Next Generation BMPs: Soil Mapping Enhancements via Veris MSP3
FDACS Contract No. 21384, 2016 Final Report

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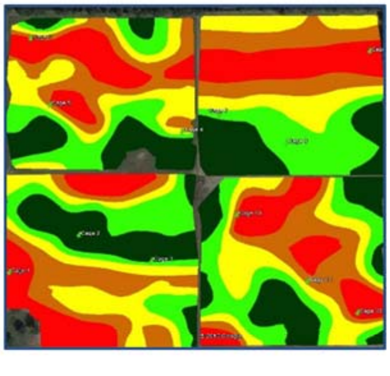

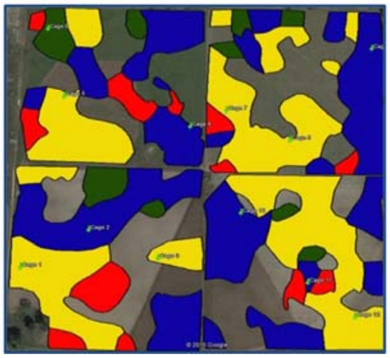

Next Generation BMPs: Soil Mapping Enhancements via Veris MSP3
Florida Department of Agriculture and Consumer Services
Office of Agricultural Water Policy

FDACS Contract No. 21384, 2016 Final Report

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BACKGROUND

Pursuant to the Florida Watershed Restoration Act (FWRA), section 403.067(7)(c)3, F.S., the Florida Department of Agriculture and Consumer Services (FDACS), Office of Agricultural Water Policy (OAWP), develops, adopts, and assists with the implementation of agricultural Best Management Practices (BMPs) to protect and conserve water resources. This two-year project proposes to demonstrate the effectiveness of soil mapping enhancements in North Florida as a long-term means to refine nutrient management inputs.

This is the final report, covering September, 2014 through June, 2016.


Fig. 1. Veris MSP3 prepared to map bahiagrass field.

Among new equipment technologies, soil mapping is increasingly being used to guide water and fertilizer application rates in the field, thereby improving overall water and fertilizer use efficiencies. On-the-go soil sensors, such as the Veris with GPS (Fig. 1), have the coverage required to delineate soil differences across a field that other technologies may miss (Adamchuk et al., 2004). Bianchini and Marllarino (2002) have reported that the spatial dependence range is less than the distances used by USDA soil surveys or with most grid sampling techniques. It stands to reason that shorter sampling distances may enhance the effectiveness of variable rate technologies, thereby improving input and production efficiencies.

The Veris MSP3 (Veris Technologies Inc., Salina, KS) uses dual wavelength (visible and near infrared) optical sensors for organic matter, pH sensors for soil pH, and pairs of coulter electrodes for direct electrical conductivity readings at dual depths (0 to 12 inch and 0 to 36 inch). The data is then logged on GPS maps, as the implement is pulled behind a tractor across the field at speeds up to 6 mph. These maps can guide fertility management decisions, including split fertilizer applications, or the data may be used in conjunction with other precision ag technologies, such as variable rate seeding, herbicide and pesticide applications, and of course, irrigation management.

The vast majority of Florida surface soils are comprised of 85% or more sand, where leaching potential is potentially high. Fertilizer nutrients can be quickly transported to the subsoil and eventually reach ground water through leaching or surface water through sub-lateral flow. Characterizing the effect of long-term agricultural practices on soil composition and fertilizer leaching is therefore difficult because the soil retention time is extremely short. However, soils developed from parent material with somewhat greater clay content (i.e., Ultisols) and/or those soils having deeper water tables (> 6 m or 20 feet), may benefit from deep coring to better assess the long-term (years or decades) impact agricultural management has had on fertilizer leaching losses.

Preliminary cores have revealed elevated inorganic N plumes down to 5 m in some cases or as shallow as 2m. The source or age of this N has yet to be determined. Neither has the extent of these observations across different agricultural land management been investigated. Unfortunately, extensive, deep coring is not practical, due to time and labor constraints (minimum 3-person team and approximately 1.5 h per 6 m core). Therefore, including mapping equipment, such as the Veris MSP3, can complement the coring by creating high resolution maps to help identify promising coring sites. Surface soil develops from the underlying parent material and substratum, thus surface soil mapping should be a good indicator of zones prone to nutrient leaching.

OVERALL OBJECTIVE

Develop comprehensive, spatial soil data sets to identify field management zones for demonstrating and validating row crop and forage BMPs.

Specific Objectives:

1. Use Veris-based mapping, in tandem with deep-core (20 ft) soil sampling, as a means to elucidate long-term (> 10 years) impacts on water resources, as affected by various agricultural management and N fertilization practices.
2. Use Veris mapping in 2015 to aid with the selection of on-farm locations for testing and demonstrating BMP technologies in 2016.

METHODOLOGY

Veris MSP3: The Veris MSP3 (Veris Technologies Inc., Salina, KS) uses two pairs of coulter electrodes for direct electrical conductivity readings at dual depths (0 to 1 ft and 0 to 3 ft) (Fig. 2), pH sensors for soil pH (Figs. 3 and 4), and a dual wavelength (red and near infrared) optical sensor for organic matter (Fig. 5). The data are logged on GPS maps, as the implement is pulled behind a tractor across the field at speeds up to 6 mph.

The Veris MSP3 was received at the end of January, 2015. The next eight weeks were spent installing the equipment, equipment familiarization, and calibrations, prior to field testing. Initial field testing at the Marianna Sod-based Rotation (SBR) began in spring, 2015. All four 40-acre quadrants were mapped for EC, pH, and OM. This included the second year bahiagrass quadrant. Maps are provided in this report to illustrate the process and field spatial variability. Mapping also occurred at the Front Office Block (FOB) NFREC, Quincy, in late spring, 2015 and at three Florida dairies in fall, 2015.

Blue Spring watershed deep soil cores: In spring 2014, soil cores (2 cm dia and approximately 6 m depth) were collected from nine agricultural sites and one natural site in and near the Jackson Blue Spring watershed (Appendix 1a). Each location was represented by two soil cores. Cores were air-dried, and passed through a 2 mm sieve. Analyses included pH, plant-available (Mehlich-1 extraction) nutrients, inorganic nitrogen (N) (2 M KCl extraction), and total carbon (C) (loss-on-ignition) at several depth increments. Additional sponsor funding through grantsmanship did not materialize, to help support sampling and analyses of the different land-use sites. Therefore, repeated core sampling in spring 2015, was limited to the natural area, the conventional crop rotation system and the SBR (Appendix 1b). Soil characteristics from the sod-based rotation (SBR) site were used to compare with soil surface data captured by the Veris MSP3.

Fig. 2. Each coulter is fitted with an EC sensor to measure EC at two depth ranges (0 to 1 ft and 0 to 3 ft) simultaneously.

Fig. 3 Between two coulters (located behind the EC coulters), the pH sampling scoop prepares to collect soil sample for pH measurement.

FOB 1 m soil coring: In spring, 2015, 1 m deep soil cores were collected from the Front Office Block (FOB) to coincide with soil mapping (Appendix 1c). Cores were air-dried, and passed through a 2 mm sieve. Analyses included pH, plant-available (Mehlich-1 extraction) nutrients, inorganic nitrogen (N) (2 M KCl extraction), and total carbon (C) (loss-on-ignition) at several depth increments. Discussions will be limited to the surface (0 – 15 cm depth) soils.

Dairy soil sampling: In fall 2015, surface soils (0 – 15 cm depth) were collected from three Florida dairies where annual winter grass forages were demonstrated in fall 2015 through spring, 2016, via sponsorship by the Southeast Milk Cooperative (Appendix 1c).

Soils were air-dried and tested for pH, Mehlich-1 extracted nutrients, inorganic N (NH_4-N and NO_3-N), and cation exchange capacity. It is noted that these soils were sandier (Entisols and a Spodosol) than what was tested in the SBR in Greenwood or at the FOB sites in Quincy.

Fig. 4. After the soil sample is collected, the sensor (gray probe above cup) and cup meet, where the pH reading is taken. Following the reading, spray nozzles wash the sensor clean prior to the next sample collection.

Fig. 5. In front of the pH sampler (close to tractor cab), lies the OM sensor (rectangular block). A sapphire window measures soil reflectance from IR and red light beams aimed at the soil.

Blue spring crop sampling: Following soil mapping in spring 2014, the 64 ha research and demonstration field (Marianna) was planted with the following: bahia 1 (NW quadrant, first year), bahia 2 (NE quadrant; second year), peanut (SE quadrant), and cotton (SW quadrant) (Appendix 2). Soils were sampled in spring, 2015 to determine the effect the 2014 crop might have had on nutrient dynamics. Exclusion cages (232 m^2; 2,500 ft^2) were used to compare cattle integration (outside cage) with no cattle (inside cage). Each quadrant hosted three exclusion cages (2 under pivot irrigation and 1 outside the pivot reach or dry corner). Cages were not used during the row crop years, as cattle were not allowed in those quadrants. The exclusion cages are always returned to the same locations during the bahiagrass years, with the aid of GPS coordinates.

Crop yields were calculated at maturity by subsampling the graze and ungraze sampling areas identified in Appendix 2. Only the cotton yields from 2014 will be used in discussion on soil mapping relation to crop yields in the SBR.

FOB crop sampling: for the purposes of this report, the crop response across treatments will not be addressed further. Discussions will be limited to the soil map and manual soil sample comparisons.

Dairy forage sampling and aerial imagery: Three commercial dairies were selected to compare crop growth with soil and aerial mapping and crop management. Annual winter forage grasses (rye, triticale, oats, ryegrass and some mixed ryegrass/small grain combinations) were drilled into strips under pivot. At all locations, the pivot provided dairy effluent at times during the grow-out. The BD location had only one effluent application, while the other two locations (UF and NFH) received several effluent applications. Soil mapping was conducted within a week of planting.

Additional nitrogen fertilizer (45 kg ha^{-1}) was applied as a 3.5 m wide band across all of the forage types approximately 6 weeks prior to harvest, in order to calibrate the normalized Difference Vegetation Index (NDVI) instruments (aerial and manual). The aerial NDVI provided a general assessment of crop health and potential productivity (productivity index) and results were compared against manual NDVI readings (Trimble Greenseeker™). Aerial imagery (visual, NDVI, infrared, and thermal images) were collected by Agribugs™. Forage was harvested in late March, 2016.

RESULTS AND DISCUSSION

Blue Spring watershed deep soil cores: The 2014 soil core NH4-N values are provided (Fig.6). Ammonium-N tended to accumulate in the upper soil, as compared to NO_3-N. The natural system had surface soil NH4-N of approximately 5 mg kg^{-1}. Bahiagrass pasture (upper panel) and SBR dryland hay are under similar types of management but at different locations. It is interesting to note that surface soil NH_4-N values were similar. However, at moderate depths (3 to 5 m), it appeared that the SBR dryland bahia hay had somewhat elevated NH_4-N. This may be related to minor difference in subsoil chemistry and/or fertilization practices. The conventional crop rotation and SBR under irrigation showed elevated NH_4-N at the deepest samplings. The trend towards lower soil pH, particularly under row cropping may have had a positive influence on NH4-N accumulation at the greatest depths.

For comparison against 2014, the 2015 soil core NH_4-N values are provided (Fig.7). Note that the 2014 x-axis scale maximum is 12 mg kg^{-1}, while the 2015 scale maximum is 25 mg kg^{-1}. As with 2014, the 2015 NH_4-N values tended to peak in the surface soil (0 – 15 cm depth), but unlike 2014, greater NH_4-N was found with soil depth in 2015 in the natural landscape. Grazing (with or without irrigation) and nongrazing or hay (with or without irrigation) performed similarly among years.

Based upon two years of deep core data, it appears that NH_4-N was mostly retained in the surface soils, with values from 10 to 12 mg kg^{-1} not uncommon. At greater soil depths, NH_4-N concentrations declined to values below 4 mg kg^{-1}. At depths below 4 m (13 ft), there was little, if any, difference between NH_4-N values from the natural area and the other types of land management. It is commonly believed that NH_4-N, derived from organic matter mineralization, is rapidly converted to NO_3-N via nitrification. In addition, NH_4-N uptake by plants requires less metabolic energy than NO_3-N. Therefore, one might expect a low NH_4:NO_3 ratio in soil solution. In contrast, in the natural and forage systems, NH_4-N concentrations were several times greater than NO_3-N in surface soils. This suggests one or more of the following: 1) systems with relatively high (~ 10 mg N kg^{-1}) soil NH_4-N were likely not N-limited, 2) there may be a natural release of nitrification inhibitors by some of these systems, namely within the forage and natural systems., and/or 3) soil composition (including acidity in the subsoils) helped to hold soil NH_4-N. It is intriguing to contemplate that forage agriculture may help conserve inorganic N via its effect on nitrification. Subbarao et al. (2012) reviewed the concept of developing NH_4-N-based agriculture (slowing nitrification and NO_3-N leaching losses) by assessing biological nitrification inhibition (BNI) in different forage grass species. Use of Veris MSP3 soil maps can help discern inherent and management-induced surface soil differences that can be used in future soil collection trips that might help provide answers as to where and how nitrification might be inhibited across landscapes.

There was a much greater range of soil NO_3-N concentrations with soil depth and across production systems. In 2014, the natural area had among the lowest values and conventional cropping had among the highest NO_3-N values (Fig. 8). In fact, the greatest NO_3-N values in 2014 were in the conventional cropping deep (5 m or 16 ft) subsoils. As expected, there were relatively low surface soil NO_3-N values, regardless of production system, due to plant uptake and leaching losses. The trend of greater deep subsoil NO_3-N under dryland production systems is likely a reflection of less deep leaching under these systems (non-irrigated).

In comparison, the conventional rotation resulted in the greatest concentration of NO_3-N (over 20 mg kg^{-1}) with soil depth (Fig. 9, upper panel). The next highest NO_3-N concentration was with the SBR at 15 mg kg^{-1}. A 5 mg kg^{-1} difference in subsoil NO_3-N is approximately 80 kg ha^{-1} NO_3-N per meter of soil depth, based upon an estimated bulk density of 1.6 g cm^{-3}. It is likely that nitrates in the subsoils moved with the water front. It is unclear how much reaches the shallow groundwater (approximately 9 to 10 m below the surface), but the coring results from 2014 and 2015 demonstrate that NO_3-N plumes are common in subsoils below 5 m, especially under conventional crop rotations. Cotton fertilizer inputs are typically 90 kg ha^{-1} or less. In an established SBR, applications of 55 kg N ha^{-1} or less are attainable. In comparison, corn N applications are over kg ha^{-1} and some of the most production intensive farmers are approaching 300 kg N ha^{-1} rates. Implementing a SBR with corn, may reap much greater N savings and protection of water resources.

The SBR exemplified in Figure 9 (upper panel), was on ungrazed land (bahia rotation was hayed). Comparing soil samples following cotton on ungrazed SBR against grazed SBR, tells a somewhat different story. The cotton grown under SBR with grazing resulted in greater subsoil NO_3-N than under hay management (Fig. 9, lower panel).

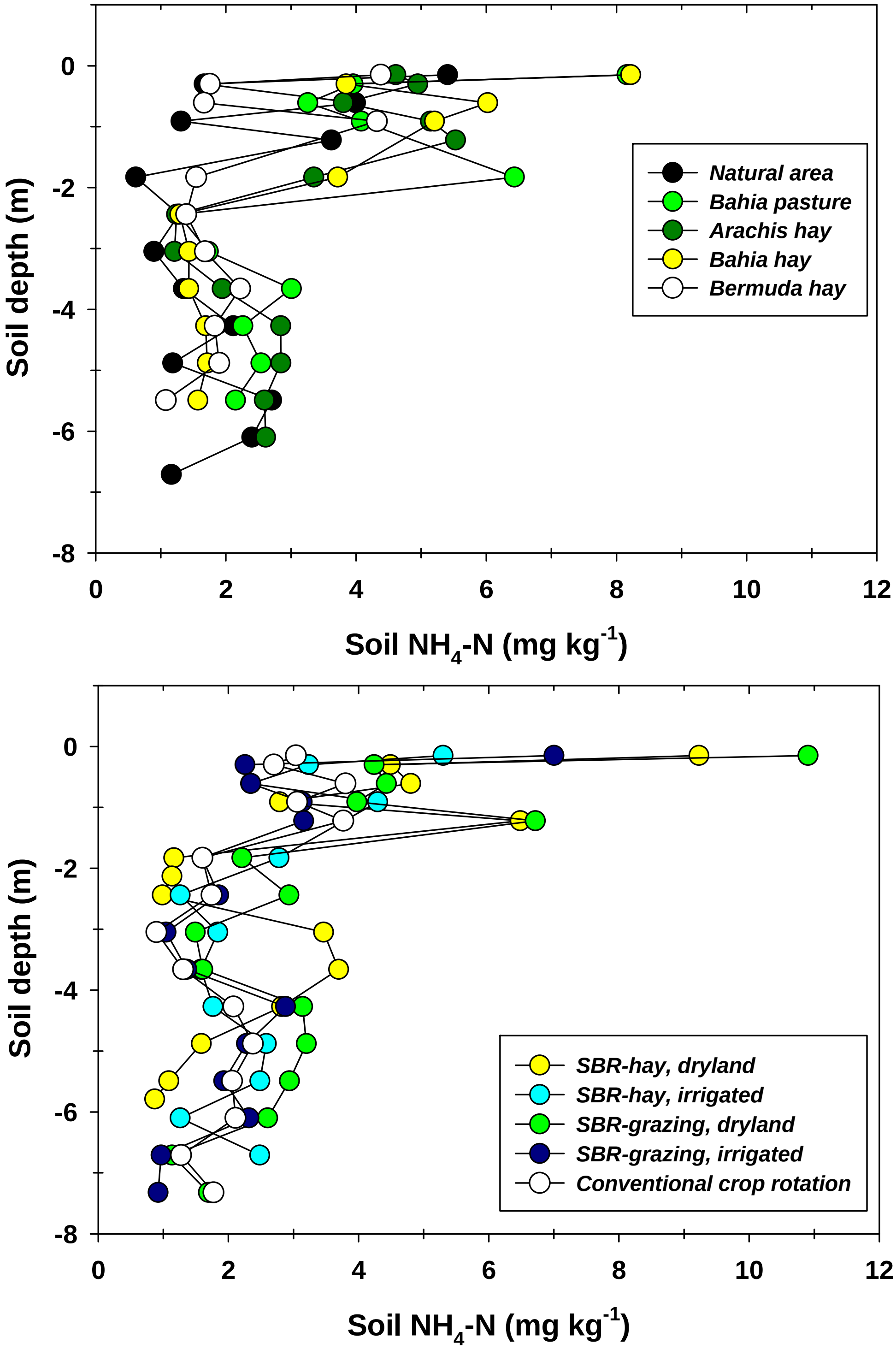


Fig. 6. 2014 KCl extracted (2M) soil NH_4-N. Data presented in two panels to reduce clutter. Symbols represent the mean of 2 samples.

