Colorado Division of Parks and Wildlife
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WILDLIFE RESEARCH REPORT

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ABSTRACT

Rangeland restoration often fails due to inadequate moisture to support germination, overwhelming competition from non-native annuals, or both. Two techniques which have helped ameliorate these difficulties in a prior CPW study are the use of a roughened, or pothole, surface, and addition of super-absorbent polymer (SAP) to the soil. Both of these techniques have been helpful, when used alone, in restoring well pad disturbances in northwestern Colorado under pressure from the non-native cheatgrass (*Bromus tectorum* L.). In this study, these two techniques are combined in the restoration of previously undisturbed rangeland which is heavily invaded by cheatgrass. The study site is within Horsethief State Wildlife Area near Fruita, Colorado. To prepare the site, scattered sparse greasewood plants were cut with a brush hog and the entire area was sprayed with 70 g ai/ha (4 oz/acre) of imazapic herbicide. A new implement, called a pothole seeder, was developed in order to make the creation of the potholed surface more efficient. Four polygons, totaling 6.7 acres, were treated with the pothole seeder in November, 2012. Two of these polygons received granulated SAP, which was applied at 300 lbs/ac by mixing the granules with the seed and broadcasting over the potholed surface. A custom-built chain drag trailer was used to cover the seed and polymer. In 2013 and 2014, seedling counts and soil moisture data were collected, and 2013 data were analyzed for this report. In 2013, virtually no cheatgrass was detected in treatment areas, and little established offplot, likely due to unusual weather patterns. SAP crystal density correlated with perennial seedling density in early 2013, but by September 2013, most seedlings had died and no correlation with SAP was evident. SAP improved soil moisture in July 2013, the month with lowest average soil moisture. Visual inspection of treatment plots in 2014 showed that some perennial plants had survived, and treatment areas continued to have lower cheatgrass cover than untreated areas. In 2015 and 2016, cover data will be assessed annually.

WILDLIFE RESEARCH REPORT

RANGELAND RESTORATION WITH SUPER-ABSORBENT POLYMER AND POTHOLE SURFACE AT HORSETHIEF STATE WILDLIFE AREA

DANIELLE B. JOHNSTON

PROJECT OBJECTIVES

1. Develop an implement (called a 'pothole seeder') which can quickly and efficiently create a roughened soil surface of large mounds and holes.
2. Using the pothole seeder, treat a several-acre area which can be conveniently viewed by those interested seeing results of the technique.
3. Examine the effectiveness of pothole seeding in combination with a light herbicide application for restoration of a degraded, cheatgrass-invaded rangeland.
4. Compare the results of restoration when pothole seeding is done with vs. without application of granulated super-absorbent polymer (SAP).

SEGMENT OBJECTIVES

1. Analyze seedling density, SAP crystal count, and soil moisture data from 2013.
2. Monitor seedling density and soil moisture in study plots during 2014 growing season.

INTRODUCTION

In the CPW study 'Restoring Energy Fields for Wildlife', two techniques which improved restoration were the creation of a rough, or potholed soil surface, and addition of super-absorbent polymer (SAP) to the soil (Johnston 2012). Both of these techniques were helpful in establishing desirable perennial vegetation while under competition from cheatgrass (*Bromus tectorum* L.). The potholed soil surface reduced cheatgrass cover about 7-fold at a site with low cheatgrass propagule pressure, and also reduced cheatgrass biomass, when in combination with imazapic herbicide (Plateau ®, BASF corporation), at a site with high cheatgrass propagule pressure. The mechanism is not entirely known, but it is possible that potholes trap seeds in areas where soil moisture is concentrated, and that cheatgrass seeds are less competitive in that environment. SAP reduced cheatgrass cover 2-4 fold at two different sites over a two year time span. It is thought that SAPs reduce the competitive ability of cheatgrass by extending the period of time soils are moist, as cheatgrass is more competitive when soil moisture is more variable (Chambers et al 2007).

In the prior study, these techniques were explored in independent experiments, on simulated well pad disturbances, and in the absence of herbivory from livestock or wildlife. The focus of this study is to explore how these techniques perform when combined with one another, when applied to a previously undisturbed rangeland, and when exposed to herbivory by wildlife. This study also focuses on how to apply these techniques at a scale more meaningful to rangeland restoration than the prior study, which utilized small research plots.

