Progress Report on the Use of Piligrass (*Heteropogon contortus*) Hay Bales for the Island of Kaho`olawe's Highly Erodible Sites

Glenn Sakamoto, September 2008

Piligrass is an erect perennial native bunch grass and is commonly found, although not in great numbers, on all major islands. It was once the main thatching material used by Polynesians for the construction of their homes. Piligrass has a world-wide distribution and is found in the warm tropical regions of both hemispheres. Under natural conditions in Hawaii, it grows between 1 to 3 feet in height. In Hawaii, it mainly grows in arid and sometimes rocky areas from sea level to over a thousand feet. The long-awned seeds are sharp and pointed, forming tangled masses as they mature. When the seeds come in contact with moisture, the long awns and sharp barbed tips arch and twist planting them into the soil.

Though the utilization of hay bales for conservation is relatively new to Hawaii and its use on Kaho'olawe, the practice has long been used and documented on the mainland for many years. In recent years, hay bales on the mainland have been used to reintroduce native rangeland and pasture grasses to areas where they once existed. This approach capitalizes on the concept of baling mature stands of grasses, which are producing seed and use livestock to ingest and transport the ingested seed to areas that need to be populated with a specific species of forage. The use of piligrass bales on Kaho'olawe utilizes the same concept, but without livestock.

The use of hay bales for controlling erosion on Kaho'olawe is unique in that it is not only being utilized on an island where decades of overgrazing occurred, leaving a desolate barren landscape, but is also being used on an island that was once littered with unexploded military ordinance. Though the island has been partially swept or cleared of these ordinances, there are no assurances the island is completely void of ordinances. Ideally, if no ordinances were ever used on Kaho'olawe, implementing conventional conservation practices, (with or without hay bales) would be a much easier task. The use of machinery such as disks, tillers, and drills to prepare seedbeds is inadvisable. Also, much of the area that needs treatment is steep, gullied and rocky, and as such, not recommended for tractor machinery work. The use of bales, though tedious, time consuming and expensive, is much safer and environmentally friendly, to the overall mission of KIRC.

Materials and Methods:

The Kaho'olawe Island Reserve Commission (KIRC) staff is faced with the daunting task of re-vegetating the eroded hardpans of the Island of Kahoolawe. The top one third of the island of Kaho'olawe is severely eroded and void of any significant vegetation. The area is extremely windy, dry, infertile and at times inaccessible by vehicle.

Piligrass seed bales are one of the main products being provided by the Hoolehua PMC to KIRC to aid in the healing of the island. The original seeds of piligrass were collected by Robert Joy, Plant Materials Specialist and Stephanie Aschmann, Pacific Division, Naval Facility Engineering Command near the summit crater of Lua Makika, Kahoolawe. These seeds were brought back to the Hoolehua PMC for testing and seed production increased.

During the baling process, mature piligrass seed is incorporated into the bales. The piligrass seed bales are then transported by helicopter to various distribution sites on the island of Kahoolawe. At these sites, different methods to effectively control the erosion on the severely damaged island are tested, modified and evaluated. Each bale weighs approximately 30 pounds and has the dimension (length, width and height) of 27"x 18" x 15". The bales are held together with polypropylene UV resistant baler twine.

The piligrass seed bales are multi-purpose in that they serve as a seed source of piligrass, provides physical barriers to trap sediment and aids in protecting newly planted plants, as well as seedbeds of native plants. They also, serve as good mulching material and are great diversions, which are helpful in diverting water from roadways or other highly erodible areas. The use of piligrass seed bales, controls soil erosion, increases soil moisture retention, and provides a micro-environment for native plants to establish.

One of the methods tested, is in the construction of sediment traps, where the bales are placed in gullies and washouts. These sediment traps, not only caught soil carried by runoff and wind, but they also provided a place for seeds to germinate and grow. These structures utilized the entire piligrass bales and were placed end to end within shallow gullies, depressions or washouts. Depending on the size of the treatment area, anywhere between 7 to 12 bales may be used.

Another method utilized to trap sediment, is the construction of berms. Due to the nature in which the piligrass is compressed during the baling process, the bales can be peeled apart into various sized "flakes" or sections. The KIRC staff has taken advantage of this characteristic and fabricated "bundles" with piligrass flakes encased in commercially manufactured erosion control matting (geotextiles) in an attempt to conserve materials. Geo-textile matting is comprised either of straw, coconut fibers or polypropylene yarn, which are encased within polypropylene netting. Bundles are constructed by placing piligrass sheets or flakes within the geotextile matting and rolling it like a "burrito". These bundles are placed cross-slope on highly erodible sites and fastened in place with short wooden stakes.