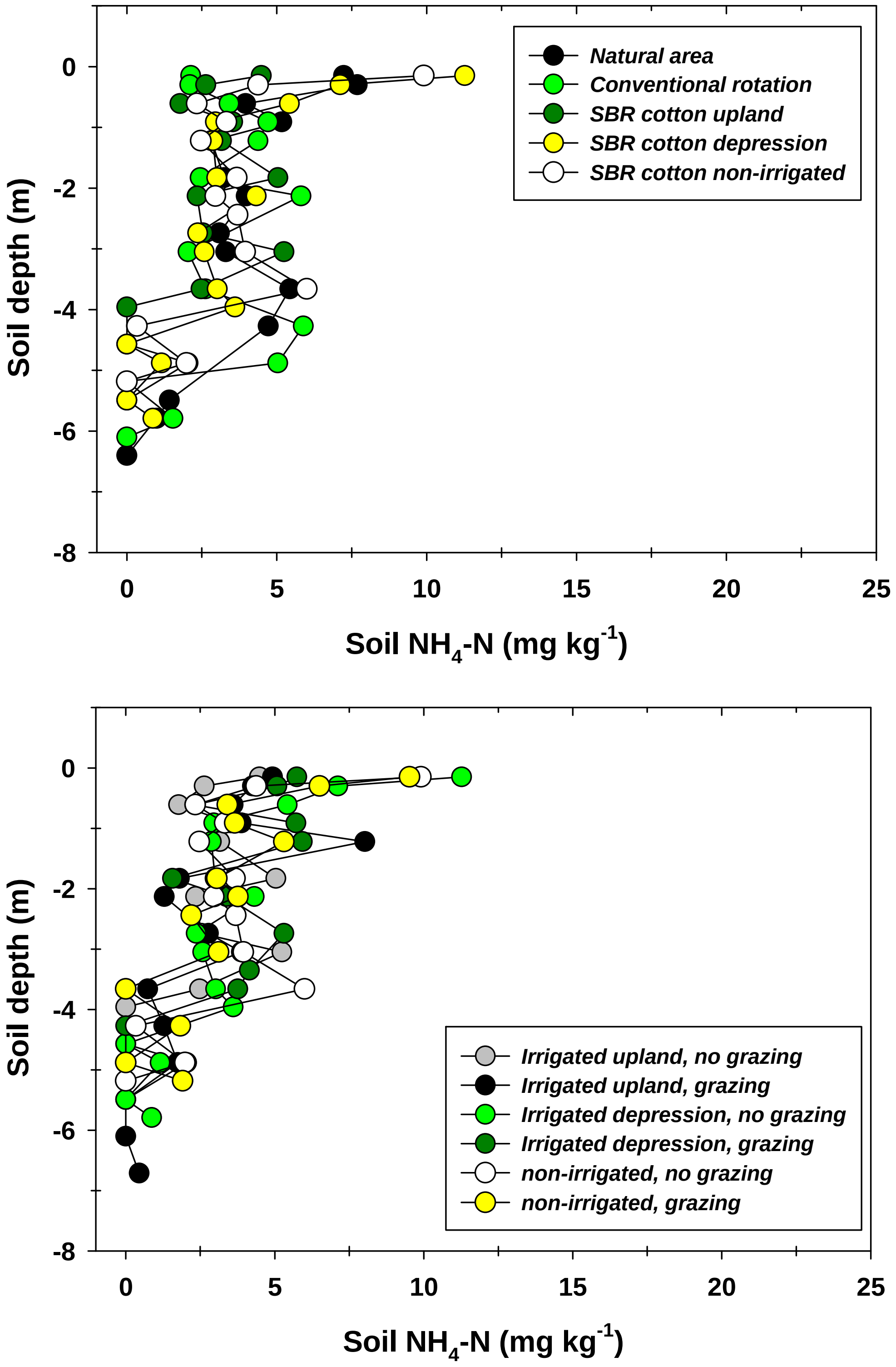


Fig. 7. 2015 KCl extracted (2M) soil NH$_4$-N. Data presented in two panels to reduce clutter. Additionally, the lower panel data are limited to soils following cotton in sod-based rotation, in order to discern soil type, grazing, and irrigation influences on soil NH4-N.

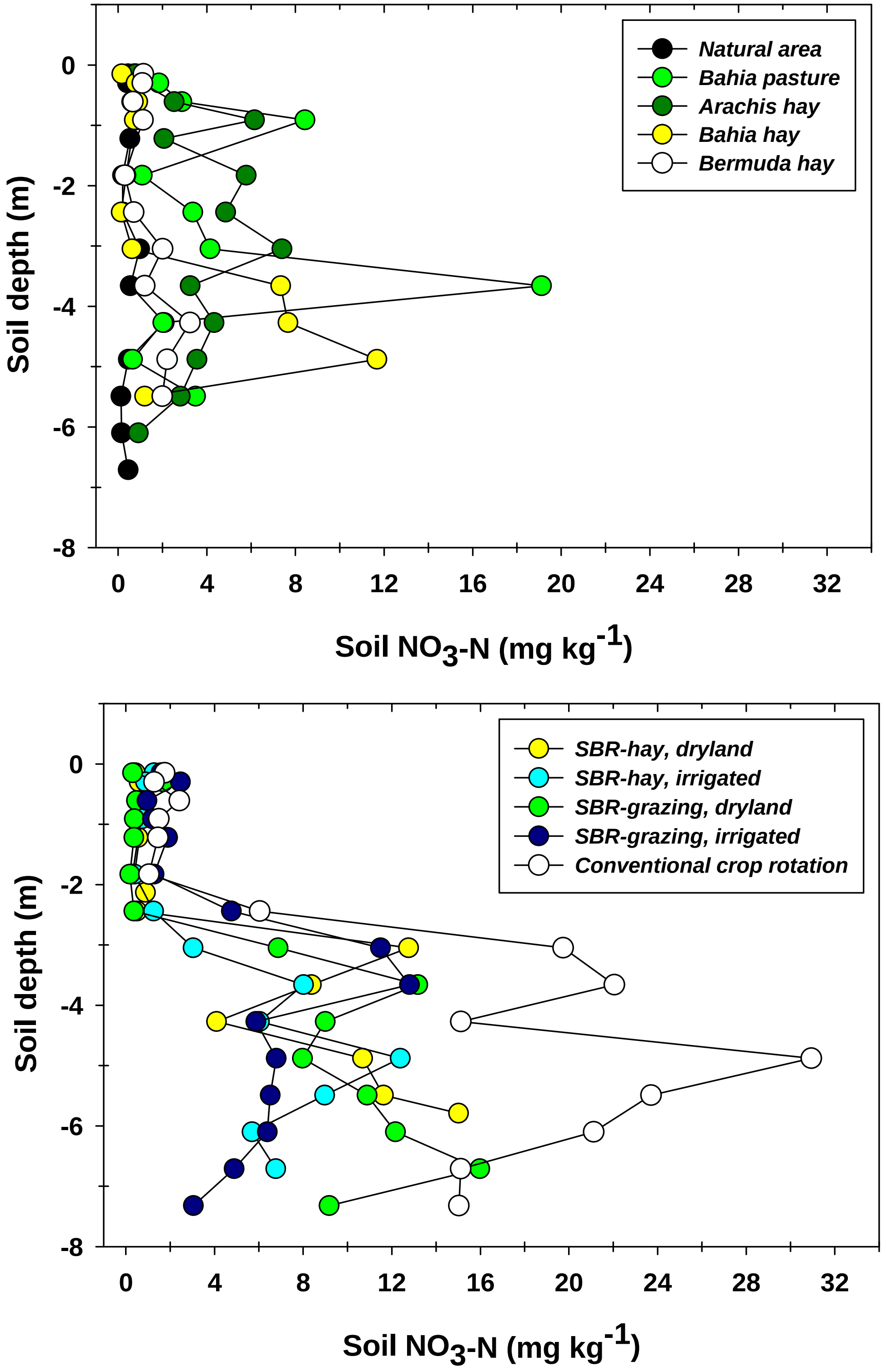
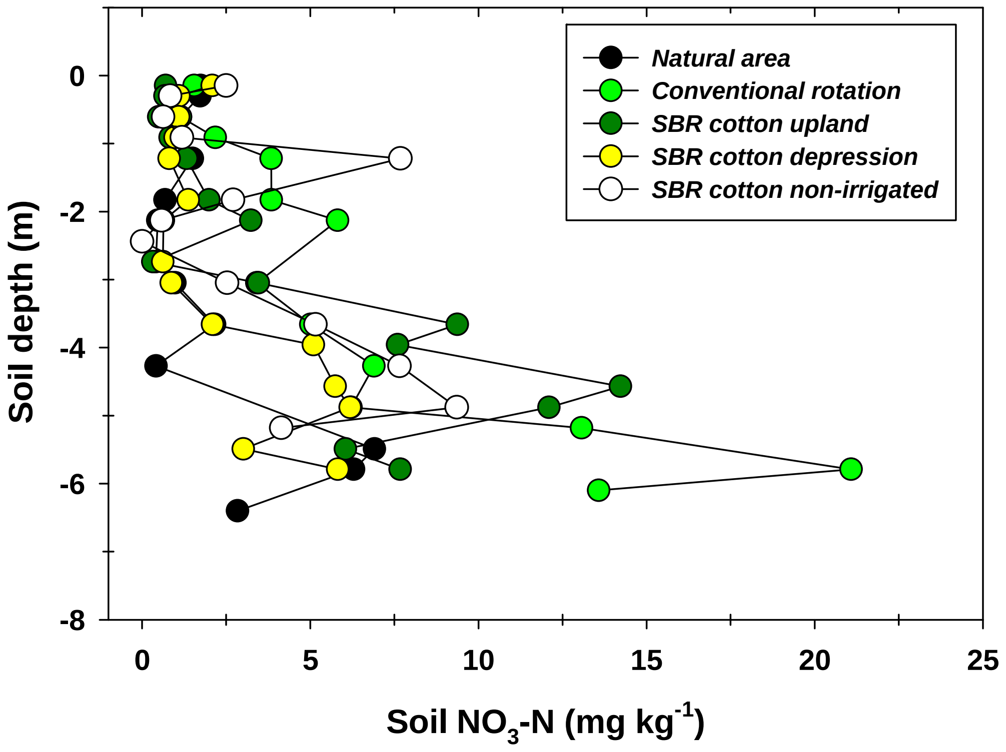


Fig. 8. 2 M KCl extracted soil NO$_3$-N. Data presented in two panels to reduce clutter. Symbols represent the mean of 2 samples.



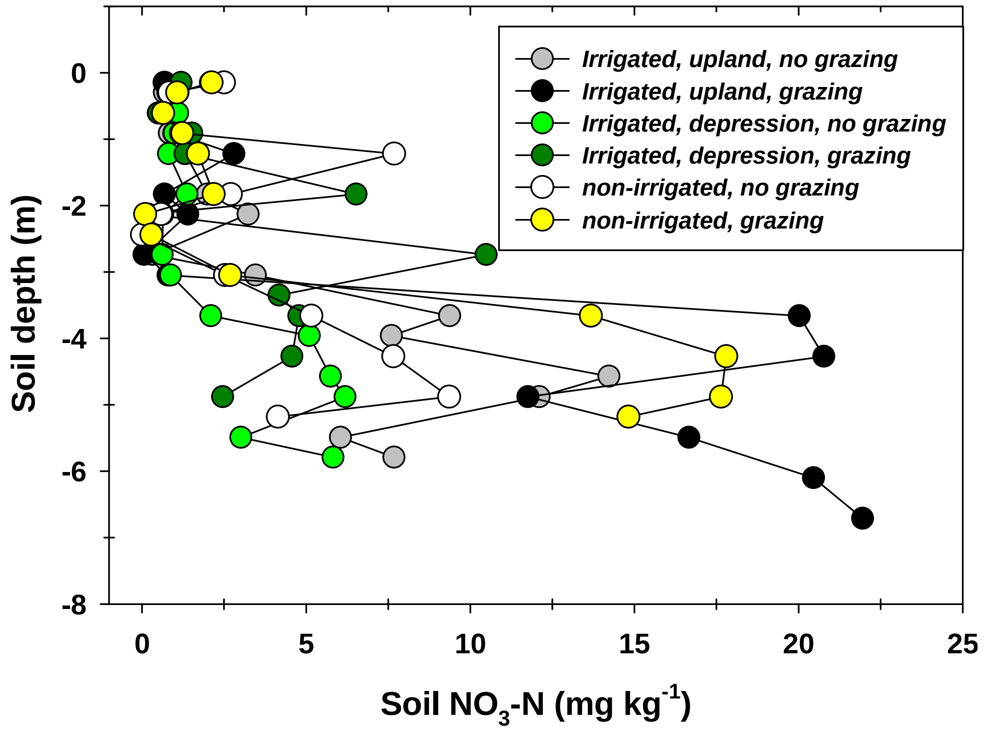


Fig. 9. 2015 KCl extracted (2M) soil NO$_3$-N. Data presented in two panels to reduce clutter. Additionally, the lower panel data are limited to soils following cotton in sod-based rotation, in order to discern soil type, grazing, and irrigation influences on soil NO3-N.

In fact, the cotton grown on irrigated land that was grazed resulted in comparable NO_3-N subsoil concentrations as the conventional crop rotation. There may be a couple of things at play here. Cattle integration into the SBR improves water penetration into the soil. Greater water movement will transfer more NO_3-N into the lower soil profile, as well. Additionally, cotton production under SBR with cattle requires less N fertilizer. However, it is quite difficult to convince the leaser that they can greatly reduce their N applications. When producers continue with past fertilization practices on a system that does not require as much, additional leaching losses are likely. In the SBR under grazing, the lower limit of N applications to support a cotton crop has not yet been realized. More research under these systems is needed to optimize crop production while minimizing NO_3-N losses.

The 2014 soil phosphorus (P) figures demonstrated greater concentrations in the surface soil that declined with soil depth. This is what is typically expected when sampling soil P with depth. However, the SBR dryland systems in 2014 showed increasing subsoil P at the greatest depths (Fig. 10). The bahia pasture also displayed some increasing subsoil P with depth.

In 2015, the soil cores from irrigated cotton systems (conventional and SBR), demonstrated a classic P response, with greater P in the surface soils and declining values with soil depth (Fig 11, upper pane). Although it is difficult to discern at the higher x-axis scale, the non-irrigated systems had increasing deep soil P (although they remained below 10 mg kg^{-1}), similar to what was observed with the 2014 cores. A comparison of the grazed SBR with ungrazed SBR history in 2015, revealed a large P spike under grazing in the depression area in the SBR (Fig. 11, lower pane). It is unclear why the hayed area (inside 50 x 50 ft exclusion cage) did not produce a similar P signature. With the trend occurring at several depth increments, the spike appears real. There are sink holes within a few dozen meters of the sampling area.

A spike in soil organic matter in 2015 also occurred in the depression area (Fig. 12). This suggests that the high P might be associated with the higher organic matter. Perhaps these high values are an artifact of long-past activities (burials or dumping), although 3 m (10 ft) is rather deep. Additional transect sampling may be warranted to better characterize the zone. Within 20 ft of the surface, limestone can be found. Since this depression tends to be wetter, perched water may be holding some of the nutrients and organic matter that would have normally leach to lower depths. The trend of increasing soil P with depth of non-irrigated samples, also suggests that some P may be leaching from systems under irrigation. Phosphorus leaching is known to occur in very sandy soils, but we are not aware of any reports of P leaching from Ultisols. This may be worthy of further investigation, particularly in areas having shallow water tables or drainage to nearby surface waters.

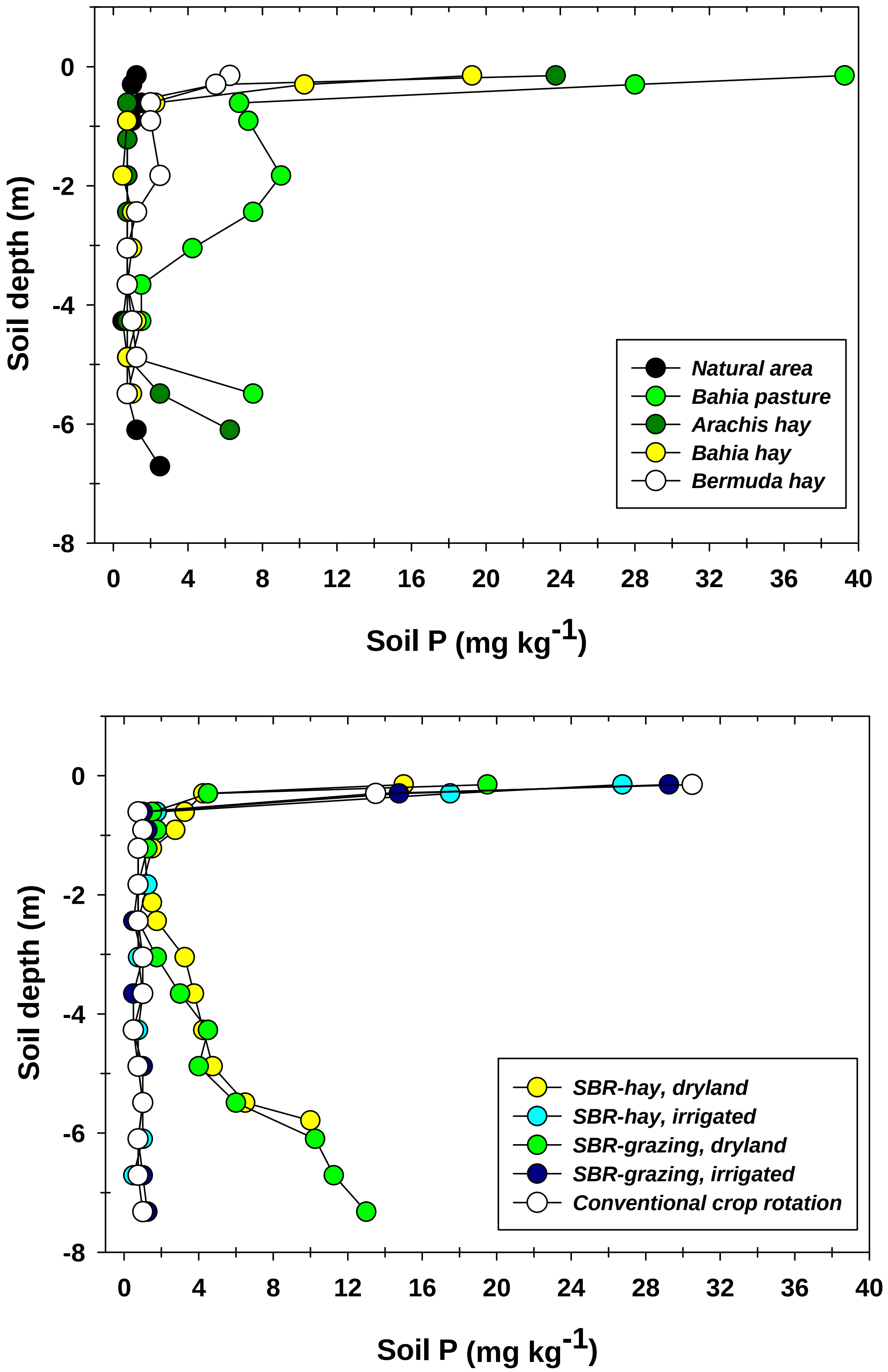


Fig. 10. Mehlich-1 extracted soil P from 2014 cores. Data presented in two panels to reduce clutter. Symbols represent the mean of 2 samples.

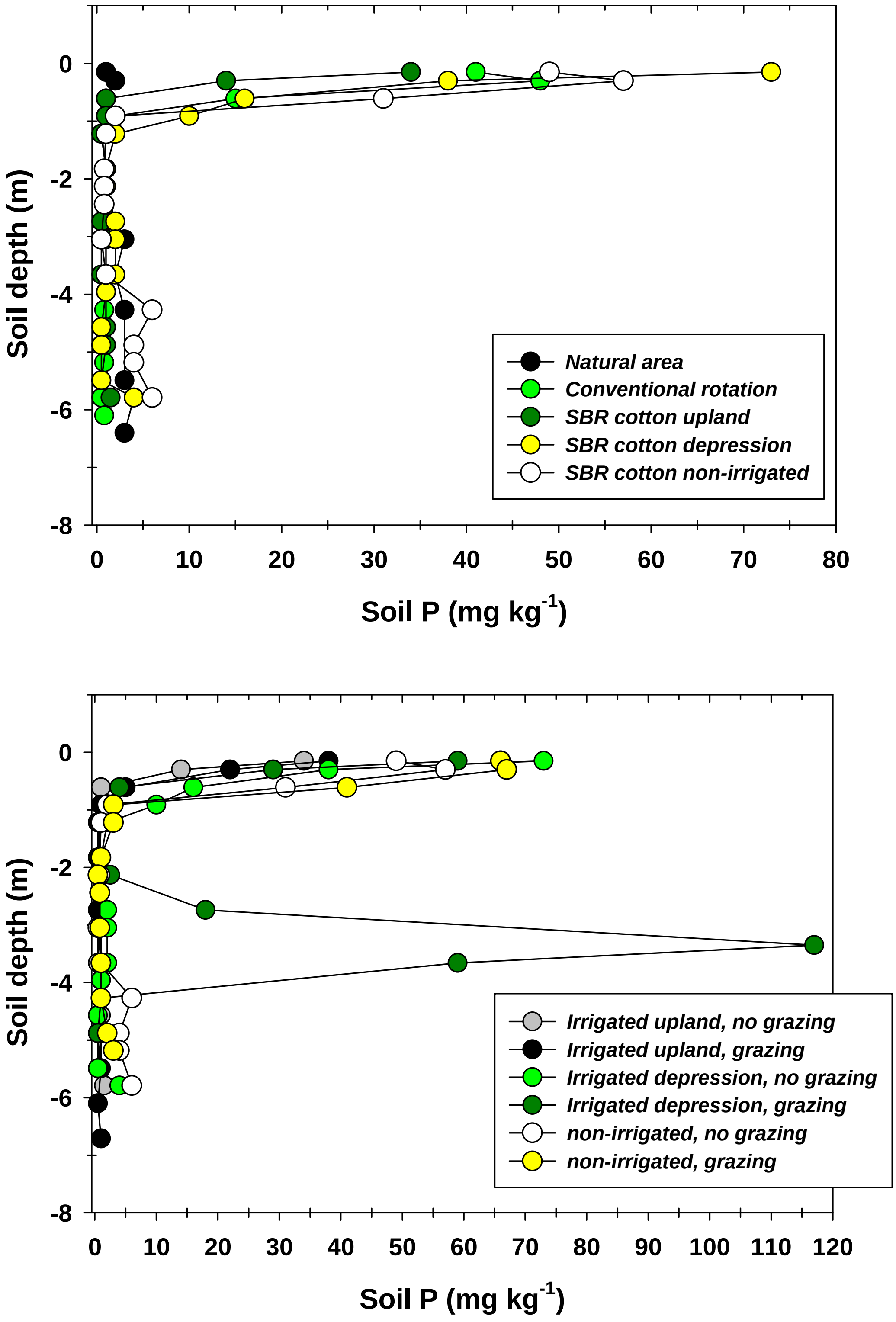


Fig. 11. Mehlich-1 extracted soil P from 2015 cores. Slight increase in subsurface P in the non-irrigated and natural area (upper panel). The subsoil P accumulation found in the grazed depression zone was unexpected (lower panel).