STUDY AREA

The study was implemented on four polygons totaling 6.7 acres (2.7 ha) at Horsethief State Wildlife Area (SWA) near Fruita, CO (Figure 1). The area was ideal for this study because it possessed several acres of level ground with complete or near-complete domination by cheatgrass, and easy access for equipment and for those who might wish to view the project in the future. The region is arid, receiving about 9 inches (230 mm) of precipitation per year, with about half falling during the growing season of April through September (NOAA Fruita CO US weather station records, 1990-2011). Common vegetation includes cheatgrass, Sandberg's bluegrass (*Poa secunda*), needle-and-thread (*Hesperostipa comata*), greasewood (*Sarcobatus vermiculatus*), Wyoming big sagebrush (*Artemisia tridentata* spp. *Wyomingensis*), Russian thistle (*Salsola tragus*), halogeton (*Halogeton glomeratus*), plains pricklypear (*Opuntia polycantha*), sego lily (*Calochortus nuttalli*), and yellow rabbitbrush (*Chrysothamnus viscidiflorus*). Soils are sandy, derived from Wingate sandstone.

METHODS

Equipment development. In the prior study, the 'rough' soil surface was created with a mini-excavator. Each hole was dug individually with the backhoe, and the process was expensive and time-consuming. To apply a similar treatment on a larger scale, a more efficient process was needed. This required building a new piece of machinery, which was done through a collaborative effort between Colorado Parks and Wildlife and WPX Energy. The 'pothole seeder' was constructed of a Land Pride DH2596 disk harrow (Land Pride, Salina, KS, USA) with custom 28-inch (71 cm) disks, a Herd 2440 broadcast seeder (Kasco manufacturing Co, Inc., Shelbyville, IN) and a custom-built chain drag trailer (Figure 2). The front gang of disks was removed from the cultivator, and every other disk was removed from the rear gang. The remaining disks were deeply notched with two large notches. Notches of adjacent disks were offset by 90 degrees, so that when an un-notched portion of one disk contacted the ground, and thereby would dig, the adjacent disk's notched portion would contact the ground, and thereby would not dig (Figure 3). As a result, the machine produced a checkerboard pattern of mounds and holes when dragged over the ground (Figure 4). The holes were approximately 30 cm deep, as measured from the bottom of a hole to the top of an adjacent mound. The broadcast seeder was mounted to the rear portion of the cultivator, and a shroud was built to help contain the broadcast seed to within the strip of ground prepared by the notched disks. The chain drag trailer helped to incorporate seed over the potholed surface. Welding and structural engineering were completed by Roustabout Specialties of Grand Junction, Colorado. Funding was provided by WPX Energy, and Rob Raley of WPX Energy contributed to the design. The pothole seeder requires at least a 75 HP tractor with 4WD.

Site preparation. Scattered sparse greasewood plants were cut with a brush hog prior to treatment implementation. All four polygons were sprayed with 70 g ai/ha (4 oz/acre) of Plateau ™ (ammonium salt of imazapic, BASF Corporation, Research Triangle Park, NC, *hereafter* Plateau) and 50 gal/acre of water using a 7-nozzle boom tow sprayer on 8/28, or 8/29, 2012. At the time of application, no emerging cheatgrass was visible.

Treatment. Polygons were potholed and seeded in a single pass of the pothole seeder on 11/5, and 11/6, 2012. The seed mix in Table 1 was used. Potholing and seeding was done at a rate of 3 mph (5 kph), and about 2 acres (0.8 ha) could be treated per hour.

Two of the four polygons were randomly selected to receive SAP. In these polygons, Tramfloc® 1004 granulated polymer (a cross-linked copolymer of acrylamide and potassium acrylate; Tramfloc®, Inc, Tempe, AZ, USA) was added at 300 lbs/acre (270 kg/ha). The product was mixed directly into the broadcast seeder along with the seed, and the seeder was recalibrated to accommodate the SAP's additional volume. Tramfloc 1004 has an average 4 mm grain size, and this large grain size allowed the dense polymer to remain in suspension with the seed. Periodic checks of the hopper during seeding showed that the polymer remained in suspension well. However, the flow rate of both seed and SAP declined as the hopper emptied, which resulted in some variation in both seeding rate and SAP application rate.

Responses measured. We set up plots in spatially balanced, random locations within each polygon for assessment of responses. Most polygons received five plots, but the small size of polygon 4 would only accommodate three plots. In addition, three plots were chosen in each of two untreated polygons in order to gather reference data. Plots are circular with a radius of 8m.

