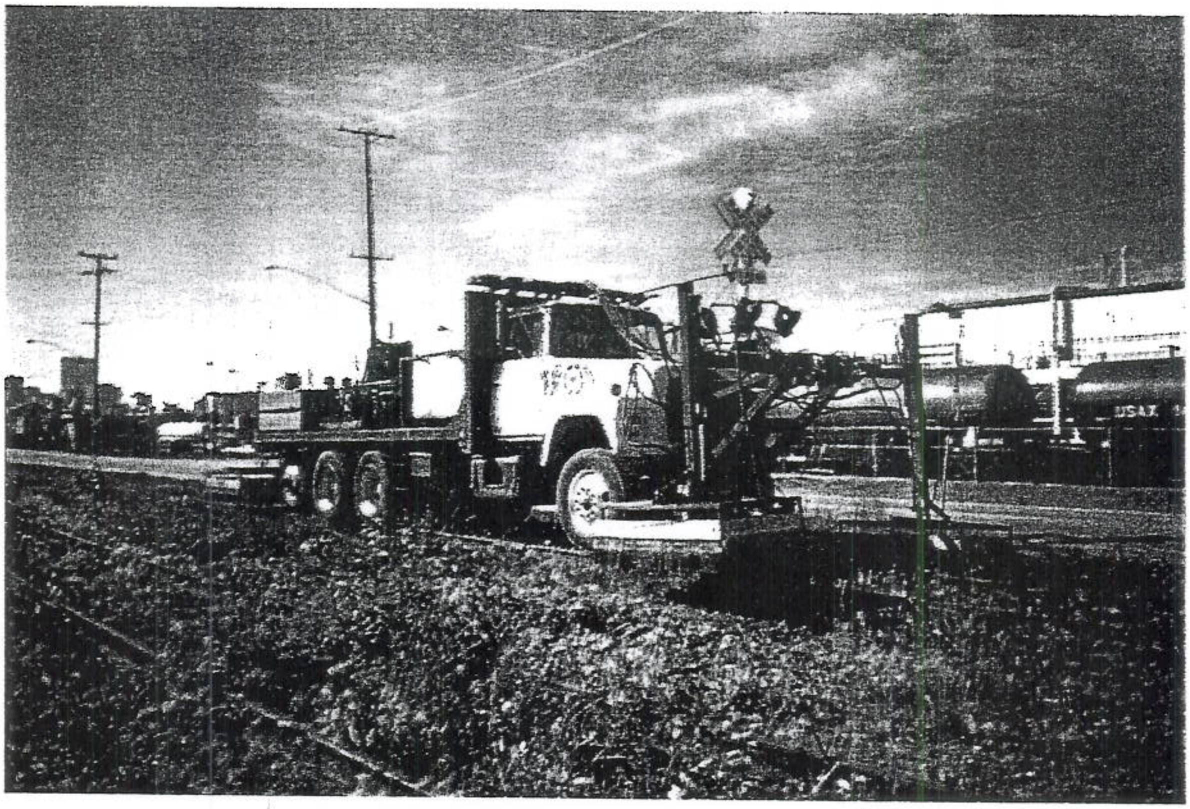
Trial date	June, 1998
Miles of applications (total)	36.7
Main line	25
Sidings	1.7
Yards	10
Materials used	Propane
Days in service	6: 6/16–20, 22
Average production per day	6.1
Total cost	$66,710
Average cost per mile treated	$1818
Effectiveness on target plants	Four weeks dieback due mostly to scorching
Penetration	Fair
Impact on regeneration	Estimated to be minimal
Overall impact	Moderate mortality and heavy wilting
Problems	An open flame system which must be controlled and contained. Difficult to control during periods of low humidity and in areas with a high fuel load.
Advantages	Compact, relatively low cost

Infrared

This process used fire, not the actual infrared spectrum of light, to attempt to control vegetation. Propane was used for fuel to produce multiple small flames which burned at orifices mounted on plates, which were curtained off to contain and direct these flame plates. The propane tanks and flame distribution equipment, along with water to control or extinguish errant fire, were mounted on a hi-rail truck.

