FORT DIX RANGE BERM STABILIZATION PROJECT
Planted March 2001

Typical Range Berm – Fort Dix

Range 24- - the fall after planting

Results after four growing seasons

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INTRODUCTION

Fort Dix constructs high berms to serve as backdrops for rifle, pistil, and machine gun practice areas. These berms are made up of sands, or sands and gravels with no topsoil that are difficult to stabilize. They erode to a point where they must be reconstructed. The Fort Dix installation has seeded some of these berms with limited success. In the spring of 2001 Fort Dix contracted with the Natural Resources Conservation Service to develop and test out different methods to stabilize these berms.

Fort Dix is located in the northern end of the Pine Barrens of New Jersey. The Pine Barrens are noted for their sandy infertile acidic soils, where pitch pine, a drought fire tolerant species dominates. This region is characterized by hot summers and cool winters. Though rainfall is evenly distributed throughout the year, summer droughts occur. The combination of hot summers, excessively well drained soils, and summer droughts means that any plants used to stabilize these berms must be drought tolerant. In addition, these range berms contain no topsoil. The original topsoil was lost upon range berm construction, so the berms are purely sands, or sands and gravels.

METHODS

Six treatment methods were developed and tested on three range berms on Fort Dix - Ranges 24, 33 and 86. These three berms were selected due to their different characteristics and that they would not be used for military training during the one month window in mid March to mid April 2001, when the work would be done. The conditions of each Range Berm are described below.

TREATMENT AREAS – i.e. BERMS

Range 24

Range 24 was a small arms range that has been designated as a “green” Range. Lead bullets and fragments were removed from the berm using a sifting operation and an experimental PhytoRemediation process completed in 2000. The berm was reconstructed the fall prior to planting. Only approved “green” bullets may be shot at this range.

This range was chosen because soil lead levels are low. When rebuilding the berm, the contractor scraped sands from below the seasonally high water table. The water seen in the photo is this water. This wetlands dries out in the summer.

RANGE 33

This range is another pistil range, much like Range 24. It is shaped like a long “U”. The photo to the left shows the side berm just prior to planting. A bulldozer smoothed out the gullies in this berm to facilitate planting and to create dozer tracks. These tracks provide mini pockets that trap moisture. These traps give new grass plants moisture to grow. All three ranges were tracked like this. This range gets repeated use by the military.

RANGE 86

This range is not a backdrop into which bullets are fired. Instead, on this range laser guided systems are used from on top, where the truck is parked. The picture was taken prior to the berm being smoothed by a bull dozer. A number of rills and gullies up to 1 foot deep were formed on the side slopes of this berm.

TREATMENT METHODS

Six treatment methods were tried on each of the three range berms. These treatments are described and pictured below.

TREATMENTS

TREATMENT 1

This treatment consists of Cape American Beachgrass alone. Cape American Beachgrass *(Ammophila breviligulata*) is a 1970 release from the USDA Cape May Plant Materials Center (PMC). Beachgrass is native to sand dunes from Maine to North Carolina growing in almost pure stands. Each year 150 to 200 acres of sand dunes are planted to beachgrass to provide flood protection. Beachgrass thrives on the wind blown sands of primary dunes. These dunes tend to increase in height as beachgrass captures sand blown from the beach. This provides flood protection to shore communities. On primary sand dunes, beachgrass lasts 3-5 years before it succumbs to insects and diseases..

Culms were planted at a one foot by one foot spacing, 2 culms per hole. The beachgrass culms were foundation plants obtained from the Cape May PMC.

