

FOUR CASE STUDIES IN PRECISION AGRICULTURE

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Introduction

Precision agriculture is an inclusive term referring to the application of new information technologies to agriculture. Some of the applications are based on using a global positioning system (GPS) to geo-reference the location of a soil sample, tissue sample, or some other agronomic practice or to monitor yields by the meter rather than by the field. This data is then integrated into a geographic information system (GIS) to produce a map containing information about the physical dispersion of the test results or yield. Other applications make use of remote sensing: satellites or airplanes take pictures of fields, which are geo-referenced with a GPS to provide information about differences in vegetative matter or other aspects of the field in question.

The following four cases are presented as examples of how precision agriculture is being used on farms and ranches in California. These cases are presented for classroom discussion, to explore how and why farm managers might adopt one of these systems, and not as an example of correct or superior management. Interviews for the cases were done in 2001; some of the information may be obsolete given the rapid pace of change in technology. In all cases names have been changed.

1. Vineyard GIS – I

Bob Deck has been working in agriculture for about 12 years, the last four with a vineyard management company in the Central Coast of California. His company has contracts to manage 7,000 acres of vines, the output of which is contracted to a single multinational vintner. In effect, Bob grows the grapes that yield between 2-4 million cases of wine a year, depending on weather and other factors. His buyer is one of the 20 largest vintners in the US.

Bob's company prides itself on being leading edge; of being what the economists call "early adopters" of the latest in agronomic practices and technology. Sometimes this early adoption works well, other times they have bought a new technology before all the bugs were worked out. Bob's boss still laughs about being impressed in the early 1980s with a demonstration of a desktop computer and a financial spreadsheet, so he bought one of the first desktop computers and a spreadsheet program. A week later he finally figured out that the spreadsheet wasn't compatible with his computer.

Nevertheless, the company continues to actively seek out new practices and technology.

Bob was trained in soil science and agronomy, and learned viticulture on the job. He likes to say that his education gave him the basics he needed to learn about what he does now. For example, he never had a class in precision agriculture, but a lot of his decisions these days are either about precision agriculture systems, or use information from those systems.

Bob is currently building a GIS database of his farms. So far the process has required a lot of input, but has produced limited output. As a start, Bob created digital maps of the farms he manages using a GPS which is accurate to within a meter. Data from the GPS is transformed into a map of the vineyard using SS Toolbox, an off-the-shelf software program. The software and training on how to use it cost about \$7,000. The GPS unit and a field computer to operate the GPS was about \$10,000. The field computer can also control variable rate fertilizer application and monitor yields with a grape-bin weighing device. It has the capacity and flexibility to do more. So far, the system has cost the company about \$22,000.

This year Bob is adding "remote sensing" to his bag of precision agriculture tools. In effect, remote sensing refers to pictures taken from satellites or high-flying planes. These pictures are more than just aerial photographs; by changing the color used to represent different parts of the light spectrum, a field that appears a homogeneous color to the naked eye can be displayed to show variation due to any number of factors. Once these differences are identified, it is up to an agrologist to figure out why the differences exist, if they are important and what to do about them.

Bob says that remote sensing has limited use in vineyards. In a crop with a solid cover, such as corn or soybeans, remote sensing can clearly identify differences in vegetative matter and color, but a vineyard with bare areas between vines can create a distorted picture, or if there is a cover crop between vines, the cover crop can distort the color resolution. However, even with the stated limitations, Bob is paying about \$1/acre for digital images of his vines. Using GPS reference points, Bob can overlay the images onto the GIS map of his fields.

With the GIS map, Bob has redone the way he samples his grapes and soil. Previously, he sampled soil on a grid

system (1-5 acre grid, depending the conditions), and would test brix (sugar content of the grapes) randomly in a given vineyard. Now he uses the aerial images to see if he can differentiate areas within fields into uniform blocks. For example, previously a 20-acre vineyard might have called for 10 soil samples taken uniformly across the vineyard. A careful analysis of the photos (in effect looking at the photos through different filters) might indicate that there are six distinct areas in the vineyard, but the vines within each of those distinct areas are quite uniform. Given his analysis of the photos, Bob now takes six samples and uses his GPS unit to record precisely where the samples were taken. He uses a similar method when sampling brix.

