Progress Report for Greater Sage-Grouse Recovery Devil’s Garden/Clear Lake Population Management Unit
Modoc County, California

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Abstract:

Since 2005, 133 Greater Sage-Grouse from Oregon and Nevada have been translocated, radio-marked, and monitored in the Devil’s Garden PMU. In 2013, 13 male and 9 female grouse were translocated from 2 leks in Washoe County, Nevada. The peak lek count in spring was 29 males, the highest count recorded since 1994. 6 nesting attempts were documented, with a nest success of 50.0%. Annual survival was 73.7%, which was significantly higher (i.e., outside the 90% C.I.) than recorded for previous years of the study. Future plans involve translocating more sage-grouse to the Clear Lake AMA and continuing to monitor nesting, movements, and mortalities.

The Devil’s Garden Working Group considers juniper encroachment and sagebrush conservation and restoration a priority in the Devil’s Garden PMU. Since 2005, 11,539 acres of juniper-encroached habitats on Clear Lake NWR have been cleared. Projects are also underway for roughly another 60,000 acres of juniper removal on public and private lands over the next few years.
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This marks the ninth year of translocation and consequent monitoring of Greater Sage-Grouse (*Centrocercus urophasianus*) in the Devil’s Garden PMU as part of an ongoing recovery project for this nearly extirpated population. There is no doubt that the sage-grouse population in the Devil’s Garden declined significantly from 1950 to 2005, but it is impossible to speculate about when or where population declines occurred due to the lack of consistently collected data before the 1990s. However, there is a strong correlation between decreases in sage-grouse abundance and the loss or fragmentation of sagebrush steppe in the region due to juniper encroachment and the introduction of invasive exotic grasses, such as cheatgrass and medusahead (Hall, 1995).

In 1970, the California Department of Fish and Wildlife (CDFW) estimated that 14,000 sage-grouse existed in Modoc County (CDFW data, unpubl.). In 1977, nine leks were known to be active (CDFG data, unpubl.) in the vicinity of Clear Lake NWR. In an effort to learn about basic survival and movements of this population nine sage-grouse were radio marked between April 2000 and April 2002 on the refuge and monitored primarily from aircraft. However, by 2002, spring lek monitoring indicated that only one lek, found on Clear Lake NWR, was still active in this area. Furthermore, between 1992 and 2005 the number of strutting males on the Clear Lake lek declined from sixty to six males. In response, 2005 began the current Greater Sage-Grouse recovery project for the Clear Lake NWR/ Devils Garden Population.

The foremost goal of this project has been to reach a self-sustaining population of sage-grouse (500 individuals) in the Clear Lake AMA, and the eventual production of satellite populations. One facet of this recovery project includes supplementing the existing Devil’s Garden population through translocating birds from nearby healthy populations to increase genetic diversity and subsidize recruitment of resident birds.

Progress toward re-establishing a self-sustaining population has been evaluated through the following means:

1. Translocating sage-grouse from geographically adjacent areas.
2. Estimating annual survival of translocated and resident sage-grouse.
3. Examining factors influencing sage-grouse reproductive success.
Secondly, in order for this population to be sustainable and not a sink for all relocated individuals it is imperative that active habitat management is implemented to restore sufficient tracts of sagebrush steppe. The original habitat goals for this project are:

1. Restore 28,000 acres of R3 habitat, those with juniper encroaching historical sagebrush communities, to healthy sagebrush communities (R0).
2. Restore 34,000 acres of R1 habitat, those dominated by perennial grass but lacking a shrub overstory, to healthy sagebrush communities (R0).
3. Prevent wildfire from damaging habitats near existing sage-grouse populations in the PMU.
4. Collaborate with Modoc National Forest to establish procedures for juniper treatment that can accomplish habitat management objectives in a timely manner and still protect cultural resources.
5. Manage grazing to maintain and enhance sage-grouse habitat.

**Study Area**

The Devil’s Garden and Clear Lake Sage-grouse Population Unit (460,000 ha) is located in northeast California. It covers almost one-quarter of Modoc County and a small portion of Siskiyou County. The land ownership is divided among the Modoc National Forest, Clear Lake National Wildlife Refuge, Lava Beds National Monument, California State Lands and a few private landowners. The sage-grouse management unit was defined by the historical sage-grouse lek locations and other locations where sage-grouse have been observed since 1960. Currently, management has focused on a smaller portion of the sage-grouse population unit (121,000 ha) known as the Active Management Unit (AMU) that includes the Clear Lake National Wildlife Refuge and surrounding areas of Modoc National Forest.