The natural area also had increasing soil organic matter with depth (Fig. 12). The nature of the organic matter is unknown, but generally, these carbon materials tend to be less prone to mineralization in subsoils than in the surface soils. A better delineation of the zone of high subsoil P and C in this field may be warranted.

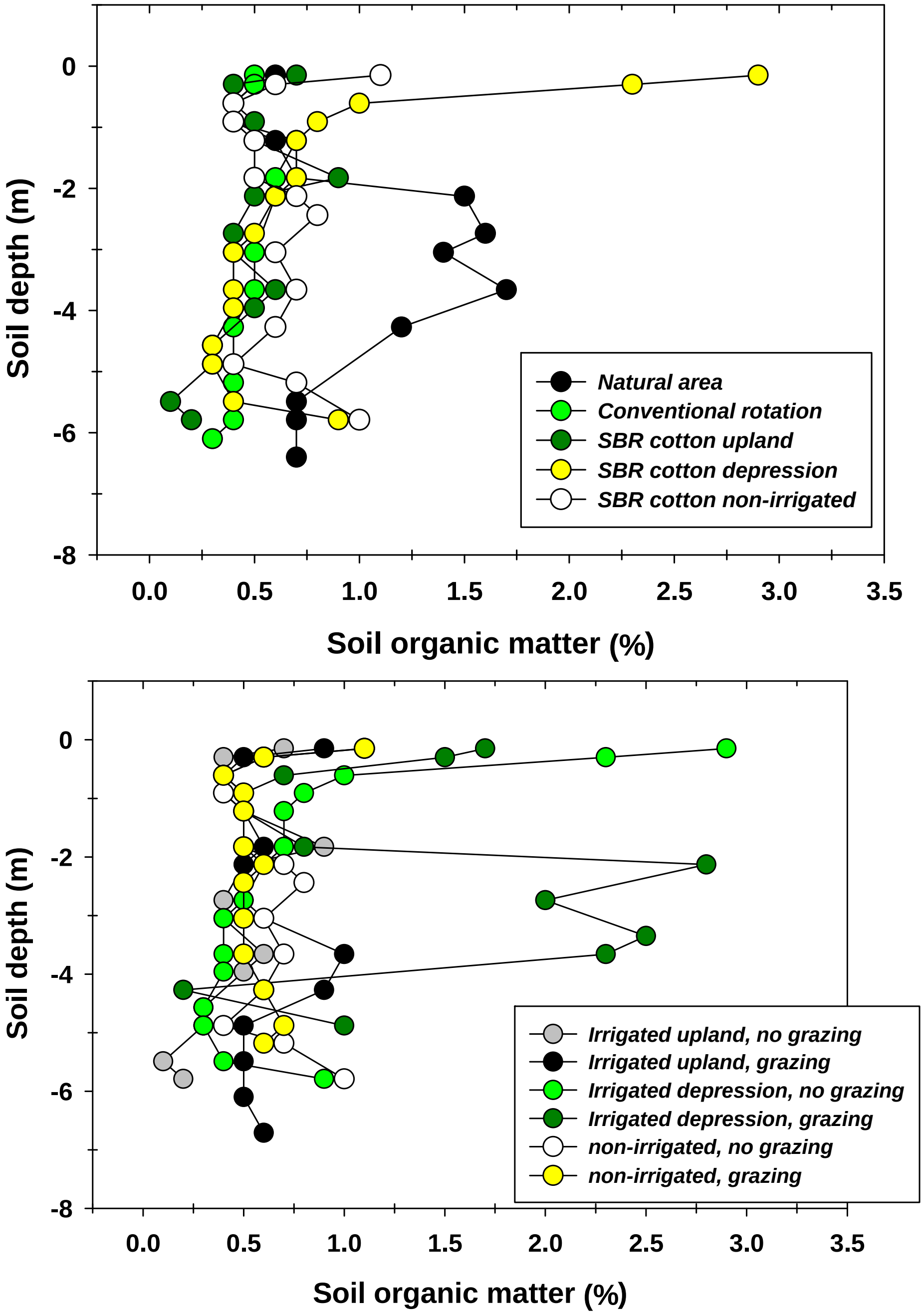


Fig. 12. Soil organic matter (OM) accumulation demonstrated in the depression zone under grazing, (upper panel), which corresponds to high subsoil P, as well. Lower panel demonstrates non-grazed OM accumulation at surface in the depression and also elevated subsoil OM under natural conditions.

Figure 13 shows soil potassium (K) with depth in 2014. In all but three cases, soil K was greatest at the surface, as expected. The bahia pasture tended to hold more soil K in the subsoil than other systems, including the SBR grazed bahia. The perennial peanut (*Arachis* hay) location demonstrated an accumulation of deep subsoil K in a non-irrigated field. A similar pattern was found with 2015 soil core K, where irrigated systems had lower subsoil K values than non-irrigated (Fig. 13). The pattern similarity among systems provides additional support that the irrigated systems are likely resulting in greater nutrient leaching. Additionally, the SBR without grazing might not be any more effective at limiting K leaching than conventional cotton production (cotton in upland SBR vs cotton in conventional rotation) (Fig. 13). However, including grazing appears to retain somewhat greater subsoil K, but not as much as growing under dryland conditions.

SBR soil mapping: The deep soil coring helped to verify that long-term farming practices are likely having consequences on the surveyed subsoils. Therefore, good surface soil management should translate to less subsoil nutrient leaching losses over time. This also suggests that long-term data monitoring is required to ascertain the surface soil management impacts on subsoil nutrient dynamics over time.

In order to improve surface soil nutrient and water management, soil mapping can delineate management zones, based on spatial surface soil data gathering. Soil mapping of the SBR at NFREC, Marianna, was completed in spring 2015. Figure 15 demonstrates shallow (0 to 1 ft depth) apparent EC in mS m^{-1}. Darker colored zones relate to finer textured, more moist soils. The OM values in both, red and IR spectral ranges (Fig. 16) help to further distinguish soil textural differences from soil fertility differences. As with the soil EC, the darker colors correlate with greater OM. Soil pH presented patterns that did not typically match EC or spectral data but seemed to have some relationship with topography (Figs. 17 and 18), where higher pH values were in low areas and lower pH values were at higher positions. This supports the supposition that nutrients (including lime) have been susceptible to run-off. It is not clear, based upon the recent mapping and soil core data if the SBR is mitigating run-off and leaching, although the non-irrigated areas do seem less prone to nutrient leaching.

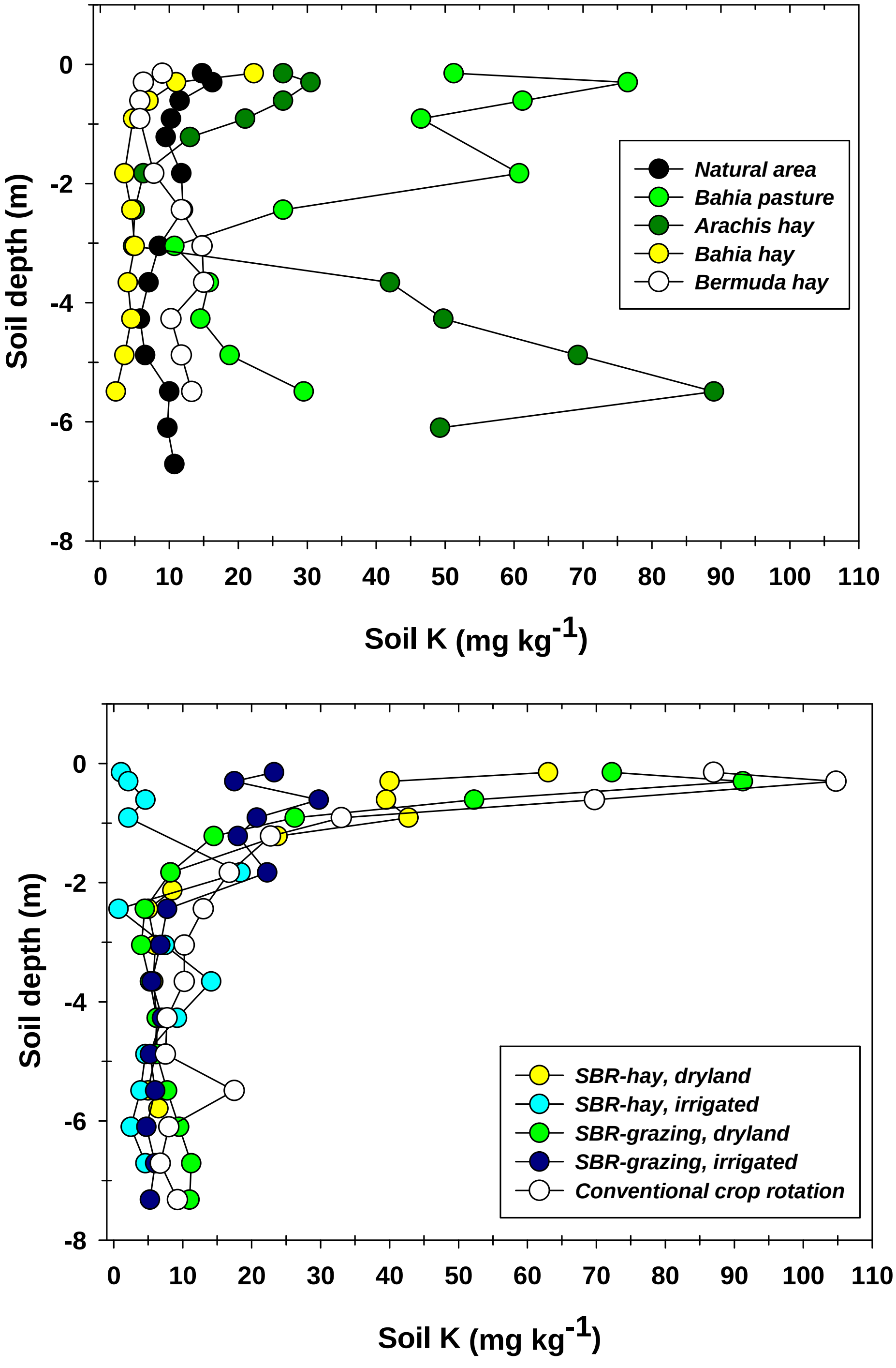


Fig.13 Mehlich-1 extracted soil K. Data presented in two panels to reduce clutter. Symbols represent the mean of 2 samples.

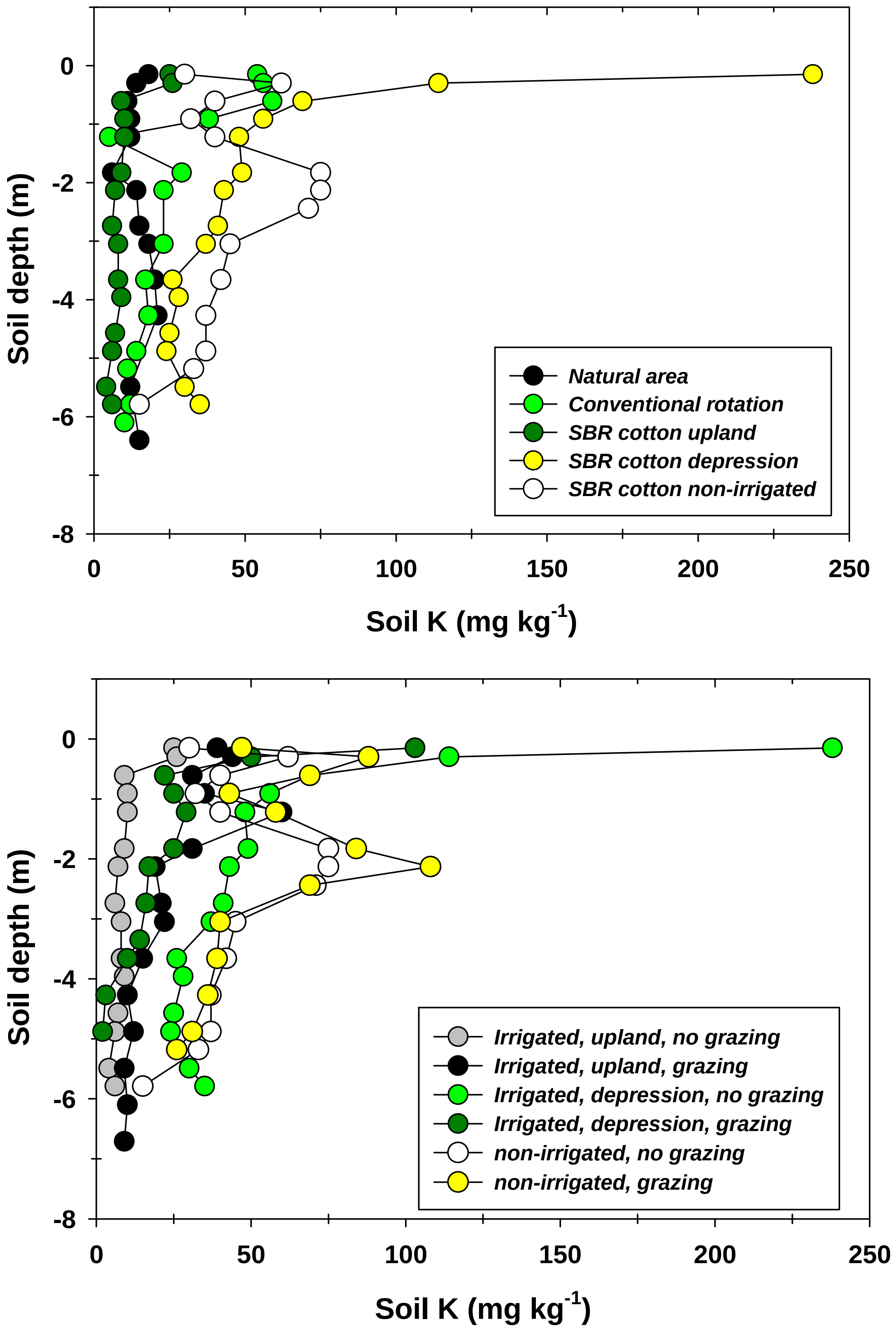


Fig. 14 Mehlich-1 extracted soil K. Upper panel represents natural area vs conventional cropping and SBR cropping. The lower panel compares the relative response irrigated vs non-irrigated and grazing vs non-grazing has on surface and subsurface K.

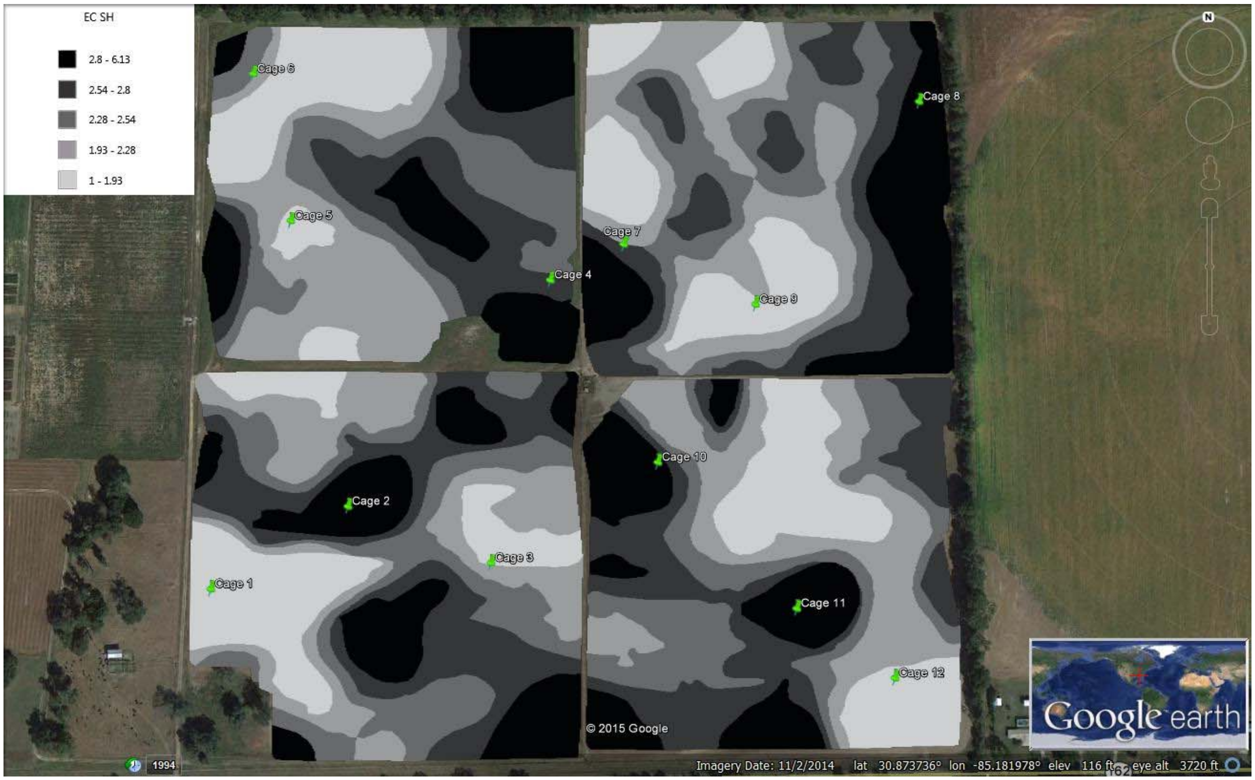


Fig. 15. Soil apparent EC (mS m^{-1}) from 0 to 1 ft depth. Pins mark exclusion cage locations.

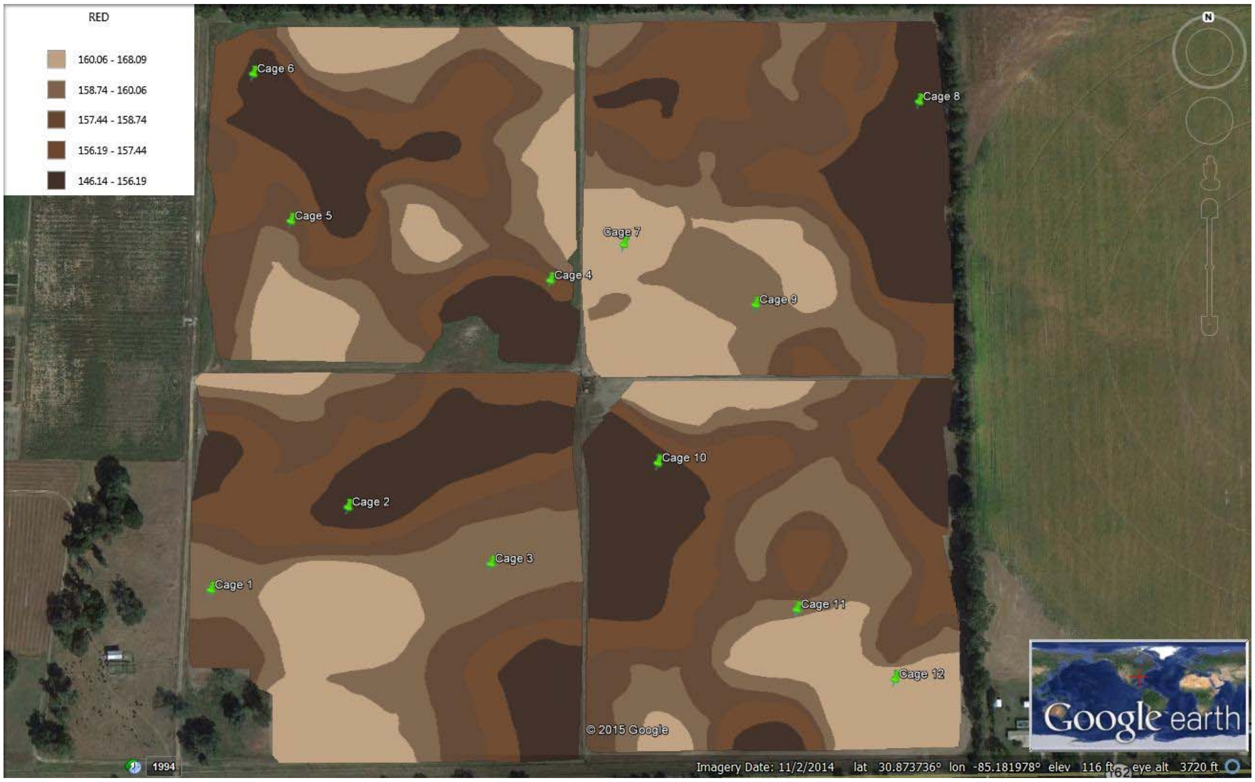


Fig. 16. Soil red spectral scan to estimate surface soil OM. Pins mark exclusion cage locations.

