What Will Grow:
Native Grass Research to Assist in Mining Reclamation Projects

Restoring lost rangeland for wildlife and livestock by successfully establishing native plant life on abandoned mine site waste fields through natural re-vegetation programs

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By: Serina Pack of Cliff High School, Cliff, NM

The focus of this project was to conduct extensive research on native grasses that would potentially
grow on abandoned, contaminated mine waste fields in Grant County, New Mexico.

Introduction:
With over 15,000 abandoned mines in New Mexico
ranging from Prospect Holes to mines over 500 feet deep, the
history of New Mexico mining, leaves a significant mark on the
land still today. In Grant County, New Mexico, alone there are
estimated to be over 300 mines. Many of these sites have waste
fields that remain polluted or disturbed in such a way that little to no plant life grows (Fig.1). This
results in notable concerns such as contamination of beryllium, cadmium, lead and zinc. Also, with
mill tailings and mine waste rock, many old mining areas present erosion issues and lost use of
rangeland for wildlife and livestock. Though operational mines today have to adhere to extensive
laws and regulations that were enacted in 1977 and reinforced thereafter in order to protect the
environment, there are many old, abandoned mine waste fields that go unaddressed. With costly soil
reconditioning processes being the standard practice, this research returns to the fundamentals of
matching potential native grasses to the types of contaminated and disturbed soils typically found in
Grant County, NM, to determine if there are other, less costly, natural ways to reclaim the lost
rangeland.

The goal of this research: Restore lost rangeland with palatable, native vegetation for wildlife
and livestock by successfully establishing native grasses on abandoned mine site waste fields through
a natural re-vegetation program. Success of this goal would also improve the watershed and
functional condition of the land by improving hydrological, biotic and ecological processes of the watershed. The overall objective: To find native grasses that potentially will grow in the contaminated, disturbed soils in order to slow erosion, provide palatable foliage and habitat for wildlife and livestock and to restore the land’s condition to support plant life.

Over the past three years, in three phases, secondary and primary research has been conducted in an attempt to achieve this goal and objective. **Phase I** closely examined a wide array of secondary research on range management, soil, native grasses, the region, habitat, and mining. This phase involved the development of a “Weighted Score Grass-Selection Model” that was used to evaluate over sixty native grasses and led to the selection of six native grasses for further study.

**Phase II** involved the actual research of six native grasses in a controlled greenhouse setting through four comprehensive studies, over the course of six months, with over one thousand logged observations and measurements. **Phase III** is “on-location research” and a “semi-controlled outdoor environmental research” project through three additional studies.

**A closer look at each phase of research:**

**Phase I:**
In Phase I, an in depth evaluation of different abandoned mine site locations in Grant County, NM, was conducted. The abandoned Rio Grande Mine site, located near “W” Mountain, north of Silver City, was selected for further study over an additional two year period and is on-going.

(Fig. Set 2.) This location shares a commonality to other mine...
site locations in the region and has two types of common waste fields. One type of waste field is that of a contaminated-disturbed, yellowish soil and the other waste field is that of a contaminated-disturbed greyish soil. The mine site’s waste fields have been void of vegetation for nearly 100 years after its operation in the late 1800’s and early 1900’s for gold and silver.

Phase I involved an extensive search of literature, secondary research and range-land site evaluation. It was conducted to determine potential native grasses that could be matched to ecological site determinants, taking into consideration the harsh soil conditions of the polluted mine site. This included secondary research reviewed and compiled from Department of Agriculture; Bureau of Land Management; New Mexico Energy, Minerals, and Natural Resources Department; and the USDA. Also, secondary research was conducted on the evaluation of the soil and mining situation in Grant County to determine previous, potential, relevant research such as from New Mexico Ecological Soil Management group; Department of Biology Herbarium at Texas A&M; and State Soil Engineering Lab at New Mexico State University.

**Surrounding Site Habitat:**

Surrounding habitat and the environment in the region was evaluated to determine the specific area’s situation.

Common grasses in the region include the grasses of black grama, sideoats grama, bluestem, blue grama, and tobosa. Woody plants and succulents include juniper, mountain mahogany, and some pinon pine.

