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Effective Aerial Reseeding Methods: Market Search Report

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Introduction

The standard practice of reseeding wildfire-devastated areas with native seed mixes, by use of helicopter-borne seed buckets, presents a myriad of problems and often poor results. Seed mixes tend to segregate based on size, shape, and density when subjected to vibratory conditions, including those associated with road-based delivery or the engine vibration of a motorized sling located at the bottom of the seed bucket. When seed is ejected from the bucket, it is also subjected to air currents created by the helicopter as well as any prevailing wind.

The San Dimas Technology and Development Center (SDTDC) studied the various causes of poor aerial reseeding and conducted a market search for useful solutions. Several general recommendations for assuring rapid regeneration and stabilization presented themselves during research. These recommendations appear in the section titled, "General Native Seed Issues." The researched solution proposals or current and possible techniques for mitigating unevenness in seed distribution are first analyzed and compared.

Purpose

Those responsible for rehabilitation have encountered problems using standard reseeding practice for dropping native seed mixtures. Uneven distribution, settling, jamming, and poor germination are some examples of these problems. An opportunity to test two solutions arose during the market search. Preliminary results from this test indicate an improvement, but further study is necessary to confirm this supposition.

Applicable Directives

Forest Service Manual

FSM 2523.03—Policy includes the relevant directive for burned-area emergency rehabilitation, specifically Subsection 3. Compatibility with Forest Plans directs:

> "Include native plant materials when possible to meet the objectives of the burned-area emergency rehabilitation. When practicable, use seeds and plants in burned-area emergency rehabilitation projects that originate from genetically local sources of native species. When native materials are not available or suitable, give preference to nonnative species that meet the treatment objectives, are nonpersistent, and are not likely to spread beyond the treatment area."
>
> "Treatments that qualify for emergency funding provide essential protection at minimum cost to achieve on-site soil and slope stability, runoff control, and unimpaired stream channel carrying capacities."
>
> "Treatments are primarily temporary measures that do not require maintenance or are removed after objectives have been met."

FSM 2520.2—Actions should be implemented with the objective as the motivation:

> "To protect National Forest System watersheds by implementing practices designed to retain soil stability, improve or maintain site productivity, secure favorable conditions of water flow, and preserve or enhance aquatic values."

FSM 2323.43b—Wilderness rehabilitation watershed improvements FSM 2323.43b:

> "Permit emergency burned area rehabilitation only if necessary to prevent an unnatural loss of the wilderness resource or to protect life, property, and other resource values outside of wilderness."

Forest Service Handbook

FSH 2509.13, Amendment 2509.13-95-7, Section 24—Goals of Emergency Rehabilitation Treatment:

> "Emergency rehabilitation includes only those treatments that are immediately needed to prevent or reduce potential damages (commensurate with values at risk) due to the effects of a wildfire on the watersheds. Each treatment must be directed at correcting or effectively mitigating the adverse effect that the fire had on the watershed, as identified in the Watershed Condition Inventory (sec 23.3)."

Section 26.1—Types of Emergency Rehabilitation Treatments, Land Treatments, Subsection 1, Revegetation:

> "Revegetation is prescribed to be effective for the first or second year after treatment. Considerations for revegetation treatments include:
>
> a. The target area to be revegetated.
>
> b. A seed mix of species known to be effective for erosion control, adapted to the target area and compatible with future management objectives."

Service directives dictate the focus of this market search by demanding a low-cost, immediately available solution that addresses watershed stability and specifically prohibits treatments intended to enhance soil quality or water yield. Only treatments with proven effectiveness are allowed, further limiting the market search. Each identified possible solution must meet all criteria and should also be readily available and useful with existing equipment.

Identified Problems

Seed Segregation

Regenerating plants in their previous location is the most effective long-term treatment for wildfire-devastated areas. Inducing rapid ecosystem regeneration in these areas requires an even distribution of the native seed mixture, so the specie most suited to each particular microclimate will be established first. Any situation that may exclude the most appropriate seed from a certain area will slow regeneration and recovery of the area. SDTDC has identified three major contributors to seed segregation, all of which must be mitigated to ensure even ground distribution.

Contributor 1—Transporting Seed

As many seed distributors ship unpackaged bulk mixed seed, the seed mix generally is subjected to agitation by vibration during travel. Prepackaged seed mixes are less vulnerable to this factor, but given sufficient agitation, any normal packaging of seed mix containing variously shaped and sized seeds will segregate. A variety of factors hinder segregation and facilitate incidental remixing of prepackaged seed. For this benefit, whenever the option is available, premixed seed should be shipped in containers with as little open space around the seed as possible (e.g., full burlap sack). All seed mixtures should be visually inspected for segregation before loading into a seed bucket or hopper.

Contributor 2—In-Bucket Agitation

Even if the seed reaches the helicopter seed bucket well mixed, the bucket may create the same vibration problems as the delivery. On many helicopters, seeds are distributed using a gas-powered impeller. The gas engine delivers a vibration to the bucket which can cause seed segregation. Additionally, the bucket that is usually connected to the helicopter by steel cables and connectors is also capable of delivering vibrations. These contributions also depend on the amount of vibrational damping provided by the engine mounts, the type of engine, and the amount of vibration translated by the bucket connection system. Overall effect is determined by the length of time the seed is exposed to vibration. It is impossible to predict, without further study, whether this type of agitation by itself poses a significant risk of causing uneven ground distribution.

Contributor 3—Aerodynamic Characteristics

Once the seed mixture leaves the bucket, its ultimate resting place is determined by each seed's aerodynamic properties, including mass and the local wind conditions at the time of release. Heavy, dense seed experiences the least wind influence, while seed specifically evolved for aerial distribution will probably follow the path dictated by the prevailing wind at the time of release. The side motion of the impeller will also cause segregation, since dense seed will be slowed less by air resistance when slung perpendicular to the direction of the flight. This causes lighter seed to occupy a narrower swath than dense seed.