At each plot, we measured soil moisture monthly from March-September, 2013 and April-August 2014. Soil moisture measurements were stratified by mounds vs. holes, with five measurements taken in each category in each plot. Soil moisture readings were taken to 12 cm using a Hydro Sense® Soil Water Measurement System (Campbell Scientific, Inc, Logan, Utah).

Seedling counts were also conducted at each plot, in June 2013, September 2013, May 2014, and August 2014, on eight 0.5 m by 1.0 m miniplots per plot. These were arrayed along the cardinal axes of each plot, with two miniplots per axis, with one 3 m and one 6 m from the plot center. The placement of miniplots was random with respect to the presence of mounds and holes. Seedlings were identified to species where possible. Plants which were obviously survivors of the treatment implementation were not counted as seedlings. In 2014 only, seedling counts were also made in 6 offplot locations, 3 in each of 2 offplot polygons.

On May 21, 2013, counts of SAP crystals were made for five randomly chosen holes per plot in the two polygons which received SAP. This was data was collected because some SAP had extruded from the soil surface, and it was apparent that the SAP application was not even across the polygons. An SAP density variable was calculated from these counts by assuming a hole area of 0.3 m^2.

Data analysis. Only data from 2013 were analyzed for this report. Seedling counts per square meter and soil moisture data were averaged to the plot level. A linear mixed model was used to analyze responses to SAP application, with polygon included as a random effect. This allows 'polygon' to act as a grouping factor which accounts for the non-independence of plots within polygons (Bates 2005).

For seedling counts, fixed effects were SAP, date, and their interaction. All perennial species were grouped. Two models were initially considered, one which considered SAP treatment as a categorical variable, and another which considered SAP crystal counts as a continuous variable. The model using the SAP crystal counts had a lower AIC value, and that model is presented here.

For soil moisture, fixed effects were SAP, date, location type (mound or hole) and all possible interactions.

Means are presented ± standard errors.

RESULTS

In 2013, 92% of all seedlings detected on study plots were perennial grasses. No cheatgrass was detected. Throughout the region, cheatgrass cover appeared to be lower than in prior years, likely because of an unusually dry winter and spring in 2012 which limited cheatgrass growth.

The effect of SAP crystal density depended on date ($p = 0.0001$). On 11 June 2013, seedling density increased with SAP crystal density ($p = 0.0001$; Figure 5). On 11 September 2013, there was no correlation ($p = 0.34$). Seedling density dropped from 0.52 ± 0.12 in seedlings/m^2 in June to 0.01 ± 0.01 seedlings/m^2 in September.

Date, location type (mound or hole), and their interaction had strong effects on soil moisture ($p < 0.0002$). SAP treatment also influenced soil moisture, but the effect was dependent on date (interaction $p = 0.02$). Soil moisture was low throughout most of the growing season, averaging only 4-6% in the spring months and dropping to 0-1% in the summer months, before increasing to 19% in September

(Figure 6). Holes averaged 3.6 ± 0.2% higher soil moisture than mounds, and holes were wetter than mounds on every date measured ($p < 0.006$), although the effect in the driest months was smaller than in wetter months. SAP had a statistically significant effect on soil moisture only on the driest month measured, July, where it increased soil moisture by 1.1 ± 0.3%, although a trend for higher moisture with SAP treatment was evident each month measured (Figure 6).

DISCUSSION

Unusual weather patterns prior to and during the first post-treatment year led to very little cheatgrass cover in undisturbed locations in 2013, and virtually no cheatgrass where treatments had been implemented. In 2013, perennial seedlings established within treatments, but many seedlings had died by the end of the summer, following a period of extremely dry soils. The SAP treatment increased soil moisture during this driest period of the summer, and there was a correlation between density of SAP crystals applied and the number of seedlings in early summer. However, by the end of the summer, seedling density was very low and no effect of SAP was apparent. Also, because SAP and seed were applied at the same time, it is possible that the correlation between SAP crystal density and seedling density is due to a heavier seeding rate where more SAP was applied.

2014 data was not analyzed for this report, but upon site visits, cheatgrass cover and tall tumble mustard cover appeared to be much lower in treatment plots than offplot. Some perennial species had become fully established on treatment plots, especially yarrow. An effect of SAP treatment was not apparent to the eye, but the pothole seeding treatment appeared successful in comparison to untreated areas (Figures 7 and 8).