The mine site research location (Fig. 3) is adjacent to the Gila National Forest, at an elevation of 7000 feet above sea level, identified in EPA Region 6, USDA Climate
Zone 7b and positioned 5.2 miles North of Silver City, New Mexico.

According to the Natural Resources Conservation Service and the Ecological Site Descriptions for New Mexico, this mine site is located in the 38.2 section of the Mogollon Transition (Fig. 4).

**New Mexico Land Resource Description of Site:**

Precipitation in this WP-3 “hill rangeland region” (Fig. 5) is 12 to 16 inches of rain with more than half of the total rainfall occurring during the months of July, August, and September. Slopes range from a low 15% to an extreme high of 75%. The average frost-free period ranges from about 165 to 190 days and extends from approximately the third or fourth week in April to mid-October. Average air temperatures are about 65 degrees F. Summer maximums can exceed 100 degrees F and winter minimums on occasion go below zero. Monthly mean temperatures are 70 degrees F for the period of June through August. “Growing conditions are known to favor warm-season perennial vegetation, although late winter and late summer precipitation is adequate to foster a significant cool-season component for annual forb production, but frequent winds from the west and southwest are common during this time of year and tend to deplete soil moisture at a critical time for growth of these plants” (USDA Ecological Site Description Rangeland Hills R036XC103NM).

Review of literature also included examination of publications on the history of mining in the region to determine potential soil situation/pollutants with a potential of beryllium, cadmium, lead and zinc. Research on proper creation of a greenhouse type-setting, with appropriate grow lights and condition, to construct an appropriate test area.
Soils were collected throughout the course of the study, tested and analyzed. This was accomplished through self-testing kits and also soil samples were submitted to the New Mexico State University Soil Lab. (Fig. Set 6.) The analysis of the soil composition was used to determine potential matches to native grasses and to understand the environmental situation present.

**Types of Soils / Tailings:**

For the two-types of soils prevalent at the mine site, the grey soil texture Sandy-Clay-Loam, has a neutral pH, is Phosphorous deficient, is considered Nitrogen depleted and passed the Potash K test being sufficient.

The yellowish soil is clayey, returned a 6.0 acid rating, is Phosphorous deficient, Nitrogen depleted and sufficient with Potash.

Through the course of Phase I, over sixty native grasses were carefully evaluated as to their potential of being successfully adapted to the disturbed soils of this mine. This work included developing a special “weighted-score model” that analyzed and scored the native grasses on many criteria. Examples of criteria included consideration as to the soil type, sunlight required, moisture rating, climate zone, and specific critical markers such as grasses known to grow in acidic soils or contaminated/disturbed soils. Over sixty grasses were considered for the study. Of the sixty, sixteen grasses were evaluated more extensively. (Fig. 7.) After careful evaluation, with the aide of secondary research of native grasses common in southern United States, six native grasses were selected for experimentation in Phase II. This would be a controlled, greenhouse setting study.
Grasses determined through comprehensive selection process: (Fig. 8.)

- **Western Wheatgrass**—(Pascopyrum smithii), Cool-season, perennial, sod grass, palatable, likes salty challenging soils, great for erosion control with dense, fibrous root system, germination at 66 to 73 degrees with germination not dependent on light.

- **Feathergrass**—(Hesperostipa neomexicana), Cool-season, perennial, noted as extremely tough, likes all kinds of soils (sand, loam, clay, and caliche) and all kinds of sunlight and is matched to pH levels, germination at 68 to 73 degrees with light needed for germination.

- **Prairie Wild Rye Grass**—(Elymus Canadensis) Cool-season perennial, produces quick ground cover, palatable, grows in all types of soils (sand, loam, clay, and caliche) and all types of sunlight, and dry, medium and moist soil moisture situations, and very palatable, 66 to 68 degrees for germination.

- **Curly Mesquite**—(Hilaria belangeri) Warm-season, perennial, sod grass, propagated by seed and sprig, cold stratification is not required for germination, high tolerance to drought and restricted water conditions, noted to grow in difficult growing situations and fits pH levels, grows in loam, clay, caliche and full sunlight, germination 68 to 72 degrees.

- **Sideoats Grama**—(Bouteloua curtipendula) Warm-season, perennial bunch grass, very palatable, grows in all soil types (sand, loam, clay, and caliche), full and partial sunlight and is matched to pH levels, germination 68 to 72 degrees.