Bob sees a lot of the benefit from his system is being able to specify exactly where a problem exists. For example, grid samples indicated that a 20-acre vineyard needed 10 more pounds of compost per acre, but representative sampling based on differentiated areas indicated that only three to four acres needed additional compost. Bob says similar situations over the 7,000 acres he manages will quickly make the \$22,000 he has spent on the GIS system and \$7,000 per season for the remote sensing pay for itself.

Bob thinks that precision agriculture systems have the potential to increase efficiency and lower costs in farming, but adoption of the systems is constrained by cost for the equipment as well as the time required to learn to use it. He doubts that he would have spent the time and money to learn the system on his own, but with the encouragement of his boss, he worked through the steep part of the learning curve.

2. Vineyard GIS – II

Perry James had several years experience with dot.com companies in the Silicon Valley when he decided to change gears and move to the Salinas Valley. He thought that being an “Information Technology Agronomist” with a large-scale vineyard would be a slower paced, less stressful job than what he had been doing in Silicon Valley. So he sold his house, moved south, started working on the farm. At first he wasn’t sure the change was a good decision.

Shippy Vineyards is an investor-owned ranch, with 6,000 acres of vineyards. Strategic decisions are made at corporate headquarters in Southern California. The ranch

has a general manger and five supervisors who are responsible for specific blocks of vines. Perry was interviewed and hired at the corporate headquarters by the CEO and the Controller, who later introduced him to the general manager and the supervisors. Perry didn’t think that the manager and supervisors were favorably impressed at first. They each had 5 - 30 years experience growing grapes and Perry had virtually no agricultural experience, but he was somehow supposed to help them “do their jobs better.” The manager and the supervisors were friendly, but they seemed to have no idea how Perry fit into their team. Perry figured he had to get these guys on his side before he asked them to change their practices in order to gather the information he wanted to give them.

Grapes are susceptible to frost damage, and the Salinas Valley frequently has frosts early in the growing season. When temperatures go low enough to damage the young buds, the supervisors have to turn on irrigation sprinklers, which results in a thin coating of ice on young buds. This ice coating keeps the buds just above freezing and thus protects them from being damaged by lower temperatures. The only problem with the system is that the supervisors have to monitor the temperature in order to turn on the sprinklers if it gets close to freezing.

Given the rolling terrain of the Shippy vineyards, one central weather station would not be sufficient; the microclimate of each block has to be monitored separately. The supervisors often sleep in their trucks during potential frost periods, checking the temperature throughout the night.

Perry’s first project was to set up six weather stations to cover the different microclimates of Shippy Vineyards. Each weather station recorded temperature, humidity and wind speed and direction every 15 seconds. This data was automatically sent via modem every 15 minutes to the block supervisor’s personal computer. The computer was programmed to transform the raw weather data into average, minimum and maximum temperatures, humidity and wind speed and direction for the entire growing season. There was also a frost alarm: the temperature and dew points could be set to trigger an automatic phone call to the supervisor to warn of an impending frost. It took awhile for the supervisors to learn to trust the frost alarms, but once they did, they could sleep at home in the early growing

season, knowing that the monitoring system would call them if the temperature dropped precipitously.

Perry's second project was to install a system to weigh and monitor each bin of grapes dumped into the 6-ton gondolas used to transport grapes. Given the type of trucks Shippy had, their upper limit was four gondolas or 24 tons of grapes per truck. The harvest supervisors are told to make sure each bin is full before it is put on the truck. An under-loaded truck is an inefficient use of resources. However, an over-loaded truck can cost the company three ways if it is caught. First, there is a \$1,500 ticket. Second is the cost of sending out another truck and driver to take the off-load, and third is the ill-will at the winery caused by having an expected load arrive three to four hours late. Previously, 10-12 trucks per year were ticketed for overload. Last year, due to the weight monitor systems, there were no overload tickets. The trucking manager was pleased with the system.

The first year the weigh system monitored yields on a field basis: the fields ranged from 40 acres to several hundred acres. This year Perry plans to geo-reference the weigh system with his GPS so that yield is monitored on a 10-40 square meter basis. Combining the yield data with soil moisture data and brix will provide a digital map of the entire ranch that will indicate the quantity and quality of grapes at specific locations. This information is expected to help with irrigation and fertilizer and soil amendment applications. The increased site specificity is expected to lower application costs and also be environmentally friendly.