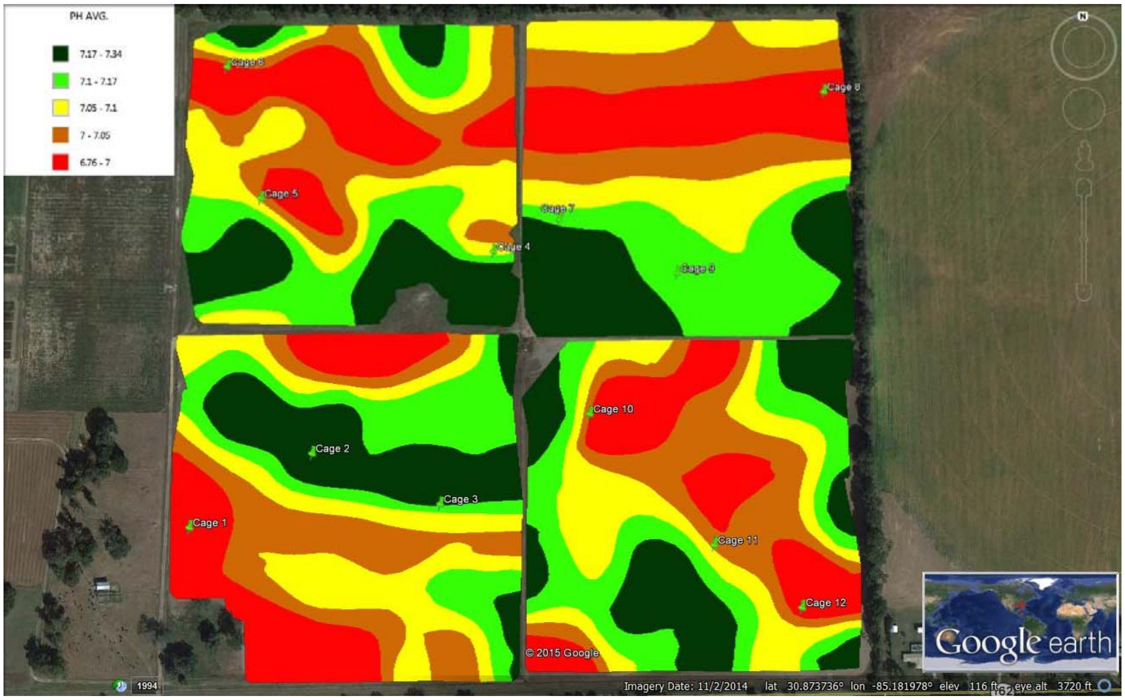


Fig. 17. Soil apparent pH. Pins mark exclusion cage locations.

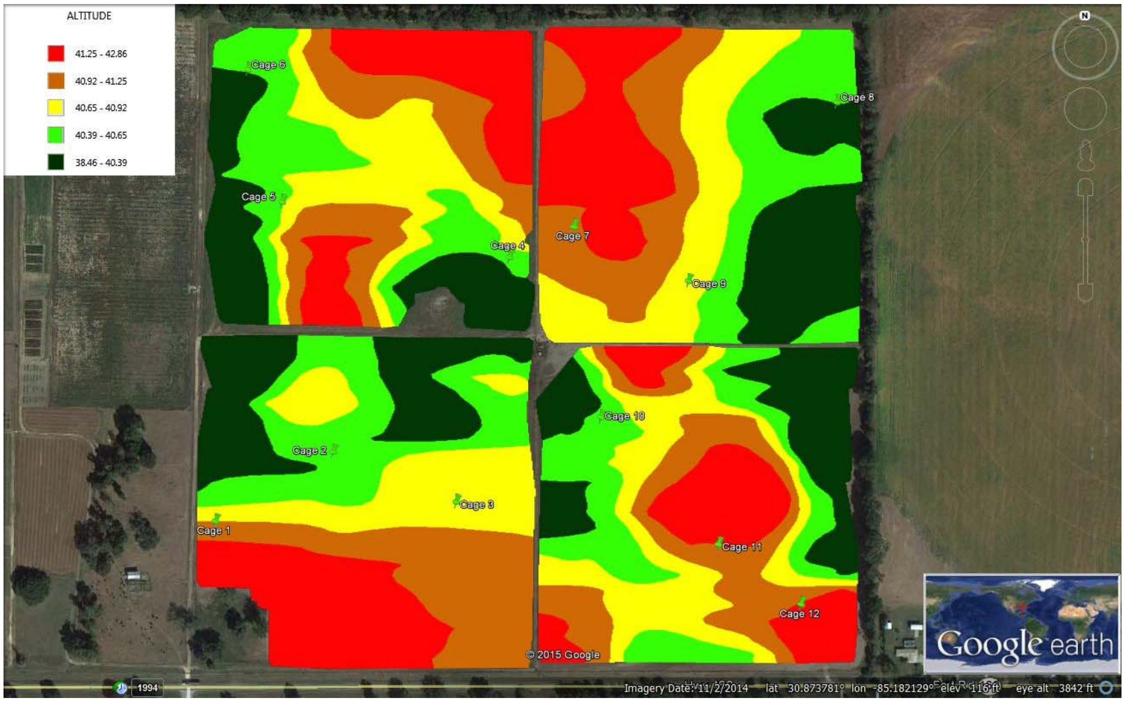


Fig. 18 Altitude (m) from GPS. Pins mark exclusion cage locations.

Preliminary comparisons of the soil wet chemistry data appears to support the Veris mapping results. Two of the SBR quadrants were used to compare the wet chemistry with mapping results. The southwest and northeast quadrants of the SBR were used. The relative pH values matched up well with the mapping results, where the highest values were dark green and the lowest were in red. The mapping values read high, which is due to a calibration off-set (Fig. 19). This is corrected by using a small number of samples analyzed in the lab as a reference. The use of hard well water for the water tank might help explain this discrepancy. However, offsets are easy to correct with calibrated soils. The company recommends a few samples per field be analyzed by a certified laboratory for calibration purposes.

A similar success was noted when comparing the textural soil maps (created with EC and OM values) against our laboratory readings for cation exchange calculations (based upon soil chemistry K, Ca, Mg, and pH) and soil OM. Soils that were deemed finer textured and dark or rich had greater CEC and OM values (in blue) than soils that were more coarse textured and had lower OM (in yellow) (Fig. 20). The given textural zones were developed by Veris staff. The parameters and class ranges can be used as is or new parameter ranges and delineations created to best suite the client/producer. Again, the spectral values are not provided in percent OM. The calibration data will be used to make the needed adjustments to OM and pH data. The needed calibration data may add an additional $50 to $100 to a field mapping event, depending upon the number of calibration samples (6 or more) and analytic costs ($10 or more per sample).

A farmer will want to know if surface soil characteristics identified by soil mapping will translate into yield response differences. The Veris company takes the data layers and creates zones for variable rate applications. Figure 21 is comparable what a farmer's map might look like after having his/her mapped field data converted into zones. Using zones created by the company, cotton lint yields (mean ± SE) on these soils in 2014 were greatest from the irrigated upland (Cage 3) location (1,849 ± 79 kg ha^{-1} for ungrazed; 1,819 ± 29 kg ha^{-1} for grazed). The non-irrigated (Cage 1) lint yielded 1,568 ± 113 kg ha^{-1} for ungrazed and 1,237 ± 25 113 kg ha^{-1} for grazed. Both locations shared similar texture and color (indirect measure of soil organic matter) attributes. Yields between ungrazed systems were similar, suggesting that low soil moisture was not a limitation in 2014. In comparison, the heavier soil (Cage 2) resulted slightly depressed lint yields compared to the lighter irrigated soil, with cotton from the ungrazed area yielding 1,538 ± 79 kg ha^{-1} and 1,549 ± 72 kg ha^{-1} from the grazed area. Under dry years, one might expect greater yields from a somewhat heavier soil, but there was heavy rainfall near the time of planting (March = 7.7 inches and April = 13.18 inches), as well as above average rainfall in September (6 inches), as the bolls were ripening.

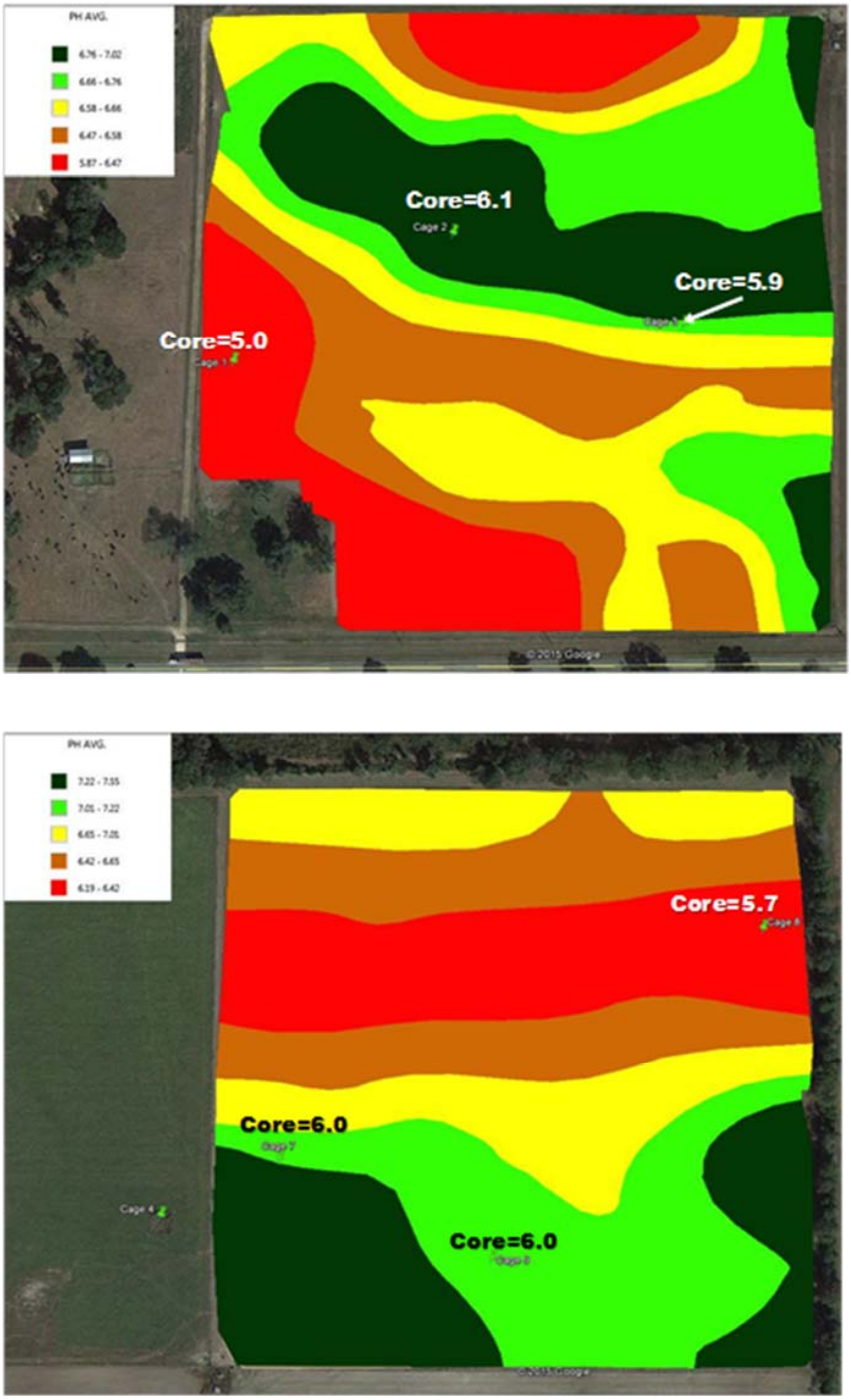


Fig. 19. Southwest (upper panel) and northeast (lower panel)Veris pH map with a surface soil (0 to 15 cm) laboratory pH comparison given for each sample location.

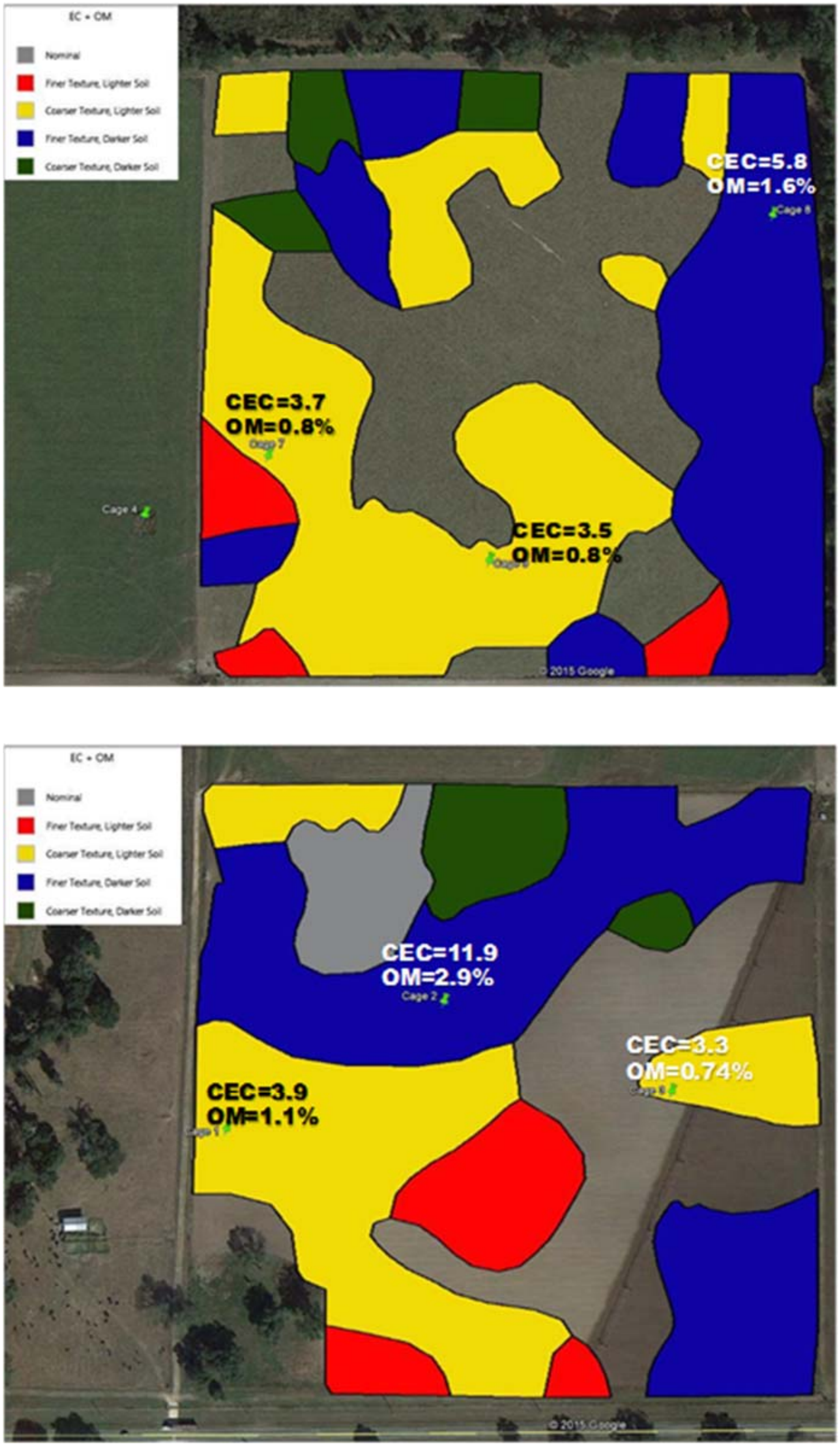


Fig. 20. Southwest (upper panel) and northeast (lower panel)Veris soil quality map with a surface soil (0 to 15 cm) laboratory comparison of cation exchange capacity (correlates with EC) and organic matter for each sample location.

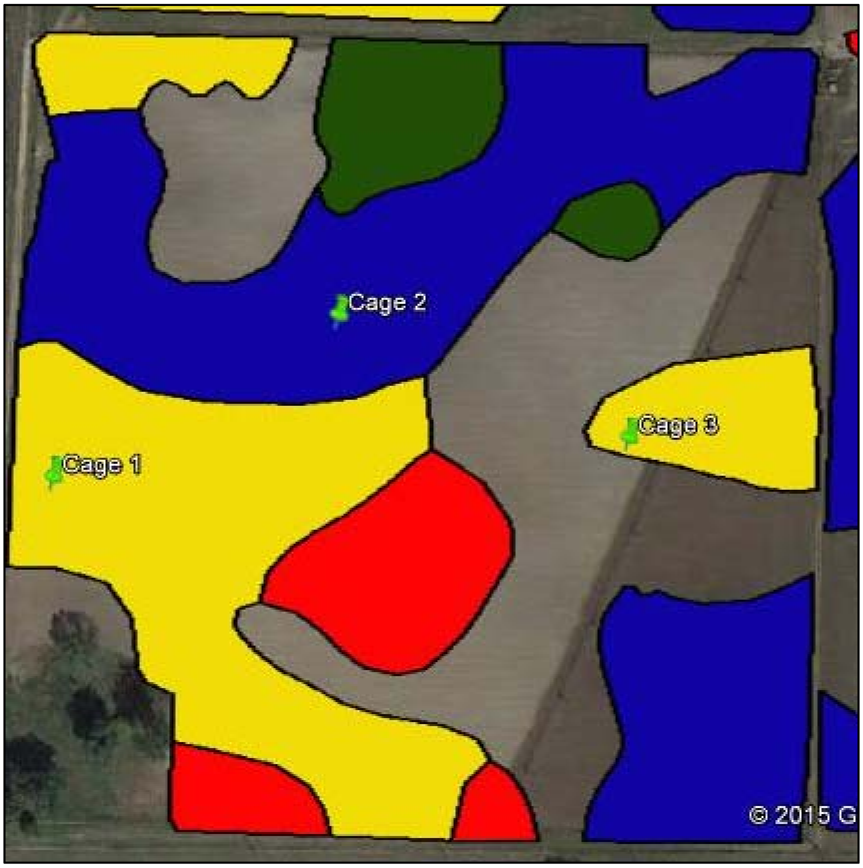


Fig. 21. Cage 1 = non-irrigated cotton (grazed or not); Cage 2 = irrigated cotton in depressional area (grazed or not); Cage 3 = upland irrigated cotton (grazed or not). Color codes: blue = finer texture, darker soils; green = coarser texture, darker soils; yellow = coarser texture, lighter soils; red = finer texture, lighter soils. Uncolored areas are nominal in texture and color.

Front Office Block (FOB) soil mapping: A central goal of this project was to ascertain if the mapping values appeared reasonable for the locations that it was sampling. Making comparisons at multiple locations provides supporting evidence that the mapping tool works as purported by the company. The FOB soil type is described in Appendix 1c. Manual sampling across several plots was conducted. Most of the FOB at Quincy, FL, has been in SBR (compared to conventional rotation) for well over a decade. Plots were mapped in 2015 (Appendix 2b). The collected data was used to assess how closely the actually mapping points corresponded to manual soil sampling results (within a meter).

Soil pH values taken by the instrument were approximately 0.5 pH units higher than manual sampling. This off-set exemplifies why soil calibration (6 or so samples analyzed in the lab) are required to verify mapping values (collected from relatively low and high pH areas). However, even without the calibration, the relative differences among pH values remained similar. The 0.5 unit offset seemed fairly constant across different

Florida locations, and is likely related, in part, to the tap water used for rinsing the probes between samples.

Mapping for soil pH is shown in Figure 5. Although experimental blocks run west to east, the pH gradient appears north to south, with lower soil pH trending in the more northern plots (Fig. 22). The mapping points were further consolidated into low (red/brown), moderate (yellow/green) and high (green/blue), resulting in approximately 0.2 pH unit differences. The manual soil pH data were gathered from some of those regions and compared, using box plots (Fig. 23). It is clear that even at a fine resolution (0.2 units), we seem to be able to discern real pH differences that are shared by mapping and manual sampling. The south portion of the field where the highest mapped pH was located had the fewest available manually sampled points to compare with the mapped points. Even so, a trend of increasing minimal pH values is apparent in Figure 23 and suggests that the mapping pH values were reasonable. Further sampling and statistical analyses is required to fully understand the relationship across soil types and spatial distance. This is true for each of the mapping parameters.