The reality is that seed is never released in ideal conditions, since the prop wash of the helicopter assures chaotic airflow around the seed when the seed is dropped. The effect that windy conditions have on seed drops can all but eliminate the intended benefits of dropping a native seed mixture. Avoiding seed drops in conditions windy enough to cause segregation is both impossible and impractical, given the urgent nature of reseeding efforts after wildfires. Minimizing the effect of wind on all types of seed mixtures used by the Forest Service is possible using the techniques outlined here. Determining cost effectiveness will depend on evaluating many factors beyond the scope of this study.

Seed Removal by Animals

Seed dropped in burned areas sometimes represents the only food source for many animals. Birds may easily locate the drop area and eat any variety they find attractive. Other animals and insects that survived the fire underground may be forced to feed on the dropped seed. Only if all seeds in a mixture are equally unattractive to wildlife will the original mixture be preserved through germination.

Seed Bridging/Jamming

Some seed, in bulk quantities, tends to form a woven layer due to unusual shape or appendages. This is particularly common with seeds having large awns or bristles. This layer, or bridge, can be so strong that both the seed composing the bridge, and other seed in the mix, may not flow through an opening. The only solution during flight is to mechanically disrupt the layer, which may be particularly problematic when the seed is blocking the outlet port of a flying helicopter bucket. Removing the awns is a commonly practiced option, but can sometimes hinder seed germination as well as introduce new mixing problems. The identified seed treatments listed below can solve this problem.

Identified Possible Solutions

SDTDC has addressed each problem to determine a set of possible solutions and evaluate the effectiveness of each. A market search for reasonable alternatives produced two candidates of varying availability, effectiveness, and cost. Other alternatives are listed with their characteristic drawbacks.

Seed Coatings

The technique of coating seeds began in New Zealand. The purpose was to facilitate aerial distribution and high germination of seed on rough terrain and unstable soil in sheep pastures. The technology evolved in the United States to further enhance germination characteristics and facilitate ground-based mechanical planting. Coating is now a method used worldwide for enhancing germination, facilitating accurate aerial spreading, and increasing mechanical planting efficiency. United States seed coating companies presently provide planting and germination solutions for every type of plant used by the agricultural industry. Two companies located in the market search have developed and tested seed coatings to ensure even aerial distribution of seed mixes.

Figure 1–Coatings have little effect on seed shape or size, but seed weight may be increased for relatively low cost.

Coatings vary in quality, thickness, ingredients, buildup characteristics, effect on germination, aqueous affinity, and animal attraction. Some companies distinguish coatings by using the term coating, to refer to a thin buildup of chemicals on the seed to add color, introduce an antifungal agent, promote or retard germination, or any other desirable quality. By the same standard, pelleting refers to a coating (usually thicker) intended to smooth irregularities in the seed, prevent clumping or matting, increase seed mass, or generally aid in the planting process. Pelleted seeds often incorporate any desired qualities of coating as well. Most seed pelleting is done for precision mechanical planters in the cash crop industry. Not all seed coating companies adhere to this standard nor do they offer the same alternatives for seeds.

Both coating and pelleting have demonstrated improved seed separation and ensured even flow. Some companies offer techniques to remove excess dust from the final coating. Whether this is necessary in aerial seeding is unknown.

High-density coatings may offer another especially valuable benefit to stand establishment and watershed stability restoration. Since many native seeds are less dense than water, ungerminated seed can be susceptible to runoff during heavy rains. Seed that is more dense tends to strike the ground at a higher velocity, sometimes allowing the seed to bury itself in loose soil. Even when the seed does not become buried, it can better resist runoff than seed that floats. Seed that floats requires negligible water flow to be displaced, while seed that is denser than water will remain stationary until the water's ground velocity reaches the carrying velocity for the seed. This implies that coated seed subjected to rainy conditions would experience far less runoff and pooling than uncoated seed does, possibly reducing the need for runoff flow control.

Seed coating or pelleting companies are generally contract-driven and eager to tailor their product to meet customer requirements. Some companies work mainly through a few seed providers, while others receive most of their business directly from seed consumers. All companies listed here are willing to produce samples of coated seed to meet the Forest Service's needs. All the companies accept large orders, with minimum order requirements. Turnaround time on jobs can vary from 1 or 2 days to several weeks.

Ballistic properties of seed is the final and most critical issue to resolve for even distribution. Using the experience of the two companies that have engaged in ballistic tests of coated seed, the problem can be identified as nonuniformity in seed density. Coatings have the sole purpose of unifying the densities of disparate seeds in order to unify a mixed and aerially dispersed seed mixture. Companies that have identified themselves as capable of providing density-unifying coatings hold central importance to this market report.

Coatings that may be of use to the Forest Service for aerial reseeding of wildfire-damaged, erosion-sensitive land must ensure uniform ground distribution. The seed coatings must not increase risk of removal by animals or increase stress caused by the local or global environment. Nearly all coating companies have custom-tailored coatings to meet Forest Service needs except ground distribution. The techniques they presently use will work with the wide range of seeds used in reseeding.

The most economically feasible coating method, high-density coating, generally costs between 30 and 50 cents per coated pound (before packaging and delivery costs). According to coating companies, weight gain for good ballistic improvement is usually double the original seed weight, meaning that the coating cost in terms of the original delivered seed weight is generally 70 cents to $1 per uncoated pound. Commonly used native seed species range in cost from approximately $1 to over $20 per pound. Average seed cost per project is roughly $5 to $15 per pound. Full consideration of the cost for each researched method is discussed later.

Coating offers a possible solution for providing even distribution characteristics with only slightly greater effort or time commitment than regular uncoated seed. This is the targeted benefit of the market search, but other benefits from the operation affect the technique's worth. The enhanced ballistic characteristics of the seed cause it to strike the ground at a higher velocity when it is dropped from a helicopter, allowing it to penetrate the surface and gain more contact with the ground. This can enhance germination and speed site recovery. Certain coatings can also offer hydrophilic properties that speed water absorption and germination. Others offer hydrophobic (water repellent) properties that may be advantageous in extremely wet situations where excess water may slow germination. Hydrophilic coatings would probably be more useful.