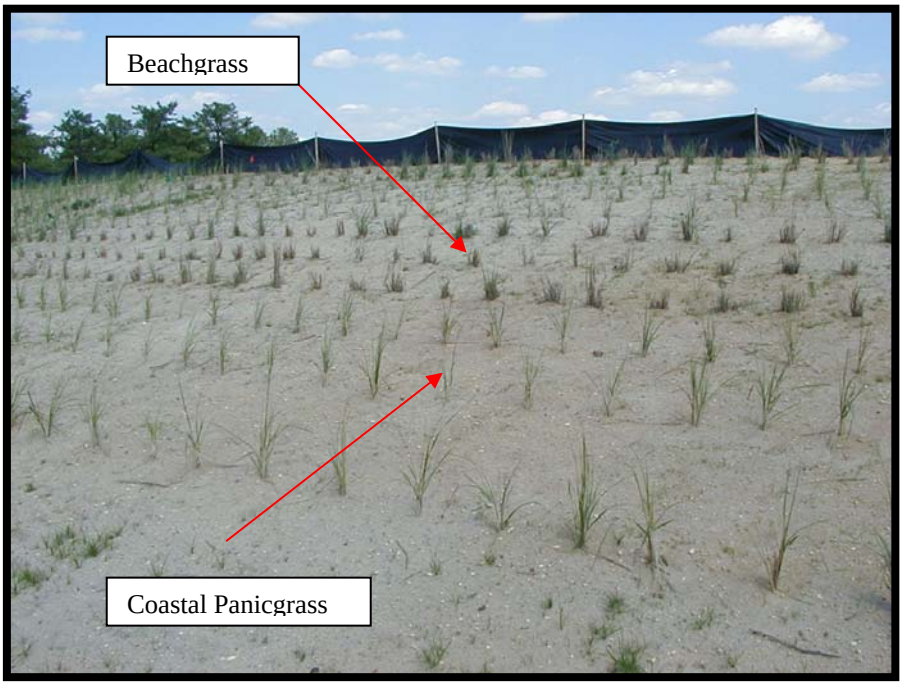
This photo shows treatment one on Range 24 six weeks after planting.

TREATMENT 2

Treatment 2 consists of alternating rows of Coastal Panicgrass *(Panicum amarum var. amarulum*) vegetative plugs and Beachgrass *(Ammophila breviligulata*) culms. (Plant beachgrass at 2 culms per hole.)These rows are 3’ apart. Plants are planted 18” apart in the rows. Entire area is also seeded to a warm season/cool season grass mix, same as treatment 6. The authors hope that rows of beachgrass and panicgrass will provide breaks in the steep slope, thus, reducing erosion. Also, panicgrass, a tall warm season grass, would grow rapidly to a height of two to three feet creating a favorable microclimate for seeded grasses to get a start.

This treatment is identical to Treatment 3 except for the grass seed mix. See Treatment 3 photo below.

TREATMENT 3



Treatment 3 consists of alternating rows of Coastal Panicgrass vegetative plugs and Beachgrass culms. (Plant beachgrass at 2 culms per hole.)These rows are 3’ apart. Plants are planted 18” apart in the rows. Entire area is also seeded to a cool season grass mix, same as treatment 5. Coastal Panicgrass plugs were obtained from the Cape May PMC.

This photo was taken two months after planting on Range 86. The silt fence was placed above the planting to reduce runoff.

TREATMENT 4

In this treatment, Beachgrass culms were planted at a 1.5 foot by 1.5 foot spacing. Entire area is also seeded to a warm season/cool season grass mix, same as treatment 6. (Plant beachgrass at 2 culms per hole.)

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This photo shows treatment 4 on Range 24 two months after planting.

TREATMENT 5

Treatment 5 was seeded to a cool season grass mix of:

SPECIES	RATE
Hard Fescue	50 lbs. /acre
Red Top	2 lbs. /acre
Canada Bluegrass	10 lbs. /acre
Annual Ryegrass	5 lbs. /acre

TREATMENT 6

Treatment 6 was seeded to a warm season/ cool season grass mix of:

SPECIES	RATE
Switchgrass	5 lbs. /acre
Coastal Panicgrass	3 lbs. /acre
Little Bluestem	3 lbs. /acre
Indiangrass	5 lbs. /acre
Hard Fescue	15 lbs. /acre
Red Top	1 lbs. /acre
Annual Ryegrass	5 lbs. /acre

