Decision Support Systems for Precision Ranching

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Ranching is a very old profession with a lot of time honored ways of doing things. It is also a profession with very innovative individuals who are not afraid to use new technology as long as it improves their bottom line. Many ranchers are adopting new tools from the information age to better manage their livestock and pastures. These new digital tools can be considered a decision support system for the rancher, combining and organizing all of the management practices of a ranch into a way that allows the rancher to better interpret, visualize, plan, and communicate to others the daily operations required within his ranch to maximize net income.

It is interesting to think of a rancher's decision support system as a tool to better allocate assets over a geographic area. You can really call ranch management a "spatial asset allocation problem". That is, where on my ranch (spatial region of interest) should I place my capital (investment in time and money) to return the most income? Adding the ability to manage a ranch on a site specific basis (precision ranching) makes the ranch manager very much like a stock market portfolio manager…where do you invest dollars to return the best income? It can become an artful blend of portfolio / asset allocation analysis along with agronomy / range / cattle management.

Let's take a look at the tools and data needed to transform a well-managed ranch with a "precision ranching" system. In this article, we'll examine the types of input data needed for a good decision support system. We will also examine how one rancher uses these tools for invasive weed management and asset allocation on his ranch. The final section takes a look into the near future with new technologies that have real potential to increase the temporal resolution that can be applied to livestock management. Real-time, directed cattle grazing control with "Virtual Fencing System" may become the final piece of the puzzle to get the most income by actively managing the live assets on a ranch.

Where investors in the stock market have many decision support tools, what type of tools are needed for a rancher? Charting historical stock process, rates of return, dividends over time, future income and marketing projections and other reports are all available in digital form to help the portfolio manager allocate his investment dollars wisely. A rancher has a spatial portfolio (his ranch) to allocate his dollars into. This means a large part of his decision support system needs to handle spatial (geographic) data.

Four types of data should normally be collected when you begin a spatially based decision support system: Background, Activity, Current, and Management data layers all need to

be collected. Each one has an important roll in a decision support system. Each class of data is more expensive to generate than the previous layer type.

Background data is one of the least expensive spatial data types that must be collected. Some of the best places to locate this data are government sites or other low cost providers. To start with, minimal background data includes Orthophoto and digital raster graphics (quad sheet maps at 1:24000 scale). Digital Elevation Models (DEMs) are also useful when calculating drainage patterns and runoff areas within a ranch. You can also frequently find soil maps in digital form as well.

Of course, free and inexpensive data isn't perfect. It generally comes in many different formats and nearly as many projections. This can cause problems in building you decision support system. All of these spatial layers need to overlay correctly before they can be used to create the Activity class of data. There is also the problem of sharing this data. It could become expensive, both in staff training and software cost, to supply the digital information to everyone who needs it on a large ranch. Fortunately, a software package called TNTmips® from MicroImages, Inc. in Lincoln, Nebraska, solves these problems. Hundreds of different formats can be imported into TNTmips. This software also automatically re-projects all layers while displaying them to a common, selectable projection. TNTmips also has a free data viewing package, TNTatlas® that allows you to publish your data in digital form on CDs or over the Internet.

Activity layers are created over top of the background layers. Activity layers include fences, hay meadows, watering locations, and livestock handling facilities. These layers are created by heads up digitizing over top of the background layers within TNTmips. This makes them gereferenced to the right location in the world and gives you a starting point for more detailed management of your property. How many acres are in each pasture? How many miles of fences do I have (what is the replacement cost of the fences)? How much hay acreage do I have in production? All of these questions can be answered by building this layer.

These Activity layers also include spatial records of actions taken on each part of the ranch including weed control, fertilizer applications, and grazing calendars. Each layer is slightly more expensive to create since more of your time is required to build it interactively. It takes more effort and time than a simple import and you create a new Activity layer each time you apply chemicals, renovate pasture, or do any activity you want to record and add to your model.

Current layers are more expensive to collect. They include recent satellite images and air photographs of your ranch. They are one of your best sources of information about the current status of erosion, invasive species concentrations, grass availability and health, and drainage and water availability. Recent advances in satellites have made this layer more cost effective than in the past. The government owned (and subsidized) Landsat 7 satellite has a relatively low price of around $700 per scene and covers a large area (each scene is 115 miles (183 kilometers) wide by 106 miles (170 kilometers) long).

Commercial industry image providers need to price their imagery differently for ranching than for other industries. It can take anywhere from .5 to 640 acres per Animal Unit Month (AUM). An AUM includes cattle over one month of age or a cow with a calf less than 6 months old. The carrying capacity of much of the rangeland in the world just doesn't support a large expenditure for imagery. Imagery can be viewed as an input cost for production. Fortunately, lower resolution imagery tends to be less expensive but still quite usable to manage large areas of pasture.

If commercial image providers can deliver just the pixels that fall within the customers area of management, it seems that a price level that conforms to the productivity and uses of that area should be established. No one else would be interested in that area for ranch management (it is not like a city were thousands of individuals have property ownership within a single scene), so no additional sales would be lost. The time requirements for rangeland management are more relaxed than for high value crops such as grapes or vegetables. This allows a larger window of scheduling for the satellite to acquire a requested image. Filling this need can also create a market in what is normally a satellite's geographic "down time" (low customer potential zones). This allows the targeting managers more flexibility to maximize the revenue generated from their imaging satellites.

Management layers are the "shape the future by examining the past" tools where all of the data collection work from other layers begins to pay off. This layer is derived from the Background, Activity, and Current layers. These layers are integrated with university research, industry trends, and personal experiences about managing the ranch. They are a plan of action. These derived layers become "work orders" for day-to-day operations on the ranch. This includes which areas to spray for brush and weed control, where to fertilize and possibly inter-seed to improve grass growth, where to improve infrastructure (fences, watering systems) for handling livestock, and when to move cattle in a rotational grazing system.

Many ranch managers keep this kind of detail in their head. That can work up to a certain point. An increase in acreage under management, a more complex herd, a new grazing system, or a desire to more closely manage current resources can all be reasons for moving to a more formalized, digital decision support system. A decision support system can really prove that "a picture is worth a thousand words" when communicating a management plan to others involved with the ranch such as employees and absentee landowners. Good ranch managers are hard to find. They are normally spread over multi-unit ranches where a digital system can help leverage their expertise (along with others) to make a plan work successfully.

An excellent example of a spatial decision support system can be found on the Peace Pipe ranch in West Texas. Bert Wallace has put together a decision support system that is tailored to his ranch where controlling mesquite (an invasive brush) is a primary management concern. Since 1987, Bert has used TNTmips to collect his Background layers including soil types, digitize Activity layers such as fence boundaries and zones of management, and build up Current layers including infrared photos and satellite images. He then skillfully combines these layers to map the mesquite distribution on his ranch by classifying the imagery within TNTmips.

Bert then takes a very practical approach to using this information to derive his Management layers. He budgets a set dollar amount for chemicals to control the mesquite. This is his principal to allocate or dollars to invest in his spatial market. Using his collected layers, he models his ranch to locate the parts of his property where better controlling the mesquite will return the most grass. This translates into additional pounds of beef, which is ultimately converted into income. It is very similar a portfolio manager picking the stocks or investments where the investments he makes will return the most income.

Once he has located the areas that have the potential to return the most dollars, he then makes his Management layer to spray (allocate his input dollars) into those areas. Since the ranch is sprayed from the air, GPS headings are generated using TNTmips to cover those one-acre cells in a practical manner using modern crop duster guidance computers and mission planning systems.

Bert's method of modeling his ranch for allocating his investment dollars into areas that have the potential to return the most income is impressive. Bert has continued to work at this complex technology over this decade as "its use makes money for me". However, it mainly concentrates on invasive species vegetation management. New technologies are coming along which can refine this model and provide some more active management of the cattle within a ranch.

Several new satellite based imagery providers are coming on-line these days. The effect of more competition and the ability to deliver just the pixels needed for a rancher customer is lower prices and more repeat coverage over an area. Each new image can be incorporated into a ranch model for estimating the current state of grass (and carrying capacity) as well as the pattern of weed distribution within the ranch. If the model is accurate and timely, the most profitable grazing zone within any ranch could tend to spatially "shift" from day to day. This shifting is caused by natural changes throughout the growing season, weather patterns, weed dispersal, soil productivity, market trends, livestock grazing needs and many other parameters. With enough time, ground validation, and experience, an accurate approximation of the location of this "maximum profitability-grazing zone" can be located within the ranch.

Other goals can also be programmed into competing models. Perhaps weed control is an overriding factor (for a few years, anyway), more desirable than profitability? Riparian protection and wildlife management are other goals that are gaining increased attention. These goals can be incorporated into the profitability model.

So what? What difference does it make if you can locate the most profitable "grazing sweet spot" on the ranch unless you can do something about it in a practical manner? Grazing management today is a lot like the pre-GPS days of precision farming. You may know what needs to be done on a spatial basis to allocate your resources and move your cattle to that profitable "sweet spot" which maximizes income, but you cannot jump on a horse to manually herd your cattle or afford to construct enough fences to keep them in that shifting spot in a cost effective manner.

Fortunately, these last puzzle pieces are falling into place. Tools like the Digital Angel™ can make tracking many animals at once (and in near real time) cost effective. You can use this livestock grazing pattern information to update the pasture growth model and estimate the grazing pressure within an electronically "fenced" area. This real-time tracking system can help you refine a pasture model to bridge the gap between acquisition dates of remotely sensed imagery over a pasture. This tracking system can refine the pasture-grazing model over time as multi-date imagery is collected before and after cattle are rotated into a grazing area. Multiple goals (as described above) can be programmed into the geospatial-grazing model, creating an active and updated "best region of grazing." This fifth type of layer can be called an "Action Map." It is used to electronically push the cattle into the GIS derived region.

The other piece of this active grazing management tool is the "fenceless grazing system" (Hay & Forage Grower Magazine). Once the feedback from the GPS positioning system verifies the location of each animal and the latest remotely sensed imagery is combined with a history of grazing locations, a GIS system will model the next best region to move the cattle into for optimizing profitability or other selected management goals. The new pasture "action map" is generated by the GIS and is passed to the "cyber cowboy" (November 2000 issue of Agricultural Research magazine) software/hardware/wireless networking system to slowly herd the cattle with audio cues reinforced by small, very limited, shocks in an ear tag or collar.

Once these components can be miniaturized, perhaps in an ear injected "cow management chip" which is similar to the Digital Angel tracking, animal health, and history recording and wireless networking capabilities combined with active control functions of the fenceless grazing system could be cheaply developed as disposable, use once per cow's productive life, electronic chips. It seems like a lot of capability to pack into an injected pellet, but it is hard to bet against miniaturization of electronic components in this era of advances in computer hardware.

Another key component is a reliable, wireless network system that can tie the pasture modeling geospatial system on a PC in the ranch headquarters (or a ranching consulting service) to the cattle and electronic fence broadcasting towers on site. Again, this is a rapidly advancing field of research, as can be seen at the JPL Sensor Webs Project website described in the reference list below. The key component of this system is it's' ability to "hop" data as described by Wired Magazine: "Data is transmitted between probes at 28.8 Kbps, with a range of several hundred yards, via 916-MHz wireless radio. The sensor readings hop from probe to probe until they reach a hub that sends the data to a central computer." Fewer hub towers, perhaps the same ones used to build (broadcast) the electronic fences, would be able to cover large areas at relatively low power if grazing region extents can hop from cow to cow (using the injected chip) and individual GPS and health readings can be transmitted back along the same multi hop path.

The Background, Activity, Current, and Management spatial information collected over time are valuable today to build up a rancher's decision support system as a tool to better allocate limited assets over the geographic area of his ranch. These layers should be collected now to begin developing a pasture modeling system to locate grazing regions, prioritize fertilizer and pasture renovation zones, productivity ratings, and invasive weed control plans.

In the same way that GPS and other equipment advances has enabled a more active management in precision farming systems, it seems nearly possible to build a pasture spatial modeling decision support system that can incorporate near real time cattle positioning information. Cattle tracking components can supplement remotely sensed imagery, providing cow sense (real "end user" ground truth inputs) to refine pasture image classification input into a grazing model. Action maps can be generated and passed along to an advanced "cyber cowboy" herding system. This precision ranching system can begin the active management of rangeland by rotational grazing to maximize income or reach other goals within that geospatial ranch portfolio; just like variable rate application tools do in precision farming systems.

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