Summary of Activities Performed to Date

In 1998, the Alaska Railroad Corporation contracted with a company known as IPM to test the "Infrared" system.



Analysis of the Effectiveness of Infrared

This process resulted in limited plant mortality, affecting the above surface portion of plants in the same manner as a light ground wildfire. Although a few plants burned, as in the Tejas open burning trial, many plants rebounded after a few days, as previously described. Light or partial burning may well result in increased plant propagation, as some species depend on fire to open cones or seed sacks (serotinous species) which then disburse to create new individual plants through propagation by seed. Unless the fire (or resultant heat) goes deep enough to sterilize the soil (as occasionally happens in wildfire) the "cropping" of the surface portion of the plant simply signals the root system to send up new shoots. The "Infrared System" can be directly compared to hand labor and the cutting off of the tops of plants, which often results in multiple stems being produced by the surviving roots.

The application of water and water-based fire retardant prior to the actual application of this system (and the Tejas system) and the follow-up application of water for containment and safety, may serve to stimulate growth and help the impacted plants recover from the flash heat.

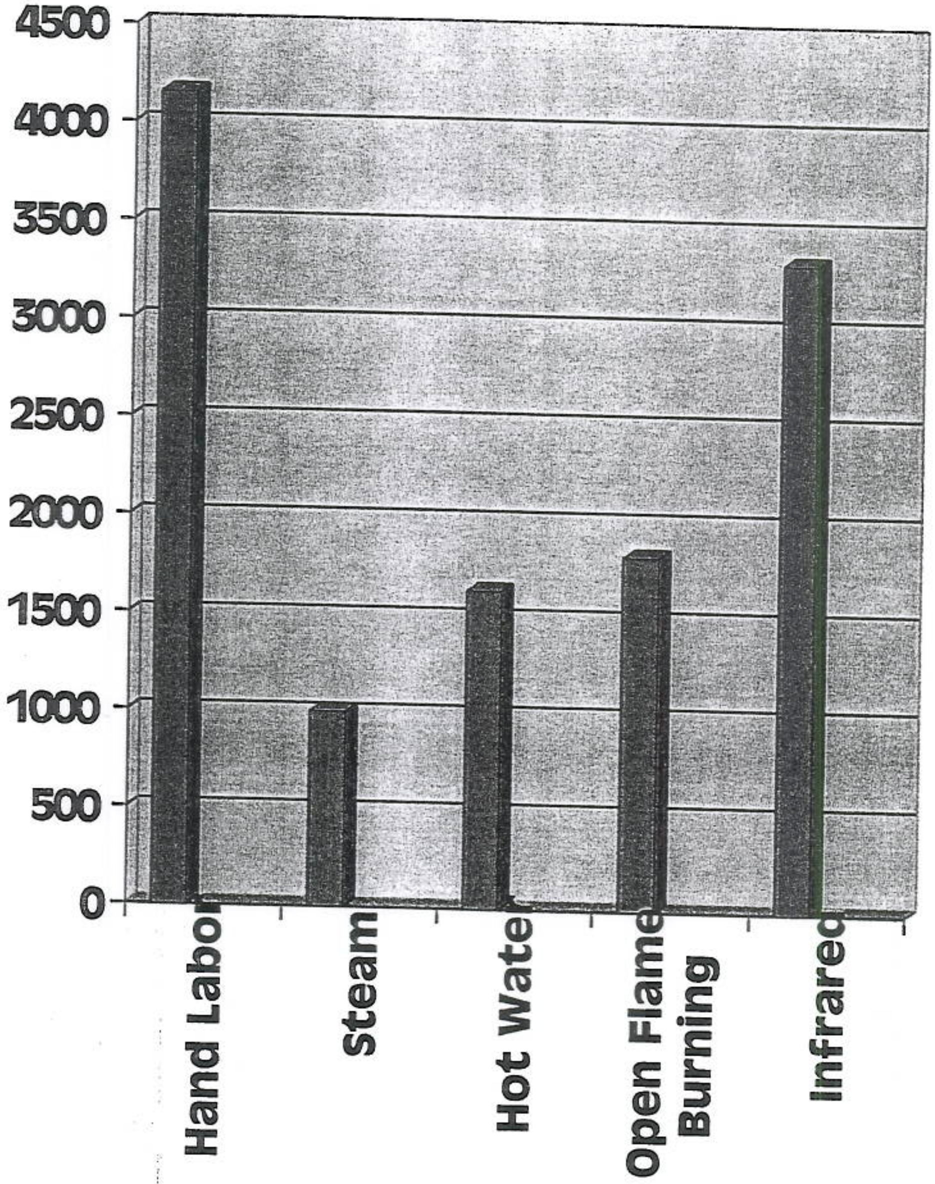
Summary: IPM

Trial date	August, 1998
Miles of applications (total)	30.8
Main line	12
Sidings	
Yards	16.8
Materials used	Propane
Days in service	6: 8/15-19, 21
Average production per day	5.1
Total cost	$102,303
Average cost per mile treated	$3322
Effectiveness on target plants	Five week dieback
Penetration	Good
Impact on regeneration	Estimated to be moderate
Overall impact	Good, most plants impacted by direct burning
Problems	Fire-based system which must be carefully controlled but more controllable than Tejas open flame; expensive on a per mile basis but more effective than several other approaches
Advantages	Very controllable and good coverage of the entire ballast prism

Cost Conclusions

There are two cost variables with each of these methods; the actual cost per mile of applying the control methodology and the frequency of application. Obviously, a more expensive per mile method, if effective on a single application, may be more economical than multiple applications of a less expensive per mile method. It appears that of the methods tried so far by ARRC, hand labor has the longest lasting impact. However, physical destruction of each unwanted plant is a time consuming, labor intensive, high cost approach to vegetation control. Further, the other three methods which have been tried using steam or flame lack the thoroughness of hand labor and appear to require multiple treatments to effect control of the unwanted vegetation.