- **Sand Lovegrass Grass**—(Eragrostis trichodes), Warm-season (usually 2 weeks earlier than other warm-season grasses), perennial bunchgrass, palatable, grows in all soil types (sand, loam, clay, and caliche), full sunlight, grows in harsh soil conditions with poor drainage and in sandy areas, deep root system, germination 68 to 72 degrees with light needed for germination.
**Phase II:**

The project’s primary research was divided into four green-house studies and completed after Phase I’s secondary research had been conducted. The scope of Phase II’s, four part study, involved more than one thousand recorded observations and the invention of an eco-friendly, coir planting aeration grid. The grasses studied were: Sand Lovegrass, Western Wheatgrass, Feathergrass, Curly Mesquite, Sideoats Grama and Prairie Wild Rye Grass.

**Phase II-Study 1** for each grass specimen selected, grasses were planted in various soils. This included planting seeds in two types of quality potting soil to represent a control group. This also included then working with two different types of soils from the distributed soil of the mine sites (yellowish soil and grayish soil), and planting those collected soil samples with the same grass seeds, each in two versions of each test soil. One soil sample represented the exact soil as collected. The second soil sample was watered with a liquid fertilizer upon initial planting of seeds. Overall, each sample was then observed for 25 days and measured for growth with four total versions of the experiment being undertaken on each type of grass. (Fig. Set 9.)

The green house study was in a controlled environment with 18 hours of lighting per day furnished by three light sources: natural, 6500K and 2700K light. A room temperature of 75 degrees was attempted to be maintained, with a soil temperature that averaged between 65 and 70 degrees, with afternoon natural lighting raising soil temperatures to 75 degrees. Study included regular watering with samples planted in peat moss containers for moisture retention.
Phase II-Study 2 involved conducting a duplicate observation study to determine validity of findings in Study 1. The entire experiment was conducted a second time for another 25 day study to repeat the original study.

After the completion of Study 1 and 2, some issues with the “Yellowish-Soil” were determined. The soil hardened after watering and grasses exhibited difficulty. This potentially was from the hard crust and lack of permeability of soil for additional water and air, once planted. The yellowish soil, with its clay texture, became hydrophobic.

Phase II-Study 3 ensued. This resulted in extensive research on matting and ground-covering possibilities. The purpose of finding and designing a mat or ground covering blanket was to assist in the yellow soil hydrophobic soil situation, provide erosion control, assist with moisture retention, protect the seeds, and to overall promote soil permeability. This led to the creation of a bio-friendly Coir (coconut husk fiber) grid with wood pegs. (Fig Set10.) The coconut fiber matting concept provided a reasonable alternative to other potential mats or ground covering mats. Coir fiber is completely biodegradable, environmentally friendly and offers a more cost-effective, available product over peat moss, which is identified as an evasive plant that is considered a non-renewable resource.

The coir mat, with the special design, incorporates the wood pegs that can serve as anchors and also pierce through the hardened clay surface soil barrier that is present in the yellow soils. Study 3 was conducted in single unit containers with the yellowish soil samples covered with self-designed eco-friendly coir grid. Study 3 also involved a gray soil growth observation study. Overall, the study produced favorable results.
Phase II-Study 4 involved the continuation of Study 1, completing an additional 25 day study, totaling 50 days of observation on the grass study. This study also continued to 75 days.

Overall, extensive research was conducted over 6 months. Research included primary and additional secondary research on both the grasses and the soils. Soil was tested during various times of the project to see if the soil acidic and Ph levels changed, which some improvement was noted.

Results and Discussion of Phase II: Grey soil analysis illustrated a pH neutral level, phosphorus deficient, nitrogen depleted, and potash sufficient soil. The yellow soil analysis produced a pH 6.0 acid rating, phosphorous deficient, nitrogen depleted and potash sufficient soil.

Grayish Soil Phase II--Study 1 and Replication / Validation Phase II--Study 2 produced similar results. Curly Mesquite and Side Oats appear to grow favorably. Western Wheat Grass produced promising results as well. Curley Mesquite and Side Oats appear to be adaptive to the condition of the soil and will be introduced to the mine site in Phase III of this project. Sand Love Grass and Prairie Wild Rye could also represent potential possibilities. In Study 4, Sand Love Grass demonstrated potential long-term acclamation to the soil. (Fig. 11.)

