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Insights in development and deployment of the GLA and NUTBAL decision support systems for grazinglands

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Abstract

The evolution of two decision support systems are traced from their roots in academia to deployment to technical advisors in USDA Natural Resource Conservation Service. The Grazing Lands Application (GLA) decision support system (DSS) was designed to provide forage inventories for grazing management of ranches. The other tool, NUTBAL, evolved as a stand alone DSS, emerging as a component of GLA when a supporting monitoring technology for nutritional profiling of free-ranging animals provided the user rapid estimates of diet quality from fecal scans with near infrared reflectance spectroscopy (NIRS). The adoption pattern of GLA and NUTBAL were quite different, with GLA experiencing less widespread adoption in USDA NRCS. The primary causes were (1) limited adoption rate of GLA within NRCS associated with changing culture in the information technology development group, (2) time overloading and staff reassignments for new programs, (3) changing software/hardware development environments imposed by the client disrupting development and system design and (4) large up front conversion of a largely paper-based system to a digital form. GLA was transformed to web-based delivery and streamlined to gain greater acceptance by users and ease time constraints on use of spatial tools. The NUTBAL system experienced more of a user driven evolution since it emerged from the GLA suite of tools and was supported by on-ranch monitoring systems capability of directly linking the livestock producer's animals with the software. NUTBAL's linkage to animal monitoring systems seems to have accelerated adoption rates. Ease of access to supporting input data coupled with early involvement of the target user and extensive analysis of the decision environment were critical to

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future success of these systems. Targeting technical advisors instead of livestock producers appears to be a more viable development track unless new innovations in DSS delivery systems can emerge using the internet.

Keywords: DSS; Assessment; Adoption; Software; Nutrition; Resource; Management

1. Introduction

The success or failure of most decision support systems (DSS) can be traced back to root circumstances under which they were developed and the sequence of key decisions made through the design, testing, deployment and maintenance process of these systems. It is particularly important to know what contributed to the success or demise of a DSS in agriculture given the limited number of products and shrinking resources available to create these products.

In this paper we reflect on the key issues surrounding the co-development of the Grazing Lands Application (GLA) system for United States Department of Agriculture (USDA) and the subsequent "spin off" of the Nutritional Balance (NUTBAL) software (or DSS) for grazing land planning. GLA is a planning tool designed to assist technical advisors in the United States Department of Agriculture–Natural Resource Conservation Service (USDA-NRCS) in conducting conservation plans on private grazing lands. GLA also helps with forage resource inventories and the design of grazing strategies for commercial livestock ranchers. GLA allows characterization of land resources in terms of acreage, accessibility, productivity, livestock carrying capacity, and ecological conditions/trends. GLA also provides modules on grazing systems, nutritional management, and economic investment analysis. The NUTBAL DSS was originally the nutritional management module in GLA and emerged eventually as a stand-alone product.

2. The roots of GLA

Prior to any product presentation to the consumer public, someone must have an idea in a creative and nurturing environment. He or she must find a source of development funding, usually via a person or organization interested in the concept. At issue is whether the funding organization is the primary target user. The benefactor will usually fund all or a few of the necessary stages in the process of turning the idea into a product available for the public. If the target user values the product, the product will be adopted. It is the linkage of the idea to a "champion" within an organization that ignites this creation process. However,

> A system must be used to be successful. Most decision-makers are time-limited and will make a decision regardless of the aids available. Therefore, the DSS must be perceived as more valuable to the decision maker than current methodology, and its adoption and use must be easy rather than a major disruption of on-going activities (Stuth et al., 1993).

GLA's roots are grounded in academia. Three professors: Richard Conner, Wayne Hamilton and Jerry Stuth, have taught a senior level college course in resource and ranch planning at Texas A&M University. This capstone course is taught in a team arrangement. Richard Conner provides economic expertise, Wayne Hamilton covers resource inventory and land practices, and Jerry Stuth covers grazing management and livestock husbandry practices.