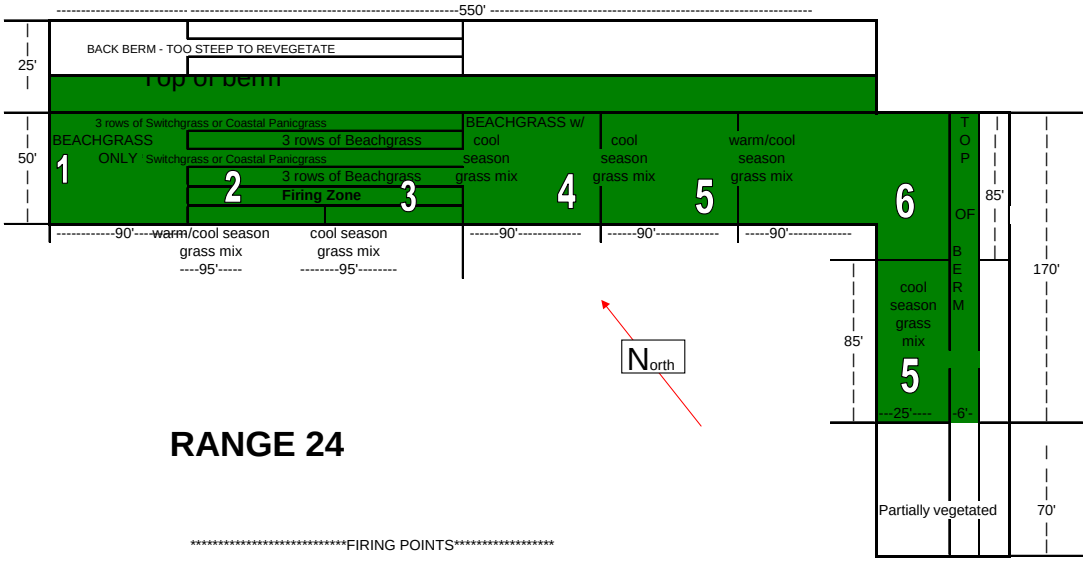
NOTE: Erosion control blankets were proposed for Treatments 5 and 6, though not installed due to funding constraints. All treatments were limed and fertilized according to soil test.