Fig. 22. Front office block (FOB) soil pH mapping. pH ranges are as follows: red = <6.0; brown = 6.0 -6.1; yellow = 6.1 – 6.2; green = 6.2 – 6.3; blue = >6.3.

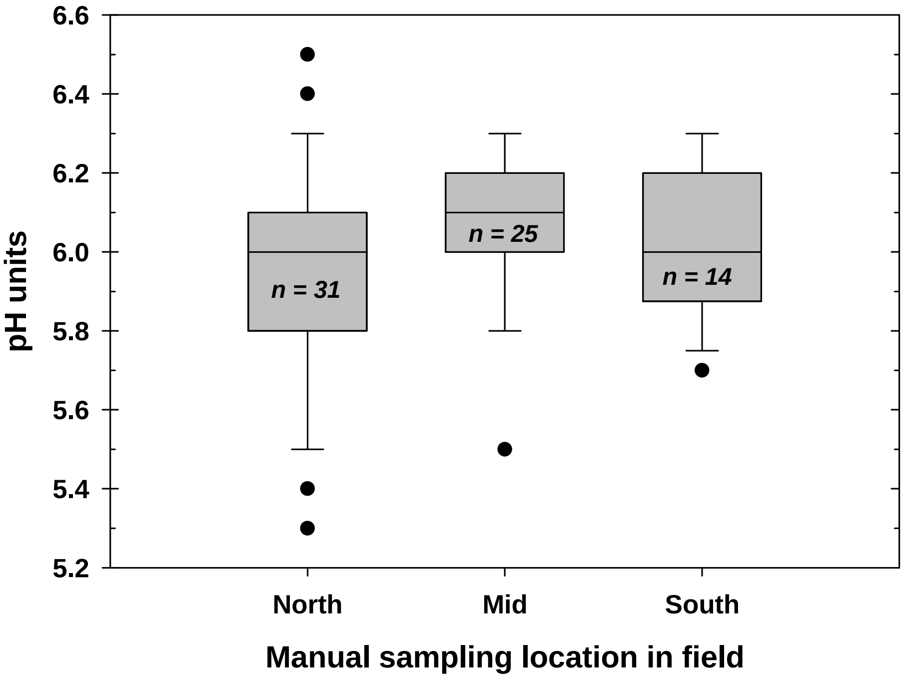


Fig. 23. Box plots of surface soils (0 – 0.15 m depth) sampled manually from the relative low, moderate, and high pH points taken from the soil mapping results (Fig. 5). The horizontal line in each box represents median value, the vertical bars = 10 and 90% quartiles, while the closed symbols represent outliers.

Soil electrical conductivity (EC) was mapped similarly to the pH, except with EC, the readings are continuous (no time delay between samples), therefore a more smooth transition between points (Fig. 24). Due to the narrow range and limited sampling areas to choose from, only a low vs relatively high cation exchange capacity (CEC) association with the soil mapping was evaluated. Box plots using the manual values showed that the manual CEC seemed to respond in the same fashion as the soil mapping lowest and highest EC points (Fig. 25). There was not as obvious an EC gradient across the field in the EC map. As these are relatively small plots with several factors included, there did not seem to be any obviously delineation of SBR vs conventional rotation. The east side of the field appeared to have somewhat lower EC values, and it may be due to greater slope in this part of the field, where its more prone to erosion forces.

As with EC, Soil organic matter (SOM) was mapped continuously (Fig. 26). Again, only a low vs high comparison was made with manual sample results. In this case the mapping values were compared to organic matter estimated from loss-on-ignition values. As with EC, there seemed to be a relationship between the mapping values and LOI (Fig. 27).

Fig. 24. Front office block (FOB) soil EC mapping. Electrical conductivity color gradient ranged from light gray (lowest values) to black (highest values). This is an indirect measure of soil nutrient content and it can also be associated with soil moisture, to some extent. Darker shades should be somewhat more fertile and perhaps finer textured that hold more moisture.

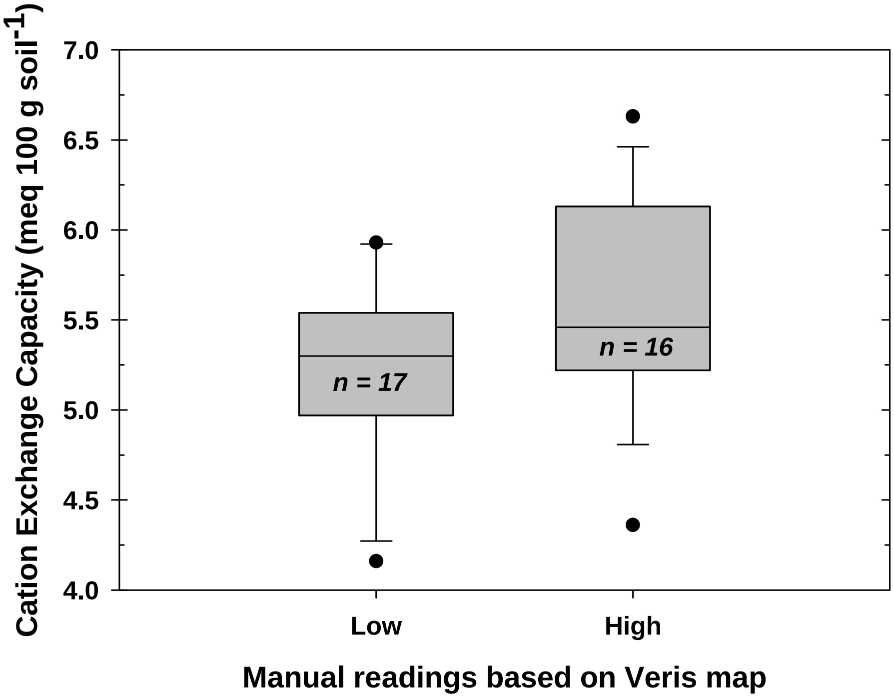


Fig. 25. Box plots of surface soils (0 – 0.15 m depth) sampled manually from the relative low, vs high CEC, taken from the soil mapping results (Fig. 5). The horizontal line in each box represents median value, the vertical bars = 10 and 90% quartiles, while the closed symbols represent outliers.

As well as with soil EC mapping, the SOM mapping did not lend itself to follow any recognizable pattern in terms of soil management within the plots. Our best increases in SOM are when livestock are integrated into the SBR. Otherwise, conservation tillage (as was used in the conventional crop rotation) also helps retain SOM. The spectral shoe has a limited soil penetration of 1 to 2 inch depth, depending how hard the soil surface is. It seems that rather than trying to reach a quantitative goal in terms of EC or SOM, the best use of this mapping equipment is to delineate differences within a field so that prescriptions can be developed for variable rate management, whether that is residue retention, liming, fertilization, pesticide management, or irrigation. Florida soils often fall into the “marginal” category. Based upon results from this high resolution mapping trial, we found that we can ascertain differences in soil characteristics (within a given soil type) that may be amenable to variable rate application technologies. It has been shown that we can discern differences on a small plot (1 m^2) scale, based on supporting wet chemistry analysis. It can be concluded that discerning zones across an entire field should be even more rewarding. There does not seem to be a lack of variability within a soil type, as the Veris MSP3 shows that it can locate even small differences in soil characteristics. Zoning complexity (from 2 to several) is determined by the software technician or end-user.

Fig. 26. Front office block (FOB) soil infared (IR) mapping, which is related to soil organic matter (SOM). The IR color gradient ranged from biege (lowest SOM) to dark brown (highest SOM). This is an indirect measure of SOM. Darker shades should be somewhat more fertile and perhaps hold more moisture.

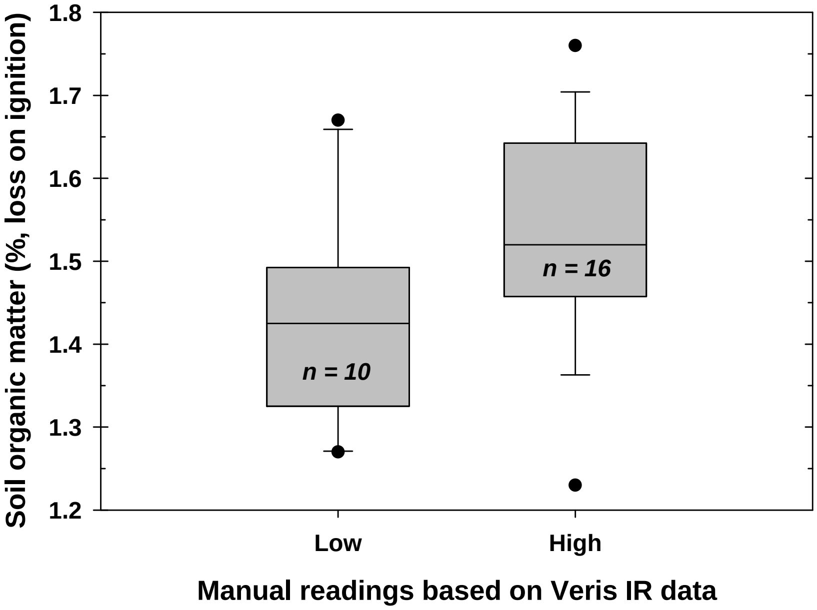


Fig. 27. Box plots of surface soils (0 – 0.15 m depth) sampled manually from the relative low, vs high SOM (via loss on ignition), taken from the soil mapping results (Fig. 5). The horizontal line in each box represents median value, the vertical bars = 10 and 90% quartiles, while the closed symbols represent outliers.

Productivity index development (Florida dairy trials): To further test the practical application of the Veris MSP3 unit and its potential to aid in creating productivity indices, we mapped sections of fields at three dairies across Florida. The question was: Can we use soil mapping and other data collections (such as aerial mapping) to aid in the development of a crop productivity index? Through financial support from the Southeast Dairy Cooperative, we took some of these technologies on-farm to perform a cursory assessment of their purported attributes and challenges.

Three cooperators were selected to test these technologies. Soil characteristics are given in Appendix 1c. It is noted that these soils were much sandier (Entisols and a Spodosol) than what was tested in the SBR at Marianna or at the FOB location in Quincy. Annual winter forage grasses (rye, triticale, oats, ryegrass and some mixed ryegrass and small grain combinations). At two locations, the pivot provided dairy effluent periodically during the production period (December to March, whereas the BD field received only one effluent application. Application of an additional 45 kg ha^{-1} N (calibration test strip) improved forage productivity for most forages at the NFH and BD dairies, while there was little to no response at the NFH dairy. The test location at NFH was near the bottom of a sloped field and the end gun tended to over-apply effluent at this section of the field.

In order to ascertain what respectable forage yields and corresponding NDVI should be, the top 50% highest yielding observations across all three dairies were compiled (Table 1).

Table 1. Forage reference characteristics harvested in March, 2016, based upon top 50% dry mass yields in each group (mean ± standard error).

Forage	Yield	NDVI[Z]	TKN[Y]	CP[X]	Nitrates
	(kg ha^{-1})	(x 100)	-------------------------(%)-------------------------		
Triticale					
Tricale 342	9,360 ± 682	67 ± 11	2.5 ± 0.1	15.7 ± 0.6	1.07 ± 0.54
Triticale/RG[W]	10,450 ± 836	78 ± 01	2.8 ± 0.1	17.5 ± 0.6	1.85 ± 0.48
Rye/Oat[V]	5,713 ± 180	74 ± 11	3.3 ± 0.3	20.6 ± 1.9	1.35 ± 0.54
Oat					
Legend	10,664 ± 789	81 ± 01	2.7 ± 0.8	16.9 ± 5.0	1.70 ± 0.90
FL0720	8,822 ± 679	69 ± 06	2.8 ± 0.5	17.5 ± 3.1	1.35 ± 0.16
Horizon 270	8,303 ± 723	66 ± 10	2.3 ± 0.3	14.4 ± 1.9	1.44 ± 0.38
Rye					
Florida 401	12,144 ± 76	66 ± 01	2.4 ± 0.1	15.0 ± 0.6	1.47 ± 0.72
Elbon	6,387 ± 928	75 ± 06	4.5 ± 0.3	28.1 ± 1.9	1.44 ± 0.80
Wrens Abruzi	6,382 ± 1,043	77 ± 02	4.3 ± 0.3	26.9 ± 1.9	3.17 ± 0.76
Annual Ryegrass					
Earlyploid	6,460 ± 804	84 ± 01	3.7 ± 0.4	23.1 ± 2.5	2.46 ± 0.81
Big Boss/Prine	6,066 ± 653	85 ± 02	4.2 ± 0.3	26.3 ± 1.9	2.91 ± 1.19
Meroa	6,149 ± 595	88 ± 00	4.7 ± 0.4	29.4 ± 1.3	3.73 ± 0.23

[Z]NDVI = normalized difference vegetation index; [Y]TKN = total Kjeldahl nitrogen; [X]CP = crude protein, on a dry mass basis.
[W]Triticale/RG = Trical 342/annual ryegrass (Earlyploid); [V]Rye/Oat = rye (Elbon)/Oat (Horizon 201).

Those forages with earlier maturity (Florida 401 rye, Legend oat and Trical 342 triticale) resulted in the greatest yields, as they were at a later development stage (head-fill), where heads and stems contribute a greater proportion to total biomass. Leafier forages (Elbon and Wrens Abruzi rye, annual ryegrass) yielded about 40% less, as they did not have stems. The two later oats, FL0720 and Horizon 270 were intermediate in yield, as they had begun developing heads but head fill had not yet begun. The forage TKN, CP, and nitrates were provided as general reference in terms of what other plant characteristics contributed to yield. It is interesting to note that leafier forages (annual ryegrass) tended to have the highest TKN (CP calculated from TKN) values, along with the highest nitrate concentrations. If the forage was fed as harvested (green-chop) the nitrates would be roughly 10% of listed values and therefore not a concern for animal health. However, those considering hay cuttings of forage with CP above 20% should also consider testing the forage for nitrates. Values above 1% nitates as feed may pose health risks to cattle and other livestock.

The NDVI values also correlated to some extent with maturity. This index is calculated from the following relationship:

$$\text{NDVI} = \frac{(NIR-VIS)}{(NIR+VIS)}$$

where VIS and NIR represent the spectral reflectance values acquired in the visible (red) and near-infrared regions, respectively.

Generally speaking, the less amount of visible (red) radiation reflected, the more likely that it is being captured by the plant for photosynthesis. Non-living materials and maturing grain heads will likely reflect relatively more VIS than NIR, resulting in lower NDVI values. Leafier (no stems or maturing heads) forages (ryegrasses) tended to have higher NDVI values (using GreenSeeker), and the later maturing Elbon and Wrens Abruzi wheat had higher NDVI values than the earlier maturing Florida 401 rye (Table 1). It is recommended that NDVI be collected approximately at the time of full canopy cover, while plants are in the vegetative stage. In general, the healthiest plants seem to have NDVI values near or above 80. However, it becomes clear that it will be beneficial to calibrate NDVI within each crop species, if not also within a cultivar. Once an acceptable calibration of the NDVI is complete, reference N strips will not likely be needed in the future.

The use of NDVI has also been applied to satellite imagery to assess global vegetation. The aerial NDVI imagery of our forages via aerial flights could discern maturity differences among forage types, where Florida 401 rye was more mature than adjacent rye cultivars (Fig. 28). Additionally, there was slightly greater green value within the N application strip than not for many of the test forages. The IR imagery (left image) also showed greater canopy cover among the ryegrass cultivars treated with additional N. These differences were particularly easy to identify through observation on the ground, as well.

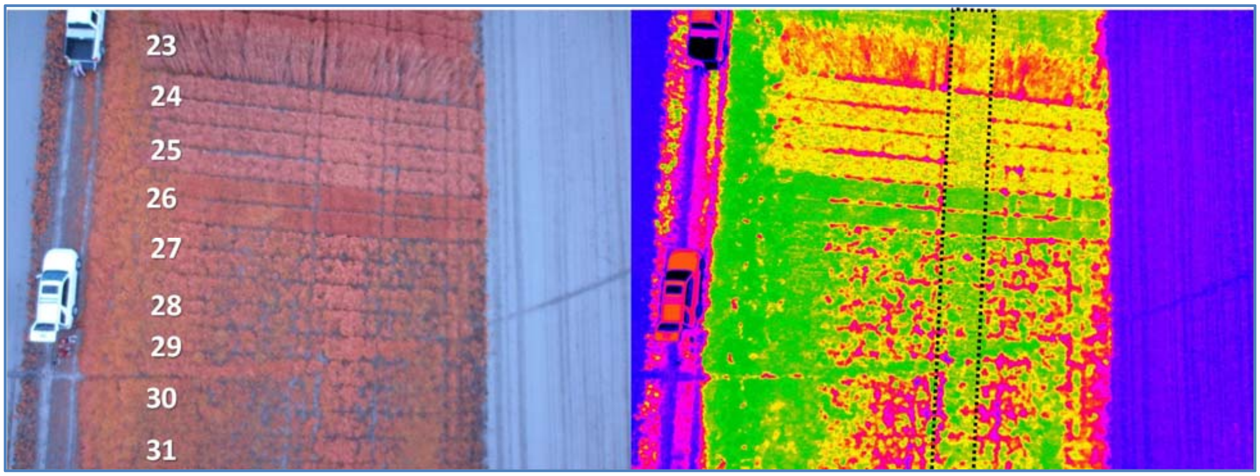


Fig. 28. Plots at UF dairy with IR imagery (left) and NDVI imagery (right). Numbers correspond to double row forage treatments: 23 = Florida 401, 24 =Wrens Abruzi, 25 = Elbon, 26 = wheat, 27-31 = different annual ryegrass cultivars. Black rectangular box on NDVI image represents where 45 kg N ha^{-1} was applied. Green = healthier (higher NDVI) than yellow>orange>red>blue.

Thermal imagery supported the NDVI imagery in that cooler temps were found with forages that were less mature or having greater coverage and growth (Fig. 29). Cooler temperatures are most likely due to increased transpiration (akin to evaporative cooling). When a crop is stressed (or midday on hot, summer days), leaf stomata tend to close, thereby causing the plant to accumulate heat. However, high transpiration rates might also be a sign that a plant is less water efficient and therefore one might consider thermal imagery as a useful field screening tool in drought tolerance research and breeding (Ruiz et al, 2015).

Relating the soil mapping results with the forage yields, we found some trends that suggest the Veris MSP3 mapping can help predict relative crop response. Three example forages are used to exemplify this. The highest yielding forages in all three cases were at the NFH dairy (Fig. 30). It is interesting to note that visual imagery illustrates the excessive spray path (forages began to lodge) at the test site. This is also exemplified by the relatively higher EC values on the soil mapping, where EC averaged 8.5 on a scale from 0 to 20 (Fig. 31). In comparison, the lowest yielding rye and ryegrass were at UF dairy (Fig. 32). The EC at these sites averaged 5.5, while the lowest measured EC at that location (white symbols) represented 3.5 to 5.1 (Fig. 33). It is interesting to note that the lowest EC ranges coincided well with lighter areas depicted in earlier Google Earth maps (Fig. 34). These lighter colored swaths are likely created by spatial variability in pivot emitter performance over time. Also one of the top yielding triticale samples came from under the same pivot (Fig. 33, green symbol), closer to the higher EC soil.

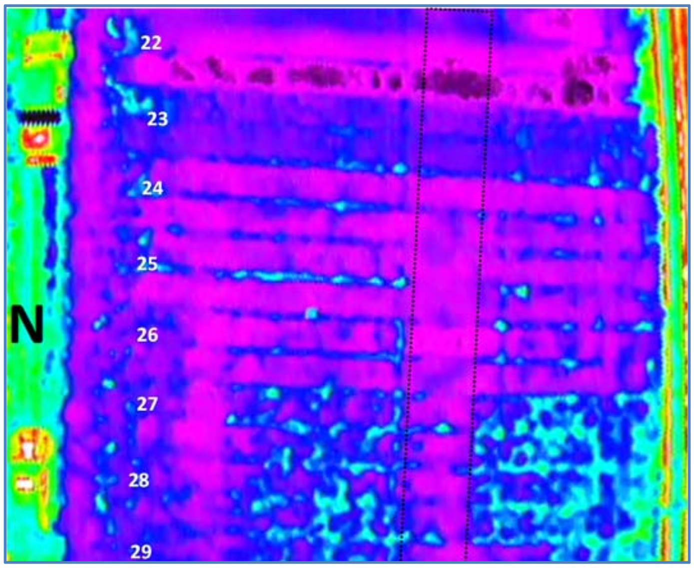


Fig. 29. Plots at UF dairy with thermal imagery. Numbers correspond to double row forage treatments: 22 = Horizon 227 oat, 23 = Florida 401, 24 =Wrens Abruzi, 25 = Elbon, 26 = wheat, 27-29 = different annual ryegrass cultivars. Black rectangular box on NDVI image represents where 45 kg N ha^{-1} was applied. Black is cooler than pink>blue>aqua>yellow>red>white.