Coating generally meets all Forest Service requirements. The relatively small weight concession of coating, to unify density, is the technique's greatest asset. The techniques described show how this consideration can adversely affect a solution's utility. As coating companies work on a contract basis through seed suppliers, with proper preparation seed supply used to rehabilitate a site will not be excessively delayed by the coating operation. This is most easily arranged when prior agreements are made with a dedicated native seed supplier who has a working relationship with a coating company. Seed ordered for rehabilitation can then be specified as coated seed, avoiding adding another step for the contracting officer.

Figure 2–Aerial hydroseeding enables precise application on almost any terrain but the amount of material required neccessitates expensive, specialized equipment.

Hydroseeding/Hydromulching

Hydroseeding or hydromulching began in the late 1970s. Seed is distributed in a slurry form combined with processed woodchip fibers and other optional enhancements. Fertilizer and a tackifying agent are often added to speed the growth and prevent seed/slurry runoff or pooling. Hydroseeding and hydromulching are defined differently by some businesses.

Hydroseeding is sometimes defined as spreading mulch concentrations less than 3,000 pound per acre, or a coverage insufficient to offer a dedicated layer of moisture protection to the ground. The mulch cover still hydrates the seed and traps any incidental moisture, but it is considered insufficient to offer erosion protection itself or prevent dehydration in constantly dry conditions.

Hydromulching is spreading mulch concentrations greater than 3,000 pound per acre. At or above these concentrations, the mulch is supposed to form a linked matrix, making a crude blanket over the ground. The blanket absorbs the initial shock of any incident water droplets and then absorbs the water itself before it ever reaches the ground. In addition to the fertilizer that may be added to the slurry, the wood fiber itself provides long-term fertilization as it decomposes.

The water/wood fiber suspension is generally thick enough to prevent segregation of the seed mixtures, and the high water/fiber to seed ratio eliminates segregation due to wind conditions. Hydroseeders with modern equipment have never encountered problems with uneven ground distribution of seed mixes.

The main drawback of hydroseeding is that it requires a large amount of water to create the slurry. This causes the ratio of seed weight to cargo weight to be extremely low. While targeted seed counts per acre are not difficult to achieve, the increase in weight associated with each load of seed means that the number of trips required to seed a single acre may be more than the number required for conventional seeding.

A conventional seed bucket will typically hold enough seed to cover several acres at the desired application rate. Carrying the same weight, the helicopter would have to make many trips dropping slurry to achieve the desired application rate on a single acre.

Due to its generally specialized application, information on animal reaction to hydroseed-applied seed is unavailable. It is likely, however, that the seed attractiveness to animals is minimized by the rapid germination of the seed. If low quantities of slurry are applied and germination is about the same as for plain seed, current hydroseeding technology offers no benefits or solutions to seed removal by animals.

The current technology of aerial reseeding also requires special equipment. One company has built a reasonable base of experience with the process, but the helicopters used are designed for large liquid transport and dropping, as with fire retardants. Adapting other helicopters to handle the slurry could prove costly, time-consuming, and ultimately impractical.

Organic Mulch Pellets

Two companies offer a direct solution for achieving uniform distribution of seed mixtures. Gluing mixtures of seed to organic mulch pellets, provides a premixed product that guarantees no seed separation. The pellets are certified weed-free and made from compression- and heat-formed green waste material. Unique Forest Products uses urban waste for material while Elk Grove Milling relies on farm residue. The diameter of the base pellet used varied from 5/32 to 5/8 inches. The length may also vary as required.

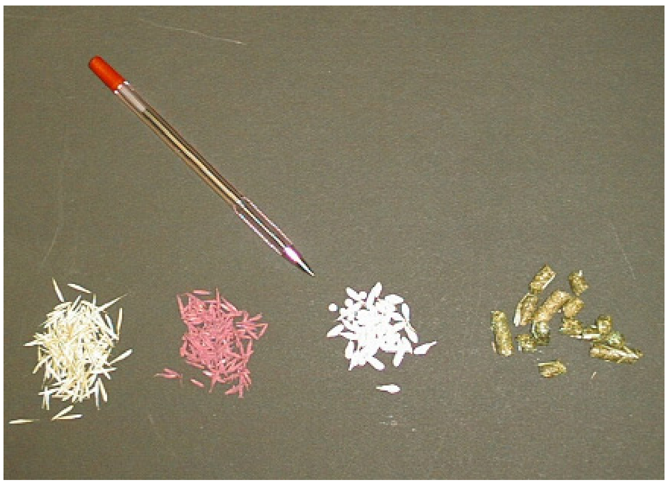

Figure 3–Organic Mulch pellets (far rignt hold seeds of any size on their surface but to achieve uniform coverage only a few seds may be attached to each pellet. The resulting cargo weight requires many more helicopter trips to deliver the entire payload.

Attaching seeds to each size pellet has advantages and disadvantages from both the production and the consumer standpoint. The 1/4-inch-diameter pellet has worked well in the past for attaching seed mixtures, while the 5/32-inch-diameter pellet maximizes the seed to cargo weight ratio. Larger seeds attach poorly to any size pellet, while small seeds present accurate ratio problems. Although many different adhesives are available, each company uses a standard adhesive unless unusual conditions dictate otherwise. In addition, Elk Grove Milling uses a calcium carbonate dust coating on seeds to prevent pellets from sticking to each other. Elk Grove Milling provided pellets for burn area reseeding before SDTDC began research but never attempted to attach a variety of seeds to pellets.

The pellet itself offers multiple benefits to the seed. It is hydrophilic, and when exposed to water, the pellet rapidly expands and opens from the direction of the incoming water. In the case of rain or sprinklers, this property causes the seed attached to the outside of the pellet to contact the ground after rain while gaining a cover layer of mulch on top. The mulch adequately retains water and offers nutrients to the seed. In seeding lawns, the mulch layer has proven effective enough to form a pseudo ground cover for the grass, allowing the grass to form a layer of sod on barren, rocky ground. Unique Forest Products offers nutrient enrichment for their pellets. The composition of the pellet may be modified to suit particular ground conditions.