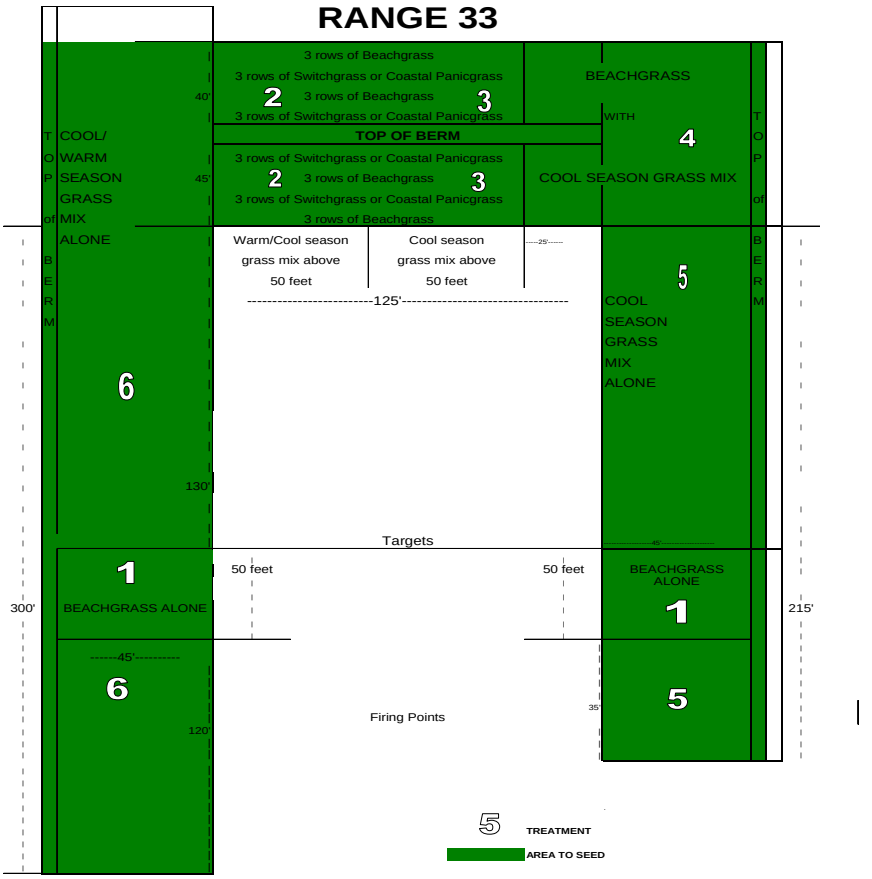
TREATMENT SUMMARIES

TREATMENT	WHAT
1	Beachgrass alone. Culms planted at a one foot by one foot spacing, 2 culms per hole.
2	Alternating rows of Switchgrass or Coastal Panicgrass vegetative plugs and Beachgrass culms. (Plant beachgrass at 2 culms per hole.) These rows are 3' apart. Plants are planted 18" apart in the rows. Entire area is also seeded to a warm and cool season grass mix.
3	Alternating rows of Switchgrass or Coastal Panicgrass vegetative plugs and Beachgrass culms. (Plant beachgrass at 2 culms per hole.)These rows are 3' apart. Plants are planted 18" apart in the rows. Entire area is also seeded to a cool season grass mix.
4	Beachgrass culms planted at a 1.5 foot by 1.5 foot spacing. Entire area is also seeded to a cool season grass mix. (Plant beachgrass at 2 culms per hole.)
5	Entire area is seeded to a cool season grass mix.
6	Entire area is seeded to a warm and cool season grass mix.

TREATMENT LAYOUT

Each treatment was done on each berm one or more times. Treatments 2, 3, and 4 were done on both the front and back side of the berm on Range 33 and 86. This allowed us to observe how the treatments performed on different aspects and with or without a firing zone. These layouts are shown below:

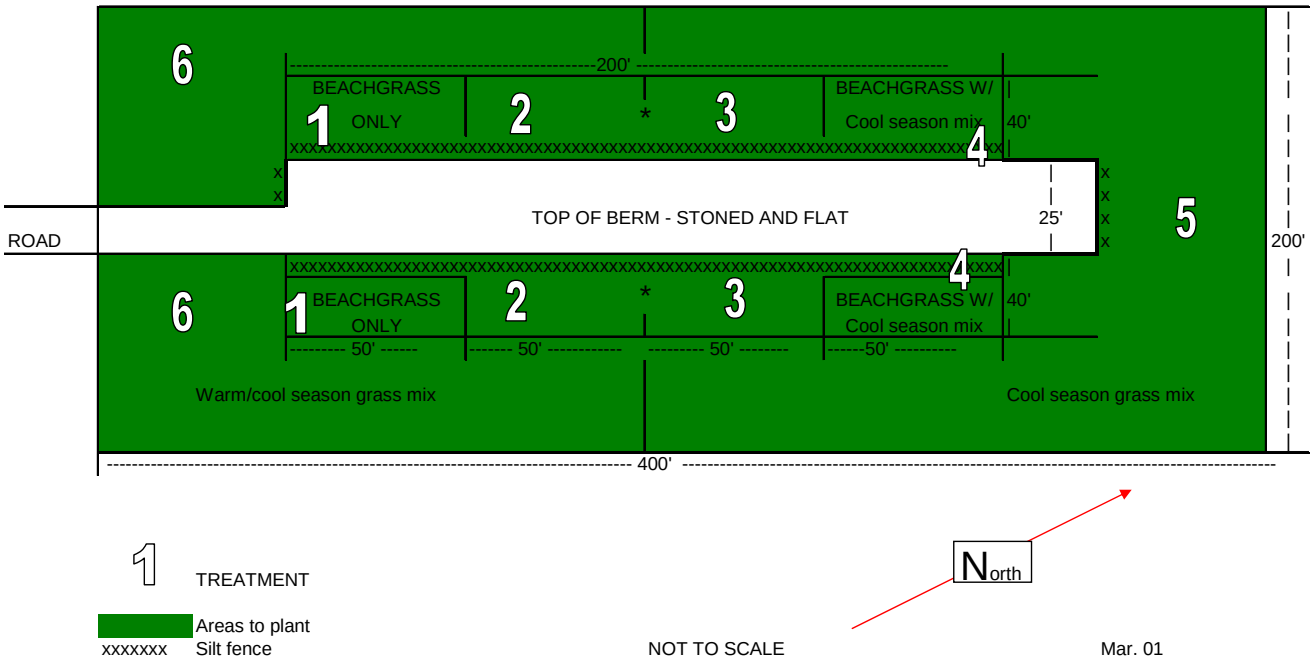




RANGE BERM SOIL STABILIZATION PROJECT

RANGE BERM SOIL STABILIZATION PROJECT

RANGE 86



RESULTS

SOIL LOSS

The main purpose of these trial plantings is to reduce soil erosion on these berms to acceptable limits. Using the Universal Soil Loss Equation[1] soil loss of these berms is estimated by:

BEFORE: Annual Soil Loss/acre = RKLSCP = (200)(.2)(2.6)(.45) (1) = 47 Tons of Soil Loss/acre/ year.