The pothole seeder was effective at producing a similar soil surface to that previously achieved with a mini-excavator, and the process was much more efficient. The broadcast seeder worked well, although about 30% of seed was not broadcast over the potholed surface, as the shroud which was designed to constrain the seed was not completely effective. Making the shroud larger is not practical, as that would interfere with the turning of the machine. Most of the seed which missed the shroud was cast to the left-hand side. Applying the treatment in a clockwise fashion within a polygon is a practical solution, since this would allow the seed which missed the shroud to be covered over in the next pass of the machine.

The SAP used had a 4mm granule size, and when it absorbed water, the particles swelled to about 2 cm in size. This large size caused much of the product to extrude from the soil surface, indicating that the degree of soil covering provided by the chain drag was inadequate to keep the product incorporated into the soil. SAPs degrade when exposed to light, so the effectiveness of the SAP application may be compromised. Even so, in late August, 2013, nearly a year after application, the product was still evident within potholes.

In 2015, cover data will be assessed in July on both treatment plots and offplot locations. Data from 2014 will be synthesized with that from 2013. We plan to continue monitoring cover data in 2016.

LITERATURE CITED

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Johnston, D. B. 2012. Restoring energy fields for wildlife. Colorado Parks and Wildlife annual research report, Avian research program. http://wildlife.state.co.us/SiteCollectionDocuments/DOW/Research/Habitat/RestoringEnergyFieldsforWildlife2011AnnualReport.pdf.

Table 1. Seed mix.

Type	**common name**	**Genus**	**Species**	**Seeds/ m^2**	**PLS/ acre**
forb	Western yarrow	*Achillea*	*millefolium*	30	0.04
bunchgrass	Indian ricegrass	*Achnatherum*	*hymenoides*	60	1.67
shrub	Wyoming Sagebrush	*Artemisia*	*tridentata*	120	0.32
shrub	Fourwing saltbush	*Atriplex*	*canescens*	40	5.89
bunchgrass	Blue Gramma	*Bouteloua*	*gracilis*	100	0.56
shrub	yellow rabbitbrush	*Chrysothamnus*	*viscidiflorus*	50	0.31
bunchgrass	bottlebrush squirreltail	*Elymus*	*elymoides*	60	1.26
bunchgrass	Streambank wheatgrass	*Elymus*	*lanceolatus ssp. psammophilus*	40	0.95
bunchgrass	slender wheatgrass	*Elymus*	*trachycalus*	40	1.22
rhizomatous grass	Thickspike wheatgrass	*Elymus*	*lanceolatus ssp. lanceolatus*	50	1.30
shrub	rubber rabbitbrush	*Ericameria*	*nauseosa*	60	0.40
forb	Aspen fleabane	*Erigeron*	*speciosus*	50	0.13
forb	Sulfur-flower buckwheat	*Eriogonum*	*umbellatum*	23	0.45
forb	Utah sweetvetch	*Hedysarum*	*boreale*	15	1.81
bunchgrass	needle and thread	*Hesperostipa*	*commata*	30	1.06
shrub	winterfat	*Krascheninnikovia*	*lanata*	10	0.36
forb	Lewis flax	*Linum*	*lewsii*	40	0.54
rhizomatous grass	western wheatgrass	*Pascopyrum*	*smithii*	30	1.07
forb	Dusty Penstemon	*Penstemon*	*comarrhenus*	90	0.61
forb	Palmer penstemon	*pestemon*	*palmeri*	60	0.40
bunchgrass	Sandberg Bluegrass	*Poa*	*sandbergii*	60	0.26
bunchgrass	bluebunch wheatgrass	*Pseudoroegneria*	*spicata*	60	1.73