Previous aerial reseeding projects demonstrated no difficulties with bridging or plugging of the pellets, probably due to the uniformity in size, shape, and density. The finished pellets also discourage animal consumption for two reasons. The calcium carbonate dust coat, applied by Elk Grove Milling, masked the smell of the seed, and both companies use a pellet that is composed of nonnutritious organic waste. Animal consumption has never been noticed in any pellet application.

On average each pellet receives an equal mixture of seeds. The uniformity in both size and density of each pellet ensures that the seed mixture will neither segregate due to agitation nor differ in ballistic characteristics.

One major concern with the overall effectiveness of the technique is seed retention of the pellet. The glues used are reportedly quite strong, but whether the glue can retain all seeds equally during agitation is unknown. A mixture of varying seed sizes requires a large pellet to maintain an accurate ratio on each pellet, but larger pellets increase cargo weight for the same quantity of seeds.

Differential Metering Bucket, Mixing Bucket

Speculation that a modified bucket could assist in achieving even distribution led to research into bucket designs. Although buckets with an effective mixing device, such as an auger within the hopper, or separate compartments and variable-aperture spouts, can ensure that accurate mixtures leave the bucket, each type has its drawbacks. Neither ensures that all seeds travel equal horizontal distances in the air or fall at the same rate. The mixing bucket may also harm the seed as some auger devices subject the seed to a grinding or shearing force. Careful calibration of the metering system is also required to ensure that each type of seed flows out in its proper ratio. Bucket compartments should also be considered. The best number of compartments for the bucket is both critical to cost considerations and very difficult to predict, since only one major fire may require a wide variety of seed mixtures. Because some compartments may be unusable when seeding with a mixture containing an odd variety of seeds the helicopter will not be fully loaded.

The bucket alone can offer no solution to the problem of unpredictable wind conditions. Several helicopter pilots have recommended using short tethers connecting the bucket to the helicopter, small helicopters, and wide-open gangs (minimizing bridging problems as the seed flows to the impeller) to minimize ground segregation. With the gangs wide open, distribution density can only be controlled by the helicopter's speed. Pilots must consider the flow rate of the particular bucket used in each situation to determine the appropriate speed necessary for achieving target seed density. Swath width differences may be minimized by flying low to the ground, but this may reduce the overall swath width, leading to more passes with the helicopter and more flight time.

Suspension/Fillers

Some reseeding operations utilize material such as rice hulls or sand to create a suspended mixture of seed in the seed bucket. The primary benefit of the technique is the availability and cost of the necessary materials. It also offers benefits for seed particularly prone to bridging or rapid settling. The central drawback to the technique is its inability to offer a solution to wind segregation. Although components are capable of significantly slowing vibrational segregation, they cannot eliminate it. The technique can only ensure little segregation over an extended flight and cannot significantly affect aerodynamic segregation. The technique's origin was not apparent, nor were the recommended application rates documented.

Alternative Delivery Practices

Some agencies discussed their practice of requesting that seed mixes be delivered to them in bags or other packages after they discovered that the mixes remained mixed when delivered this way. While the technique offers the benefit of minimizing segregation due to automobile-related vibration, the issue of in-bucket agitation and aerodynamic segregation are not addressed. While helpful to operators, this technique alone cannot solve the problem.

Market Report—Seed Coating Companies

Seed coating in the United States has been driven by two major markets, each seeking different advantages from coating. Several companies attempt to service both markets, but all the companies identified in this report derive the majority of their profits from one of the markets, if not from a single type of seed.

Companies offering low-volume, high-weight buildup coatings generally cater to the ranching and fodder industry. Alfalfa and clover are the most commonly coated seed types in this category. The seeds themselves are generally of moderate cost, and the coatings provide soil and nutrient enhancement for the germinating seed. Clover and legume seeds generally have inoculants added to the coating to aid in stand health.

The two companies involved in this market report, CelPril and Seedbiotics, coat millions of pounds of seed per year. CelPril has manufacturing facilities in Manteca, CA, and Hermiston, OR, as well as several sales and distribution offices around the United States. It operates in cooperation with a sister company in France that supplies coated seed worldwide. Together the sister companies have over 60 years of experience in seed coating technology.

Since Seedbiotics began operation in 1989, it has experienced a steady 20 percent annual sales growth. The company now coats several million pounds of seed per year with significant contributions from native and nonnative grasses.

Manufacturing facilities in Caldwell, ID, and St. Joseph, MO, supply seed throughout the United States and recently worldwide. Other smaller businesses fill the market needs unmet by these companies. Only these two companies participated in this study.

Companies coating for the cash crop market address completely different product demands and have developed completely different technologies to suit the market. Most individual coating orders for cash crop seeds, such as lettuce and tobacco, involve very low quantities of seed. Of the palletizing companies identified in this report, Incotec and Harris Moran represent the largest and oldest. Table 1 combines both markets and identifies the current capabilities of each business.

Table 1—Markets and current capabilities of each business.

Company	Coating	Pelleting	Burn Experience	Aerial Experience	Trees	Grasses	Flowers	Treat mix
Seedbiotics	x			x	x	x		x
Celpril	x		x	x	x	x		
Incotec	x	x					x	
Synergene	x	x		x			x	
Seed Technologies	?	x						
Seed Dynamics	?	x			x		x	
Elk Grove Milling			x	x		x		x
Harris Moran	x	x						

The companies bearing a question mark in the Coating column have identified the availability of a high-density coating applicable for using standard pelleting machinery. This coating is different from the standard pelleting coat as well as from the coatings used by Seedbiotics and CelPril. In general, the more items in which the company has experience (as shown by the table), the greater their interest in this particular project.