Acceptable Soil Loss on these berms, or the "T" value is determined to be <3 Tons/ac/year. To reach this lower soil loss, the Cover factor (i.e. "C") of 0.45 in the equation above must be reduced to 0.03.

ACCEPTABLE AFTER Annual Soil Loss/acre = RKLSCP = (200)(.2)(2.6)(.03) (1) = 3 Tons of Soil Loss/acre/ year.

A "C" Factor of 0.03 will be reached **when vegetation on the berms covers over 70% of the ground.** Though, reducing soil loss to "T" is the goal, it is valuable to note if and when soil loss on these treatments is significantly reduced. The authors considered a 75% reduction in soil loss to be significant.

The following tables states when each treatment had stabilized it site.

TABLE 1

DATE SIGNIFICANT SOIL LOSS REDUCTION BY TREATMENT

RANGE BERM	TREATMENTS					
	1	2	3	4	5	6
Range 24	6/01	6/01	6/01	6/01	6/01	Failure
Range 33	9/02	9/02 back of berms, front sides failed			Failure	Failure
Range 86	11/01	11/01	11/01	11/01	9/02	9/02

TABLE 2
DATE SOIL STABILIZATION BY TREATMENT

RANGE BERM	TREATMENTS					
	1	2	3	4	5	6
Range 24	8/01	8/01	8/01	8/01	8/01	Failure
Range 33	4/03	9/03 backsides close to 70%, front sides failed			Failure	Failure
Range 86	9/02	9/02	9/02	9/02	Not yet	Not yet

[1] The Universal Soil Loss Equation is detailed in the Ag Handbook 537 Predicting Rainfall Erosion Losses USDA 1978. The newer Revised Universal Soil Loss Equation (RUSLE) was not used for this erosion prediction as RUSLE is more accurate for cropland erosion predictions.

COST CALCULATION

Treatments 1 to 4 used unique methods to stabilize the range berms. These treatments proved successful on Ranges 24 and 86, and moderately successful on Range 33. Cost of these treatments, however, must be considered before recommending these methods for other range berms. Below are actual cost per treatment calculation for comparisons.

TREATMENT 1 - Treatment 1 on Range 24 was used for this calculation. This treatment is 4500 square feet in size.

MATERIALS COST			
Materials	**Quantity**	**Cost/Unit**	**Cost**
Beach grass culms	9000 culms	$ 0.15	$1350
Lime	400 lbs	$5/50 lb. bag	$40
Fertilizer	50 lbs	$10/40 lb. Bag	$12
TOTAL MATERIAL COST			**$1402**
LABOR COST			
ACTIVITIES		**COST**	
• **Lime, Fertilize, and rake in materials** • **Plant Culms**		**$972**[2]	

TOTAL COST = $2374 PER 4500SF OR $53/100 SF

TREATMENT 2 - Treatment 2 on Range 24 was used for this calculation. This treatment is 4750 square feet in size.

MATERIALS COST			
Materials	**Quantity**	**Cost/Unit**	**Cost**
Beach grass culms	760 culms	$ 0.15	$114
Coastal Panicgrass plants	380 plants	$7	$2660
Warm season grass seed	2 lbs.	$25/lb.	$50
Cool season grass seed	2 lbs.	$2/lb	$4
Lime	400 lbs	$5/50 lb. bag	$40
Fertilizer	50 lbs	$10/40 lb. Bag	$12
TOTAL MATERIAL COST			**$2880**
LABOR COST			
ACTIVITIES		**COST**	
• **Lime, Fertilize, seed and rake in materials** • **Plant Culms and live plants**		**$728**	

TOTAL COST = $3608 PER 4750 SF OR $76/100 SF

[2] Labor cost per treatment were determined by dividing total labor cost for Range 24 by the proportion of time the labor crew spent on each particular treatment. For example, 20% of the labor time was spent on treatment 2. The total labor cost for Range Berm 24 was $3640. Thus, $729 was the labor cost for this treatment. ($3640 X 0.2 = $728)

TREATMENT 3 - Treatment 3 on Range 24 was used for this calculation. This treatment is 4500 square feet in size.