Yellowish Soil Phase II--Study 1 and Replication /Validation Phase II--Study 2 Curly Mesquite and Side Oats produced minimal growth in the yellowish mine site waist soils. Prairie Wild Rye might be best adapted to the soil if started from a sprouted seeding. There was no distinguishable advantage to the use of liquid fertilizer used in the initial watering of the seeds. Overall, the yellowish soil demonstrates the more challenging soil of
the two soil situations prevalent at the mine site. The grasses that did germinate and that had minimal growth appear to struggle, but do show some adaptation ability to the harsh acidic conditions of the poor soil. However, the soil presents several challenges in that it hardens and become almost impermeable to air and water after watering. (Fig. 12.)

**Phase II--Study 3:** With the situation of the yellowish soil becoming encrusted and almost impermeable after watering, hydrophobic, Phase II: Study 3 was undertaken after much additional research on soil permeation and alternative forms of soil conditioning were evaluated. However, a focus on the goal of the project was adhered to which was to find an economically sensible and environmentally friendly approach in finding a solution. This led to the creation of a coir (coconut husk) aeration grid/matt invention to serve as a topical grid placed over the test samples with wood pegs permeating the soil. The overall effect did produce more favorable results for these grasses and should be incorporated into an on-location study. (Fig. 13.)

**Phase II--Study 4:** This study continued observation over 50 to 75 days produced similar results in Study 1 and 2; however, long term observation also shows that Sand Love Grass needs to be researched further, especially in gray soil. The yellow soil is more challenged, with Curley Mesquite showing the most long-term promise.

**Conclusion of Phase II:**

(Fig. Set 14.) Overall the purpose of this Phase was to determine if there were possible grasses that might be able to adapt to mine waste sites if they were to be introduced on location. After
four different studies, on six types of grasses, over six months, all conducted in a controlled greenhouse environment and compared against control groups, the studies for this phase were completed with over one thousand logged observations and measurements. This project produced at least two potential prospect grasses for both the yellowish and grayish contaminated soils. Those identified grasses being Curley Mesquite (Hilaria belangeri) and Side Oats Grama (Bouteloua curtipendula). Sand Love Grass (Eragrostis trichodes) and Prairie Wild Rye (Elymus Canadensis L.) also represent a potential prospect grasses for both soils.

Overall, the yellowish soil demonstrated the most challenges in not only nutrient and contamination condition, but also the hydrophobic situation after watering. With the goal of the project being to find cost-effective ways to introduce plant life, without removing soil or reconditioning soil with heavy fertilizers and treatment options, this soil situation may be able to be addressed with a matting system made of coir fiber that is eco-friendly and cost effective. This design utilizes wood pegs held in place by the coir mesh that could then be easily unrolled over the waste field, after seeding or plugging with grass roots. The coir grid, especially with plugs, would allow for permeation of the soil and also protection of the seeds for germination and retention of moisture. The vision of this environmentally friendly grid would then decompose over time after the grass was established. Further research is needed for refinement and testing on location. Overall, the research produced favorable results (Fig. Set 15.) Phase III then was planned and initiated.
Phase III:

The project’s second-year primary research was divided into an additional three studies. The scope of this phase involved performing mine site on-location research. The project involved the establishment of test plots on location (Fig. 16.) and a semi-controlled outdoor research project. (Fig. Set 17.)

Research was continued on the six native grasses studied in Phase II: Sand Lovegrass (Eragrostis trichodes), Western Wheatgrass (Pascopyrum smithii), Feathergrass (Hesperostipa neomexicana), Curly Mesquite (Hilaria mesquite), Sideoats Grama (Bouteloua curtipendula), and Prairie Wild Rye (Elymus Canadensis L.).

Phase III-Study 1 involved a seed study of forty-eight test plots on location in the greyish and yellow contaminated soils. Phase III-Study 2 involved a live root-plug study of twelve test plots on location. Phase III-Study 3 involved a semi-controlled outdoor study compared against a control set in test trays with a total eighteen plot tray sections.