Per Mile $ Costs - ARRC Vegetation Control Trials



REVIEWS OF OTHER POTENTIAL SOLUTIONS

Because of the universal interest in finding an effective solution to the problem of right-of-way vegetation control, many methods have been tried. This section of this report summarizes the results of a literature review of several control methods.

Weed Barrier

A physical method of plant growth prevention, as opposed to a "kill agent", the weed barrier approach involves placing a plant-impervious layer within the ballast prism. The theory of this approach is that plant propagation will be impaired because this barrier will physically constrain emergent plants. Modeled after plastic sheet weed control techniques for gardening, this approach appears to have some promise.

In practical application, the barriers would have to be installed during construction of the ballast prism or when major track work is being performed, otherwise, there appears to be no practical way to emplace the barrier continuously through the ballast prism.

Several materials have been suggested, including non-woven geotextile fabrics, treated needle felt (tarpaper, and a layer of sprayed-on asphalt.

One experimental material is a polymer flow coat, which could be sprayed on the ballast to seal out emergent plants. This material is currently being tested in Denmark.

Brushing

One method being tried in Sweden is the use of stiff bristle brushes rotating in a horizontal plane, mounted on on-track self-powered carriers. Working like a street sweeper, these brushes would be used to break or rip off the vegetation growing between the rails and on the sides of the ballast prism.

Although is appears that the brushing method would only break off plants at or above the ground line, there is some indication that certain combinations of bristle stiffness, arrangement, and application pressure may cause this equipment to pull certain plants out of the ballast altogether, although larger plants with well established root systems are not impacted this way.

This is an experimental method that in many ways appears to perform the same job that has been done by the modified ballast regulator developed by ARRC, i.e., removing annuals and grasses.

This system may be faster and somewhat more effective and could be the subject of more specific investigation.

Vacuum Clearing

What amounts to a very powerful portable vacuum cleaner has been tested in Sweden. This test machine has been tested in conjunction with a hydraulically controlled arm that enables the operator to move the intake to any specific location.