Piligrass seed bales have also been used to construct "planter boxes" or "kipuka" to help establish native plants. Eight to ten bales are arranged to form a square (6' to 7.5'in length). Within the square, recycled potting mix from previous planting projects are utilized to provide a planting media for native plants. If available, water is sparingly applied. In some cases, no recycled media was added, but instead one end of the box was left open on the windward side of the square. This enabled the windblown soil to accumulate within the box and provide a media for plants to take hold. These configurations are located near Landing Helicopter Zone 3 (West of Kanapou) or LZ-3

and along the Moiwi bypass road on Kahoolawe. This area is extremely arid and windy, with no appreciable vegetation.

Other configurations, such as the "C" and "X" have proven to work well utilizing the piligrass hay bales. The "C" or crescent shape configuration works as such: six piligrass bales are lined up to form a crescent shape, with the opening facing the prevailing trade winds. These configurations range in length of between 10 to 12 feet. This allows windblown sediment deposition and seeds to be captured in the cup of the crescent shape structure. And the "X" configuration works with the concept of the bales forming an "X" shape, the center of the "X" forming a square hole. This method utilizes four to eight bales per "X", and is designed to trap windblown soil deposition and seed from the any direction. Depending on the availability of bales, four bales created a 6' x 6' "X". An eight bale "X" configuration created a 10.5' x 10.5' "X". The center of the "X" with its square (18" by 18") hole acted as a planter box where seeds could be planted.

Piligrass hay bales have also been used simply as mulch. Sheets of hay two to three inches thick were peeled away from the bales and laid directly on the hardpan surface. The sheets were laid end to end across the slope. The sheets were also placed end to end in an oval shape in less sloped areas. Due to the thickness and weight of the hay sheets, staking pegs were not necessary to prevent them from blowing away.

Still another use for piligrass bales is the construction of water diversion structures. These structures are strategically placed along access roads and small waterways, to divert water off road shoulders to where it can exit to a safe outlet. Hay bales are placed end to end at approximately thirty degrees to the shoulder of the road and gradually taper the angle of the bales to the desired outlets.

Discussion of Methods

Since its introduction to the island of Kaho'olawe in 2000, piligrass bales have taken on many shapes and names to reflect its uses. Planter boxes, kipuka's, berm's, shingles, sheets, flakes, C's, X's, C sections, and bundles are just a few of the names utilized to identify specific uses of the piligrass. The use of piligrass hay bales all have one common denominator, in that they alter the micro-environment and provides an environment conducive for plant growth and sediment retention. The use and placement of these bales should not be considered a permanent fix to the problems of erosion, but should be looked upon as a temporary structure to aid in a series of steps towards a permanent erosion control system. Piligrass bales will deteriorate over time and unless a suitable control measure is taken to replace or stabilize these piligrass bales, erosion will continue and the use of the piligrass bales will have been in vain.

Mulching

Mulching by separating flakes or sections from bales and placing them on the hardpan areas is working. At one site visited, it was observed that by placing these flakes across the slope on gently sloping areas (less than 2 percent) enabled wind blown sediment and soil runoff to accumulate within and up slope of these flakes. This accumulation of soil provided a suitable environment for seeds within the piligrass bales to germinate and grow along these flakes. These flakes were approximately 2-3 inches thick and laid side by side in a single row. According to Paul Higashino, Natural Resource Specialist for KIRC, the sheets were installed in February 2005. During a site visit in October of 2005 of the same area, the piligrass was approximately 14 inches tall and soil deposition by wind and runoff was very noticeable. The growing piligrass formed a vegetative barrier along the edges of these flakes and trapped sediment. Though the treatment area visited was small (less than10 feet long), the effects were positive and effective in controlling erosion. In August of 2008, a site visit to the same area showed piligrass, natal redtop, (*Rhynchelytrum repens*) and `Uhaloa, (*Waltheria indica*) growing within and along these piligrass sheets. The overall vigor of these plants was good, considering it was in the middle of summer and not irrigated. The use of this method also enabled the KIRC staff to maximize the use of the bales. Mr. Higashino estimates that for each bale used in this method, one could cover approximately 15 to 20 linear feet of mulch. In contrast, using entire bales that have not been separated would require 24 bales.

It was interesting to note that the flakes did not blow away with the wind. This was either due to the placement of the flakes in a slight depression or direction of the prevailing trade winds. Placing these flakes along the contour of a slope, staking the flakes to the ground in the hardpan areas, would be most beneficial. Mulching as a conservation method is simple and requires minimal amount of resources.