MATERIALS COST			
Materials	**Quantity**	**Cost/Unit**	**Cost**
Beach grass culms	760 culms	$ 0.15	$114
Coastal Panicgrass plants	380 plants	$7 each	$2660
Cool Season Grass seed	7 lbs.	$2/lb	$14
Lime	400 lbs	$5/50 lb. bag	$40
Fertilizer	50 lbs	$10/40 lb. Bag	$12
TOTAL MATERIAL COST			**$2840**
LABOR COST			

ACTIVITIES	COST
• **Lime, Fertilize, seed and rake in materials** • **Plant Culms and live plants**	**$728**

TOTAL COST = $3568 PER 4750 SF OR $75/100 SF

TREATMENT 4 - Treatment 4 on Range 24 was used for this calculation. This treatment is 4500 square feet in size.

MATERIALS COST			
Materials	**Quantity**	**Cost/Unit**	**Cost**
Beach grass culms	4000 culms	$ 0.15	$600
Cool season grass seed	7 lbs.	$2/lb	$14
Lime	400 lbs	$5/50 lb. bag	$40
Fertilizer	50 lbs	$10/40 lb. Bag	$12
TOTAL MATERIAL COST			**$666**
LABOR COST			

ACTIVITIES	COST
• **Lime, Fertilize, seed and rake in materials** • **Plant Culms**	**$728**

TOTAL COST = $1394 PER 4500 SF OR $31/100 SF

TREATMENT 5 - Treatment 5 on Range 24 was used for this calculation. This treatment is 7135 square feet in size. NOTE: This treatment was marginally successful on the flatter slopes, where the phytoremediated soil placed. This treatment failed on the original berm soil.

MATERIALS COST			
Materials	**Quantity**	**Cost/Unit**	**Cost**
Cool season grass seed	11 lbs.	$2/lb	$22
Lime	650 lbs	$5/50 lb. bag	$65
Fertilizer	80 lbs	$10/40 lb. Bag	$20
TOTAL MATERIAL COST			**$107**
LABOR COST			
ACTIVITIES		**COST**	
Lime, Fertilize, seed and rake in materials		**$243**	
LABOR & MATERIAL COSTS for Erosion Control blanket (not installed)			
COST/UNIT		**COST**	
$2.75/SY		**$ 2180**	

TOTAL ACTUAL COST = $350 PER 7135 SF OR $5/100SF
TOTAL PROPOSED COST = $2530 PER 7135 SF OR $35/100 SF

TREATMENT 6 - Treatment 6 on Range 24 was used for this calculation. This treatment is 7135 square feet in size. NOTE: This treatment was marginally successful on the flatter slopes, where the phytoremediated soil was placed. This treatment failed on the original berm soil.

MATERIALS COST			
Materials	**Quantity**	**Cost/Unit**	**Cost**
Cool season grass seed	11 lbs.	$2/lb	$22
Warm season grass seed	6 lbs.	$25/lb.	$150
Lime	650 lbs	$5/50 lb. bag	$ 65
Fertilizer	80 lbs	$10/40 lb. Bag	$20
TOTAL MATERIAL COST			**$257**
LABOR COST			
ACTIVITIES		**COST**	
Lime, Fertilize, seed and rake in materials		**$243**	
LABOR & MATERIAL COSTS for Erosion Control blanket (not installed)			
COST/UNIT		**COST**	
$2.75/SY[3]		**$2180**	

TOTAL ACTUAL COST = $500 PER 7135 SF OR $7/100SF
TOTAL PROPOSED COST = $2680 PER 7135 SF OR $38/100 SF

[3] From USDA NRCS 2004 cost table

COST SUMMARY

The costs per treatment are given below in the table. The first four treatments have been successful on Range 24 and Range 86.

TREATMENT	COST/100 SF	COST/ACRE[4]
1	**$53**	**$23,100**
2	**$76**	**$33,100**
3	**$75**	**$32,700**
4	**$31**	**$13,500**
5	**$35**[5]	**$15,200**
6	**$38**[4]	**$16,600**

[4] Cost estimates rounded to the nearest $100. The author feels that these costs will be less if these techniques done again due to economies of scale, the learning curve, and improved technologies.

[5] These costs included the cost of installing erosion control blankets, which were not done in the trial. Consequently, these treatments were not successful.