The Swedish machine has enough suction to pick up ballast and is apparently used to pick up ballast and plants together, requiring new ballast material to replace that which is vacuumed up, or the ballast and plants are screened and then replaced.

Apparently there are other uses for this machine, such as vacuuming up ballast to safely gain access to power cables buried in the ballast prism.

The usefulness of this specialized machine in solving vegetation control problems appears questionable in light of its specialized nature and probable high costs.

Hot Air

A gas turbine mounted on rail-capable equipment was tested in Sweden in 1994. Hot air produced by the turbine was ducted through a horizontal plate that was curtained off. This plate was mounted on the side of the turbine carrier and could be lowered close to the ballast surface.

The temperature of the exiting air was measured at 700 degrees C. The results were described as "not fully satisfying" and further development is ongoing.

Gas turbines consume very large volumes of fuel and this appears to be a very inefficient way to produce heat. In addition, the dangers posed by the open flames and infrared methods with regard to catching ties and adjacent vegetation on fire would apply to this method as well.

Freezing

The use of cryogenics, such a liquid nitrogen or carbon dioxide to kill plants by rapid freezing is a control method which may be useful. By rapidly subjecting plants to temperatures of –200 degrees F. or colder, plant tissues are frozen and desiccation (drying) and crystallization of water in the vacuoles and cytoplasmic layers takes place. This rapid intercellular freezing is uncommon under natural conditions and is exacerbated by the intensity of the cold applied. It causes cell walls to burst and the damage is irreparable, resulting in rapid and almost total mortality.

Through a review of the literature, it appears that although cryogenics has been tested in Europe as a vegetation control method it has not been tried in the United States, and the methods of application have not been worked out.

Like fire, the use of super cold liquids or gasses requires worker safety, but unlike fire, there is little likelihood of damage to the track infrastructure or adjacent vegetation.

This method of vegetation control appears to warrant further evaluation. It appears to have the best potential of the methods which have been reviewed but not actually tried by ARRC.

Electro-thermal

This approach involves the use of electrical currents to kill vegetation. A rail-mobile carrier containing a diesel driven generator is used to generate power that is transmitted to the target plant using electrodes. A similar but slightly different method uses microwave energy to achieve the same result. Rapid heating caused by the electrical current or microwave energy kills the plants by boiling inter and intracellular moisture, which causes desiccation and damage to cell walls.

The critiques of these methods described them as slow. Larger, taller plants require significantly larger charges of current to cause mortality. Herbaceous (soft succulent stem) plants and grasses are reported to respond to this treatment better than woody-stem plants (such as spruce, willow, and alder) which appear to require repetitive treatments. While the direct contact, electrode method has been tried in Europe with limited success, the microwave method is unproven and experimental.

Ultraviolet Light

The final method, which was evaluated through literature search, is ultraviolet or UV Light. UV Light has been used on an experimental basis for control of unwanted vegetation. UV is another form of thermal control.

When a plant is subjected to UV Light, the absorbed energy is transformed into heat which in sufficient doses can kill plants. It appears that broadleaf plants are more susceptible to UV treatment than grasses. There was no mention of impact or effectiveness on tree species. Partial or non-lethal exposure to UV in certain spectrums may actually cause certain broadleaf species to produce a UV-resistant pigment much like melanin in skin pigment of people who tan.

The effectiveness of UV on heavy clumps of vegetation is unknown but deep penetration beyond surface foliage is unlikely.

The amount of radiation necessary to cause rapid, widespread plant mortality may be harmful to applicators and bystanders. High levels of UV may be harmful to human eyes and skin. In addition, the use of UV in this application can produce large volumes of ozone which can be deleterious to human health. High concentrations of ozone are thought to be harmful to human respiratory systems.

Another potential problem with UV may be fire. Prolonged application in one spot may cause vegetation to ignite.

The usefulness of UV Light as a method of vegetation control is very speculative. Although it has been used experimentally in Northern Europe, there is no record of any application in North American.

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