Phase III--Study 1: In this part, a “Seed Study” was conducted on location with the six prospect grasses (Fig. Set 18).

With an extreme drought, not uncommon in recent years, occurring through spring and early summer, Phase III’s planting ensued in late July when rains finally began. Even
though these grasses represent warm and cool season grasses, because of the moderate climate region and the transitional zone of the region, all grasses were deemed viable for evaluation in the only growing season available for 2011 (Late July through October) where temperatures ranged from 60 degrees at night to 95 degrees in day and 10” of rainfall in three months. Each of the grasses were planted (seeds) in both types of soils found at the Rio Grande mines and in two different locations representing each type of soil (total of four locations at the mine site) (Fig. Set 19.) Selection of test sites took into consideration slope, exposure, purity of plot locations, and general site attributes including security and potential disadvantages.

Forty-eight different plots were designated and established for study in Phase III-Study 1. For the yellowish soil region, two locations were selected (Section I and II). Section I location is located on a flatter part of the tailings, in a fully sunlit portion of the mine site. Section II location is near the edge of a fifty foot decline with a 75% slope, but does have some sheltering protection from nearby trees from wind, potentially driving rains and washout. For the greyish soil region, two locations were also selected (Section III and IV). Section III location is in a fully sunlit portion of the lower tailings, does have exposure to all elements, and is the top edge of a seventy-five foot decline with a 60% slope. Section IV location is in a more protected flattop segment, where there is some protection from wind, potentially driving rains and washing out.
Overall, the forty-eight plots were carefully designed, laid out with flagging, string, stakes, marking, planted and documented in journals and with photography. Soil was only moderately disturbed for planting of seeds, without removal of rocks sediment. Seeds were watered upon planting and watered weekly for two months. Natural rainfall also occurred regularly.

**Phase III--Study 2:** This involved a “Live Grass Root-Plug Study” on location with the six prospect grasses. For each of the grasses being studied, in addition to a seed growth study, a live root-plug study is also underway. Each of the grasses were grown from seed in a “controlled greenhouse setting” and then transplanted on location when grasses reached a minimum height of three inches. Phase III-Study 2 was prepared in coordination of the timing of the planting of the seeds, so that both Phase III-Study 1 and Study 2, could be evaluated against other sites under the same climatic and environmental situations present during late summer-early fall growing season. Twelve test plots were designated for this study, six of which are in the yellowish soil and six of which are in the greyish soil. (Fig. Set. 20.)

**Phase III--Study 3:** This part was for a semi-controlled outdoor study. Due to issues discovered in conducting Phase III Study 1 and 2, it was determined to more adequately be able to analyze the potential success of the any of these prospect grasses, a semi-controlled study needed to be undertaken with the advantage of also being able to conduct a simultaneous control set study with seeds planted in professional potting soil.

In Phase III-Study 1 and 2, there were issues of birds and an ant colony taking seeds, especially birds taking the Curley Mesquite seeds and ants taking the Sand Love Grass seeds. There were also some minor human vandalism/disturbance issues in the mine site region such as with the
stakes of the plot area. However, there did not seem to be disturbance of the actual grass root plug-growth study. Nonetheless, it was determined that in order to gain a more accurate perception of whether the prospect grasses would grow “outdoors,” Phase III-Study was undertaken. The environment had similar lighting, weather, temperatures, and non-sheltered. It was set-up in as close of a similar setting as possible to the actual mine site. The greyish and yellowish soils were collected, transported and placed into trays that were set up on tables at a residence located two miles from the mine site, having only a minimal drop in elevation (7000 feet to 6300 feet). The environmental control factor eliminated the possibility of site vandalism and human, wildlife and insect interference. Another factor was ease of access to watering every three days, instead of once a week to the difficult to access mine site. Trays were exposed to similar rainfall, but had the additional watering, which was deemed appropriate in that a full-scale mining reclamation project could entail regular watering especially in times of drought, which is evident in the region.

Each of the six prospect grasses were planted in plot trays of yellowish soil, greyish soil, and professional potting soil to serve as a control set. This resulted in eighteen plots for study. (Fig. Set 21.)