The course demanded a significant portion of the students' time and required them to complete a case study of a hypothetical ranch followed by an actual ranch survey and analysis. The mathematical computation demands for the subjects taught in the course were complex. From 1976 to the mid-1980s, the students performed all necessary calculations with electronic calculators. Students used a manual planimeter to compute acreage from large mosaic aerial photographs.

2.1. Emerging technologies

When the *Apple II+* microcomputer emerged along with the *VisiCalc* spreadsheet in 1982, we immediately recognized the value of such tools and began the process of transferring our data analysis to this hardware/software platform. Initially, we set up the forage inventory in *VisiCalc*. However, we quickly found that the spreadsheet format constrained the more complex analyses. At that time, the CMP operating system was available for the *Apple II+* via an add-on card. A graduate student in the course who understood CMP programming created a simple, sequential input program for computing the internal rate of return and net present value analysis of investments for land practices. The arrival of graphic tablets on the market allowed us to do area determinations to support our mapping activities. Unfortunately, these area determinations were limited in capacity and were neither usable on large format maps nor useful in the context of current geographical information systems (GIS).

In 1986, when the IBM microcomputer came onto the market, we started the process of moving our applications to the Lotus-123 spreadsheet. We created a new nutritional management tool called RATION (McGrann et al., 1991). We also wrote a BASIC program called FORAGE that allowed us to compute forage inventories and stocking rates (Hamilton et al., 1989). During this period, we also created a series of spreadsheet tools to help determine graze/rest periods in grazing systems and a mature breeding unit calculator that translated animal unit carrying capacity (animal units/hectare) to actual animal numbers by kind and class. We also transferred the economics investment program written for CPM over to the IBM microcomputer platform.

2.2. Introduction of the project

By 1987, the FORAGE program had matured to the point where we felt that our peers in range management should see the program and evaluate its usefulness. We introduced the system at the 1987 meetings of the *Society of Range Management* (SRM) at the commercial exhibits area with demonstrations and brochures describing how the system worked. Until this time, our target user was a senior (4th year) range management student entering a job market where resource planning and analysis skills would position him/her at an advantage relative to students from other universities. At that time, our undergraduate program was the only one using computers in the classroom to teach resource planning.

During the SRM meetings, a team from USDA–Soil Conservation Service (USDA-SCS, now NRCS) came and discussed our FORAGE program. They were part of a design team that used McDonnell Douglas' Structured Systems Analysis method to create a DSS to support grazing land planning activities within the agency across 3000 field offices in the United States. NRCS provides technical assistance to farmers and ranchers who participate in federal cost-share programs for conservation. One of their primary activities is assisting landowners in the development of conservation plans. Anyone who receives cost assistance for conservation farming or grazing land practices must first have a conservation plan prepared. In the case of ranchers, this process includes a forage inventory, grazing system design, fencing/water development, brush/weed control, reseeding, and erosion control.

2.3. Resource Systems Planning Model

Since the FORAGE program and suite of spreadsheets used in our ranch planning course matched the design analysis of the USDA-SCS, a series of negotiations with the USDA-SCS culminated in the signing of a cooperative agreement in March 1988 to develop a field office grazing land planning system. The original name of the program was to be RSPM or Resource Systems Planning Model. A full description of the RSPM was published by Stuth et al. (1990) and first unveiled at the *Stress and Savannas Conference* held in Darwin, Australia. Several other early rangeland-based DSS tools from Australia and South Africa were introduced at this meeting. The meeting represented the first opportunity for grazing land DSS developers to see each other's applications and share ideas for future developments. What became apparent at that meeting was the different evolutionary development processes of each application and, conversely, the similarity in functions performed by each application.

Our first impression from the conference was that the DSSs were highly focused on specific geographical regions and lacked the generalization that would allow them to be applied in other settings. At the time, this overspecialization could be attributed to the isolated environments in which the DSSs developed and the narrow objectives of the developers who tried to solve limited-scope problems in resource management. However, each DSS required the same set of analyses that were used worldwide. We returned from the meetings with a strong sense that we should ensure the worldwide applicability of our DSS. To help promote more universality in DSS applications, we organized an international conference in 1992 on "*Decision on Support Systems for Natural Resource Management*" resulting a book published by UNESCO's Man in the Biosphere program (Stuth and Lyons, 1993).