**METHODS:**

**Translocation and Fall Capture**

Between 28 March and 4 April 2013, capture teams translocated sage-grouse from two stable populations in Nevada to Clear Lake NWR. The sage-grouse were captured at night by spotlighting two active leks in Nevada: Flycatcher and Nolan (Wakkinen et al., 1992). Captured grouse were aged, sexed, and fitted with ATS brand necklace style VHF radio transmitters with a battery life of approximately 800 days (Beck et al., 1975). We collected blood samples from all translocated birds to test for *Mycoplasma gallisepticum* and *Salmonella pullorum* as required by California law.
for all poultry entering the state. All captured birds were transported via cardboard house cat
carriers lined with wood shavings in the back of a pickup truck to Clear Lake NWR. They were
then released onto the “U” ≤ 1 mile from the active lek site before sunrise of the same day. The
day following the release monitors scanned the study site to listen for and record a general
location for newly translocated birds.
On 1 October relocated grouse were trapped at Clear Lake in an attempt to replace old or
malfunctioning collars. This year there were four collars in need of replacement due to age. One
malfunctioning collar was successfully replaced one on 1 October. Further trapping efforts were
postponed due to a federal government shutdown the first two weeks of October. It is often
difficult to capture target birds because grouse are found in large groups in the fall, therefore
resident grouse are opportunistically captured and fitted with the same radio transmitters as
translocated birds.

**Lek Counts**
California Department of Fish and Wildlife scientific aides conducted weekly lek counts during the
spring breeding season between 15 March and 15 May 2013. Monitors arrived at the lek site
before sunrise to minimize disturbance to the birds. Every 10 minutes we recorded the number of
males and females present at the lek until the birds began dispersing. On 18 April we found a
satellite lek north of the main lek with a few strutting males. In subsequent counts one monitor
was stationed at the main lek and another at the satellite lek. Regular communication between the
monitors ensured no birds were missed or duplicated while counting.

**Nest Monitoring**
During the egg laying and brood rearing season, early April through mid-June, scientific aides
monitored each radio-collared hen at Clear Lake NWR twice a week to determine nesting status.
Using radio telemetry, we approached hens from several different locations, no closer than 20
meters to avoid flushing the hen from the nest. A GPS location and compass bearing of the signal
were then recorded from each location in order to later triangulate the hen’s position. We did not
attempt to get a visual of the nest to reduce any possibility of nest abandonment. We considered a
nesting attempt to be a hen in the same location for ≥7 days or three consecutive visits. Once a
hen moved from a nest site, we used triangulation to locate the nest and determine its fate
(abandoned, depredated, or successful). We considered a nest successful if ≥1 egg hatched.

Seasonal Movements and Habitat Use
Radio collared birds were monitored from the ground at Clear Lake NWR between 11 March and 30 November 2013 using radio telemetry. We also used periodic flights to survey larger areas around the refuge in order to search for any birds that could not be located from the ground. All collared birds were located at least once a week to determine survival and movements across the landscape. We recorded UTMs using GPS for every grouse encounter, radio collared or not. We located birds ≤ 2 days upon hearing a mortality signal to determine cause of mortality. One carcass with an unknown cause of mortality was sent to California Animal Health and Food Safety Laboratory System in Davis, CA to determine cause of death and any presence of disease.

Data Analyses
Annual Survival and Nesting Propensity
To estimate female annual survival for radio collared hens during the nesting season we used the Kaplan-Meier product limit estimator. The number of females that survived through the nesting period was divided by the total number of hens online at the start of nesting season. We obtained nesting propensity by dividing the total number of nesting attempts by the number of reproductive aged hens alive during nesting season. Nest success was calculated as the number of successful nests over number of attempted nests.

Population Estimate
Multiple methods were used to determine grouse abundance in the Devil’s Garden PMU in order to increase the strength of the overall estimate. First, spring lek count data were entered into an N-mixture model (Kery and Schwaub, 2012). This Bayesian model was chosen because it accounts for detection and abundance simultaneously, which reduces any detection error in the estimate and allows for a better ecological analysis of the population. The N-mixture model assumes that all individuals can be detected independently and that the population is closed, which are both correct in regards to this population. In order to provide a more accurate estimate, any counts that were affected by extraneous factors, such as poor weather, were ignored.

For the second population estimate method, we focused on data collected from the months of July
through September, a time period when groups of grouse are most concentrated and move very little across the landscape. We organized these data into cycles representing locations of all radio-marked birds once. It typically took two to three days to locate all radio-marked birds once, and we considered each of these segments of time to be one cycle. We completed thirteen cycles during this 3 month period. These data were also analyzed using N-mixture models with multiple assumptions to determine the proportion of the population encountered during a cycle. The numbers were extrapolated to an entire population estimate using the proportion of unmarked groups that were opportunistically encountered to groups with at least one marked bird that were systematically encountered.