Precision agriculture has been a big investment for Shippy Vineyards. In addition to Perry's salary, building the foundation required for precision agriculture meant investing in new equipment, learning new software and changing attitudes on the part of some of the farm supervisors. However, now that the worth of the frost alarm and weigh systems has been demonstrated to the ranch management team, there is much more enthusiasm about recording data for Perry's precision agriculture systems.

3. Variable Rate Application

Ben Williamson farms approximately 800 acres in the eastern San Joaquin Valley of California. His primary crops are cotton, corn, alfalfa and black-eye peas, with a rotation

based in part on agronomics and in part on prices. He uses conventional, uniform application methods on 600 acres and variable rate technology (VRT) on 200 acres. Growth and yields on the 600 acres appears to be somewhat uniform, while the 200 acres has quite a lot of variability in soil fertility; hence yields vary as well. He hopes to achieve a more uniform stand on those 200 acres through VRT of soil amendments. Alfalfa on those acres has some variability, but he expects most of the benefit of VRT to come from more uniform stands of corn and cotton.

Tenyson Ag Services is a 30-year-old, family owned company, which sells seed, agricultural chemicals and fertilizer and soil amendments. They are considered a small to medium sized firm, with 17 full-time employees and five Pest Control Advisors. They firmly believe in using fertilizers and soil amendments together: increased nitrogen does little good if the other primary nutrients are out of balance and the trace elements limit the uptake of the nitrogen. Tenyson has two variable rate applicators, which can apply six dry soil amendments and one liquid in one pass across a field. They limit their business to a 40-mile radius because highway travel is too hard on the machines and they don't have trailers on which to haul them. The first year they had \$3,500 of VRT business; two years later they did \$20,000 of VRT business.

Tenyson approached Ben Williamson three years ago with the idea of changing how he applies his fertilizer. Ben was told that VRT would either lower his fertilizer application or keep it the same but maximize its benefit by applying it where it could do the most good. Either way, his fertilizer costs would stay the same or even go down, with the benefit being a more uniform and likely higher yielding crop. However, there would be start-up costs. Ben liked the idea of the uniform and higher yielding crop, but the \$5,000 start-up costs for his 200-acre field was more than he thought he could afford.

The quoted start-up costs were mostly due to Tenyson's preferred soil sampling on a 2-acre grid. Even with quantity discounts, 100 samples require a lot of lab time. Tenyson preferred sampling on a grid, but they had frequently sub-contracted with a local Consulting Agronomist who had a Veris 3100, which measured electrical conductivity of the soil in order to determine homogeneous regions

of a field. For a few hundred dollars the Agronomist would drag his Veris through a field, simultaneously shooting a GPS every few seconds, and then integrate the data into a map indicating the shape and boundaries of the soil types in the field. This method indicated that Ben's 200-acre field had seven distinct types of soils. The Agronomist took two samples in each of the district soil areas. The total cost of a prescription for variable rate application of fertilizer based on 10 soil amendments was well under what the grid-based soil sample would have been.

The prescription called for about the same amounts of N, P and K, but added aggressive rates of gypsum, sulfur and potash in some areas, along with increased rates of zinc and boron. Ben's total fertilizer and potash costs are about the same as before, but the application is far from uniform across his field.

Ben has no hard figures on the benefits of VRT. He is reluctant to compare yields from year to year because there are too many variables to attribute a change in yield to one factor. His Agronomist continues to encourage Ben to monitor his yields so that there are hard figures on the benefits of VRT with the Veris and representative sampling. Ben expects that he will buy a yield monitor eventually, but is in no hurry. However, after one year of VRT on 200 acres, he is thinking about asking the Agronomist to run the Veris over his 600 acres to see if there are indications that that field would also benefit from VRT.

4. Consulting in Precision Agriculture

Bas Ryan has been working as a Consulting Agrologist for six years. After graduating from college and receiving his Pest Control Advisor license he worked for an agricultural chemical company for two years. Then he decided to take a plunge and see if he could make a go as an independent Consulting Agrologist. So far he thinks he made the right decision. He is known throughout the San Joaquin Valley as an innovator who makes good recommendations. His files list hundreds of clients, mostly in California, but he has also worked in Texas, Arizona and several Latin American and European countries. However, he estimates that 80% of his time is spent on five major clients. These major clients have large acreage and do everything they can to maximize the economic returns from their fields. Bas'

business has grown with these clients. For example, he advised one client on 133 acres the first year, 640 acres the second year and 3,800 acres last year. This year he expects to advise on about half of this client's 12,000 acres of mixed field and row crops.