**Results and Discussion of Phase III:**

**Phase III--Study 1:** This study was a seed study of the six prospect grasses, in two locations of each type of soil situation, promising results were achieved.

Due to issues beyond the control of this experimental design, Section I and II of the yellowish soil area, the seed plot growth does not produce any conclusive results. This is assessed to be because of the ant colony removing seeds from the plot areas and the evidence of birds disturbing
the plots to retrieve seeds. Therefore, an overall analysis of the growth percentage of seeds is difficult to determine for this particular locations. The extenuating environmental situation will need to be addressed for additional study.

The greyish soil Section III and IV seed plots are producing favorable results to Phase II research. Section III still has issues of environmental factors of insects and birds, but not as great as in the yellowish soil plots. Section IV, appears to be located in a place that has not been disturbed by birds and insects. It proves to be the most valuable of the test locations as far as ability to obtain a reasonable analysis of the prospective grasses. All six of the grasses germinated with the most growth evident from Curley Mesquite and Side Oats Grama. (Fig. 22.) Sand Love Grass and Prairie Wild Rye also show much promise, but are taking longer to get established.) Also, noted in Section IV, due to a very hard week of rains in September, some of the plots were affected moderately. Also, stakes were disturbed by human interference.

**Phase III--Study 2:** Each of the grasses were transplanted into the yellowish and greyish soils on location. For the yellowish soil, this represents the best test of adaptability as the live root-plug study and it did not seem to be impacted by birds nor insects. Prairie Wild Rye and Curley Mesquite are showing great promise (Fig Set 23.) In the greyish soil, all six grasses continue to live with evident growth of Curley Mesquite and Sand Love Grass.

**Phase III--Study 3:** The yellowish soil still exhibits the problems of being crusted when watered, thus less penetrable to water and air as the study continues. The greyish soils produced results for all the prospect grasses with all grasses growing favorably. (Fig. 24.) There
was minimal growth from Western Wheat Grass and Feather Grass, which could be due to being considered a more cool-season grass. Best growth was from Curley Mesquite, Sand Love Grass, Side Oats Grama (all warm season grasses) and Prairie Wild Rye (a cool season grass). In should be noted, that the control set produced similar results with Wheat Grass and Feather Grass producing the least results. Consideration is given to time of year, weather, and temperature, but also is compared again Phase II research.

**Conclusion of Phase III:**

Overall, Phase III is producing exciting results showing that in the greyish soils of the mine that a combination of Curley Mesquite, Sand Love Grass, Rye, and Side Oats Grama prospectively represent a blend of grasses that could adapt. Long-term evaluation is ongoing as the grass plots are allowed to mature. Grasses seem to be more successful in the live root-plug studies, than from seed, but environmental factors could be a cause. Yellowish soil plots with grass seeds are non-conclusive both on-location and with the semi-controlled outdoor project. However, yellowish soil plots containing the live root-plug studies show favorable results for Prairie Wild Rye and Curley Mesquite.

Overall findings support findings in Phase II.

During Phase III additional secondary research was conducted along with meeting with professionals in the career fields of mining reclamation, environmental science, and range plant management. Enjoyed were the opportunities to tour local mining reclamation areas and interview professionals. This provided additional insight to reclamation efforts underway in existing mining operations and information about the grasses being studied in this project.
Additional soil testing has been and continues to be conducted to determine if the soil composition is changing with the growth of plant life. Analysis is inconclusive at this time, but additional studies are planned with larger plots being designed with use of coir matting. Additional seeds from the six prospect grasses are being grown in a greenhouse setting to be transplanted on location in the near future.

**Overall Summary:**

The overall goal of this project has been to find an economical, natural way to restore the land, improve the watershed, better the environment, and provide habitat for wildlife and livestock in mining reclamation programs. The Rio Grande Mine, in Grant County, NM, represents an all too common abandoned mine situation in the state of New Mexico, with an area containing soils that have not grown vegetation for nearly one hundred years. The objective of this project was to determine if there were native grasses, common to southwestern United States, that if introduced, either by seeding or by planting live root-plugs, could adapt to the harsh soil situation.