**RESULTS:**

**Translocation**

In 2013, we captured a total of 22 individuals (13 males and nine females) from two leks on BLM property in Washoe County, Nevada and relocated to Clear Lake National Wildlife Refuge (Table 1). This amount equals 2007 for the greatest number of individuals translocated to Clear Lake during the project’s nine year history and brings the total number of relocated birds to 133 individuals (48 males and 85 females). Success of this year’s capture is attributed to the warm, dry weather experienced during the lekking season. Favorable weather allowed capture teams easy access during the peak of the season when more birds can be found on or near the leks. Capture teams were also able to spend four nights over two weeks capturing birds when normally capture events are hindered by unfavorable weather.

**Table 1. Origin, sex, and capture dates for all sage-grouse translocated to Clear Lake NWR between 2005 and 2013.**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>DATE</th>
<th>CAPTURE LOCATION</th>
<th>YEARLING MALE</th>
<th>ADULT MALE</th>
<th>TOTAL MALE</th>
<th>YEARLING FEMALE</th>
<th>ADULT FEMALE</th>
<th>TOTAL FEMALE</th>
<th>YEARLING MALE</th>
<th>ADULT MALE</th>
<th>UNK AGE MALE</th>
<th>TOTAL MALE</th>
<th>TOTAL CAPTURED</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>2-Apr</td>
<td>Hart Mtn NAR - Swede Knoll Lek</td>
<td>7</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>29-Mar</td>
<td>Hart Mtn NAR - Swede Knoll Lek</td>
<td>6</td>
<td>7</td>
<td>13</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>21, 29-Mar</td>
<td>Sheldon NWR - Bald Mtn Lek</td>
<td>5</td>
<td>7</td>
<td>12</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>2</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>27 Mar-1 Apr</td>
<td>Washoe Co., NV - Fatty Martin Lek</td>
<td>1</td>
<td>14</td>
<td>15</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1 Apr-4 Apr</td>
<td>Lake Co., OR - Mule Lake &amp; Rabbit Creek Leks</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>25 Mar-5 Apr</td>
<td>Washoe Co., NV - Flycatcher &amp; Nolan Leks</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>25 Mar-9 Apr</td>
<td>Hart Mtn NAR - Swede, Paxton, &amp; Lookout Leks</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>3 Mar-11 Apr</td>
<td>Washoe Co., NV - Macy &amp; Nolan Leks</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>25 Mar-4 Apr</td>
<td>Washoe Co., NV - Flycatcher &amp; Nolan Leks</td>
<td>7</td>
<td>2</td>
<td>9</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>13</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td><strong>Total Captured 2005 - 2013</strong></td>
<td></td>
<td></td>
<td>31</td>
<td>54</td>
<td>85</td>
<td>4</td>
<td>43</td>
<td>1</td>
<td>48</td>
<td>1</td>
<td>133</td>
<td>133</td>
<td></td>
</tr>
</tbody>
</table>
Lek Counts

It was only possible to conduct four lek counts between 15 March and 15 May of this year because those responsible for lek counts were also part of the capture team in Nevada; even with these constraints we were able to obtain promising data. The peak lek count for the 2013 reproductive period, which occurred on 25 April, was 29 sage-grouse (Table 2). This count is the highest number of males observed on the Clear Lake lek since 1994 (Fig. 1). It is also likely that the count on 27 March would have been higher than observed, but a sudden early morning rain storm seemed to inhibit grouse activity.

Table 2. Results of 2013 Clear Lake NWR lek survey. Observers: Andy Richardson and Emily Lind, Scientific Aides, CDFW.

<table>
<thead>
<tr>
<th>Date</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
<th>Frequencies Detected on Lek</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-Mar</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>None</td>
</tr>
<tr>
<td>25-Apr</td>
<td>29</td>
<td>0</td>
<td>29</td>
<td>Males:160.047,160.137,160.338,160.398; Females: None</td>
</tr>
<tr>
<td>2-May</td>
<td>22</td>
<td>0</td>
<td>22</td>
<td>Males:160.398; Females: None</td>
</tr>
</tbody>
</table>

Figure 1. Peak lek counts 1988-2013 on Clear Lake National Wildlife Refuge. Counts were conducted between 15 March and 15 May; greatest number of males occupying the lek at one time was recorded. Lek was not monitored during years showing no males.
Movement and Habitat Use