Fig. 30. An aerial visual image of the plots was overlain upon the base map. The points show where the best yielding ryegrass (Earlyploid), rye (Wrens Abruzi) and oats (Legend) across all dairies were located at NFH.

Fig. 31. Veris MSP3 mapping of EC, where increasing EC relates to increasingly darker colors. Relative EC index of 8.5 was measured at the forage points (star symbols).

Fig. 32. An aerial visual image of the plots was overlain upon the base map. The points show where the worst yielding ryegrass (Earlyploid) and rye (Wrens Abruzi) across all dairies were located at NFH (red symbols). Also included a relatively high yielding triticale (Trical 342) location in this field (green symbol).

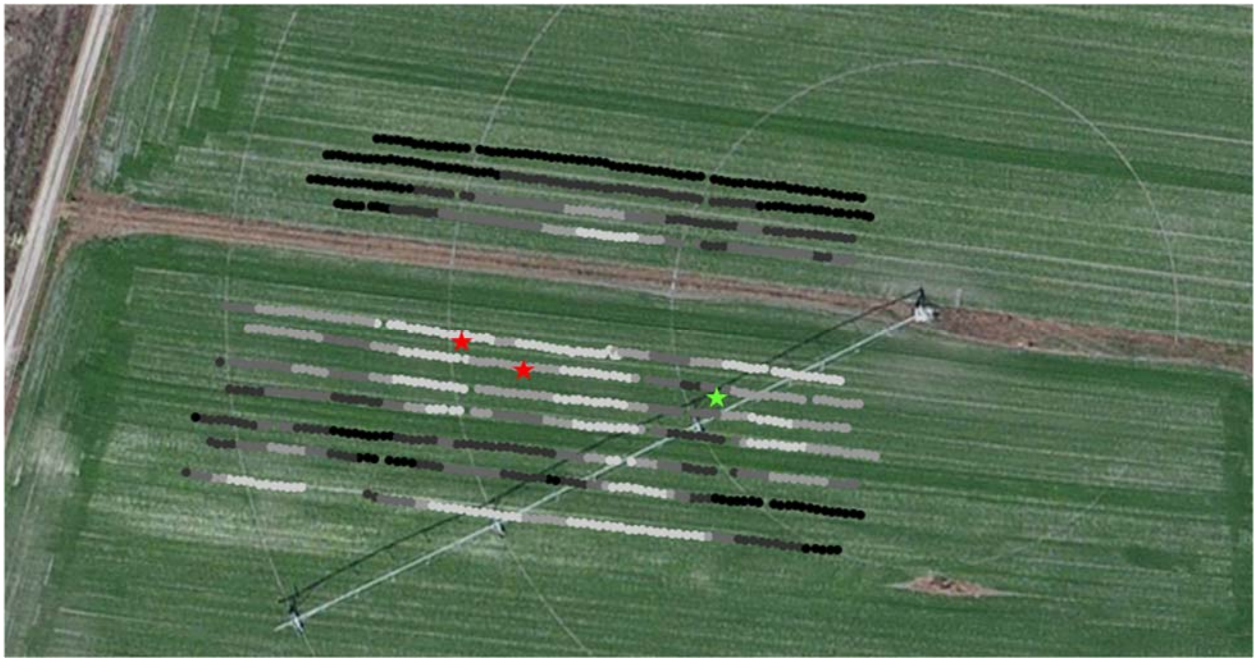


Fig. 33. Veris MSP3 mapping of EC, where increasing EC relates to increasingly darker colors. Relative EC index of 5.5 was measured at the forage points (red star symbols). Green symbol equates to a relatively high yielding legend sample.

Fig. 34. Earlier Google Earth map demonstrating the visual variation in color pattern associated with irrigation pivot performance. The EC in Fig. 33 seems to fit the pattern exposed in this figure.

However, the lowest yielding oat was located at BD dairy (Fig. 35). Unlike the UF dairy, the location of this sample had an EC index (8.6) comparable to NFH dairy (Fig. 36).

Fig. 35. An aerial visual image of the plots was overlain upon the base map. The points show where the worst yielding oat (Legend) across all dairies was located at BD (red symbol).

Fig. 36. Veris MSP3 mapping of EC, where increasing EC relates to increasingly darker colors. Relative EC index of 5.5 was measured at the forage points (red star symbols).

Therefore, EC does not explain yield differences in all cases. The soil pH ranges and OM ranges did not appear to show direct relationships with forage yields. However, calibrated pH maps can provide a good assessment of liming needs, but since dairy soils tend to increase in alkalinity over time, they are not good candidates for testing the Veris MSP3 for liming prescriptions. For example, NFH, BD, and UF dairy soil pH averaged 6.6, 6.5, and 7.2, respectively.

Some of the lowest EC mapped zones were also the ones that ranked lower in red and IR reflectance (lower values signifying greater organic matter). Based upon our results it seems that these longer established dairies have nutrient content (as exemplified by EC) that is decoupled from the OM maps. Often EC was high were the spectral OM was lower and the best yields were not typically where the greatest OM values were. Organic matter can immobilize several micronutrients. Since dairy soil fertility tends to be out of balance with lots of competing elements, the highest OM areas in this case might be signally potential micronutrient limitations or imbalances. Additionally, greater EC values tended to follow topography more than did the OM values. This was not the case in the SBR, where EC and OM seemed to be better coupled.

It appears that a combination of imaging and mapping tools, along with strategic sampling, can be used towards developing productivity indices, but much further research and testing is required to refine them. Additionally, different agricultural systems will require somewhat different types of indices or factors weighted in different combinations to best serve more target production system (i.e., crop production under effluent, under water irrigation, under dryland, pastures, hay, etc.). Even so, the tools that we tested can play an important role in their development as soil is the foundation to good crop production. In the case of North Florida dairies and lands sensitive to nitrate leaching, a N index, based on existing models might be valuable. Soil mapping can help discern the “hot spots” where irrigation or cropping changes may be warranted. Some strategic aerial imagery and/or crop sampling will help to determine response to management changes. It should be noted that sometimes management restrictions can also cost the grower money. For example, two of the three dairies maintained surface (0 – 15 cm depth) soil nitrates below 10 ppm but these dairies also hosted some of the lowest yielding forages during the trial.

Refining the nutrient management of an agricultural production system can sometimes result in a smaller operational buffer if things go wrong. We all need to be careful and remain attuned to what our recommended changes in management, based on newer technology, might bring about (good or bad) over time. If some of our management decisions need revising, we may need to quickly reverse earlier management recommendations without extended bureaucratic delay, in order to ensure environmentally sustainable and economically viable farming in our state.

Outreach: Along with the mapping efforts, we have been educating Florida and regional extension agents, as well as the public on soil mapping technologies and our future efforts using the Veris system. We sponsored presentations and demonstrations at the UF-IFAS Agronomy in-service in January, 2015 and 2016 (Appendix 3a). At the Southern Pastures Forage Crop Improvement Conference (SPFCIC) we provided a venue to demonstrate our MSP3 to over 100 science and extension professionals on March 31st (Appendix 3b). We also provided a static demonstration of the MSP3 at the Perennial Peanut Producers Meeting at NFREC, Marianna in June 2015 (Appendix 3c). Besides the equipment, Dr. Mackowiak demonstrated the differences among soils using soil cores, and provided handouts on mapping technologies and how to use general online mapping services, such as NRCS. Sponsorship from the Southeast Milk Check-off allowed us to demonstrate soil mapping and discuss results with the Milk Check review committee. More details on various events can be found in Appendix 3.

<u>Highlights are listed below, in chronological order:</u>

- Mackowiak, C.L., 2015. Soil EC-based nutrient management and on-the-go-sensors. Certified Crop Advisors. April 14th, polycom from Quincy to Lake Alfred.
- Wright, D.L., 2015. Potential impacts of sod-based rotation on climate change through less water and fertilizer use. Southeast Climate Extension Meeting, May 11-12, Quincy, FL.
- Wright, D.L., 2015. Tour of sod-based rotation farms with FDACS and farmers in Jefferson, Madison, and Suwannee, counties, July 17.
- Wright, D.L., 2015. Sod-based rotation, why adopt. Southeast Climate Extension Meeting. Orange Beach, AL. Aug 10.
- Wright, D.L., 2015. Economics of farming system in times of low prices and methods for profitable farming. Peanut Field Day, Aug 20th, Marianna, FL.
- Mackowiak, C.L. 2016. Agronomy In-service training demonstration: Next Generation BMPs: Soil mapping and equipment demonstration. This covered results comparing nitrate movement under sod rotations vs conventional farming. January 19, 2016, Quincy, FL.
- Wright, D.L. 2016. Spoke at the SE regional review of USDA/ARS in Florence SC on using variable rate application of water and nutrients –March 10-11, 2016
- Wright, D.L. 2016. Climate change workshop in Headland, AL and spoke on efficient use of nutrients using management zones- March 14, 2016.
- Mackowiak, C.L. 2016. Outdoor presentation/tour about soil mapping and forage production BMPs at a local dairy to seedsmen and local dairy producers, March 24, 2016, Lorida, FL.

- Wright, D.L. 2016. Hosted a legislative tour of the sod based rotation showing data from the Veris to help manage water and nutrients- May 25, 2016

DELIVERABLES

- The Veris MSP3 was purchased and delivered in early February, 2015 (Appendix 4).
- Mapping was completed on the SBR at NFREC, Marianna, FL in late March, 2015 and the SBR research plots at NFREC, Quincy, FL in April, 2015.
- Deep soil cores were gathered from several land-use areas in 2014 and 2015 and the soils analyzed for soil fertility parameters in support of the mapping efforts.
- Mapping of three dairies across Florida completed in December, 2015. Data from these locations and the previously mapped locations were used to assess the feasibility of a crop productivity index. Crop productivity parameters for winter annual forages were created.
- Semi-annual, annual reports for Years 1and 2 were completed. Final report was completed.

FUTURE CHALLENGES/RECOMMENDATIONS

Through our experience with the Veris MSP3 mapping tool over the past several months, we found that is has powerful potential in aiding with land management decision making. We found sufficient soil variability, even in dairy effluent impacted soils that affected plant productivity. We also think that managing based on this or similar mapping technologies will improve nutrient use efficiencies, but much more research is needed to better quantify potential gains. The EC package is the most refined component (also has the longest history) and it was aptly able to track nutrient variation in a field. The pH tool was also impressive when calibrated against field samples. With our limited sampling, it appeared that mapped and observed values were a simple offset, but more detailed calibrations should be conducted to verify this response. We had a few technical glitches with inexperienced operators, where they were not ensuring that collections (soil scooping for pH measurement) continued through the entire course of mapping. This sometimes led to missing pH values (i.e., UF and portions of BD dairy fields). This should not be a concern when using a more experienced tractor/technical operator. The OM tool is the least evolved tool in terms of data management and interpretation, although data collection went smoothly. Data interpretation requires further development to reap the most benefit from its capabilities. It was at times, challenging working with the company to get adequate data support, particularly the creation of KML files to use on basemaps of our own choosing (such as Google Earth). The text files were freely downloadable and can be used to create a database and conduct more detailed statistics (calibrations) and to tie into other data streams (aerial imagery). The company has the capability to create management zones and provides easy to handle standard packages that support farmers. However, the interface should be improved for research needs.

We recommend that it is best to train one or two tractor drivers who will be dedicated to the Veris MSP3 rather than rely on several people with only cursory knowledge of its maintenance and operation. We had hired part-time OPS (Ed Poppell, retired from FDACS) who was able to assist us. He was becoming increasingly proficient in equipment operation and already had experience with towing and tractor operation. Dr. Wright also has a farm technician (Maynard Douglas) who became the most experienced with operations, but his ongoing duties did not allow as much operator support as was required for this contract. We recommend a similar caliper of expertise be identified to assist Mr. Love (BMP Outreach/Education Coordinator) when he uses this equipment. Mr. Poppell is interested in assisting part-time, if that is of interest to FDACS.

With competing research programs, the NFREC has a shortage of tractors and transportation to adequately support the MSP3 for on-farm use. In discussions with Mr. Joel Love, we think that we can make a bigger impact with the mapping tool by allowing for an extended loan of the Veris MSP3 mapping tool to Mr. Love and the BMP Outreach/Education group at Live Oak, to complement the other variable rate equipment currently housed there. This location is also in close proximity to several dairies and farming operations that will benefit from detailed soil mapping that will aid with input management decisions. Mr. Love has a proven track record for bringing attention to tools that improve BMPs for the producer and we can assist with on-farm and on-center data collection decisions and analyses, as needed. The plan is to complete some additional mapping at NFREC for specific projects, then this fall deliver the Veris MSP3 to the Live Oak extension center to be placed under Mr. Love’s custody for as long as they require it. We will continue to maintain ownership unless conditions change. Therefore, we are requesting FDACS to support this proposed plan or consider supporting our research group funding for additional equipment to support the use of the Veris on-farm (make it portable). This requires a capable tractor, transport trailer and a truck with enough capacity to tow tractor and mapping tool. Faculty at NFREC had identified the needed support equipment, which priced below $200,000. We look forward to further discussion on this topic at the sponsor’s discretion.

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Appendix 1a. Soil core site descriptions, location, and soil characteristics (2014).

Site	Lat dec-deg	Long dec-deg	Soil series	Description*
Bahia Pasture	30.8554	-85.1867	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Bahia Pasture	30.8556	-85.1864	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Annual forage pasture*	30.8695	-85.1859	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
Annual forage pasture*	30.8695	-85.1858	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR 2nd yr. bahia hay (Area 1)	30.8750	-85.1820	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR 2nd yr. bahia grazed (Area 1)	30.8751	-85.1820	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR 2nd yr. bahia hay (Area 2)	30.8744	-85.1805	Red Bay, fine, sandy loam, 0 - 2% slopes	Fine-loamy, kaolinitic, thermic Rhodic
SBR 2nd yr. bahia grazed (Area 2)	30.8742	-85.1805	Red Bay, fine, sandy loam, 0 - 2% slopes	Fine-loamy, kaolinitic, thermic Rhodic
DRY SBR 2nd yr. bahia hay	30.8762	-85.1788	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
DRY SBR 2nd yr. bahia grazed	30.8761	-85.1788	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
Bermudagrass hay field (Tifton 44)	30.8762	-85.2048	Faceville loamy fine sand, 2 - 5% slopes	Fine, kaolinitic, thermic Typic Kandiudults
Bermudagrass hay field (Tifton 44)	30.8764	-85.2049	Faceville loamy fine sand, 2 - 5% slopes	Fine, kaolinitic, thermic Typic Kandiudults
Native vegetation	30.8743	-85.2082	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Native vegetation	30.8742	-85.2083	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
Conservation Tillage Crop rotation	30.8712	-85.2034	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Conservation Tillage Crop rotation	30.8711	-85.2034	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Bahiagrass hay field (Tifton 9)	30.7500	-85.0629	Dothan loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Plinthic
Bahiagrass hay field (Tifton 9)	30.7501	-85.0629	Dothan loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Plinthic
Perennial Peanut hay field	30.6469	-84.9886	Orangeburg, loamy sand, 5 - 8% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Perennial Peanut hay field	30.6469	-84.9888	Orangeburg, loamy sand, 5 - 8% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults

Kandiudults are very deep soils with a kandic kaolinite lay) horizon with some clay increases with depth.

Kanhapludults soils are up to 150 cm deep with a kandic horizon and the clay content decreases up to 20% within 150 cm depth (or clay content increase is less than 3%; i.e, tends to be sandier than kandiudult).

Appendix 1b. Soil core site descriptions, location, and soil characteristics (2015).

Site	Lat dec-deg	Long dec-deg	Soil series	Description*
SBR 2nd yr. bahia hay (Area 1)	30.8752	-85.1820	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR 2nd yr. bahia grazed (Area 1)	30.8750	-85.1820	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR 2nd yr. bahia hay (Area 2)	30.8763	-85.1787	Red Bay, fine, sandy loam, 0 - 2% slopes	Fine-loamy, kaolinitic, thermic Rhodic
SBR 2nd yr. bahia grazed (Area 2)	30.8761	-85.1787	Red Bay, fine, sandy loam, 0 - 2% slopes	Fine-loamy, kaolinitic, thermic Rhodic
DRY SBR 2nd yr. bahia hay (A1)	30.8763	-85.1786	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
DRY SBR 2nd yr. bahia grazed (A1)	30.8761	-85.1787	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
DRY SBR 2nd yr. bahia hay (A2)	30.8744	-85.1806	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
DRY SBR 2nd yr. bahia grazed (A1)	30.8719	-85.1781	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
SBR Cotton NG (cage 2)	30.8717	-85.1863	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR Cotton NG (cage 3)	30.8719	-85.1864	Fuquay, coarse sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Arenic Plinthic
SBR Cotton Grazed area 2	30.8717	-85.1864	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
SBR Cotton Grazed area 3	30.8728	-85.1805	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
DRY SBR Cotton NG (cage 1)	30.8729	-85.1864	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Dry SBR Cotton Grazed (cage 1)	30.8721	-85.1686	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Native vegetation	30.8743	-85.2082	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Native vegetation	30.8742	-85.2083	Troup sand, 0 - 5% slopes	Loamy, kaolinitic, thermic Grossarenic
Conservation Tillage Crop rotation	30.8712	-85.2034	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Conservation Tillage Crop rotation	30.8711	-85.2034	Orangeburg, loamy sand, 2 - 5% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults

Kandiudults are very deep soils with a kandic kaolinite lay) horizon with some clay increases with depth.

Kanhapludults soils are up to 150 cm deep with a kandic horizon and the clay content decreases up to 20% within 150 cm depth (or clay content increase is less than 3%; i.e, tends to be sandier than kandiudult).

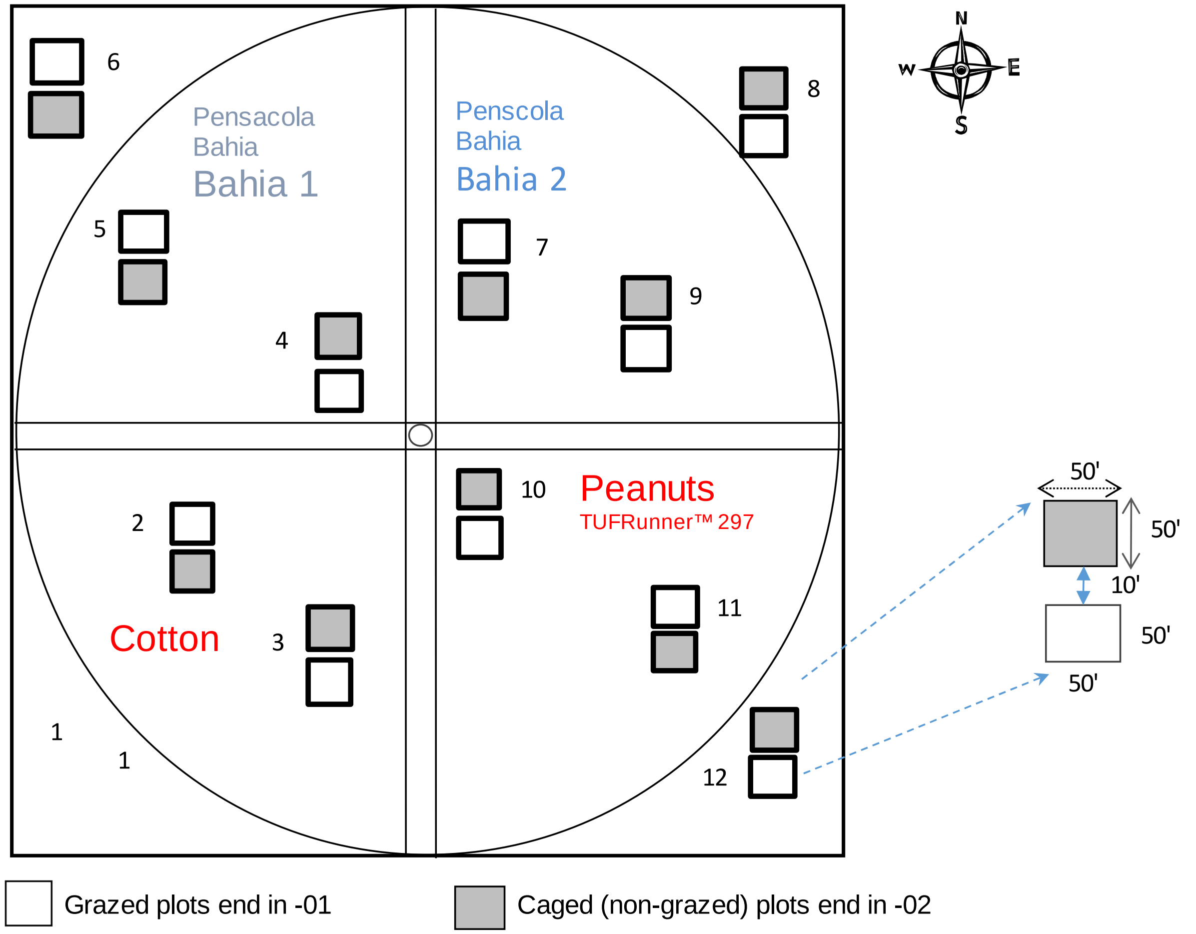
Appendix 1c. Additional soil collection site descriptions, locations, and soil characteristics (2015).