Bas offers a variety of services, including soil sampling, infra-red imaging through remote sensing, yield mapping, fertilizer and soil amendment recommendations and training and software support for producers starting-up precision agriculture systems. Basically, he helps to interpret data and transform it into information that a grower can use. Sometimes Bas provides the data, other times the data comes from elsewhere. He has about \$120,000 invested in various equipment, which he uses to provide his raw data.

Typically there are five steps involved with developing fertilizer and soil amendment recommendations for a client. First, Bas identifies differentiated zones within a field. These zones can be identified through remote sensing using infrared (IR) imaging from an aerial or satellite photo of a growing crop, yield maps at harvest time or by mapping the electrical conductivity (EC) of the soil using a Veris machine on bare land between crops. Regardless of how it is done, within each zone is a uniform IR, yield or EC, but those measures are different between the zones. All three methods are linked to a GPS to geo-reference the different zones, but the methods do not determine why the zones are different. Hence, the second step is for Bas to take soil samples within each representative zone. The third step is for a lab to do a complete analysis of the soil sample, including major soil nutrients, organic matter, trace elements, nematodes and ionic exchange capacity. The fourth step is to develop a soil analysis based on the samples. The fifth and final step is to give the grower recommendations in the form of a digital map. This map can then be used for variable rate applications of the various soil nutrients and amendments needed as identified by the soil samples.

Bas has rarely recommended that a grower use fewer inputs. Instead, he usually recommends that a variable rather than a uniform application rate be applied across a field. In most cases the result is an increase in total yield, quality and uniformity. Increases in yield and/or quality result in increased revenue. An increase in uniformity can mean lower costs, particularly for a fruit or vegetable grower. For

example, uniform ripening of tree fruit can reduce the number of times harvest crews need to go through the orchard, lowering the total harvest cost. Bas assumes that the benefits from his recommendations outweigh their costs, but his clients are either hesitant to share numbers with him, or do not have accurate enough figures to estimate the relative benefits and costs of his services. Which ever, he has many return clients and increasing calls for his services, so he figures he is providing an economically beneficial service. ■

Suggested Web Sites

Commercial Sites

www.precisionag.com
www.trimble.com/agriculture.html
www.merrellprecisionag.com
www.business.com/directory/agriculture/precision_agriculture/

Educational/Research Sites

University of Kansas:

www.oznet.ksu.edu/precisionag/

University of Minnesota:

precision.agri.umn.edu

University of Sydney, Australia:

www.usyd.edu.au/su/agric/acpa/

National Aeronautics and Space Administration:

www.ghcc.msfc.nasa.gov/precisionag/precisionag.html

Texas A & M University:

precag.tamu.edu

The Ohio State University:

precisionag.osu.edu

North Carolina State University:

www.bae.ncsu.edu/programs/extension/agmachine/precision/

Oklahoma State University:

www.dasnr.okstate.edu/precision_ag/

Cranfield University, UK:

www.silsoe.cranfield.ac.uk/cpf/

University of Kentucky:

www.bae.uky.edu/~precag/

Links

www.fse.missouri.edu/mpac/links/
www.aces.uiuc.edu/~vo-ag/gisserv.html

Suggested Study Questions

1. The benefits from the precision agriculture systems are vague in all four cases. Does this mean that the benefits are not real, or that the growers work more on intuition than on quantitative measures?
2. Suppose you buy a GPS, GIS and yield monitor for your farm in order to make precise yield maps of your fields. Do you face a risk or uncertainty that the benefits from the system will be greater than the costs of the system?
3. For each case, determine what raw data is being gathered and how and/or by whom is that data being transformed into information which has value in decision making.
4. For each case, develop a partial budget. Do not worry about dollar amounts; list the items or category of costs and benefits which would need to be considered as increased costs, decreased costs, increased revenues and decreased revenues.
5. For Case #2: yield monitors were used to accurately determine the pounds of grapes on each truck. How would you estimate the savings realized from the yield monitors? (Hint: use the past frequency of overload tickets to estimate the probability of a ticket times the cost of ticket.)
6. Use the following commercial web sites to estimate the costs of the systems presented in the case studies.
7. The benefits of new technology are somewhat uncertain. Look in the education/research web site to see if any studies have report definitive benefits from a precision agriculture system.