Coating companies catering to cash crop farmers must meet exacting germination and seed separation standards in a fairly narrow range of conditions. The high volume, low-weight specialized coating of most companies is designed to insulate the seed from temperatures as high as 140 °F, provide seeds of almost exactly the same size and shape for easy mechanical planting, leach water to the seed quickly to speed germination, and provide fungicide for the seed and plant. Because of the relatively small quantity of seed each company coats and the wide variety of special enhancements the coating must provide, the cost of this procedure is much higher than that of other coating processes.

Market Report—Hydroseeding Companies

Of the hydroseeding companies contacted during this market search, who had experience in applying native seed mixtures in hydroseed slurries, only one had performed aerial reseeding of large tracts of land in harsh terrain. Erickson Air-Crane has applied hydroseeding slurries to relatively large areas of land on mine reclamation sites several times. All the sites received hydroseeding treatment after other rehabilitation techniques failed. In one situation, hydroseed revegetated a hillside where a previous reforestation effort left a plantation consisting of 10-year-old, 2-foot-tall pine trees, jokingly referred to as the bonsai forest. The soil of the site was so acidic that the revegetation effort required the application of 1 ton of lime per acre to make the land arable.

Hydroseed application on all the sites selected was based on the failure of previous revegetation efforts. The technique costs a tremendous amount per acre when applied in the recommended quantities, and the relative benefits dissipate quickly when application rates dip much below the recommended amount. One blanket estimate received from a hydroseeding company who contracts with Erickson Air-Crane listed the recommended application rates as 16 tons per acre with a cost, not including materials, of $85 to $125 per ton. Typical application rate of seed alone on Forest Service reseeding areas average 2 to 4 pounds per acre. One load of seed dropped from a conventional bucket theoretically covers hundreds of acres, while many trips of a heavy-lift helicopter are required to hydroseed a single acre. The cost of hydroseeding could not be justified on any large general rehabilitation project.

Market Search for Buckets

Two different types of seed segregation related to aerial application, classified as either preflight or inflight, were identified. To achieve the goal of applying a uniform seed mixture to the burned land, the different segregation patterns must be eliminated. While the coatings identified provided the most promise for solving the inflight segregation problem, they may still leave the seeds vulnerable to preflight segregation. This segregation may be eliminated by providing a mixing system within the bucket.

Bucket manufacturers are interested in the project but have performed no prior research on this problem. The California Department of Forestry (CDF) developed and produced several mixing bucket models designed specifically for native seed mixtures. One helicopter bucket manufacturer is also willing to produce a prototype mixing bucket for Forest Service inspection. Individuals who worked on the development of the CDF buckets have offered to loan buckets to SDTDC for study and test. In short, solving preflight segregation wherever it occurs will be possible, but until inflight segregation is eliminated, it is impossible to say whether new technology needs to be developed to avoid poor ground distribution caused by preflight segregation.

Field Test—Kirk Fire in the Ventana Wilderness and Los Padres National Forest

A large and particularly fast-moving fire decimated much of the northern Los Padres National Forest, including large parts of the Ventana Wilderness late in the summer of 1999. Rob Griffith, the man in charge of the rehabilitation effort, submitted the proposal to study alternative distribution methods of native seed mixtures several years before. During correspondence, Griffith learned about the different techniques being studied and asked if SDTDC wished to conduct a small trial on some land designated for reseeding within the burn area. Preparations soon began with coated seed and seed attached to organic mulch pellets ready for test drops by the third week in November.

During the preparations, SDTDC arranged shipment from the native seed supplier, to the coater, then back to the field office, as well as to the mulch pellet provider and back. Having SDTDC solely responsible for this position made coordination much easier. Any widespread use of these techniques will need to be arranged during the prefire season to ensure that all burned area emergency rehabilitation team members, seed suppliers, seed treaters, and equipment operators are aware of the necessary steps involved in the operation. Other requirements, such as those for seed and treatment labeling, will need early dissemination as well.

Three hundred six acres, divided into seven separate plots, received aerially applied seed for the test. Five received seed coated by CelPril, one received organic mulch pellets supplied by Unique Forest Products, and one received seeds with no coating at all. Data gathered revealed that both the coated and uncoated seed still experienced segregation. The organic mulch pellets experienced problems as well. During the first load the pilot kept the bucket's opening partly closed. Upon return for a reload, it was discovered that only half the load had been expelled. During the next pass the pilot completely opened the bucket, but the copilot noticed that at this setting, the torque generated by the rotating slinger throwing the heavy pellets caused the bucket to spin, which ultimately caused the connecting cable to unwind. Only one-third of the pellets were actually applied before the cable was deemed unsafe.

Computer Modeling—Results and Conclusions

The results of the field testing on the Ventana Wilderness prompted a more rigorous analysis of the dynamics involved in the seed flight. Visual information as well as the distribution data gathered proved that neither seed coated to double the weight nor uncoated seed formed equal swaths when dropped in identical conditions. Computer modeling of these situations explained these observations. The only way to cause two particles to travel through the air with the same pattern is to give them the same weight and cross section area in the direction of travel. Although doubling the weight of each seed did bring the densities slightly closer together, the change was not large enough. Unifying densities requires consideration of the current densities along with the density of the coating. Seed with a relatively low-density coating demonstrated the potential drawback of this requirement; unifying the densities of 10 seeds resulted in increasing some of the seeds' relative weight up to 34 times their original weight.

General Native Seed Issues

The initiative to use native seed mixtures for soil stabilization after wildfire includes more than aerodynamic issues. Every step in the practice of native seed mix reseeding requires new implementation practices. Interviews with helicopter operators, supervisors, and native seed suppliers generated considerable information on how to improve the technique with or without seed treatment.

The first, and in many ways, most critical aspect of improving native seed reseeding is to ensure that the proper mix is used in each situation. The issue is far more complex than picking species off a list. Chuck Cambra of Kamprath Seed Co. lists many factors critical to ensuring germination of the desired species. First and most important is the understanding that not all native seed species will grow in all areas of their native region. One particularly common oversight is in neglecting to specify the altitude of application for altitude-sensitive species. Kamprath Seed offers distinct varieties of some seeds grown at specific altitudes to automatically select the correct variety. While one particular variety of specie may be more costly than another, Cambra says the only way to ensure a healthy and long-lasting stand is to use the proper variety.