The results of more than two years research conducted through three phases of studies, involving evaluation of sixty native grasses and a specific study of six of those species, has produced favorable results. The six grasses extensively studied included: Sand Lovegrass (Eragrostis trichodes), Western Wheatgrass (Pascopyrum smithii), Feathergrass (Hesperostipa neomexicana), Curly Mesquite (Hilaria mesquite), Sideoats Grama (Bouteloua curtipendula), and Prairie Wild Rye (Elymus Canadensis L.). These grasses were studied in both types of soils found on-location at the Rio Grande Mine: a yellowish soil and a greyish soil. Through comprehensive research studies conducted in a greenhouse setting, a semi-controlled outdoor plot setting and on-location, several thousand logged observations and measurements have been recorded.

The greyish soil has been successful at germinating and/or growing, at least moderately, the grasses of Curley Mesquite, Sand Love Grass, Prairie Wild Rye, and Side Oats Grama. Additional research continues as to determine the most appropriate planting time and how to deal with additional site issues such as slope, weather, human, wildlife and insect interference factors.
The yellowish soil results are not as conclusive and research continues. The live root-plug study conducted on location shows potential for Prairie Wild Rye, Curley Mesquite and Side Oats Grama for this soil type. In Phase II, a coir aeration grid/matt was designed. During the upcoming potential spring planting window of 2012, the self-designed coir matt with wood pegs, used with live-grass-plugs, is being planned.

**Proposed Utilization of Successful Findings:**


**Yellow soil mine’s tailings** – Create a mix of live-root plugs of Curley Mesquite, Prairie Wild Rye and Side Oats Grama. Planted during warm, rainy season beginning in August.

**Time of planting:** During warm, rainy season beginning in August, with recommended weekly watering for two months during establishment due to common drought conditions in region.

**Matting Recommended:** Due to hydrophobic soil situation, especially prevalent in the yellow mine tailings, it is proposed to utilize a coir coconut fiber matting (economical and bio-friendly) anchored with wood pegs and planted with plugs to assist with soil permeability.

**Cost analysis Overview:** 1 acre = 43,560 square feet.

- Grass seed cost: *(source Native Seed Company and Plants of the Southwest)*
  1. **Prairie Wild Rye Grass** – *(Elymus Canadensis)* Planting Rates: 10lb per acre, seed cost of $149.50 per acre
  2. **Curly Mesquite**– *(Hilaria belangeri)* Planting Rates: 2lb per acre, seed cost of $119.20 per acre
  3. **Sideoats Grama**– *(Bouteloua curtipendula)* Planting Rates: 7lb per acre, seed cost $123.97 per acre
  4. **Sand Lovegrass Grass**– *(Eragrostis trichodes)* Planting Rates: 2lb per acre, $33.34 per acre

- Some grass seed companies will provide live root plugs for some species of grasses. Some also accept contracted services. The above pricing was determined for seeds and these seeds would then need to be grown into plugs for best results.
Grey Soil planting cost of seeds: Utilization of four types of grasses (listed above 1-4) Curley Mesquite, Side Oats Grama, Wild Prairie Rye and Sand Love Grass covering one acre total cost of seeds = $106.50

Yellow Soil planting cost of seeds: Utilization of three types of grasses (listed above 1-2-3) covering one acre Curley Mesquite, Side Oats Grama and Wild Prairie Rye covering one acre total cost of seeds = $130.89.

- Additional cost = Coir Fiber Matting Estimated cost per roll may be as great as $250 for 6.5ft x 165ft = 40 rolls needed to cover 1 acre = $10,000.
- If adaption coir matting into a grid with wood pegs, the design might require additional cost of the invention matting

**Future Plans for Research:**

During spring warmer season 2012, plant plugs on location in larger test plots representing a minimum of 30% ground surface of each type of tailings. Grey tailings planted with a mix of live-root plugs of Curley Mesquite, Sand Love Grass, Prairie Wild Rye, and Side Oats Grama with two studies (one with coir matting and one without). Yellow tailings with mix of live-root plugs of Curley Mesquite and Prairie Wild Rye with two studies (one with coir matting and one without). If drought continues, then water regularly while grass is being established.
References

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Western Regional Climate Center, Burro Mountain New Mexico (RAWS), Burro Mountain New Mexico Weather Station
Figure References

Figure 1: Example of typical Grant County abandoned mine tailings and mine waste rock. (Photo Credit: New Mexico Mining Museum.)