Boxes: C's & X's

The use and placement of these configurations is by far the most eye catching, as one approaches LZ-3(West of Kanapou) and the Moiwi area on Kahoolawe. From a distance, whether you approach by air or vehicle the "X" and "C" boxes look out of place in the barren, windy and desolate hardpan of Kahoolawe. As one gets closer, you begin to realize that these configurations are sustaining plant life. The first of these configurations was installed in August of 2003 at LZ-3 and with each succeeding year, more of them were installed and expanded to include the Moiwi bypass road area. It is clearly evident that each of the different shapes did have an impact in collecting sediment and or promoting plant life. In an area that is totally dependent on natural rainfall, it was impressive to note at many native plants such as `Aweoweo, *Chenopodium oauhense*; `A`ali`i, *Dodonaea viscosa*; Piligrass, *Heteropogon contortus*; and Kawelu, *Eragrostis variabilis* are growing within these structures. Whether native seeds were intentionally seeded by KIRC employees or naturally windblown into these structures, it does indicate a positive step toward the vegetation recovery of the island.

In one area of LZ-3, adjacent to and directly downwind of Rene Silva's native planting site, the "C" hay bale method was placed in rows perpendicular to the prevailing trade winds. Each succeeding row was slightly off set from the previous row and formed a staggered formation. A total of four rows approximately 250 feet long were installed. The spacing between and within the rows are approximately 12 to 15 feet. Further downwind of these crescent structures, larger "C" bales were situated, using more than 6 bales per crescent and spaced farther apart. Seven rows of this configuration were installed. These structures collect a considerable amount of windblown sediment. On some of these structures, soil deposition by wind erosion reached the top of the bales (15") within a one year period. Plants such as Pili, `Aweoweo, and`A`ali`i were growing in good condition and mainly growing along the edges of the piligrass bales and sediment deposits. The plant height of the piligrass ranged from between a few inches to over 22 inches in height. `A`ali`i plant heights ranged from several inches to heights of 32 inches. These plants grew from seed under natural rainfall conditions and were either naturally windblown into these "C" structures or manually distributed by KIRC staff. The original "C" structures (2003) remain intact, though the baling twine and hay were brittle. The decomposition of the bales has been slow and thus, should withstand the elements, as long as the bales are not trampled or stepped on.

Just north and adjacent to the "C" structures, are the box or kipuka configurations. These boxes were also initially installed in August of 2003. The use of the piligrass box configuration was gradually increased, as piligrass became readily available at the PMC. These boxes were installed in rows approximately 15 to 20 feet apart. The number of rows was estimated to be between 10 to 15 rows and 250 or more feet in length. Seed of Pili, `A`ali`i, `Aweoweo and Kawelu were sprinkled in these boxes prior to the rainy season. If recycled potting mix was available from other planting projects, they were deposited in these boxes. According to Paul Higashino, after the 2003 rainy season, native plant seeds germinated and grew. `Aweoweo, Pili and `A`ali`i faired the best and survived the first dry summer of 2004. The Kawelu seedlings, however, did not fair as well. During a site visit in October of 2005, `Aweoweo plants were the dominant species within these boxes. Their height was approximately 20 to 30 inches and in good vigor. Piligrass and `A`ali`i were noted within and along the boxes, their numbers were few, and plant heights were between a few inches to a foot tall. During another visit in August of 2008, `Aweoweo continued to be the dominant species within the boxes, but in fair vigor. `A`ali`i and piligrass were noted in the original boxes and growing in fair to good vigor, 12 to 24 inches in height.

The "kipuka's" or boxes have proven to be one of the successful methods to establish native plants on the Kahoolawe hardpan. It traps windblown soil deposition and provides the needed environment for plants to grow. Wind protection and moisture retention is one of the positive attributes of this design. The concept is simple, with no materials other than bales and seed. No wooden staking or mechanical intervention was involved to secure the bales or to establish the plants. This concept is extremely important due to the hazards of unexploded military ordinances.

Sediment Traps and Berms

This method of using piligrass for sediment trapping, was initially installed in the summer of 2002 along the outer rim of the Lua Makika summit. Pili bales were used to trap and slow down the movement of soil in depressions and gently sloping (less than 5% slope) washouts. Piligrass bales were simply laid length wise, end to end to create a wall of piligrass. By installing the bales perpendicular to the direction of the flow of water, sedimentation of soil after a storm was immediate. The concept has been somewhat successful and its use is being increased with in specific areas of Kahoolawe. The sedimentation that has occurred upslope of these bales has made it an excellent medium to plant native grasses and shrubs. The original bales that were installed in 2002 are currently in place, as of the August 2008 site visit. These bales, though old and crumbly are still doing the job it was intended to. The disadvantage of this method, in the long term (7 to 8 years) would be the maintenance of these sediment traps. As stated earlier, hay bales should be used as a temporary structure to aid in a series of steps towards a permanent erosion control system. It was noted that though the bales worked well in trapping soil, eventually, the sediment traps filled up with soil, and water overtopped these bales. This overtopping of water during storms on the down slope of the bales began to undermine and erode beneath the bale. The proper construction of these sediment traps is crucial. The USDA NRCS does provide information on the construction of "checkdams" that is quite similar to the ones being used on Kahoolawe.