Paul Albright of Albright Seed Co. argues the practicality of replicating the exact native seed mixtures formerly appearing on the wildfire-damaged land. He pointed out that the immediate goal of soil stabilization might be lost quickly if the particular native seed mixtures are unavailable from seed suppliers, or if the particular variety of a native seed available from a seed supplier is unsuited to the area. He added that hybrid species, usually grown by seed companies, generally incorporate greater genetic diversity into the plant, making the plant hardier in a wider range of environments. Native species rapidly become genetically specialized to a particular microclimate, so that in as little as one growing season, the same specie of native grass may have two different and mutually exclusive strains growing within a few hundred yards of each other. Albright refers to these strains as ecotypes. He supports the intent of the native seed policy, but not the strict practice of it.

Similar issues apply to varying soil content and type. Wildfires can significantly alter soil chemistry, so proper seed selection necessitates knowledge of each seed's pH tolerance. Seeds that are sensitive to the acidity or basicity of soil may totally fail where they were once the primary ground cover. Coatings and seed treatments can aid in this area as well. Stu Barclay of Seedbiotics has worked on mine reclamation sites where a thin seed coating created a sufficient buffer between the pH-sensitive seed and the acidic soil that the plants established permanently with the same germination rate as on neutral soil.

Sometimes several species share common names and seed suppliers often disagree on the proper common name for individual seed. Since individual areas often buy seed from various suppliers, mistakes involving seed names are relatively common. The seed suppliers contacted during this research urged standardization of ordering according to proper Latin names to avoid such confusion.

Moisture availability is also a primary concern for reseeding. While species may be particularly drought resistant as plants, seeds may be pushed into dormancy by lack of water. If a seed enters a dormancy phase that can be broken only by floodlike conditions, the seed is likely to be worthless for establishing early ground cover. Some seed coating companies also offer treatments to prime the seed, which breaks dormancy for rapid establishment.

Some seed can be coated and aerially distributed much more easily when “cleaned” or deawned, a process by which parts of the seed pod, not necessary for germination, are removed. This can be a problem when distributing uncoated seed because some awns orient the seed in flight, causing it to burrow into the ground on impact. If the bare seed does not enter the ground, germination may suffer. In these situations coating formulations designed to enhance germination may be necessary.

General Seed Distribution Considerations

Many factors could improve revegetation results, including more strict monitoring of helicopter drop performance. Much like airtankers, helicopter seed buckets were designed to apply seed or fertilizer in a consistent line, at a consistent coverage level based on the helicopter’s ground speed and height above ground level. Unlike airtankers, no formal guide exists for determining line width or coverage level with seed buckets. This information could be generated, but the density dependence of line width would make such tables more complicated.

Drop performance could be improved in many cases by establishing more well-defined drop locations and perimeters. Topography can make this difficult, but most reseeding projects begin with Forest Service personnel flying with the pilots and establishing global position system (GPS) coordinates for each site. The simplest improvement would be to establish a northern, southern, eastern, and western border for each site. The helicopter pilot could then fly a grid pattern over the site, making even coverage easier to achieve. This grid should overlap the intended reseeding area; using native seed should prevent any harm from being incurred by dropping material outside the intended reseeding area.

Cost Evaluations

Seed coating could have become an accepted practice for all aerial seeding applications approximately a decade ago when several seed companies demonstrated the technique’s benefits. Native seed can cost 10 to 100 times as much as commonly used nonnative seed. Chuck Cambra described a demonstration at Camp Roberts Military Reservation using ryegrass. While the stands of coated seed established much faster and more vigorously than the stands of uncoated seed, the ryegrass was so inexpensive that coating tripled the seed cost. Native seed mixtures often cost approximately $10 per pound uncoated, so the expected cost of coating, around $1 per pound, is a much lower price to pay for significant stand and germination improvement.

The results of computer modeling suggest that an estimate of $1 per pound for uncoated seed will be too low of a value to significantly improve homogeneity of many dropped mixtures. Doubling original seed weight will not normally be enough to unify density; care must be taken to apply more coating to the less dense seed. A simple formula gives the necessary amount of coating when the coating density and seed density are known. Coating density is readily available from the coating company and determining seed density requires only a scale and a container with a known volume, such as a soda bottle. SDTDC will provide instructions to any interested parties. Once a relationship with a coating company is established, this step would logically become the coating company’s responsibility.

Seed Dynamics, a company specializing in vegetable seed pelletizing, returned samples of test species with satisfactorily uniform density. The coating material used to accomplish this suffered one major drawback. Because the material was less dense than many of the seeds in the test, the dense seeds required weight buildup as high as 34 times the original seed weight. Volume also became an issue. The uncoated seed samples used by the company were shipped in one small box, but the coated samples were returned in nineteen 5-gallon buckets, filling a shipping pallet. All the associated costs of such a process clearly discount it as a reasonable alternative for Forest Service emergency rehabilitation use.

Another company, Harris Moran Seed Company, devised a method for effectively unifying seed densities while minimizing the cost increase and volume buildup. Keith Kubik, Salinas Operations Manager, directed the use of two different coating materials in discrete blends to reduce two seed densities while raising the rest. Weight buildup reached as much as 11:1 on a particularly light and bulky seed, but seed volume remained much lower than that returned by Seed Dynamics. Kubik even packed the coated samples into a box about twice the size of the one used to deliver the samples. Measured densities of the coated seeds varied by less than 20 percent. Uncoated seed density variance topped 400 percent. Depending on type and size of the order, the technique used may be available for roughly $3 per pound of raw seed. The distribution and potential germination benefits available from seed coated in this manner could easily justify the expense in certain situations.