Figure Set 2: Photos taken on Location “W” Mountain, Rio Grande abandoned mine site, located in Grant, County, NM. (Photo Credit: Serina Pack photographing on location.)

Figure 3: USDA Ecological Site Description map illustrating mining location

Figure 4: NRCS Mogollon transition map indicating mine site location in the 38-2 sector

Figure 5: New Mexico Major Land Resource and Subresource areas with mine site location identified in section WP-3, Source: Ecological Descriptions for New Mexico, NMSU manual

Figure Set 6: Photos taken of soil testing in-home and at the New Mexico State University State Soil Lab. Photo includes (left to right): Ceci Marquez, Serina Pack, FW Boyle, Jr., Ph.D. (Photo Credit: Sabra Humphrey.)

Figure 7: Photo of selected grass seeds for study. (Photo Credit: Sabra Humphrey.)

Figure 8: Graphic illustration for final 16 grasses considered for study from original 60 and their overall score determined from the “Weight Scale Model.” (Illustration Credit: Serina Pack.)

Figure Set 9: Indoor-greenhouse comprehensive study of six types of grasses, in two versions of the two types of soils found on-location at the Rio Grande Mine, along with two types of control groups. (Photo Credit: Serina Pack.)

Figure Set 10: Coir Aeration Grid invention for addressing yellowish soil issues of lack of permeability. (Photo Credit: Serina Pack and Sabra Humphrey).

Figure 11: Photo taken of greyish soil grass research results. (Photo Credit: Serina Pack.)

Figure 12: Photo taken of yellowish soil grass research results. (Photo Credit: Serina Pack.)

Figure 13: Photo taken of coir aeration grid results over yellowish soil. (Photo Credit: Serina Pack.)

Figure Set 14: Photos taken in conclusion of Phase II. (Photo Credit: Serina Pack.)

Figure Set 15: Additional photos taken in conclusion of Phase II. (Photo Credit: Serina Pack.)

Figure 16: Photo taken on-location for Phase III research. (Photo Credit: Sabra Humphrey.)

Figure Set 17: Photos taken at beginning of outdoor semi-controlled Phase III research. Left-Yellowish Soil-Grass growth Plot, Middle-Control Group Potting Soil-Grass Growth Plot, Right-Greyish Soil-Grass Growth Plot. (Photo Credit: Serina Pack.)

Figure Set 18: Top photo Section I of Yellowish Soil Plot Area. Bottom left photo Section II of Yellowish Soil Plot Area. Bottom right photo Section I of the Greyish Soil Plot Area. (Photo Credit: Serina Pack and Sabra Humphrey.)

Figure Set 19: Top left illustrates several of plots in the yellowish soil. Top right illustrates plot of six sections of study in the yellowish soil Section I. Bottom left of figure set illustrates work being done on yellowish soil Section II. Bottom right of figure set illustrates part if greyish soil Section II. (Photo Credit: Serina Pack and Sabra Humphrey.)
Figure Set 20: Top illustrates live grass study in greyish soil. Bottom illustrated live grass study in yellowish soil. (Photo Credit: Serina Pack.)

Figure 21: Semi-controlled outdoor research study of all prospect grasses in both types of soil compared against control set of grasses in regular potting soil. (Photo Credit: Serina Pack.)

Figure 22: Photo of Curley Mesquite successfully growing from seed in the greyish soil in Section IV. (Photo Credit: Serina Pack.)

Figure Set 23: Photo set of live grass study showing favorable results for Prairie Wild Rye and Curley Mesquite. (Photo Credit: Serina Pack.)

Figure 24: Photo showing growth of Phase III-Study 3 research. (Photo Credit: Sabra Humphrey)

Figure Set 25: Photos of additional research work to understand the environmental situation and mining reclamation. Photo of left of George and Serina Pack on Freeport McMoran Mining Tour of reclamation work. Center photo, group tour of mining reclamation work in Grant County. Right photo of Chino Open Pit mining operations in Grant County, NM. (Photo Credit: Serina Pack and George Pack.)

Figure Set 26: Photos of additional soil testing work. (Photo Credit: Serina Pack.)