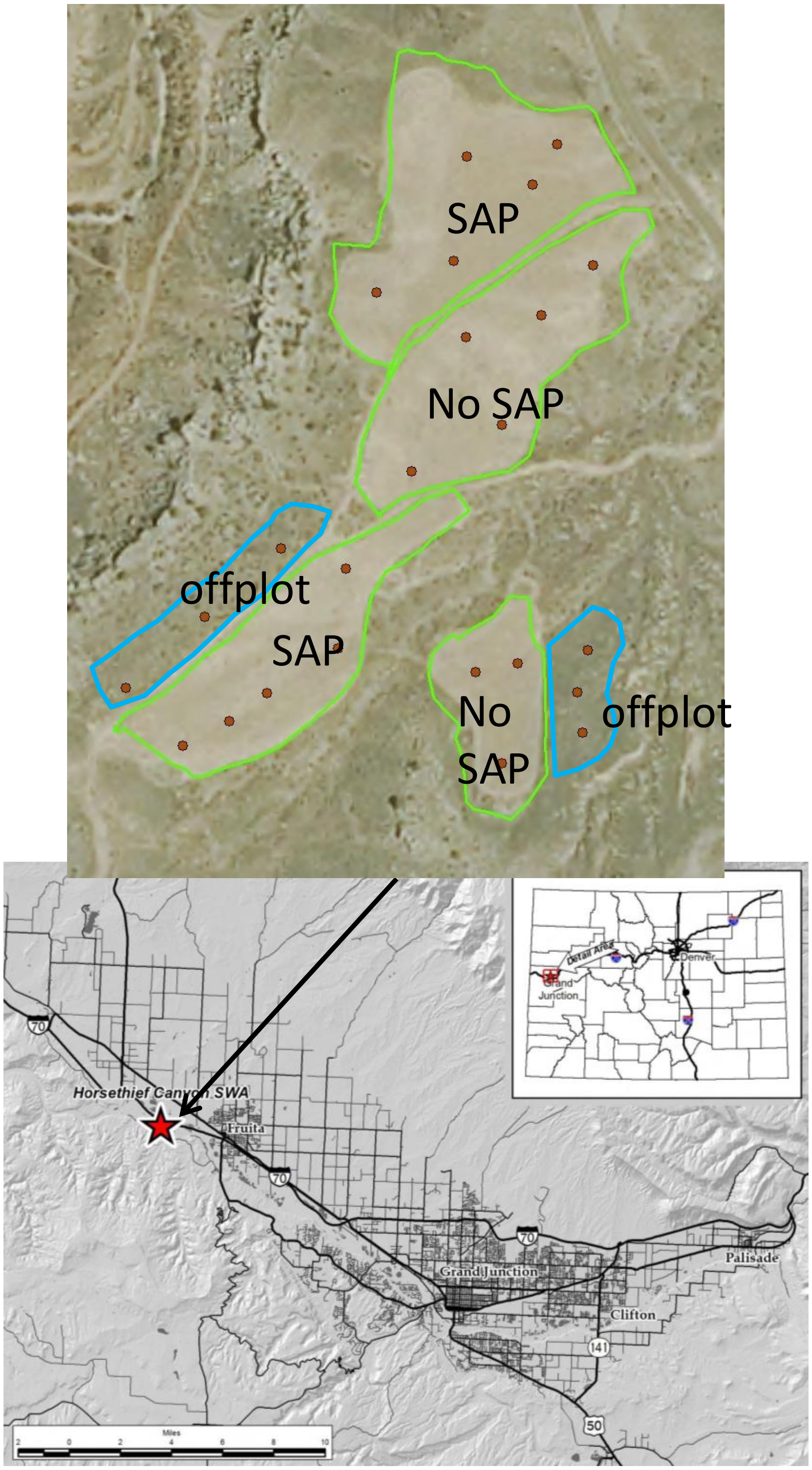

Figure 1. Study site layout and location. Two of four polygons received super-absorbent polymer (SAP).

Figure 2. The pothole seeder.

Figure 3. Disks were deeply notched on the pothole seeder, and the notches were offset on adjacent disks.

Figure 4. Alternating pattern of mounds and holes created by the pothole seeder. Orange notebook provided for scale.

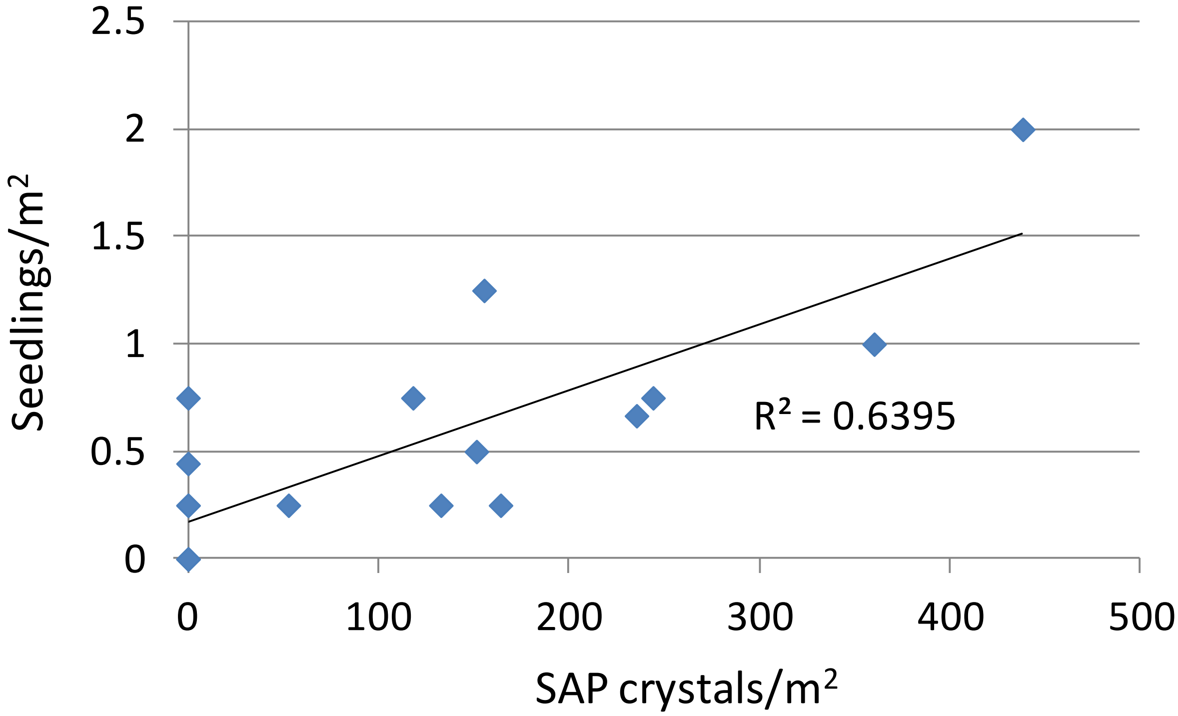

Figure 5. Perennial seedlings counted in June 2013 versus density of SAP crystals evident within holes in May 2013.

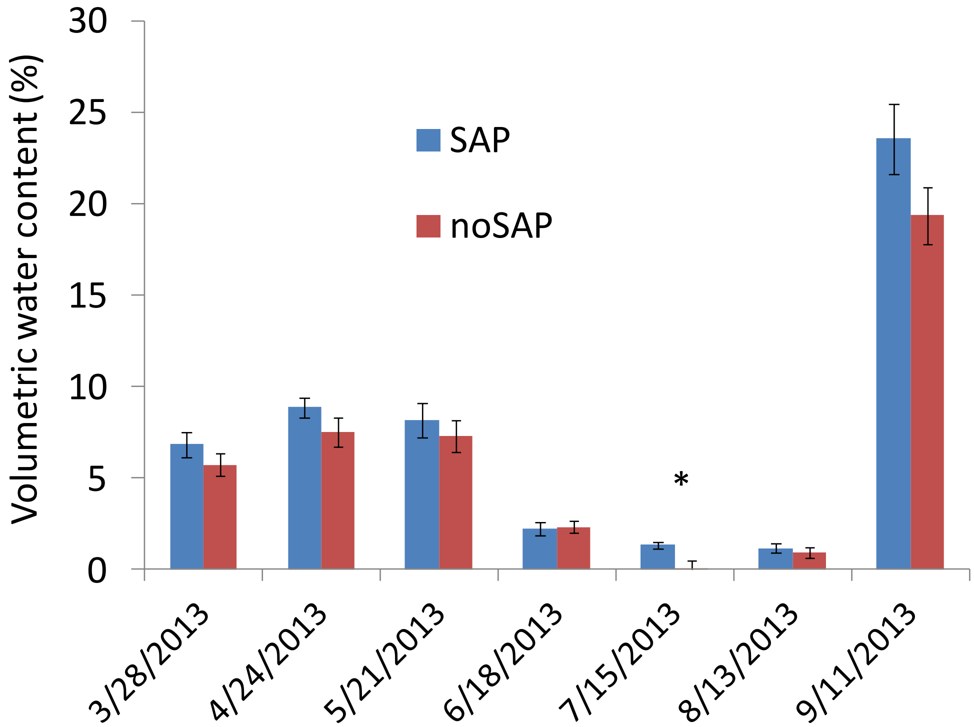

Figure 6. Soil moisture in holes of roughened mound/hole surface, in plots with vs. without super-absorbent polymer (SAP) treatment. *=significant difference at $\alpha = 0.05$.

Figure 7. Treated area which received super-absorbent polymer, August 2014 (2 years post-treatment)

Figure 8. Edge of treatment area (left) and untreated area (right) in August 2014. This treatment polygon did not receive super-absorbent polymer.