2.4. Establishing a collaborative relationship

Once we signed the contract with the USDA-NRCS (formerly SCS), the design of RSPM became client-sensitive. The DSS changed from a tool for teaching students ranch planning to a device supporting the tasks of a technical advisor for the ranching industry in the United States. More specifically, RSPM became a tool for a government agency to use as part of their legal mandate to assist ranchers who had applied for cost sharing programs in USDA in conservation planning.

At the same time, those of us in the Texas A&M development team, Ranching Systems Group, insisted on a collaborative rather than contractual relationship with SCS to allow us to include design components that met our needs as teachers and resource consultants. Therefore, we had set for ourselves the objective to conduct a design process that met the needs of both the USDA-SCS and our own academic needs, while retaining international applicability of the products to areas outside of the USDA-SCS field office environment.

2.5. RSPM becomes GLA

In 1989, the name of RSPM was changed to Grazing Lands Applications (GLA) in order to get broader acceptance by rangeland specialists, pasture agronomists and agricultural economists who would be using the tool in USDA-NRCS. Coalition building within the agency was extremely important to the development of GLA, as limited fiscal resources always created competition within the organization requiring an internal marketing strategy to promote on-going design/development activities.

Since our development group was not part of the USDA-NRCS culture, we had to establish our identity as a unique entity from Texas A&M University. We named ourselves the Ranching Systems Group, and we were composed of the original three instructors, three programmers, one technical editor and several graduate students.

The next thing we had to do was to establish ownership of GLA by our client, now the Natural Resource Conservation Service (NRCS). Although this relationship of NRCS to the program was described in a paper at the International Grassland Congress (Stuth et al., 1993), the key ingredient was early formation of a well respected design team representing the geographic diversity of the agency, and having ample experience in the tasks that GLA must support.

The first design meeting was critical in establishing a bond between developers and users. To accomplish this, the entire RSG team met for 3 days with over 20 people from the NRCS. The meeting was a revealing process for all our staff. Although the NRCS had a 1976 rangeland handbook which described the official planning process used for conservation planning on grazing lands, there was no set way the planning processes was applied across the entire USA, especially techniques for computing stocking rate and use of uniform terminology. We spent considerable time defining terms and merging the array of vegetation characterization techniques used in the field across the country. For example the terms pasture, paddock and trap were eventually all defined as management units. Sub-units within the management units representing differences in ecosites (range sites) distance to water, terrain constraints and land treatments were referred to as response units. Establishing common technical language was essential to successful design of the system.

We had originally thought that the design phase would be straight forward but found it instead to be an ongoing iterative process. Our clients often had limited experience with computers and no preconceived ideas of how the program should work. In addition, the agency was heavily burdened with centralized planning of computing environments. They were struggling with choosing between a UNIX networked system or a DOS individual, desktop microcomputer environment. In 1988 the power of microcomputers was still in question within a world dominated by mainframe, mini-computers and various forms of UNIX programming languages. Therefore, the procedural tasks and operating systems were fuzzy, requiring an iterative prototyping development scheme (Stuth et al., 1993).

A complex organizational structure evolved in the late 1980s. One of the NRCS design team was appointed as the manager of the collaborative project with the Texas A&M's RSG. This person served as the primary point of contact between RSG and the NRCS, becoming the organizational champion of the project within the agency. However, with each design team meeting (3–6 times a year), we found regional champions who built a depth of support within the agency for the software. The RSG subcontracted several development groups to the various conservation planning applications for the field office computing system (FOCS). These included engineering applications, soils databases, soil erosion calculation, plant databases, range sites databases, etc.

The need for standardization became obvious in this type of development environment. Over the period of 1988–1991, many iterations of elements of the system design occurred. Perhaps the most significant event was the final standardization of GLA's interface tool, GLA's language and ultimately GLA's operating system. RSG was required by contract to use the *Vermont View* interface development tool, the C programming language, a Unix operating system, and an INFORMIX relational database.

RSG succeeded in gaining the concession for co-development of a DOS version for academic training and grazing land consultation. At this point, we felt our product could be used by ranchers as evidenced by several statements published by our group in the early 1990s:

> the RSG...has developed decision support systems to address management needs of grazing land/grazing animal operators.
> RSPM...lets managers and owners simulate the long- and short-term effects of various...management decisions
> RSPM can help grazing resource managers analyze alternatives and make decisions [about six major aspects of management].

By using the DOS operating system with the DBVISTA network database (which did not exact licensing fees on distributed copies), we were able to keep the same look and feel for both operating systems, and the program was fast on the IBM 8088 and 286 microprocessors.

It was at this juncture that a deployment weakness in the system began emerging. The ultimate objectives had split within the agency and between developer and client. We recognized the dichotomy and went forward with a dual platform environment, one for the FOCS environment and the other a stand alone DOS application.

2.6. Deploying GLA

In 1991, the DOS application was ready for deployment after a year of beta testing among a select group of NRCS field officers around the Nation. Because the agency had not fully deployed UNIX platforms, the initial product we deployed was the DOS version of GLA. A series of 4-day training sessions were held for field office personnel, and a user's guide was written with technical support material. The training programs first covered the concept of planning with emphasis on how to collect and organize the necessary input data to meet the planning objectives of a landowner. The context of the tool was that of field staff working iteratively with livestock producers to characterize their resources, livestock operations, grazing/nutrition program, and land practices economics. The producer's role was essentially that of an information provider, interacting with a specialist who knew how to acquire the necessary data and utilize the information in the GLA system.

One of the next major obstacles to deployment was that use of the system was limited for grazing land planning in regions of the USA where rangelands are a small portion of land use, and cropland/pasturelands dominate the landscape. In these instances the NRCS usually chose to invest in agronomists and agricultural engineers to handle intensive pasture management planning workloads. This meant that preparation of supporting data in those states was not available when GLA was deployed.

A major effort had to be made by our development team to help NRCS organize the vast databases on plants, soils and range site descriptions (now ecological site descriptions) in a manner that could be used in GLA. We found that the lack of pre-populated databases severely restricted use of GLA, as it was best used where certain regional plants, soils and ecosites had been screened, edited and pre-positioned in the GLA databases. RSG worked with the national PLANTS team to coordinate national and local codes of major plant species in the PLANTS database. A data distribution system was designed so that RSG could extract species from regional databases, compare those to the new updated PLANTS database and reconcile differences in the entries. These corrected databases would be returned to the regions for final verification, and then they would be distributed to GLA users in that region.

The national soils database (NASIS) was under construction at the time, and this was one of the other development teams that had to be consulted throughout the design process. Our primary task was to reconcile soils series and range sites names to allow the GLA program to cross-tabulate between different methods of computing stocking rates.

Finally, RSG coordinated with State range specialist to insure that the plant names listed in the range site databases were consistent with the new PLANTS names. Considerable effort was made to get each major rangeland State set up with pre-configured GLA range site databases.

We observed that GLA deployment occurred faster in States with fully populated GLA databases, particularly the plant, soils and animal preference information. GLA was more readily used where the planning tasks to be performed did not involve acquiring, collating and inputting the supporting data. NRCS field office staff preferred to put only the ranch specific data into GLA generate plans

2.7. GLA becomes part of FOCS

Between 1991 and 1993, the agency implemented the UNIX platform and strongly discouraged employees from using the DOS version even though both NRCS and RSG had over 4 years' experience with the DOS version. Because GLA was to be a "component" of the UNIX-based FOCS environment, a new set of players entered the scene in 1992. These were private industry sub-contractors working on task orders from a new group of NRCS personnel. One of the people in this new group had ties to GLA's original development and was assigned as the project manager.

Our first challenge was to maintain a coherent product in a system in which it was required that planning support components such as soils, plants and range sites be kept separately from the actual planning tasks. This required users to adapt to changes to the system function and sequence of access that were counter to the previous 4 years of training with the DOS version. For example, information on animals was separated in other parts of the system from plants and soils, creating difficulty in assigning preferences of plants to animals.

During the UNIX integration phase with FOCS, we had to reconfigure all the databases to INFORMIX and provide additional data linkages to other applications. We also contracted the design and first alpha version of a national range site database to serve the FOCS environment. During 1993, the funding structure for GLA had moved from our original design team and established "champions" to the large integrated contract group. Since the emphasis was on FOCS, the culture of GLA was dramatically changed. RSG became the "outsider" and the original design team was placed outside of the development process.

When RSG delivered the UNIX GLA system and the alpha version of the ecological site data system in 1993, the team continued making upgrades to the DOS version but ceased maintenance of the UNIX version which was contracted to subcontractors at NRCS' newly formed information technology (IT) group. Training documentation and other support functions fell to this group.

For all practical purposes, GLA had become two entities. The DOS version was maintained and distributed by RSG. However, all changes in code were sent to the NRCS IT group to determine if they would integrate it into the UNIX version. Between 1993 and 1996 few changes were made to GLA since the DOS version was meeting RSG's needs as an academic tool and consulting aid. During this time period 1991–1993, GLA was also introduced into China by RSG via a World Bank project. The Agricultural Bank of China adopted GLA for use by bank loan officers to assess the capabilities of loam applicants to meet repayment obligations based on land capabilities and planned improvements (Hamilton et al., 1992).

3. The birth of NUTBAL

During this period of limited expansion of GLA, one of the tools within the system, the animal nutritional management system, received expanded use among the users of the system. RSG had noticed an increasing interest in use of GLA strictly for nutritional management. Several requests had been made by users to make the nutritional management module a stand alone product. This was done in late 1994 and the resulting product named NUTBAL (Stuth et al., 1999).

After the creation of the stand alone NUTBAL module, a parallel support monitoring technology was rolled out by RSG's Grazing Land Animal Nutrition Lab (GANLAB). This lab began providing a nation-wide nutritional profiling service within RSG that involved scanning feces with near infrared reflectance spectroscopy (NIRS) to predict dietary crude protein and digestible organic matter under free-ranging conditions (Lyons and Stuth, 1991; Stuth and Lyons, 1995). The fecal monitoring technology allowed livestock producers to collect a composite fecal sample (5–10 individual pies) from a herd and send to GANLAB via 2-day priority mail. The lab would then return the results via fax (later via email and the web) within 48–72 h. Normally, the analysis was sent to a consultant or technical advisor in NRCS, USDA, or a private company.

Since NRCS was the primary customer for NUTBAL, the agency became interested in developing a national program that blended the NIRS fecal profiling technology and the NUTBAL software to fill a gap in their conservation planning process. Eventually in 1996, NRCS created the National Forage Quality and Animal Well-Being Program (Norman et al., 1999). RSG provided the NUTBAL software via an unlimited site license to NRCS while NRCS contracted with GANLAB to process a predetermined number of samples each year. The initial contract for 4000 samples (335 ranchers) was subsequently increased to 9000 samples (750 ranchers) per year.

Since the agency had few technical staff trained in ruminant nutrition beyond basic coursework in their undergraduate programs, a series of training short courses were designed by RSG to fill this skill gap. The designated "NIRS/NUTBAL Nutritional Management System" training program involved a beginner's 2-day session where 15–40 individuals were exposed to one full day of nutritional concepts affecting nutritional requirements and dry matter intake. The second day of training involved use of the NUTBAL software to assess nutritional status of animals and make recommendations how to mediate nutritional deficiencies.

Normally, the participants would return to their offices and use the program with one or two ranchers who understood that they were "learning together" for 1 year. They would then return for an intermediate refresher course that was similar to the beginning course but with more emphasis on problem solving. In the course, participants were asked to bring one or more of the ranchers working with them to the workshop. These sessions proved to be very effective since the ranchers become more aware of the value of the program and the technical advisor was able to problem solve with real-world situations. Ranchers also realized that they needed to pay more attention to quality of inputs they provided to the technical advisor to create the most accurate advisory. Normally the session would be a half-day concept refresher and science update with one and a half days of case studies.

Each year, NRCS hosted a national advanced training session for 50 individuals who had progressed to the point where they were ready for more complicated situations. In this 4-day session, each person was required to make a 10-min presentation of his or her case(s). Then a list of attendee-derived technical subjects were made and woven into the course. Each person was asked to bring a case that they found difficult to solve. The GANLab instructor would review the cases and select a series of problems to be worked on by the entire group. Normally, the participants were put in groups of three to allow them to explore ideas together. At the end of each case, one group would be randomly selected to present their solution to a particular problem. Throughout the training session one-on-one counseling would be informally arranged to address special issues. Between 1996 and 2001, over 30 workshops were provided throughout the USA, impacting over 500 NRCS employees.

One of the exciting aspects of this program was the increased morale of the NRCS technical advisors as they were allowed to play a strong one-to-one consultation role that had been eroded with expanded bureaucratic overhead associated with new government cost-share conservation programs for cropland management. The participants in the program indicated that working with producers on animal nutrition issues allowed them to promote conservation practices, the primary mission of NRCS. Essentially, they worked through needs of the animal to meet the needs of the grazed ecosystem.

3.1. NUTBAL today

Over 1000 producers have participated in the program. GANLab has invested in providing quality customer support in use of the NIRS/NUTBAL monitoring and decision support system, interpreting the NIRS results and providing technical support information on animal nutrition. At the time of writing, web-delivery of information was rapidly replacing paper documents and faxed advisories.

A recent survey of 350 ranches that have participated in the program for 6–24 months indicated that as length of time in the program increased, the percent of respondents who reported a positive dollar added benefit as a result of being in the program also increased (Eilers, 1999; Stuth and Tolleson, 2000). This positive dollar benefit reflected either an increase in 22 kg of calf sold/cow exposed and/or a 35% decrease in feed costs. Additionally, those producers who always or frequently received a recommendation from their client representative (the person who received reports from the lab and wrote the advisories) more often indicated a positive dollar benefit. An intensive survey of 10 ranches in Louisiana that had participated in the program for the previous 7 years indicate that economic benefits continued to expand long after the 24 months represented in the larger study, averaging an increased 44 kg calves sold per exposed cow, primarily due to improved weaning weights (Tolleson and Stuth, 2001)

One of the unique aspects of the NIRS/NUTBAL program was the constant feedback on systems response relative to observed responses of both the technical advisor and rancher. When a technical advisor received the results of the NIRS fecal profiles and the subsequent NUTBAL analysis, the system was predicting protein and net energy balance and subsequent nutrient-limited weight change. The analyses were normally conducted every 30 days for brood animals and every 2–3 weeks for growing stock. The cycle of monitoring, analysis, action, and feedback allowed users of the system to identify weak areas in the system and make timely corrections to inputs and actions. Issues of interpretation of input, characterization of the situation or misdiagnosis forced a continual appraisal of the system. In over 40% of the user's of the system, major changes were implemented by the ranchers. Where system predictions were off, most producers stayed with the program, since there was an active effort by researchers to correct equations that are used to capture biological responses in the system. However, early misdiagnosis in the program in some rural communities forced our team to visit those sites and personally work with ranchers to rebuild their confidence in the system.

This pattern of feedback for the system allows the development process to improve the biology in the software, enhance the flow of information between lab, advisor and rancher, expand content in training material and improve the monitoring protocol. Since 1994, NUTBAL has experienced 18 updates in the DOS version and has just been released as NUTBAL PRO for WINDOWS. The NUTBAL PRO system reflected many of the needs identified by users over the previous 6 years and included newly requested modules on calf crop projections from body condition score composition, phosphorus balance and improved gain projections for sheep and goats.

The DOS version of NUTBAL had outlived the changing WINDOWS technology and new science related to differential protein degradability and improved thermal stress computation lead our team to deliver the NUTBAL PRO package in a WINDOWS 95/98/ME/NT/2000 format. International demands have lead to creation of a multiple-language enabled version of the system. Because of the growing capacity in agriculture to handle web-enabled application another version of the software has been implemented, using the PYTHON language interface to the core science engine and databases of the NUTBAL PRO system. All of the DSS development efforts have stressed modularity coupled with object oriented design.

As in the case of the DOS version of NUTBAL, a series of new training sessions have been designed which accommodate prior users as well as new users of NUTBAL PRO. The newer version of the software underwent the same iterative prototyping process used in the original versions of GLA and NUTBAL. A design team was formed within NRCS to address the needs of NUTBAL PRO. Each pre-beta released was issued to approximately 25 people for testing with periodic meetings scheduled to allow feedback and modifications. These iterative testing environments have lead to release of a very stable product with sufficient support and functionality to expand the skills of the user and improve the advice provided to producers.

To accommodate new science in ruminant nutrition, we have been upgrading our fecal profiling system to support NUTBAL PRO in a more geographically robust system, reflecting a much broader array of vegetation types as well as new dietary components such as rumen degradable protein levels in the diet. Because inputs to NUTBAL PRO had increased, we had to modify data forms provided to ranchers to improve the efficiency in data entry and analysis.

4. What have we learned?

Several articles by members of the RSG team expounded our philosophy of DSS design and application (Stuth et al., 1990, 1993; Stuth and Lyons, 1993; Stuth, 1996). In this section we reflect on how our philosophy has changed since we wrote those papers.

In our earlier writing, the focus was on tools to improve decision making of grazing land/grazing animal operations to analyze alternatives. Implicit in this statement was the anticipated demand for personal use of the GLA system by ranchers once they had worked through a technical advisor. However, it became readily apparent that we had designed a tool for technical advisors who were trained in natural resource planning. A tool that was not suitable for use either by ranchers or graziers. A few large, corporate ranches adopted the GLA technology but for the most part the product was adopted throughout the organization of our primary client, NRCS. Little adoption occurred among extension programs due to the limited ability of extension people to use resource planning tools, except for a small group of rangeland extension specialists. However, it was adopted by several academic programs to teach rangeland planning in capstone courses, similar to the course used in our program at Texas A&M University. Also, we have had good results in applying GLA in international settings as part of World Bank consultations in China, corporate ranches in South America, pastoral regions in Africa and FAO training programs in China and Africa.

There were four primary factors that limited the adoption rate of GLA within NRCS.

- Changing culture in the information technology development group. The development players changed.
- Time overloading and staff reassignment to accommodate new national programs focused away from grazinglands toward cropland management.
- Changing software/hardware development environments imposed by the client, causing disruption in development and system design.
- Large effort required up front to move a largely paper-based system supporting data needs to a digital form, particularly on plant names and preferences as well as ecological site descriptions.

Of particular interest are the differences in evolution of GLA and the NUTBAL module. Both systems had extensive training programs with more comprehensive training being provided for the more complex GLA system. However, the monitor and data input needs were better supported and more easily implemented in NUTBAL than GLA.

To use GLA, a complete resource inventory had to be conducted which involved acquisition of paper maps, determination of land acreages by response unit, conduct of field vegetation surveys, interviews with the producer and acquisition of economic information where investment analyses were required. The user of the software, i.e. technical advisor, also had to build a foundation resource database for their geographic area. This action required time away from large bureaucratic workloads that were mandated by the US Congress in the national Farm Bill.

The result was a collection of pockets of expertise where administrators had set aside positions to address conservation planning needs on grazinglands and widespread limited use, depending largely on the drive and interest of individuals within NRCS. Over the period of 1988–1993, mandated agricultural policy had saturated workforce time loads and budget cuts had reduced manpower to carry out the program. GLA suffered from these processes with de-emphasis on grazinglands.

NUTBAL, on the other hand, experienced an opposite trend. Use within NRCS and non-NRCS technical advisors and ranchers expanded over this period, especially after 1994. One of the primary reasons was the ease of monitoring to support use of the tool, e.g. fecal NIRS profiling. Also, the culture of NRCS has changed somewhat with renewed emphasis on grazing land conservation planning and on-site producer advisement. Political forces have arisen that place pressure on NRCS to address conservation planning for grazinglands. The national Grazing Lands Conservation Initiative (GLCI) was created and recognized by the US Congress, allowing NRCS the opportunity to revitalize this task area in their national mission statement.

The NIRS/NUTBAL nutritional management system has provided a tool for NRCS technical advisors to re-establish closer working relationships with livestock producers. At the same time, the monitoring technology and advisory services offered by GANLab has allowed producers to help themselves and expand adoption of the technology among extension specialists and agricultural consultants. The product must evolve with the user to gain and sustain user acceptance. If the culture of the organization impacts the user, the DSS must evolve with that organization or user skills. Pre-staging of data and creation of easy-to-use monitoring technologies to support the use of the DSS is also critical. Most of the DSS tools available for agriculture have not been adopted to any significant level due to an array of factors including limited user involvement in design and development, poor functionality, lack of training and support programs as well as limited cost:benefit analysis for the system itself.

Our design philosophy to date has been that it will be difficult to recoup development cost by targeting direct use of DSS tools by ranchers. Instead, we feel that in the near term, technical advisors should be targeted as primary users working directly with ranchers who become indirect beneficiaries. It has become apparent that we must clearly understand time constraints on management as well as changing skill requirements and organizational structure of ranches.

5. GLA for the future

GLA is undergoing a new metamorphosis in response to expanding interest in grazing lands and the emergence of private companies specializing in management planning services. The new webGLA under development is addressing the issue of planning on demand within a mobile environment using the Internet to deliver and maintain the software. The use of web-enabled training courses also allows organizations to raise skill levels of staff wanting to use the system. The entire system is delivered using 100% JAVA technology with open ended data linkages, eliminating the problem of changing databases.

One of the limitations to using GLA in the past has been the determination of acreage from paper-based aerial photos. The new webGLA has a spatial interface that allows rapid resource delineation and automated inventory systems, cutting mapping activities by 80%. NRCS has learned the problems associated with pre-positioning databases for GLA and are positioning critical databases for web linkage to webGLA to eliminate startup constraints as experienced in the early phases of GLA.

A major stumbling block remains in the area of field measurements of vegetation needed to support the forage inventorying process. New rapid field techniques are being pursued to link webGLA with personal digital assistants (PDA), to help speed up the process. Use of embedded biophysical models driven by remotely sensed weather data is also being tested to allow computation of forage production based on simple field measurements of species' maximum expression. The models are being designed into a fully automated system that delivers information without requiring interaction with the model itself (http://cnrit.tamu.edu/aflews). Simple DSS that utilize the output of these automated systems are being pursed with rancher focus groups to design easy to use products coupled with complex information technologies in a manner that does not require high skills on the part of the user.

Advances in information technology are creating a new environment that should help overcome many of the computational problems associated with complex models integrated with decision support systems. However, these new innovations will not remove the most important need in DSS development...early involvement of the target user and extensive analysis of the decision environment to be served by the DSS.

We believe that DSS development should evolve away from a software development mindset to a "service mentality." That is, move away from trying to commercialize a software package and instead package a series of monitoring, software, communications, training, and advisory tools around a carefully selected service that meets the needs of the agricultural clientele targeted as users of the technology. The service can be in the form of a government non-profit agency, a for-profit consultancy or within the corporate structure of a firm. The key is the design of a system that "serves" the decision making process in a manner that has tangible and non-tangible value.

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