DISCUSSION

SOIL LOSS

After 3 and a half growing seasons, we observed a number of factors that did or did not appear to have an impact on stabilizing the soil on these range berms. These observations are discussed below.

All treatments grew best and were stabilized quickest on the phytoremediated Range 24. This range was constructed from berm soils silted for lead and phytoremediated to remove additional lead. At first glance the reduced amount of lead on this berm might explain this response, but Range 86 never had lead bullets shot into it. Soil test performed on these berms confirmed that lead amounts cannot explain why vegetation grew better on Range 24. Range 86 and the side berms of range 33 had less lead in it than Range 24. What does appear to have helped Range 24 is the creation of soil organic matter as a result of the phytoremediation of the soil. Soil test done for Edenspace, the consulting firm doing the phytoremdiation on this berm, showed soil organic matter contents of 0.5 to 1.5%..

Range 24 August 2001,
Treatment 1 lower left,
Treatments 2 & 3 in middle

Bullets firing at these ranges destroyed the new seedings. We don't expect this to surprise anyone. But this is why all treatments on the front berm of Range 33 were failures. This Range gets repeated use and it was observed that there was less vegetation to the left, which get more use that the right side. The back side of this berm was moderately successful, which was protected from the bullets. Range 24 has had little use now that it is a "green" range. (i.e. no lead bullets may be fired here.) The berm on Range 86 is used to fire from and not as a backstop as is the case for Ranges 24 and 33.

Beachgrass culms grow well on the berms. Close to 90% of the beachgrass planted survived on all three treatments, where bullets did not destroy them. These berms are much like the sand dunes where beachgrass thrives. Sand dunes are basically 100% sands with little or no organic matter and no soil development, which can also be said about the berms. After the second growing season, beachgrass also provided excellent soil erosion control by the leaf residue from past years. Beachgrass on sand dunes lasts three to five years before dying due to insects or diseases. The authors expect the beachgrass to die out in time, here also. At that time native warm season grasses should colonize the berms.

Beachgrass alone, Treatment 1, Range 24, August 2001

Treatments 5 and 6, conventional seeding methods, failed in this trial. Without erosion control blankets to protect the slopes from erosion and provide moisture retention, grass seeds that germinated were washed away or died due to drought. These treatments should be attempted again using erosion control blankets

Seeded grasses were only moderately successful in the treatments they were used. (Treatment 1 to 4). After three and a half growing seasons, seeded warm season grasses cover 5 to 10% of the surface of these treatments. The cool season grasses cover a greater percentage of the treatments, but most of these plants are only 3 to 4 inches tall with bare spots between plants. These berms have not been limed or fertilized since planting. Fort Dix will fertilize these berms later this year. This may give these grasses a boost.

COST COMPARISON

Treatment 4 is the least costly, successful treatment. Treatments 1 and 4, which mainly used beachgrass, were successful, less costly treatments that treatments 2 and 3. These treatments used dormant plants of coastal panicgrass that increased the cost tremendously. The panicgrass did grow vigorously on all three range berms and reached heights of five feet. Its additional cost, though, is not justified in the numbers used in these treatments. Instead, a few plugs of warm season grasses such as coastal panicgrass, switchgrass, or bluestems, can be planted with the beachgrass to provide biodiversity and additional seed sources.

Beachgrass does not last forever on dunes, so we believe that these plants will in the next five to ten years start dying out. We will need to continue to observe these treatments on these range berms to see whether naturally occurring grasses and forbs seed here and maintain the stability of the berms.

CONCLUSIONS

- **The best stabilization occurred where beachgrass culms were used singly or with vegetative plugs of Coastal Panicgrass**. The cost is considerably more, though, for vegetative plugs, so these plants should be incorporated sparingly into future planting to provide for biodiversity and additional seed source.

- **We should monitor the beachgrass to see whether native warm season grasses will colonize these berms and provide for long term stabilization.** Since the beachgrass should not last over ten years on these sites, it is important to see what happens as the beachgrass dies out.

- **Try again standard grass seeding techniques on critical sites**. Treatments 5 and 6 were seeded with warm and or cool season grasses but were not covered with erosion control blankets. A cover of erosion control blankets would have prevented erosion during the establishment period and retained moisture for the new grass seedlings. With the protection of the erosion control blankets, these treatments may have done well. The cost of these treatments is less than treatment 1 but slightly more than treatment 4.