The hydroseeding industry is especially tailored to the sod market. While hydroseeding typically underprices sod, the market for which hydroseeding is suited is the small application market. Many departments of transportation use hydroseeding for roadcut stabilization, but again this represents a small application market. Because aerial reseeding of fire-damaged lands covers vast tracts with a comparatively low seed density, hydroseed to seed ratios are necessarily great. This alone is enough to multiply the cost of the application by large factors even before considering resource cost. Typical seed density specifications call for less than 20 pounds of seed per acre, while hydroseed wood fiber is rarely applied at rates lower than 1,500 pounds per acre. Creating the hydroseed slurry requires an amount of water weighing approximately 20 times as much as the wood fiber. Applying even 1 acre of seed suspended in hydroseed slurry would require a large helicopter or fixed-wing aircraft, while the same aircraft may be able to seed 100 acres with regular seed. Hydroseeding companies show great interest in the project but offered no insight into cost mediation.

Organic mulch pellets are a conceptually attractive option, but the technique suffers from far too many questions to be immediately viable. The current market for the technique is too small to determine an accurate cost estimate for the size associated with a typical reseeding project. The actual distribution vehicle, the mulch pellet, may be envisioned as hydroseed without the water or difficulties in application. In this sense, the pellet contains highly desirable qualities, but the mulch pellet still suffers from the large carrier weight to seed weight discrepancy that afflicts hydroseeding. If the technology associated with the technique advances, the option may become viable in the future.

The organic mulch pellets applied to the Kirk fire rehabilitation areas illustrate the need for cost mitigation before the technique experiences any general use. Of the 306 acres covered in the reseeding test, organic mulch pellets were applied to 33 acres. The total seed weight, after coating, for the other 273 acres was 2,173.2 pounds; the total weight of the pellets provided for the 33 acre test was 7,200 pounds. The cost of coating for the seed supplied to CelPril was approximately $715, which covered 242 acres. The cost of the organic mulch pellets to cover 33 acres was close to $7,000. Perhaps the most costly increase caused by the extra weight of the pellets was in the expected flight time of the helicopter. While only two to three flights were expected to apply the coated seed, approximately seven trips were necessary to drop all the pellets.

Figure 4–Helicopter distributing coated seed after the Kirk Fire, Ventana Wilderness, Los Padres NF.

The adoption of mixing seed bucket standards would definitely be the most cost-effective, long-term solution if even ground distribution could be guaranteed. Some companies offer buckets with such mixing features while others have shown interest in designing buckets to meet requirements. Should a mixing system prove necessary for coated seed mixtures, development of a new type of mixing bucket may be desirable. Coatings suffer no damage from cement mixer-type mixing designs, but auger or paddle mixers can shear off coatings.

Suspension materials offer one clear advantage of effectively suspending the mixture at minimal cost. Unless the suspension can somehow ensure uniform aerodynamic characteristics, the solution does not address the identified problem.

General Recommendations

Considerable disagreement between the parties involved has slowed the evolution of a standard practice for aerial reseeding using native species. Native specie mandates have no bearing on aerial seed application practices, and several individuals interviewed during this market search told stories of early native seed debacles when old reseeding techniques were employed. Those areas where reseeding is most common show the most progress when adopting experience-based methods to achieve the desired distribution. The Boise National Forest provided many of the tips for improving distribution contained in this report. At one time the office experimented with coated seed and saw too little improvement to warrant a change in policy. Those involved with aerial reseeding in the Boise National Forest felt treatments, such as coating, would probably be a waste of money, since they were confident their application method accomplished the goals sought by this market search.

Much of the Boise National Forest's experience with aerial reseeding comes from projects that are implemented over a timescale greater than that available to other projects; for instance, reseeding in the Boise National Forest is sometimes scheduled just after a significant snowfall so seed is sure to remain stationary relative to the ground until snowmelt can ensure rapid germination. Under these circumstances a coating would probably be a waste of money, but snowfall is not available to many of the most vulnerable burn areas in the country. This example highlights the need to evaluate every project on an individual basis.

The exorbitant cost of many native seeds, as compared to that of previously utilized species, calls for special investigation into ways to protect the investment. The available options with coatings should be carefully considered when ordering native seed. If a seed treatment promises 30 to 50 percent stronger germination at a cost of 10 percent seed cost, then money and seed can be saved by using the coating.

Those techniques that improve aerial reseeding with uncoated native seed mixtures, such as those listed in this report, should be immediately shared with all concerned parties. Sharing experience drives progress. When ordering seed, the customer should ask questions. Many species have developed varieties suited for disparate environments. Informed seed companies have this information and are eager to share it. Some seed suppliers, such as Kamprath Seed, regularly work with seed coating companies and can make informed suggestions concerning all types of seed treatments. All factors should be considered and no options ignored.

This report offers recommendations that, when combined with practice and dialogue, could economically solve the observed problems with aerial native seed distribution. Recognizing that each step in the process has the potential to cause poor distribution, each reseeding operation should be handled on an individual basis. Some techniques listed here may be impractical for certain situations but perfect for others. Hydroseeding, for instance, has proved to be an invaluable asset on several mine reclamation projects where many other techniques have failed. The chances that hydroseeding will be economically attractive to a post-wildfire reseeding operation are slim, but the option exists. Similarly, some locations may have a very low native plant diversity and will not encounter difficulties with seed segregation. Each case should be evaluated on an individual basis with priority given to the most effective native plant regeneration at the most reasonable cost.

Suggestions for Further Study

The conclusions reached by this market search should not be interpreted as standard-setting material. The actual research done to verify the various manufacturers' claims is far too incomplete to warrant trust in the methods described. The characteristics of reseeding projects conducted by the Forest Service are unique and will necessitate special consideration by any company that becomes involved in a project. Implementation of any of the options mentioned will require planning before any other reseeding preparations begin. Forest Service personnel will need to learn the requirements of each method for achieving the desired results. While careful implementation can provide the desired benefits, any mistakes or even miscommunications during the planning can be disastrous.

None of the companies offering the techniques described have regularly worked on the short timescales typically demanded by burned area emergency rehabilitation. For this reason, these companies will typically need more advance notice. The seed provider will likewise need to understand the necessity of delivering the seed in a timely manner. Introducing another element into the process demands very careful planning.