Site	**Lat dec-deg**	**Long dec-deg**	**Soil series**	**Description**[Z]
FOB[Y], all plots	30.5466	-84.5912	Norfolk, loam fine sand, 5 – 8% slopes	Fine-loamy, kaolinitic, thermic Typic Kandiudults
Dairies[X]				
UF dairy (Alachua county)	29.7831	-82.4130	Chipley sand	Thermic, coated Aquic Quartzipsamments
NFH (Gilchrist county)	29.7416	-82.8556	Kershaw fine sand, gently rolling	Thermic, uncoated Typic Quartzipsamments
BD (Highlands county)	27.2805	-81.0022	Immokalee sand, 0 – 2% slopes	Sandy, siliceous, hyperthermic Arenic Alaquods

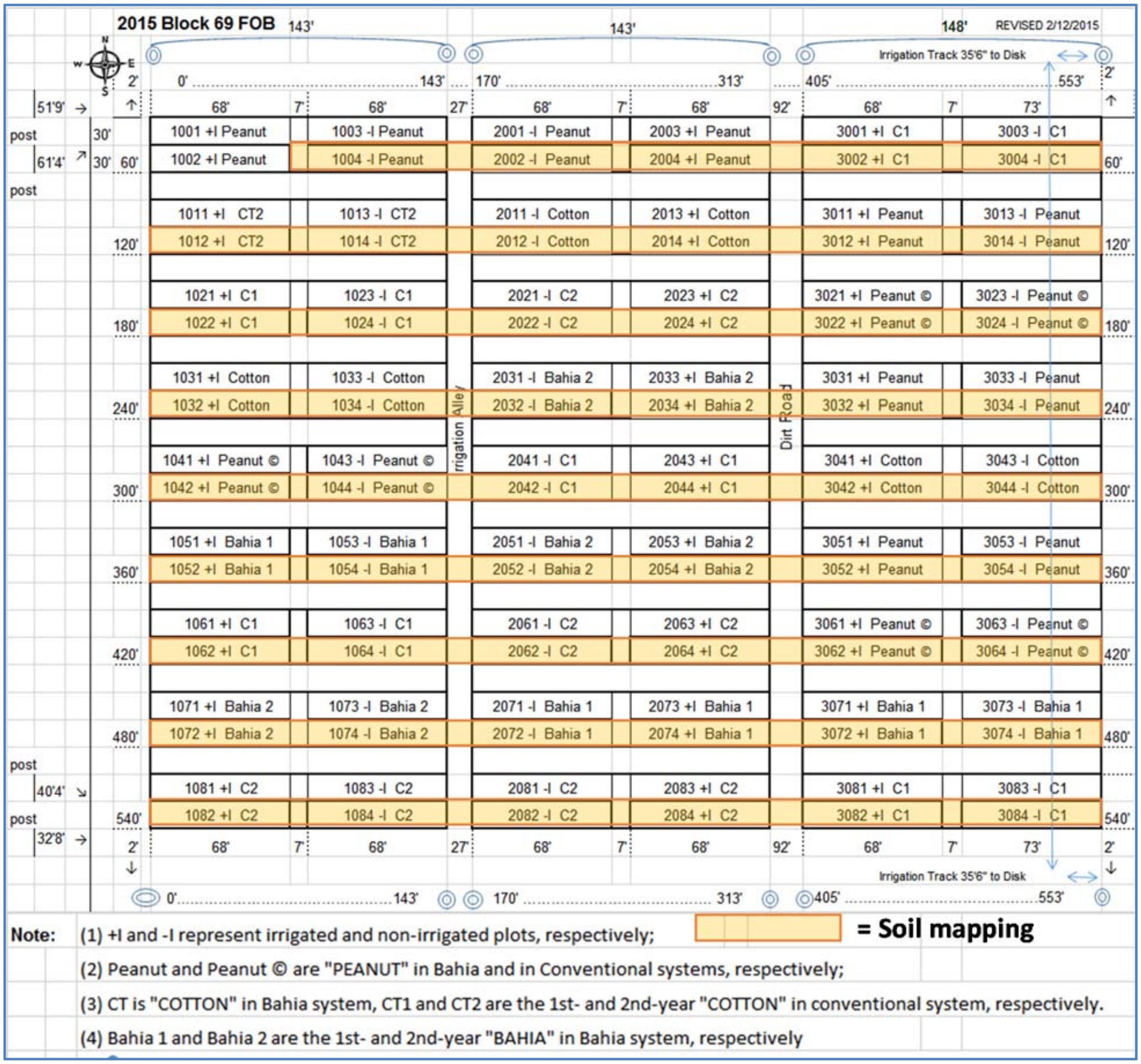
[Z] **Kandiudults** are very deep soils with a kandic (kaolinite) horizon and the clay content increases with depth.
Aquic Quartzipsamments are deep and have redox within the upper 100 cm.
Typic Quartzipsamments are deep, unconsolidated, coated sands, with no redox within the upper 100 cm.
Arenic Alaquods are deep and sandy through to the Bh horizon at a depth < 75 cm and no argillic horizon.

[Y] FOB = Front office block, located at Quincy FL represent soil cores (5 cm dia.; 1 m depth) taken from each test plot.
[X] Dairy soils represent several surface soil samples from each location (0 – 15 cm depth).

Appendix 2a. Map of sod-based rotation (SBR) located at Marianna, FL. Cropping cycle in 2014, with soil sampling the following spring (2015), prior to the 2015 summer crop.



Appendix 2b. Plot of Front Office Block (FOB) located at Quincy, FL. Cropping cycle in 2015, with soil sampling the previous spring (2014).



	68'	68'	68'	68'	68'	73'	
30'	1001 +I Peanut	1003 -I Peanut	2001 -I Peanut	2003 +I Peanut	3001 +I C1	3003 -I C1	
30' 60'	1002 +I Peanut	1004 -I Peanut	2002 -I Peanut	2004 +I Peanut	3002 +I C1	3004 -I C1	60'
	1011 +I CT2	1013 -I CT2	2011 -I Cotton	2013 +I Cotton	3011 +I Peanut	3013 -I Peanut	
120'	1012 +I CT2	1014 -I CT2	2012 -I Cotton	2014 +I Cotton	3012 +I Peanut	3014 -I Peanut	120'
	1021 +I C1	1023 -I C1	2021 -I C2	2023 +I C2	3021 +I Peanut ©	3023 -I Peanut ©	
180'	1022 +I C1	1024 -I C1	2022 -I C2	2024 +I C2	3022 +I Peanut ©	3024 -I Peanut ©	180'
	1031 +I Cotton	1033 -I Cotton	2031 -I Bahia 2	2033 +I Bahia 2	3031 +I Peanut	3033 -I Peanut	
240'	1032 +I Cotton	1034 -I Cotton	2032 -I Bahia 2	2034 +I Bahia 2	3032 +I Peanut	3034 -I Peanut	240'
	1041 +I Peanut ©	1043 -I Peanut ©	2041 -I C1	2043 +I C1	3041 +I Cotton	3043 -I Cotton	
300'	1042 +I Peanut ©	1044 -I Peanut ©	2042 -I C1	2044 +I C1	3042 +I Cotton	3044 -I Cotton	300'
	1051 +I Bahia 1	1053 -I Bahia 1	2051 -I Bahia 2	2053 +I Bahia 2	3051 +I Peanut	3053 -I Peanut	
360'	1052 +I Bahia 1	1054 -I Bahia 1	2052 -I Bahia 2	2054 +I Bahia 2	3052 +I Peanut	3054 -I Peanut	360'
	1061 +I C1	1063 -I C1	2061 -I C2	2063 +I C2	3061 +I Peanut ©	3063 -I Peanut ©	
420'	1062 +I C1	1064 -I C1	2062 -I C2	2064 +I C2	3062 +I Peanut ©	3064 -I Peanut ©	420'
	1071 +I Bahia 2	1073 -I Bahia 2	2071 -I Bahia 1	2073 +I Bahia 1	3071 +I Bahia 1	3073 -I Bahia 1	
480'	1072 +I Bahia 2	1074 -I Bahia 2	2072 -I Bahia 1	2074 +I Bahia 1	3072 +I Bahia 1	3074 -I Bahia 1	480'
	1081 +I C2	1083 -I C2	2081 -I C2	2083 +I C2	3081 +I C1	3083 -I C1	
540'	1082 +I C2	1084 -I C2	2082 -I C2	2084 +I C2	3082 +I C1	3084 -I C1	540'
	68'	68'	68'	68'	68'	73'	

Note: (1) +I and -I represent irrigated and non-irrigated plots, respectively;

🟧 = Soil mapping

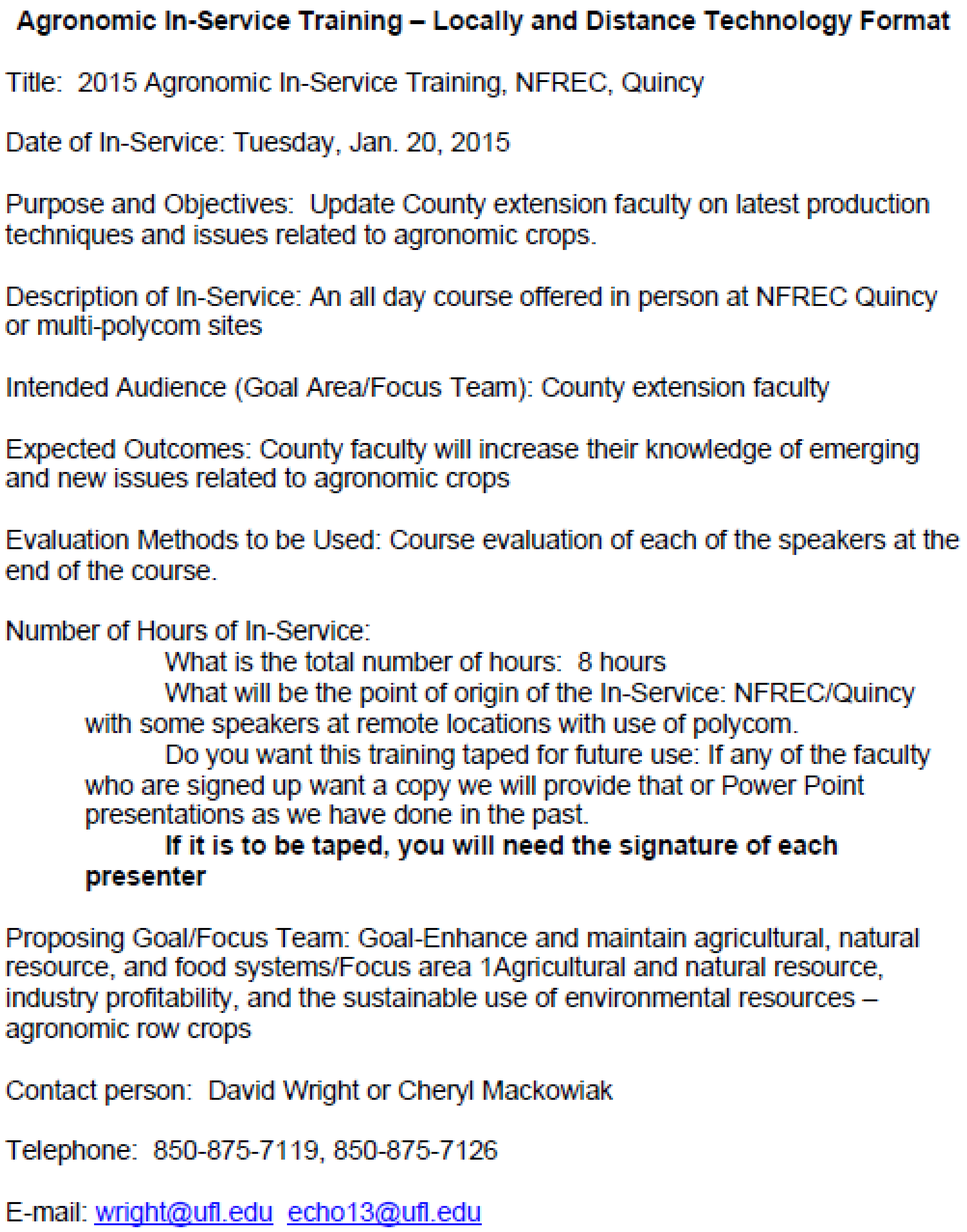
(2) Peanut and Peanut © are "PEANUT" in Bahia and in Conventional systems, respectively;

(3) CT is "COTTON" in Bahia system, CT1 and CT2 are the 1st- and 2nd-year "COTTON" in conventional system, respectively.

(4) Bahia 1 and Bahia 2 are the 1st- and 2nd-year "BAHIA" in Bahia system, respectively

Front office block (FOB) comprised of replicates of SBR versus conventional rotation with and without irrigation. The orange zones represent where soils were sampled. Plots that got mapped (orange) in 2015 had their soils compared with the manual soil core sampling that was collected in 2014 (Figs. 23, 25, and 27).

Appendix 3a. Agronomy In-service Training Agenda (Jan 20th, 2015).



Agronomic In-Service Training – Locally and Distance Technology Format

Title: 2015 Agronomic In-Service Training, NFREC, Quincy

Date of In-Service: Tuesday, Jan. 20, 2015

Purpose and Objectives: Update County extension faculty on latest production techniques and issues related to agronomic crops.

Description of In-Service: An all day course offered in person at NFREC Quincy or multi-polycom sites

Intended Audience (Goal Area/Focus Team): County extension faculty

Expected Outcomes: County faculty will increase their knowledge of emerging and new issues related to agronomic crops

Evaluation Methods to be Used: Course evaluation of each of the speakers at the end of the course.

Number of Hours of In-Service:

What is the total number of hours: 8 hours

What will be the point of origin of the In-Service: NFREC/Quincy with some speakers at remote locations with use of polycom.

Do you want this training taped for future use: If any of the faculty who are signed up want a copy we will provide that or Power Point presentations as we have done in the past.

If it is to be taped, you will need the signature of each presenter

Proposing Goal/Focus Team: Goal-Enhance and maintain agricultural, natural resource, and food systems/Focus area 1Agricultural and natural resource, industry profitability, and the sustainable use of environmental resources – agronomic row crops

Contact person: David Wright or Cheryl Mackowiak

Telephone: 850-875-7119, 850-875-7126

E-mail: wright@ufl.edu echo13@ufl.edu

Appendix 3a Continued.

Agenda:

Tuesday, Jan. 20, 2015

9:00- 9:15 Welcome -Dr.Comerford/Wright

9:15-10:00 Peanut varieties for 2015- Dr. Barry Tillman, UF

10-10:45 Forage updates- Dr. Ann Blount, UF

10:45-11:15 Disease management of row crops- Dr. Nick Dufault, Ext. Plant Pathologist, UF

11-11:30 Value of on farm cotton trials- Dr. Guy Collins, former UGA cotton specialist and now NCSU on farm trial cotton specialist (Polycom)

11:30 -12:15 Agronomic crop markets and outlook for 2015-Dr. Nathan Smith UGA (Polycom)

12:15-1:00 Lunch

1:00-1:45 Possible strategies for higher soybean yields- are 100 bushel yields possible? - Dr. John Woodruff- Professor emeritus and former soybean specialist UGA

1:45- 2:15 Weed control and crop safety considerations for new 2,4-D and dicamba tolerant crops- Dr. Ramon Leon, UF

2:15-2:45 Carinata as an oilseed crop - Dr. David Wright, UF

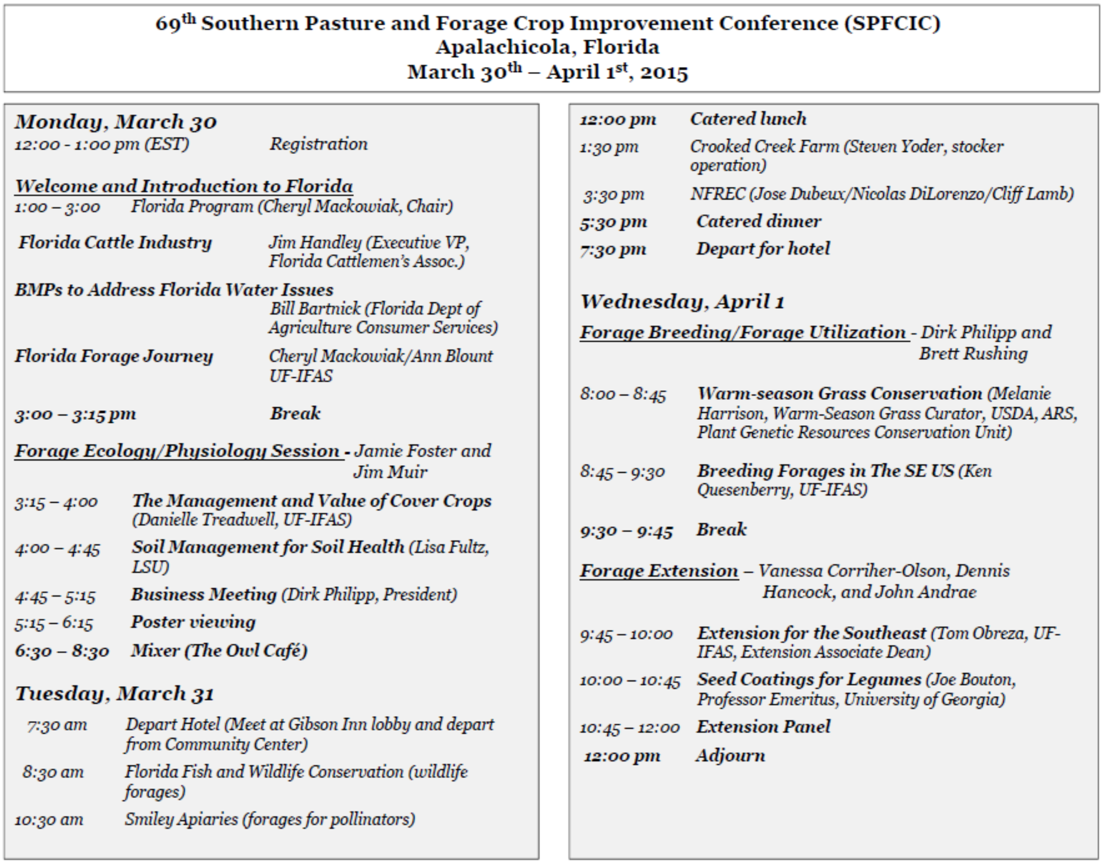
2:45-3:15 Overseeding of perennial peanut and other fertility concerns- Dr. Cheryl Mackowiak, UF

3:15-4:00 Using drones in crop management and outdoor demonstration- Darren Raj, Agribugs

4:00-4: 45 Demonstration of the Veris machine for pH, O.M. and electrical conductivity -Mackowiak/Wright

4:45- 5:00 Discussion and evaluation

Appendix 3b. 69th Southern Pastures Forage Crop Improvement Conference (SPFCIC) and in-service training (March 30 to April 01, 2015).