Piligrass berms, as described earlier, essentially works in the same manner as mentioned above. The use of these berms has proven to be somewhat successful in areas, where the land is sloping less than 5 percent. Along the north to northeast rim of Lua Makika, berms such as these were installed as early as August of 2002. These small berms are successful in controlling low flow sheet and rill erosion. Although the original berms have not been revisited, newer berms have since been installed on the northeast rim and southeast rim of Lua Makika. Berms on slightly sloping land provided enough sediment deposit for KIRC employees to plant grasses and shrubs such as *Cenchrus agrimonioides*, Kamanomano and *Achyranthes splendens* respectively. During a site visit in August of 2008, three year old berms were still intact and providing erosion control to surrounding areas. The coconut fibers within the polypropylene netting have decomposed somewhat, but piligrass straws still remain. The use of this method, though expensive and time consuming, may prove to be a good candidate for areas such as the LZ-3 hardpan area. The use of piligrass is effectively and efficiently used with minimum waste. By placing these berms on contours and are spaced appropriately, sedimentation deposit and erosion may be minimized.

Channeling Water with Piligrass Bales

Piligrass bales have been used, but to a lesser degree, in channeling water away from the main access road from Honokanai`a Bay to Lua Makika Crater (approximately 11 miles long). During heavy storms, water runoff along the access roads can severely damage road shoulders. Piligrass hay bales were installed to divert surface runoff before it caused further damage down stream along road shoulders. One noted hay bale diversion was installed in 2003 near the Moiwi bypass road area and is still intact

today. It has weathered through several major storms and continues to function for the purpose intended. It is uncertain if staking the bales was ever done, as they did not appear to have moved in any way, by the force water flow. It was interesting to note that volunteer piligrass has grown along the edges of the bales and possibly aided in the bales stability during heavy water flow. Sedimentation was also noted being trapped along side and within the bales and being slowed by the piligrass vegetation. Although the accumulation of sedimentation, and vegetation is forming a natural water bar to re-direct water flow away from road shoulders, the use of hay bales for this practice should be used with caution and in conjunction with other conservation practices.

Conclusion

Piligrass hay bales is having a positive impact on the re-vegetation process of Kahoolawe. It is clearly evident that the areas surrounding the outer rim of Lua Makika crater is beginning to look a lot greener than a few years ago. Though all of the greenery is not native plants, a good portion of it is, especially on the more severely eroded sections of northeast and southeast flanks of Lua Makika. Plants such as *Cenchrus agrimonioides*, Kamonamona; *Plumbago zeylanica*, `Ilie`e; *Achyranthes splendens*; *Chenopodium oauhense* `Aweoweo; *Heteropogon contortus*, Piligrass, and *Dodonaea viscose*, `A`ali`I is showing remarkable growth within gullies, swales and the hardpan areas.

The implementation of various conservation methods utilizing native plants, have positively impacted the sensitive environment of Kaho'olawe. Through the joint efforts of numerous agencies and individuals, success in the use of piligrass (Heteropogon contortus) hay-bales has been realized, thereby allowing other native plants to establish as well. Hence, culminating to a successful restoration project, inspiring the continuation of a worthy program.

Robert Joy, USDA NRCS; Paul Scales USDA NRCS; and Paul Higashino, KIRC April 2005 look at piligrass flakes installed in 2004. Photo taken October 2005

Established Piligrass mulch flakes installed 2004. Note pilgrass and *Walthria indica*,`Ualoa growing along mulch line. August 2008

Piligrass hay bales at LZ-3, Kahoolawe "C" and Box configurations. Photo by Paul Higashino, KIRC, May 2006

Piligrass hay bales in box configuration installed in 2004 at Moiwi bypass road on Kahoolawe. Photo inset of `Aweoweo growing in box October 2005, LZ-3

Piligrass hay bales "C" configuration August 2008, LZ-3 Kahoolawe

LZ-3, David Duvauchelle next to C" configuration installed April 2007. Photo taken August 2008, 16 months later

X configuration using 8 piligrass bales LZ-3 2005

Paul Higashino, KIRC at one of the 'X" structures at LZ-3 August 2008. The "X" was installed in April 2007 Note wind blown soil deposits

Piligrass wrapped in geotextile fabric were named the bundle or berm method. Native Kamanomano and Piligrass growing along bundles, August 2008

Piligrass bundles installed in 2005 on southeast rim of Lua Makika, Kahoolawe

Piligrass bales used to trap sediment runoff in washouts and small gullies at the summit of Lua Makika, 2005

Piligrass bales installed in 2002 continue to trap sediment. Note piligrass growth both up slope and down slope of bales. August 2008

Piligrass bales used to divert water away from road shoulders before causing further damage down stream. Structure was installed in early 2003. Photo taken in April 2003

Bob Joy stands along the same structure taken in August of 2008. Piligrass bales are barely visible but continue provide the function as it was intended.