It has not been found that sage-grouse in the Clear Lake AMA make long seasonal migrations as some populations do in the heart of their continental range; instead, individuals often move from the Pothole Valley area in winter to Clear Lake in summer (Fig. 2). Birds are congregated around the only known lek to remain in the area during the peak of the lekking season (Fig. 2). This year the 6 recorded nesting attempts were found in the Clear Lake Hills (3), the U (2), and east of Clear Lake (1) (Fig 3). Twelve mortalities of radio-collared birds occurred this year (Table 3) (Fig. 3). A majority of these mortalities (11) were due to depredation. A single adult male was found dead in May from unknown non-depredation related causes. It was evident that the bird spent substantial time at the mortality site before death due to the amount of scat that was found around the carcass, but there were no obvious signs of physical injuries or maladies on the body. Lab results were inconclusive on the cause of death, so the cause is recorded as a non-predator mortality (Table 3). A large number of mortalities were found on the edge of suitable sage-grouse habitat. This is especially evident along the east side of Clear Lake (Fig. 3). Overall, sage-grouse locations were rarely recorded outside of remaining tracts of suitable habitat or areas where juniper treatment has occurred (Fig 3).

Table 3. Causes of all 2013 sage-grouse mortalities, Clear Lake AMA, Modoc County, California.

<table>
<thead>
<tr>
<th>Mortality Date</th>
<th>Frequency</th>
<th>Age</th>
<th>Sex</th>
<th>Year</th>
<th>Translocated</th>
<th>Cause of Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-Mar</td>
<td>159.676</td>
<td>ADULT</td>
<td>M</td>
<td>2011</td>
<td></td>
<td>Mammalian Depredation</td>
</tr>
<tr>
<td>2-Apr</td>
<td>159.988</td>
<td>ADULT</td>
<td>M</td>
<td>2013</td>
<td></td>
<td>Mammalian Depredation</td>
</tr>
<tr>
<td>11-Apr</td>
<td>160.349</td>
<td>ADULT</td>
<td>M</td>
<td>2013</td>
<td></td>
<td>Unknown Depredation</td>
</tr>
<tr>
<td>16-Apr</td>
<td>160.359</td>
<td>ADULT</td>
<td>M</td>
<td>2013</td>
<td></td>
<td>Mammalian Depredation</td>
</tr>
<tr>
<td>17-Apr</td>
<td>160.306</td>
<td>JUV</td>
<td>F</td>
<td>2013</td>
<td></td>
<td>Mammalian Depredation</td>
</tr>
<tr>
<td>14-May</td>
<td>159.287</td>
<td>ADULT</td>
<td>F</td>
<td>2013</td>
<td>Resident 2010</td>
<td>Mammalian Depredation</td>
</tr>
<tr>
<td>21-May</td>
<td>160.096</td>
<td>JUV</td>
<td>F</td>
<td>2013</td>
<td></td>
<td>Unknown Depredation</td>
</tr>
<tr>
<td>4-Jun</td>
<td>160.047</td>
<td>ADULT</td>
<td>M</td>
<td>2013</td>
<td></td>
<td>Non-predatory Mortality</td>
</tr>
<tr>
<td>17-Jun</td>
<td>160.457</td>
<td>ADULT</td>
<td>M</td>
<td>2013</td>
<td></td>
<td>Unknown Depredation</td>
</tr>
<tr>
<td>9-Jul</td>
<td>160.317</td>
<td>ADULT</td>
<td>M</td>
<td>2013</td>
<td></td>
<td>Avian Depredation</td>
</tr>
<tr>
<td>25-Jul</td>
<td>160.207</td>
<td>JUV</td>
<td>F</td>
<td>2013</td>
<td></td>
<td>Avian Depredation</td>
</tr>
<tr>
<td>13-Nov</td>
<td>159.766</td>
<td>ADULT</td>
<td>F</td>
<td>2011</td>
<td></td>
<td>Mammalian Depredation</td>
</tr>
</tbody>
</table>
Figure 2. Month by month locations of sage-grouse encounters March through October 2013 on Clear Lake AMA. Note: points may represent a single marked or unmarked bird (e.g. a random encounter), or several birds at a single location. Prepared by Ken Morefield, Research Analyst, CDFW.
Figure 3. Locations of sage-grouse encounters, mortalities, and nest sites March through November 2013 on Clear Lake AMA. Note: points may represent a single marked or unmarked bird (e.g. a random encounter, or several birds at a single location. Prepared by Ken Morefield, Research Analyst, CDFW.
Data Analyses