Other concerns that should be studied before any formal change in technique is adopted include (a) whether treatments of interest affect animal behavior towards seeds, (b) how coating buildups greater than what is standard affect germination, (c) the claims by companies that certain treatments enhance germination, and (d) whether treatments that claim to offer hydrophilic enhancement actually do.

The preliminary cost analysis presented here represents the greatest shortcoming of this report. All cost estimates are accurate only in magnitude and will fluctuate from project to project. The biggest limiting factor in accurately estimating cost for the proposed methods is the unpredictability of the material requirements from project to project. Effectiveness will likewise hinge on each particular situation. As is the case with current practices of aerial reseeding, the effectiveness of reseeding with seed treated to improve ballistics will depend on effective implementation. The greater number of parties involved with any reseeding effort using treated seed creates more chances for error. The Forest Service could benefit from applying the technology available to treat seeds, but implementation on any level is guaranteed to be a complex task.

References

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California Native Plant Society. 1995. Statement of policy—seeding after wildfire. December.

Knapp, E.E.; Rice, K.J. 1994. Starting from seed: genetic issues in using native grasses for restoration. Restoration and Management Notes. 12: a40-45.

Lesica, P.; Steele, B.M. 1994. Prolonged dormancy in vascular plants and implications for monitoring studies. Natural Areas Journal. 14: 209-212.

Owen, W.R., Forest Botanist, Boise National Forest. (No date). Restlessness among the natives: an essay on the appropriate uses of native plants.

USDA Forest Service. 1994. Policy on the use of native plant material in restoration (and) other revegetation projects. From Ronald E. Stewart, Regional Forester, to Forest Supervisors, Staff Directors and Station Directors, PSW. June.

Appendix A

Seed Coaters/Pelletizers

CelPril Industrial
251 Oak Street
Manteca, CA 95337
(209) 823-1738
Contact: Chuck Loach or John Walsh

Harris Moran
1155A Harkins Road
Salinas, CA 93901
(831) 757-3652
Contact: Gil Markle

Seed Dynamics, Inc.
1081-B Harkins Road
Salinas, CA 93912
(831) 424-1177
Contact: Mel Bachman, Seed Technology Manager

Seedbiotics
818 Paynter Avenue
Caldwell, ID 83605
(800) 764–6639
Contact: Stu Barclay or Bill Talley, Owners

Incotec, Inc.
1293 Harkins Road
Salinas, CA 93901-4495
(831) 757-4367
Contact: Dave Pickenpaugh or Suzanne Emery

Unique Forest Products, Inc.
1535 East Orangewood Avenue, Suite 117
Anaheim, CA 92805
Contact: Stan Raddon, President

Elk Grove Milling
8320 Eschinger Road
Elk Grove, CA 95758-9739
(916) 684-2056
Contact: Robert Lent, Owner

Seed Technologies, Inc.
1315-B Dayton Street
Salinas, CA 93901
(831) 753-2344

Synergene Seed & Technology, Inc.
1147 Madison Lane
Salinas, CA 93907
(800) 352-9987
Contact: Merv Selvidge

Hydroseeding Companies

Tri-State Hydroseeding
P.O. Box 147
Kingston, ID 83839
(208) 784-4202 or (208) 682-3565
Contact: Shane Waechter

Conwed Fibers
1002 Bucks Industrial Park
Statesville, NC 28625
(800) 366-1180
Contact: Ambe Lewis

Quality Hydroseeding and Restoration
2017 Orange Avenue
Ramona, CA 92065
(760) 789-8040

Canfor R&D Center
#101–1750 West 75th Avenue
Vancouver, BC Canada V6P 6G2
(800) 426-6002

Erickson Air Crane Co.
3100 Willow Springs Road
P.O. Box 3247
Central Point, OR 97502
(541) 664-7615
Contact: Jeff Stein

Native Seed Sources

S&S Seed Co.
5690 Casitas Pass Road
Carpenteria, CA 93014-1275
(805) 684-0436

Truax Native Seed Drill Co.
(612) 537-6639
Product: pelletized seed, belly grinders (Drill Seeders)
Contact: Jim Truax

Kamprath Seed Co. LLC
205 Stockton Street.
Manteca, CA 95337
(209) 823-6242 or (800) 466-9959
Contact: Chuck Cambra

Albright Seed Co.
487 Dawson Drive
Bay 5S
Camarillo, CA 93012
Contact: Paul Albright

Granite Seed Co.
1697 West 2100 North
Lehi, UT 84043

Appendix B
Resources

California Department of Conservation
Division of Mines and Geology
P.O. Box 670
Santa Rosa, CA 95402
(707) 576-2275
Contact: Tom Spittler

California Department of Conservation
Division of Mines and Geology
801 K Street
Sacramento, CA 95814
(916) 327-6977
Contact: Trinda Bedrossian

California Fish, Wildlife, and Parks
Region Vegetative Management—Santa Rosa
(707) 576-2275
Contact: Brad Valentine, Kevin Shaffer
California Fish, Wildlife, and Parks
(916) 327-0713

California Native Plant Society
1722 J Street, Suite 17
Sacramento, CA 95814
(510) 649-0460
Contact: Emily Roberson

Civil Engineering Resource Lab
Contact: Dr. Steve Warren
(800) 872-2375, ext. 5455

Franklin, Scott, Consultant
25059 Highspring Avenue
Santa Clarita, CA 92321
(805) 254-2376

Iowa Department of Transportation
Product: helicopters
Contact: Steve Holland
(515) 239-1768

U.S. Department of Agriculture
Natural Resources Conservation Service
Lockeford Plant Materials Center—Pelletized Seed
P.O. Box 68
Lockeford, CA 95237
(209) 727-5319

USDA Forest Service
Coordinator of Burned Area Emergency
Rehabilitative Program
630 Sansome Street
San Francisco, CA 94111
(415) 705-2876
Contact: Robert Griffith