69th Southern Pasture and Forage Crop Improvement Conference (SPFCIC)
Apalachicola, Florida
March 30th – April 1st, 2015

Monday, March 30

12:00 - 1:00 pm (EST)	*Registration*

Welcome and Introduction to Florida

1:00 – 3:00	*Florida Program (Cheryl Mackowiak, Chair)*
Florida Cattle Industry	*Jim Handley (Executive VP, Florida Cattlemen's Assoc.)*
BMPs to Address Florida Water Issues	*Bill Bartnick (Florida Dept of Agriculture Consumer Services)*
Florida Forage Journey	*Cheryl Mackowiak/Ann Blount UF-IFAS*
3:00 – 3:15 pm	***Break***

Forage Ecology/Physiology Session *- Jamie Foster and Jim Muir*

3:15 – 4:00	***The Management and Value of Cover Crops*** *(Danielle Treadwell, UF-IFAS)*
4:00 – 4:45	***Soil Management for Soil Health*** *(Lisa Fultz, LSU)*
4:45 – 5:15	***Business Meeting*** *(Dirk Philipp, President)*
5:15 – 6:15	***Poster viewing***
6:30 – 8:30	***Mixer (The Owl Café)***

Tuesday, March 31

7:30 am	*Depart Hotel (Meet at Gibson Inn lobby and depart from Community Center)*
8:30 am	*Florida Fish and Wildlife Conservation (wildlife forages)*
10:30 am	*Smiley Apiaries (forages for pollinators)*
12:00 pm	***Catered lunch***
1:30 pm	*Crooked Creek Farm (Steven Yoder, stocker operation)*
3:30 pm	*NFREC (Jose Dubeux/Nicolas DiLorenzo/Cliff Lamb)*
5:30 pm	***Catered dinner***
7:30 pm	***Depart for hotel***

Wednesday, April 1

Forage Breeding/Forage Utilization *- Dirk Philipp and Brett Rushing*

8:00 – 8:45	***Warm-season Grass Conservation*** *(Melanie Harrison, Warm-Season Grass Curator, USDA, ARS, Plant Genetic Resources Conservation Unit)*
8:45 – 9:30	***Breeding Forages in The SE US*** *(Ken Quesenberry, UF-IFAS)*
9:30 – 9:45	***Break***

Forage Extension *– Vanessa Corriher-Olson, Dennis Hancock, and John Andrae*

9:45 – 10:00	***Extension for the Southeast*** *(Tom Obreza, UF-IFAS, Extension Associate Dean)*
10:00 – 10:45	***Seed Coatings for Legumes*** *(Joe Bouton, Professor Emeritus, University of Georgia)*
10:45 – 12:00	***Extension Panel***
12:00 pm	***Adjourn***

March 31st (Tuesday afternoon) Veris Field Demo.

Appendix 3c. Perennial Peanut Producers Field Day, NFREC, Marianna, June 6th, 2015).

UF | IFAS Extension
UNIVERSITY of FLORIDA

2015 PERENNIAL PEANUT FIELD DAY

Saturday, June 6, 2015

UF/IFAS North Florida Research and Education Center
3925 HWY 71
Marianna, FL 32446-8091

AGENDA

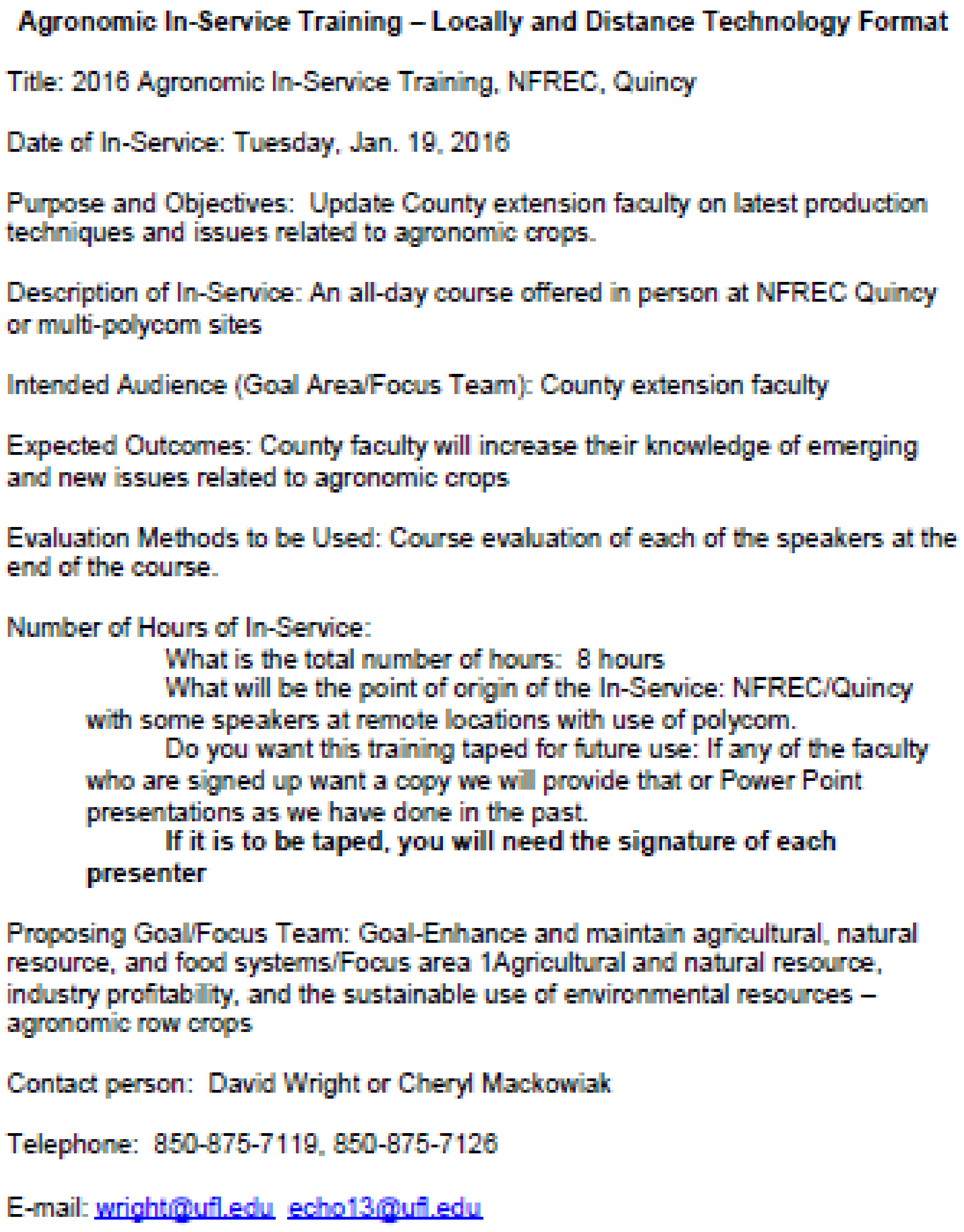
9:30 am (CDT)	Registration
10:00	**Welcome:** NFREC-Professor of Agronomy, Ann Blount and President PPPA-Steve Basford

10:10-12:00	Field Tours
	• Establishment into pastures/sod
	• Soil mapping to reduce inputs
	• Herbicide management
	• Variety trials
	  • Overall performance, visual differences
	  • Vigor measurements, nitrogen fixing differences

12:00-12:15	Sponsor Introductions
12:15-12:45	Lunch
12:45-1:15	Producer Panel Discussion: public relations, marketing strategies, establishment successes and failures
1:15-3:00	On-farm visit: Basford Farms near Grand Ridge and I-10 (take own vehicles)

Evaluation – Clay Olson and Doug Mayo (please take time to fill this out: We DO listen to you!)

Appendix 3d. Agronomy In-service Training Agenda (Jan 19th, 2016).



Agronomic In-Service Training – Locally and Distance Technology Format

Title: 2016 Agronomic In-Service Training, NFREC, Quincy

Date of In-Service: Tuesday, Jan. 19, 2016

Purpose and Objectives: Update County extension faculty on latest production techniques and issues related to agronomic crops.

Description of In-Service: An all-day course offered in person at NFREC Quincy or multi-polycom sites

Intended Audience (Goal Area/Focus Team): County extension faculty

Expected Outcomes: County faculty will increase their knowledge of emerging and new issues related to agronomic crops

Evaluation Methods to be Used: Course evaluation of each of the speakers at the end of the course.

Number of Hours of In-Service:

What is the total number of hours: 8 hours

What will be the point of origin of the In-Service: NFREC/Quincy with some speakers at remote locations with use of polycom.

Do you want this training taped for future use: If any of the faculty who are signed up want a copy we will provide that or Power Point presentations as we have done in the past.

If it is to be taped, you will need the signature of each presenter

Proposing Goal/Focus Team: Goal-Enhance and maintain agricultural, natural resource, and food systems/Focus area 1Agricultural and natural resource, industry profitability, and the sustainable use of environmental resources – agronomic row crops

Contact person: David Wright or Cheryl Mackowiak

Telephone: 850-875-7119, 850-875-7126

E-mail: wright@ufl.edu echo13@ufl.edu

Appendix 3d Continued.

Agenda:

Tuesday, Jan. 19th, 2016

9:00- 9:15 Welcome - Dr.Comerford/Wright

9:15-10:00 Peanut varieties for 2016 - Dr. Barry Tillman, UF

10-10:45 Forage updates - Dr. Ann Blount, UF

10:45-11:15 Disease management of row crops - Dr. Nick Dufault, Ext. Plant Pathologist, UF

11-11:30 Best Management Practices and conservation efforts in North Florida- Joel Love - BMP Specialist UF

11:30 -12:15 Next Generation BMPs: Soil mapping and equipment demonstration - Dr. Cheryl Mackowiak, UF

12:15-1:00 Lunch

1:00-1:45 Weed control and crop safety considerations for new 2,4-D and dicamba tolerant crops - Dr. Ramon Leon, UF

1:45- 2:15 Agronomic crop markets and outlook for 2016- Amanda Smith UGA

2:15-2:45 Making a profit with key management practices on corn, cotton and peanut - Dr. David Wright, UF

2:45-3:15 Crop insurance updates. Ms. Davina Lee, RMA, Valdosta, GA

3:15-4:00 What are ecosystem services and how can current farming system provide them - Dr. Jose Dubeux

4:00-4: 45 Climate forecast for the spring of 2016, what to expect - David Zierden, State Climatologist

4:45- 5:00 Discussion and evaluation

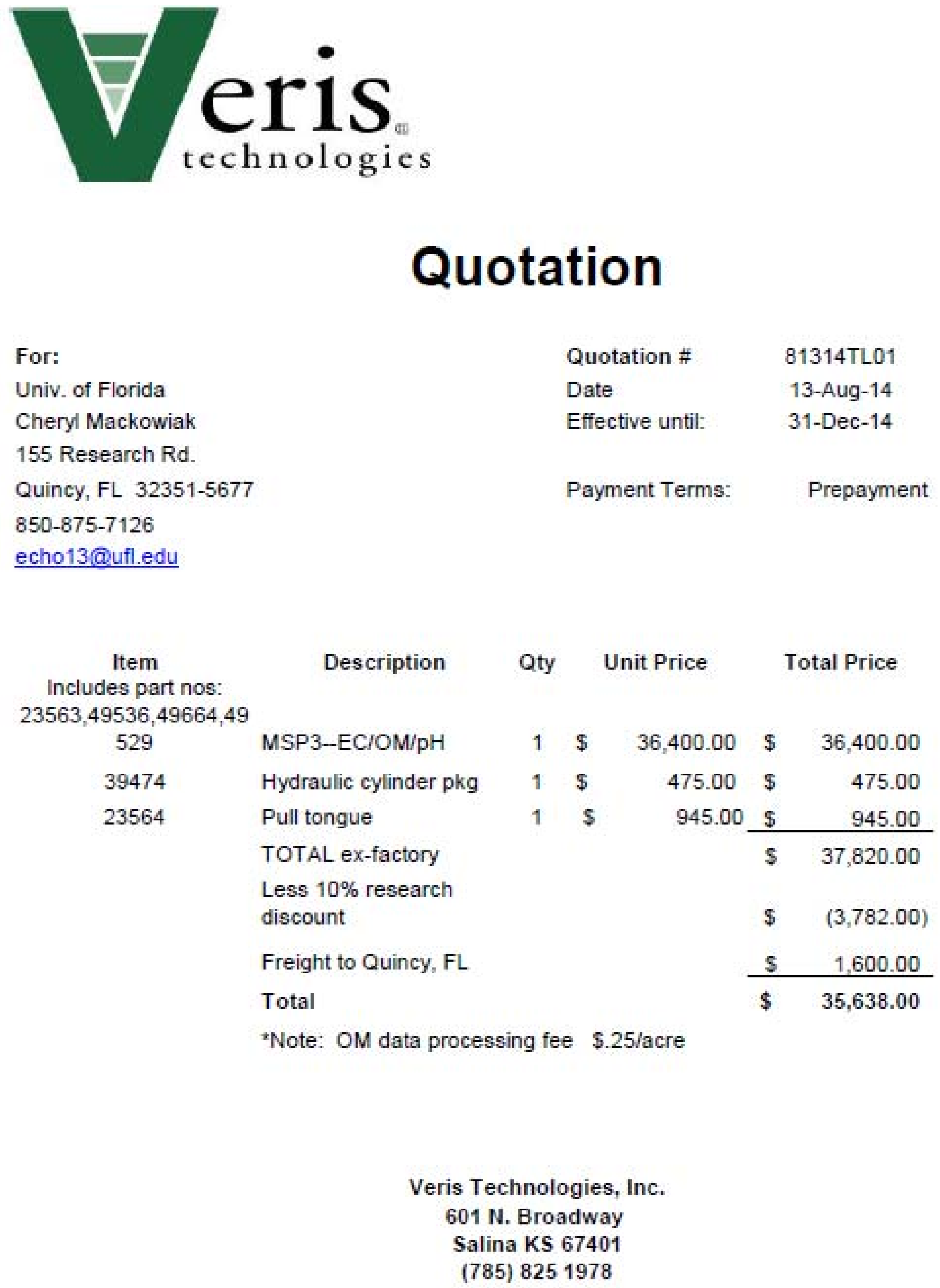
Appendix 3e. SE regional review of USDA/ARS in Florence SC (March 10, 2016).

Agenda for Customer/Partner Dialogue Workshop

USDA – ARS Coastal Plains Soil, Water and Plant Research Center, Florence, SC
March 10, 2016

8:00	**Registration, Poster Viewing, and Visit with Scientists**	
10:00	**Presentations**	
	Dr. Maurice Cook	Welcome and Introductions
	Dr. Ariel Szogi Research Leader, CPSWPRC	The Center's Recent Research Accomplishments
	Dr. Martin Locke Research Leader, USDA-ARS, Oxford, MS	Topic 'Cover Crops and Soil/Water Quality'
	Dr. Marlin Eve USDA-ARS, National Program Leader, Beltsville, MD	Topic 'Soil and Water Quality issues and research'
	Area Office USDA-ARS Southeast Area	Remarks
12:30	**Group Picture & Lunch**	
	Mr. Chester Lowder, North Carolina Farm Bureau, Raleigh, NC	Topic
1:45	**Presentations**	
	Mr. Tom Kemp, President, Carolina Eastern Pamplico, Pamplico SC	Topic 'Research needs of the fertilizer industry regarding soil/water quality'
	Dr. Patrick Dube, Research Associate, CPSWPRC	Topic 'Reclaiming nutrients from manure'
	Dr. David Wright, Professor, University of Florida, Quincy, FL	Topic 'Sod rotations with annual crops: Effects on soil and water quality'
	Dr. Jeff Novak, Research Soil Scientist, CPSWPRC	Topic 'An ARS-EPA research venture to vegetate superfund site mine spoils in … and …'
3:30	**Summary**	
	Dr. Maurice Cook	
3:35	**Adjourn**	

Appendix 4. Quotation and Packing Slip for Veris MSP3.



Veris technologies

Quotation

For:
Univ. of Florida
Cheryl Mackowiak
155 Research Rd.
Quincy, FL 32351-5677
850-875-7126
echo13@ufl.edu

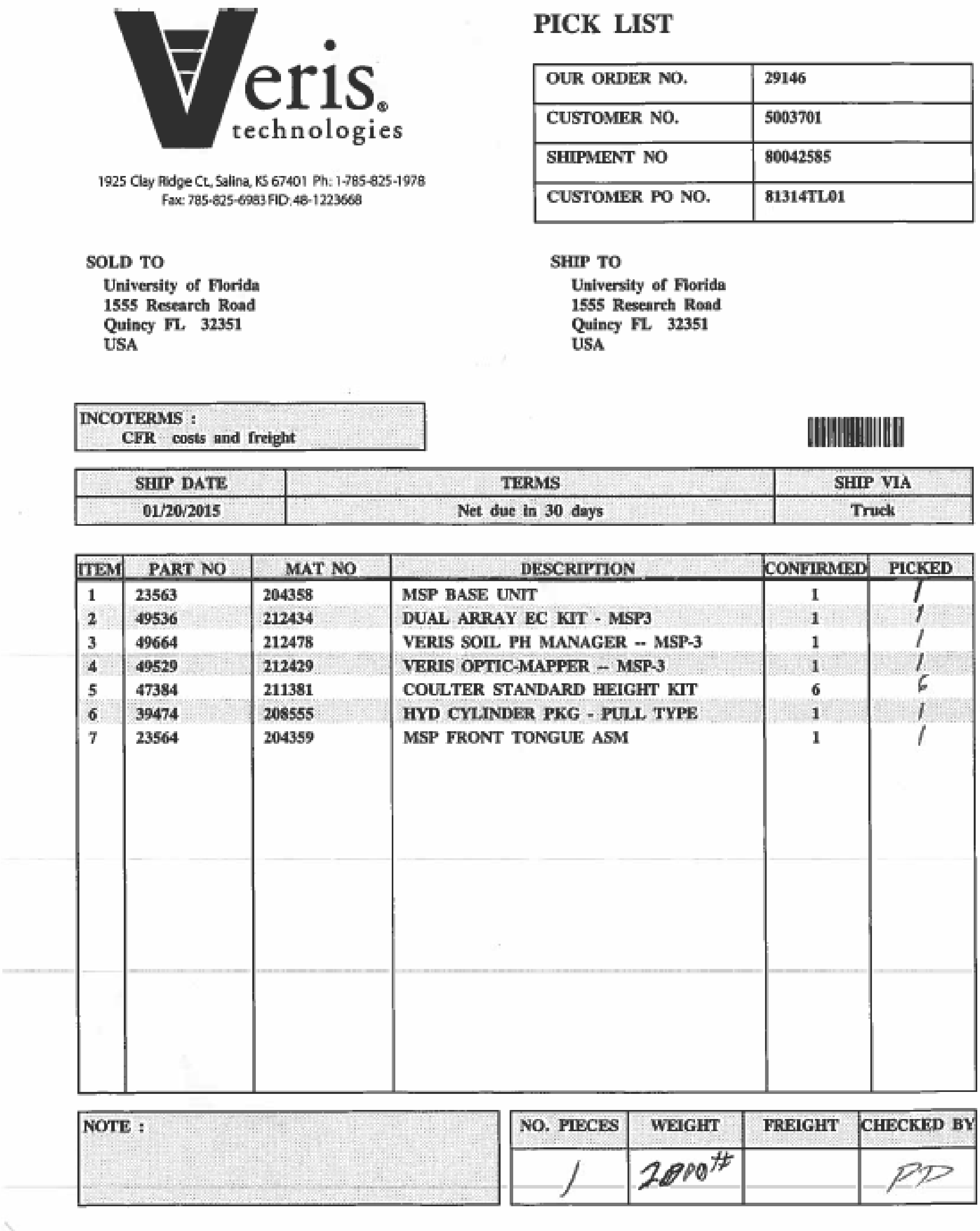
Quotation #	81314TL01
Date	13-Aug-14
Effective until:	31-Dec-14
Payment Terms:	Prepayment

Item	Description	Qty	Unit Price	Total Price
Includes part nos: 23563,49536,49664,49529	MSP3--EC/OM/pH	1	$ 36,400.00	$ 36,400.00
39474	Hydraulic cylinder pkg	1	$ 475.00	$ 475.00
23564	Pull tongue	1	$ 945.00	$ 945.00
	TOTAL ex-factory			$ 37,820.00
	Less 10% research discount			$ (3,782.00)
	Freight to Quincy, FL			$ 1,600.00
	Total			**$ 35,638.00**

*Note: OM data processing fee $.25/acre

Veris Technologies, Inc.
601 N. Broadway
Salina KS 67401
(785) 825 1978

Appendix 4 Continued.



Veris technologies

1925 Clay Ridge Ct, Salina, KS 67401 Ph: 1-785-825-1978
Fax: 785-825-6983 FID: 48-1223668

PICK LIST

OUR ORDER NO.	29146
CUSTOMER NO.	5003701
SHIPMENT NO	80042585
CUSTOMER PO NO.	81314TL01

SOLD TO
University of Florida
1555 Research Road
Quincy FL 32351
USA

SHIP TO
University of Florida
1555 Research Road
Quincy FL 32351
USA

INCOTERMS :
CFR costs and freight

SHIP DATE	TERMS	SHIP VIA
01/20/2015	Net due in 30 days	Truck

ITEM	PART NO	MAT NO	DESCRIPTION	CONFIRMED	PICKED
1	23563	204358	MSP BASE UNIT	1	1
2	49536	212434	DUAL ARRAY EC KIT - MSP3	1	1
3	49664	212478	VERIS SOIL PH MANAGER -- MSP-3	1	1
4	49529	212429	VERIS OPTIC-MAPPER -- MSP-3	1	1
5	47384	211381	COULTER STANDARD HEIGHT KIT	6	6
6	39474	208555	HYD CYLINDER PKG - PULL TYPE	1	1
7	23564	204359	MSP FRONT TONGUE ASM	1	1

NOTE :

NO. PIECES	WEIGHT	FREIGHT	CHECKED BY
1	2000#		PD