Annual Survival and Nesting Propensity

In 2013, a total of 19 female sage-grouse were collared at the start of the field season. At the close of the field season 14 of the 19 hens survived, which results in an annual survival of 0.737. Six out of the 19 hens attempted nesting, which results in a nesting propensity of 0.316. Three of the six nests were successful. Nest success was 0.500. Overall, 2013 had a statistically higher than average female annual survival, but lower than average nesting propensity (Table 4). It is expected that high female annual survival should correlate with low nesting propensity because of the decrease in risks experienced during nesting. Nesting success for the year was statistically above average, but it is important to consider that the small number of nests initiated could be skewing this calculation. Possible explanations for the low number of nesting attempts this year include continued drought and the large proportion of females that were translocated in 2013.

Table 4. Annual survival, nesting propensity, and nest success for all female sage-grouse, 2009-2013, Clear Lake AMA, Modoc County, California.

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Avg</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Females Online</td>
<td>25</td>
<td>31</td>
<td>38</td>
<td>32</td>
<td>19</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Annual Survival</td>
<td>0.880</td>
<td>0.710</td>
<td>0.553</td>
<td>0.563</td>
<td>14/19=0.737</td>
<td>0.689</td>
<td>0.064</td>
</tr>
<tr>
<td>Nesting Propensity</td>
<td>0.720</td>
<td>0.581</td>
<td>0.586</td>
<td>0.583</td>
<td>6/19=0.316</td>
<td>0.557</td>
<td>0.066</td>
</tr>
<tr>
<td>Nest Success</td>
<td>0.471</td>
<td>0.421</td>
<td>0.393</td>
<td>0.389</td>
<td>3/6=0.500</td>
<td>0.435</td>
<td>0.022</td>
</tr>
</tbody>
</table>

Population Estimate

Total population estimate derived from lek count data was 161 individuals and the estimate based on group encounters during a cycle totaled 260 individuals. Variation in estimates was due to differences in sex ratios. Lek count data skewed toward favoring encounters with males and group encounter data favored sighting females. Confidence intervals were wide for both estimates due to low sample sizes from monitoring a small population.
DISCUSSION:

Juniper Removal

Juniper encroachment can negatively alter native sagebrush-steppe habitats and the wildlife that rely on it for food and cover. Woodland species such as Western Juniper (Juniperus occidentalis) negatively affect sagebrush-steppe habitats by reducing available ground water and understory and intercanopy vegetation (Pierson, et al., 2013) important for sage-grouse diet and nesting. Junipers also provide a perch for raptors and corvids that prey on sage-grouse and their eggs (Commons et al., 1999). Past studies have seen an increase in herbaceous cover by native grasses and forbs following the removal of woody plants (Pyke, 2011).

In 2005 the United States Forest Service (USFS) and the Natural Resources Conservation Service (NRCS) began funding a major juniper removal project in Devil’s Garden. To date, 11,539 acres of juniper have been removed to complete phase I of the project goals. Most current cutting has occurred along Clear Lake Road. NEPA surveys have been completed on another 17,871 acres and cutting has already begun in some of these areas. NEPA surveys on 31,159 acres are to be completed by the end of 2013, and another 10,142 acres are planned for 2014 (Figure 4). The project’s goal is to begin returning this region back to the sagebrush-steppe ecosystem that existed before juniper encroachment occurred through combined efforts by participating agencies (USFS, USFWS, NRCS) and private landowners. Sage-steppe restoration and enhancement will increase and improve sage-grouse habitats in the area, hopefully resulting in an increasing sage-grouse population. Juniper removal will also dramatically decrease water consumption on the land allowing the return of both ephemeral wetlands and perennial streams that would be beneficial to both wildlife and ranchers.
Figure 4. Sage Steppe Habitat Restoration Project showing completed juniper removal and NEPA for future removal projects. Modoc National Forest. Prepared by Jason Brewer, USFS.
**Herbicide Treatment**

Efforts to test effectiveness of herbicides on exotic grasses on Clear Lake NWR had been ongoing from 2009-2012. The two treatments tested were Matrix and Plateau in 2010. To date, the most promising results have shown that Plateau controlled 94% of annual exotic grasses at a cost of $22.00 per acre. Due to a lack of funding in 2013 there were no treatments applied at Clear Lake NWR this year. Data were collected from treatments applied two years prior to be analyzed at the end of 2013 and, therefore, not included in this report. Future plans to test treatments are pending until further funding can be secured (Rob Wilson, Personal Communication).

**ACKNOWLEDGEMENTS:**

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LITERATURE CITED:


