Proceedings

2008 Stockman's Fall Field Day

Behavior-Based Grazing Management for Improved Animal Performance, Pasture Condition, and Ranch Profitability

Cooperative Extension Service

College of Tropical Agriculture and Human Resources

UNIVERSITY OF HAWAI'I AT MĀNOA

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The Stockman's Fall Field Day is an annual educational outreach program that provides information on forage-based livestock production to Hawaii's Livestock industry. The Stockman's Fall Field Day is a two-day event held annually at in various locations around the State in order to better serve livestock producers and therefore, it is replacing the Mealani Forage Field, a one day event that was held annually at the University of Hawaii's Mealani Experiment Station. The program has three primary goals that focus on supporting the creation of a sustainable livestock industry. They are: 1) to provide the technology and information on development of sustainable forage production systems to Hawaii's livestock industry to ensure ecological sustainability; 2) to provide information on opportunities and incentives for market development of forage based livestock products to ensure economic sustainability; and 3) to provide information to producers, processors, retailers, and the consumer about the benefits of forage based animal production systems to ensure social sustainability.

The relationships between soils, plants, herbivores and people are complex, which present many challenges for the sustainable management of pasture systems. A holistic overview of the principles and processes of plant and animal behavior as they pertain to food and habitat selection can provide a basis for this approach. To assist livestock producers in becoming more sustainable in the long run, the 2008 Stockman's Fall Field Day will focus behavior-based grazing management for improved animal performance, pasture condition, and ranch profitability.

On the first day, Dr. Fred Provenza, an animal scientist from Utah State University, will provide a full day workshop on his BEHAVE program. He will address behavior based management and illustrate its implications for enhancing dispersion of grazing across landscapes, thereby changing traditional patterns of use for managing riparian areas; for controlling weeds and maintaining fire breaks; for minimizing damage to economically valuable crops by wild and domestic herbivores; for enhancing and maintaining biodiversity; and for reducing losses in animals from toxic plants and "hard" introductions into familiar environments. Dr. Provenza has authored a book and a DVD on the BEHAVE program, which attendees will receive.

Dr. Tom Field, a Beef Production Specialist from Colorado State University, will give two presentations. The first will be on increasing the long-run profitability for a cow/calf operations and attendees will be provides a copy of his publication entitled "Priorities First: Identifying Management Priorities in the Commercial Cow-Calf Business." His second presentation will provide an overview of the US beef industry market trends and opportunities.

Following Dr. Field, Lester Ueda of Hawaii County and James Robello of Maui County will present an overview of various USDA Farm Service Agency program. These include the NAP-Forage program and various insurance and loan programs available for livestock producers. Next, Dr. Mark Thorne will make a presentation on managing pastures during drought.

As always, the field day program will provide a forum for producers, vendors and educators to network and share knowledge is an important part of the program. A large part of the event is set aside for this purpose and we hope that all participants will come away from the event feeling a greater sense of partnership.

We would like to thank the USDA Natural Resource Conservation Service and the USDA Farm Service Agency for their generous support. Without their sponsorship, this event would not have been possible. We hope that you find this year's program to be informative and enjoyable and to ultimately contribute to making livestock production in Hawaii more sustainable in the future.

Mark S. Thorne and Linda J. Cox
Co-Editors

2008 Stockman's Fall Field Day

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Schedule of Events

Hawaii County: August 22–23, 2008, Mealani Experiment Station, Kamuela, Hawaii

Maui County: August 25, 2008, Kula Community Center; August 26, 2008, Eddie Tam Memorial Center, Kula, Maui

Day 1: Behavior-Based Management Workshop

7:30 - 8:30 a.m.	**Registration and Introductions** Dr. Mark Thorne
8:30 – 9:45 a.m.	**More than a Matter of Tast**e Dr. Fred Provenza, Utah State University
9:45 – 10:00 a.m.	Break
10:00 – 12:00 p.m.	**Social Influences on Food and Habitat Selection**, **Part I** Dr. Fred Provenza, Utah State University
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	**Social Influences on Food and Habitat Selection, Part II** Dr. Fred Provenza, Utah State University
2:00 – 2:15 p.m.	Break
2:15 – 3:30 p.m.	**Variety: The Spice of Life, Part I**
3:30 – 3:45 p.m.	Break
3:45 – 5:30 p.m.	**Variety: The Spice of Life, Part II**

Day 2: Beef Production and Ranch Profitability

7:30 – 8:15 a.m.	**Registration and Introductions** Dr. Mark Thorne
8:15 – 9:15 a.m.	**Beef Production: Priorities First for Cow/Calf Operations** Dr. Tom Field, Colorado State University
9:15 – 9:30 a.m.	Break
9:30 – 10:30 p.m.	**Beef Industry Market Trends and Opportunities** Dr. Tom Field, Colorado State University
10:30 – 10:45 a.m.	Break
10:45 – 11:15 a.m.	**Farm Service Agency Overview** Hawaii County: Mr. Lester Ueda Maui County: Mr. James Robello
11:15 – 11:35 p.m.	**Drought Management** Dr. Mark Thorne, University of Hawaii
11:35 – 12:00 p.m.	**Carcass Selection for Quality Forage-fed Beef** Mr. Glen Fukumoto, University of Hawaii
12:00 – 1:00 p.m.	Lunch
1:00 – 4:00 p.m.	**Field Tour**

Welcome Address

Wayne Nishijima
Associate Dean/Associate Director for Cooperative Extension, CTAHR

On behalf of the College of Tropical Agriculture and Human Resources, University of Hawai'i, I wish to welcome you to the 2008 Stockman's Fall Field Day. I always find it a pleasure to be with ranchers and farmers. I thank all of you for being in this noble but often unappreciated or misunderstood profession. Mark Thorne and his team have put together an interesting two days of presentations, which I'm sure will present and expose you to many new ideas and information.

We are very privileged to have Dr. Fred Provenza, of Utah State University. who will be talking about behavior-based grazing management, and Dr. Tom Field, from Colorado State University, who will talk about beef cattle marketing and ranch profitability. We are very fortunate to have experts of their caliber share their knowledge and experience with us. Having taught at Colorado State University for about 3 years many years ago, I remember that CSU had been willed a working cattle ranch that was about 2,000 acres in size, just up US 287. Out of curiosity, I checked the CSU website and was surprised to see that CSU has six cattle research ranches/facilities totaling 85,175 acres! Our 180 acres here at Mealani, where we conduct research on cattle, pastures, and horticulture crops, is very modest in comparison.

The dramatic rise in oil prices is affecting everyone in the US, but more so those of us that live and work in Hawaii, because of our extreme dependency on imported goods, energy, and tourism. However, it gives us an opportunity for us to change and to encourage others to change their old way of doing things. Food sustainability has risen to the top of concerns for many in Hawai'i, which is fueling the trend towards purchasing and consuming locally produced food. Beef for local sales increased by 11% during the first 6 months of 2008 compared to the first 6 months of 2007. On the downside was the reduction by 25% of the out-shipment of cattle during the same period.

Grass-finished beef has been the focus and emphasis of our beef program at Mealani for many years, and CTAHR will continue to improve the quality and consistency of forage-finished cattle in Hawaii. We need to continue to educate the chefs and the public about how good local beef is, how healthy it is for you, and how good it is for our environment and to Hawaii's sustainability.

I am concerned, however, about the slaughtering and processing infrastructure in Hawaii meeting current and especially future needs to support the increasing sales of locally grown livestock. Our slaughtering facilities throughout the state are old and, therefore, expensive to operate, especially with the cost of electricity rising. The rendering facilities, or more accurately, the lack of rendering facilities, are also contributing to higher slaughtering costs. On Oahu, the one and only slaughterhouse (and the newest in the state) is close to going bankrupt. If it closes, the cattle and hog producers on Oahu will have only very expensive options of shipping cattle off-island and shipping back. We need to invest in upgrading local slaughtering facilities if we are to retain more cattle for the local markets.

I congratulate the cattle industry for being proactive and holding the Beef Summit about 2 months ago to address the impact of rising oil prices on the cattle industry. Although the price of oil has been declining recently, the long-term projection is for continued increases in oil prices. I encourage all of you to continue to work as an industry to find solutions.

Thank you, and best wishes for a successful field day.

Behavior-Based Management of Landscapes

F.D. Provenza
Department of Wildland Resources, Utah State University

Summary

Once understood, behavioral principles and processes can be translated into practices that provide an array of solutions to the challenges people face in managing to maintain livelihoods and the integrity of landscapes. Unlike the infrastructure of a ranch such as corrals, fences, and water development, behavioral solutions cost little to implement and they are not fossil-fuel intensive. They are also easily transferred from one situation to the next. Unfortunately, scientists and managers often ignore the power of behavior to transform systems, despite compelling evidence. The environment, continually interacting with the genome during the growth and development of an organism, creates behavioral responses that in social animals are transferred across generations. Given time, that forms the basis for what it means to be locally adapted to a landscape. Though experiences during development in utero and early in life are especially critical, genome-environment interactions continue throughout life. Thus, the issue isn't if soils, plants, herbivores, and people are adapting to ongoing changes in biophysical and social environments; they all do so continually. For those willing to understand how these ongoing interactions influence behavior, the potential is unlimited. In the case of grazing, behavioral solutions are increasingly attractive given growing social, economic and ecological concerns with wildfires, herbicides, and mechanical means of rejuvenating landscapes.

Behavior-based management offers opportunities, for example, to use understanding of 1) the relationship between palatability and plant biochemistry to rejuvenate landscapes to benefit wild and domestic animals, 2) the importance of variety in the diet and daily grazing sequences of livestock to enhance wildlife benefits to land owners, managers, and users, and 3) the value of biochemical complementarities for developing plant mixes for pastures that provide a full range of benefits -- nutrition and health for plants, herbivores, and people -- without the unsustainable fossil fuel costs associated with fertilizers, herbicides, insecticides, antibiotics and anthelmintics.

Key words: grazing management, rangelands, plant-herbivore interactions, landscape biodiversity

Introduction

There is evidence that behavioral principles and processes can be translated into practices that provide an array of solutions to the problems people face in managing to improve the integrity of the land and to make a living from the land (Provenza, 2003a). Unlike the infrastructure of a ranch or a public grazing land, such as corrals, fences, and water development, behavioral solutions cost very little to implement, they are not fossil-fuel intensive, and they are easily transferred from one situation to the next. In the case of grazing, for instance, behavioral solutions are increasingly attractive given growing economic and environmental concerns with fire, herbicides, and mechanical means of rejuvenating landscapes. Scientists and managers often ignore the power of behavior to transform systems, despite compelling evidence.

We know the environment continually interacting with the genome during the growth and development of an organism creates behavioral responses. Though experiences during development in utero and early in life are especially critical, genome-environment interactions continue throughout life and they constitute what it means for all organisms to be locally adapted to landscapes.

Thus, the issue isn't if creatures are adapting to ongoing changes in biophysical environments, they do so every day of their lives. The only question is whether or not people want to be a part of that process. For those willing to understand how environments interact with the genome to influence behavior, the potential is virtually unlimited. The challenge is to understand and apply the principles to all facets of one's life. In that sense, rather than developing and transferring "technology" packages, we aim to change, fundamentally, the way people understand and use behavior to manage ecosystems. We want people to realize the power of behavior to transform systems ecologically, economically, and socially.

To do so, we are engaged in research and outreach activities that: 1) improve the economic viability and ecological integrity of range-based enterprises on privately and federally managed landscapes; 2) use natural plant communities as models to develop bio-diverse pastures that provide the full range of benefits -- nutrition and health for plants, herbivores, and people -- without the unsustainable costs of monocultures associated with fertilizers, herbicides, insecticides, antibiotics and anthelmintics; 3) first enhance and then maintain the biodiversity of landscapes dominated by weeds; 4) optimize wildlife benefits to land owners, managers, and users; 5) use contact with nature -- gardens as ecosystems and lambs as models -- to encourage healthy lifestyles in children in middle-schools and young women with eating disorders; 6) improve the ability of people to adapt within and manage complex adaptive social, ecological, and economic systems; and 7) bring innovative researchers and managers from around the world together to share their growing understanding of behavioral principles and processes and their integration with indigenous knowledge and practices.

For the past 30 years, considerable information has appeared in the literature on how learning influences food and habitat selection in the ruminants (see Provenza 1995, 1996, 2003a). Recently, there is an attempt to actively engage land managers, as described above (see www.behave.net), that is leading to an integration of scientific understanding with local knowledge to create applications for the research. As discussed in what follows, behavior-based grazing management offers opportunities to use understanding of 1) the relationship between palatability and plant biochemistry to rejuvenate landscapes to benefit wild and domestic animals, 2) the importance of experiences early in life in creating locally adapted animals, and 3) the value of biochemical complementarities for developing plant mixes for pastures that provide a full range of benefits -- nutrition and health for plants, herbivores and people -- without the unsustainable costs of fertilizers, herbicides, insecticides, antibiotics and anthelmintics.

A functional explanation for palatability

Palatability is considered to be a matter of taste, and all popular definitions focus on either a food's flavor or its physical and chemical characteristics. Yet, if palatability is merely a matter of taste, why do goats eat woodrat houses? Why do goats, sheep and cattle supplemented with polyethylene glycol increase their intake of unpalatable plants high in tannins? Why can sheep and cattle be trained to avoid eating grapes and poisonous plants? Why can they be trained to rejuvenate landscapes?

Flavor-feedback interactions

Palatability is more than a matter of taste. Palatability is a functional relationship between a food's flavor and its postingestive consequences from cells and organs in response to primary and secondary compounds in foods. Flavor is the combination of odor, taste, and texture (Provenza and Villalba, 2006). Postingestive effects are feedback from the cells and organs. Feedback is positive (increases palatability) if the food meets nutritional needs. Feedback is negative (decreases palatability) if the food is inadequate or excessive relative to nutritional needs or if the food is toxic. Thus, flavor-feedback interactions are influenced by the nutrient and toxin content of the food and the nutritional needs of the animal. The senses of smell, taste, and sight enable animals to select among foods and provide pleasant or unpleasant feelings associated with eating. Thus, postingestive feedback influences an animal's liking or disliking for a food and that depends on how well a food meets the needs of the body.

Feedback within the body is critical for health and well-being. Bodies are made up of cells, organs, and organ systems all with nutritional needs. They interact with one another through feedback from nerves, neurotransmitters, and hormones. In the case of flavor-feedback interactions, nerves for taste converge with nerves from the body at the base of the brain. These nerves interact as they send information throughout the central nervous system. Feedback from the body to the palate is how groups of cells and organs influence which foods and how much of those foods are eaten (Provenza, 1995).

Changes in palatability through flavor-feedback interactions occur automatically. Animals don't need to think about or remember the feedback event, just as none of us need to consider which enzymes to release to digest the foods we eat. Even when animals are anesthetized or tranquilized, postingestive feedback still changes palatability (Provenza et al., 1994). When sheep eat a nutritious food and then receive a toxin dose during deep anesthesia, they become averse to the food because the negative feedback of the toxin occurs even when the animals are deeply asleep. Thus, feedback operates automatically, and often in the absence of rationality, to change palatability. For example, people acquire food aversions even when they know their illness was not caused by the food. A person often acquires strong aversions to foods eaten just before becoming nauseated even if the person knows that the flu or seasickness - not the food - was responsible for the nausea.

Goats and woodrat houses

The shrub blackbrush (*Coleogyne ramosissima*) is deficient in energy and protein. Several years ago during a winter-grazing study, we placed small groups of goats on six blackbrush pastures (Provenza et al., 1983). As the study progressed, goats became increasingly averse to blackbrush. In one pasture they began to eat the bark-covered and vegetation structured houses of woodrats (*Neotoma lepida*). Goats acquired a preference for woodrat houses because the houses contained urine-soaked (nitrogen-rich) densely-packed vegetation that helped goats overcome their N deficiency. By the end of the study, goats that ate woodrat houses lost 12% of body weight, whereas goats that had not discovered woodrat houses as a source of macronutrients lost 20%. Animals deficient in nutrients seek out new foods, and animals are likely to form a preference for a food, no matter how odd, if postingestive feedback from the food corrects a nutritional deficit or imbalance.

Polyethylene glycol

Depending on their structure and concentration, tannins can reduce the digestibility of protein and energy in foods, and some tannins are toxic (Clausen et al., 1990; Makkar, 2003)). Polyethylene glycol binds with tannins, preventing their adverse effects. Animals fed small amounts of polyethylene glycol eat much more of foods high in tannins because the tannins no longer produce negative effects. Thus, the aversive post-ingestive effects of tannins, not their flavor, renders plants high in tannins unpalatable, and the positive post-ingestive effects of nutrients in the food that makes high-tannin foods palatable. That's why polyethylene glycol can be used to train animals to eat unpalatable weeds, such as *Sericea lespedeza*, that are high in tannins (Mantz, 2008).

Training livestock to eat or avoid foods

Livestock including sheep, cattle and horses have been trained to eat or avoid particular foods. Kathy Voth has developed a program of training livestock to eat various species of weeds by spraying them with molasses, which provides positive postingestive feedback (see www.livestockforlandscapes.com).

Conversely, compounds such as LiCl that condition food aversions (Provenza et al., 1994), have been used to train sheep to avoid eating grape vines in vineyards (see www.sciencentral.com life sciences – Eco Mowers posted 09/11/07), cattle to avoid eating poisonous plants such as larkspur (Ralphs et al., 1997), and horses to avoid eating poisonous plants such as locoweed (Pfister et al., 2002, 2007). Important considerations in the training process have been outlined by Ralphs and Provenza (1999), and they include food novelty, compound dosage, and social influences.

Rejuvenating landscapes

A critical application of behavior-based management is on grazed landscapes, especially in light of ever increasing costs of fossil fuels relied upon heavily in conventional range improvement programs (Provenza, 2008). For example, sagebrush-steppe is one of the largest ecosystems in North America. Herbicides and mechanical removal of sagebrush (*Artemisia tridentata*) is expensive and can adversely impact environments. Fire often is useful, but where sagebrush is dense, intense fire storms may render areas sterile and subject to invasion by annual grasses such as cheatgrass (*Bromus tectorum*) (West, 1999).

In contrast, grazing is a more economical way to enhance diversity of landscapes by creating mosaics of grasses and forbs within sagebrush stands, thereby changing the small-scale distribution pattern, density, and age-class structure of sagebrush–steppe communities (Woodland, 2008). Grazing may also minimize re-invasion of sagebrush into areas previously treated mechanically, with herbicides, or with fire. The later is extremely important for Mediterranean shrub lands, such as *matorral*, *maquis*, *garrigue* and *phrygana*, which are managed as grazing lands (Papachristou et al., 2005).

Sheep and goats supplemented with energy and protein eat double the amount of sagebrush as unsupplemented animals, evidently because macronutrients enhance detoxification processes (Banner et al., 2000; Villalba et al., 2002). Thus, intake of sagebrush may be increased, and the impacts of sagebrush on livestock mitigated, if large numbers of supplemented animals graze sagebrush for short periods as demonstrated in a field study on how supplemental macronutrients influence consumption of sagebrush by sheep (Dziba et al., 2007), and subsequently confirmed in another field study (Woodland, 2008). In the initial study, stock densities were too low and we provided too little supplement, and hence use of sagebrush was low. When we increased stock densities and provided more supplement, sheep were much better able to consume sagebrush. Increased efficiency of detoxification likely enabled supplemented sheep to eat more sagebrush by providing nutrients required for elimination of sagebrush terpenes and their metabolites. We postulate that faster rates of elimination allow animals to ingest more sagebrush because they are able to maintain terpene concentrations in the central circulation below the critical levels that limit intake. Although these satiation thresholds vary among herbivore species and individuals within species, our results indicate that without supplements the limit toxins set may have considerable negative effects on intake of sagebrush and other chemically defended plant species. These findings are now being put into practice by sheep and cattle producers in the western U.S.

The role of supplemental nutrients on intake of chemically defended plants by herbivores is critical to enhancing rangeland biodiversity. Nutrient supplies to the soil, provided by livestock in the form of urine and feces derived from supplements and sagebrush, likely enhance the production and nutritional quality of herbaceous plants, thereby increasing the amount and variety of forage and improving the nutritional value of sagebrush steppe ecosystems for domestic and wild herbivores (Woodland, 2008; Provenza, 2008). This applied grazing management could be extended to Mediterranean Kermes oak (*Quercus coccifera*) shrublands where the management objective is to maintain a balance between kermes oak and other woody and herbaceous species (see Papachristou et al., 2005).

Social learning and culture

Palatability is the interrelationship between flavor and feedback from primary and secondary compounds. But if that's all there is to palatability, then why do dairy cows reared in confinement perform poorly on pasture and livestock reared on pastures and rangelands perform poorly in drylots or feedlots? In both cases, animals have nutritious food available free choice, but food intake is low, performance is poor, and animals are more likely to suffer diseases. Likewise, why do cows of uniform age and breeding differ markedly in performance when ingesting ammoniated straw?

Livestock culture

Pasture and rangeland researchers and managers typically consider foraging only in terms of how the physical and chemical characteristics of plants influence an animal's ability to achieve high rates of intake. The social environment is rarely considered when studying diet and habitat selection. This is an unfortunate oversight as a young animal's interactions with mother and peers have a lifelong influence on what it eats and where it goes. When it comes to managing landscape with a variety of foods and terrain, it is critically important to understand how social factors influence the foods eaten by creatures and the locations where they forage, both of which affect animal performance and carrying capacity.

The impact of social learning on adaptation helps account for why herbivores of the same species can occur in very different environments and survive on radically different foods (Provenza, 2003a). A young herbivore learns what kind of creature it will be through social interactions. A calf reared in shrub-dominated deserts of southern Utah is different from a calf reared on grass in the bayous of Louisiana. A bison reared on shrub-dominated ranges in Alaska is different from a bison reared on grasslands in Montana. We typically consider cattle, elk, and bison to be grazers and goats, deer, antelope, and sheep to be forb eaters and browsers. However, "grazers" can live nicely on diets of shrubs, and "browsers" can survive primarily on grass if they learn to do so.

Socializing with mother helps young animals learn about every facet of the environment from the location of water and cover to the wide array of hazards such as predators to the kinds and locations of nutritious and toxic foods. Learning from mother about foods begins early in life as flavors of foods mother eats are transferred to her offspring in utero and in her milk. For instance, in livestock the flavor of plants like onions and garlic is transferred this way, which increases the likelihood that young animals will eat onion and garlic when they begin to forage.

As offspring begin to forage, they further learn what to eat and where to go by following mother. Young animals learn quickly to eat foods mother eats, and they remember those foods for years. Research shows that lambs fed nutritious foods like wheat with their mothers for 1 hour per day for 5 days eat more wheat than lambs exposed to wheat without their mothers. Even 3 years later, with no additional exposure to wheat, intake of wheat is nearly 10 times higher if lambs are exposed to wheat with their mothers than if lambs are exposed alone (Green et al., 1984). Lambs exposed with their mothers to various foods - grains like barley, forbs like alfalfa, and shrubs like serviceberry - eat considerably more of these foods than lambs exposed without their mothers. Mother also reduces her offspring's risk of eating toxic foods. If a mother avoids harmful foods and selects nutritious alternatives, the lamb acquires preferences for foods its mother eats and avoids foods its mother avoids. Lambs given a choice of palatable shrubs such as mountain mahogany or serviceberry -- one of which their mother was trained to avoid -- prefer the shrub they ate with mother. Through her actions, mother models appropriate foraging behaviors for her offspring, who learn what to eat and where to forage.

Feeding animals in confinement and on pastures - In many parts of the world, livestock are reared on rangelands and then moved to feedlots for fattening. For animals reared on rangelands, riparian areas and uplands are habitat, grasses, forbs, and shrubs are food, and water comes in streams and ponds. When these animals are moved to feedlots, total-mixed rations aren't food and feedlot pens aren't habitat. One way to improve performance, and reduce illness, is to expose young animals with their mothers to foods they will later encounter when moved to feedlots. This can enhance intake and performance as shown with sheep (Ortega et al., 1992).

The same is true for beef cattle. To reduce the cost of ranch operation, researchers have explored ways to feed low-cost foods such as straw to livestock during winter. During a 3-year study, 32 cows - 5 to 8 years of age - were fed ammoniated straw from December to May. Some cows performed poorly, while others maintained themselves. Researchers were baffled until they examined the dietary histories of the animals. Half of the cows were exposed to ammoniated straw with their mothers during their first 3 months of life, while the other half had never seen straw. Throughout the study, the experienced cows had higher body weight and condition, produced more milk, and bred back sooner than cows with no exposure to straw, even though they had not seen straw for 5 years (Wiedmeier et al., 2002).

To reduce the high cost of feeding lactating dairy cows in confinement, many producers are using intensively managed pastures as a source of lower-cost, high-quality forage (Emmick, 2007). Unfortunately, for a dairy cow raised in confinement, the barn is habitat, ingredients from a total-mixed ration are food, and water comes in a trough. Mature dairy cattle reared in confinement on processed foods are at a disadvantage when put on pastures and expected to harvest forages they have never seen. Although they may be quite hungry, they lack the knowledge and the skills to eat pasture. Little wonder they stand at the gate and bellow to be fed - grass isn't food and the pasture isn't home. The fear and stress of new foods and environments cause huge decreases in intake and milk production. To ease these losses, dairy cows should be exposed to green chop in the barn before grazing the first time. The time cows spend on pasture should be increased gradually to reduce stress and losses in production. Exposing calves to pastures where they will be expected to forage later in life will help them be more productive as adults by increasing their preferences for pasture species and enabling them to acquire needed foraging skills. Likewise, before leaving home, cattle on their way to the feedlot should be exposed to the foods they will be expected to eat in the feedlot (Provenza, 2003a).

Managing livestock on rangelands

Herbivores learn to optimize intake of foods in a manner consistent with their previous experiences with the mix of foods offered (Provenza et al., 2003). When they eat only a small subset of the more "palatable" foods that provide adequate nutrition, animals are unlikely to learn about the possible benefits of mixing different foods, especially those high in secondary compounds (Provenza, 2003b). Over time, such selective foraging on pastures and rangelands will change the mix of plants on offer, further reducing opportunities to learn. However, herbivores encouraged to eat all plants are more likely to learn to eat mixtures of foods that mitigate toxicity, assuming appropriate choices are available.

For instance, experience and the availability of nutritious alternatives both influenced food choice when the preferences of lambs with 3 months' experience mixing tannin, terpenes, and oxalates were compared with lambs naive to the foods containing these secondary compounds (Villalba et al., 2004). During the studies, all lambs were offered five foods, two of them familiar to all of the lambs (ground alfalfa and a 50:50 mix of ground alfalfa:ground barley) and three of them familiar only to experienced lambs (a ground ration containing either tannins, terpenes, or oxalates). Half of the lambs were offered the familiar foods ad libitum, while half of the lambs were offered only 200 g of each familiar food daily. Throughout the study, naive lambs ate much less of the foods with secondary compounds if they had ad libitum (66 g/d) as opposed to restricted (549 g/d) access to the nutritious alternatives. Experienced lambs also ate less of the foods with secondary compounds if they had ad libitum (809 g/d) as opposed to restricted (1497 g/d) access to the nutritious alternatives. In both cases, however, lambs with experience ate markedly more than naive lambs of the foods containing the secondary compounds, whether access to the alfalfa-barley alternatives was ad libitum (809 vs. 66 g/d) or restricted (1497 vs. 549 g/d).

In a companion study, when access to familiar foods was restricted to 10%, 30%, 50% or 70% of ad libitum, animals ate more of the foods with secondary compounds and they gained more weight along a continuum (10% = 30% > 50% = 70%), which illustrates animals must be encouraged to learn to eat unfamiliar foods that contain secondary compounds by restricting the amount of familiar foods provided (Shaw et al., 2006). The results of this study have been manifest each time we have trained both sheep and cattle to eat sagebrush. Typically, 2 to 3 weeks are required for the animals to make the transition. During that time they must be supplemented enough so they are able to cope with the terpenes in sagebrush, and not acquire an aversion to the plant, but not so much they avoid eating sagebrush all together. In essence, one must play a "cat and mouse" game during the familiarization and adaptation period that requires ongoing monitoring and adjustment of the amount of supplement offered.

Grazing management influences what animals learn: continuous grazing at low stock densities encourages selective foraging, whereas management-intensive and short-duration grazing at high stock densities encourages animals to learn to mix their diets, as illustrated by Ray Banister who manages 7,200 acres of hardscrabble land in eastern Montana (Provenza, 2003a). His management style evolved over 40 years from reliance on rotational grazing that involved relatively short periods of grazing and rest to boom-bust management that consists of intensive periods of grazing followed by a 2-year period of rest. Ray's boom-bust grazing management stresses soils, plants and herbivores with intensive grazing pressure, and then allows them to recover. Ray believes that stress, and recovery from stress, strengthen systems. Occasional disturbance, followed by rest, creates and maintains a diversity of micro and macro habitats. It is hard to find any part of the ranch that lacks abundant plant cover. Heavy use of all plant species reduces undesirable plants. Abundant plant cover in the uplands and riparian areas mitigates soil erosion, which leads to clean water and great habitat for fish, waterfowl, and terrestrial species of wildlife.

The change to boom-bust grazing challenged the cattle on his ranch as they were no longer allowed to eat only the most palatable plants as they had under rotational grazing. Instead, they were forced to eat all of the plants. Under the new management procedures, Ray monitors the least palatable plant species -- shrubs like sagebrush and snowberry and various weeds -- as indicators of when to move the cattle to a new pasture. Cattle are allowed to move only after their use of the unpalatable species reaches high levels. In so doing, Ray reduces the competitive advantage unpalatable plants have over more palatable species. Heavily grazed plants are at a disadvantage when competing with ungrazed plants for moisture and nutrients. It took Ray's cows 3 years to adapt to the boom-bust style of management. During that time, the weaning weights of calves plunged from robust animals well over 500 pounds to scrawny individuals that weighed closer to 350 pounds, and then rebounded back to over 500 pounds.

Under boom-bust management, cattle begin to eat formerly unpalatable species like snowberry and sagebrush as soon as they enter a new pasture. The cows evidently have learned how to mix their diets in ways that better enable them to eat both the palatable and the unpalatable species. Once the older cows made the transition to a new way of behaving, the young calves were able to learn from their mothers how to thrive under boom-bust management. The calves that Ray keeps as replacements never have to make the harsh transition. They were trained by their mothers that all plants are food at Ray's place. Such learned patterns of foraging behavior are transferred culturally from one generation to the next.

Finally, the same is true for habitat selection. In the western U.S., many people have come to accept that cattle degrade riparian ecosystems, and that nothing can rectify the situation except to remove cattle from waterways with fencing or remove them from rangelands altogether. This view suggests that animals are somehow programmed genetically to live in specific habitats, and that cattle are bottom-dwelling swamp creatures. The belief is naive, especially when it comes to understanding the origins of animal behavior and the ability of people to change the behavior of livestock and humans. Cattle can be trained to prefer uplands over riparian areas. Experiences early in life teach livestock to prefer habitats like uplands and riparian areas. No gene codes for living in riparian areas. A rider on horseback can train cows and calves to use uplands, and discourage their use of riparian areas, by persistently and consistently moving them to desired locations. Managers also can cull individuals that prefer riparian areas and retain animals and their offspring that prefer upland sites.

Bob Budd, an innovator who formerly managed Red Canyon Ranch near Lander, WY, for The Nature Conservancy, and his co-workers used these techniques to increase cattle use of uplands and improved riparian areas (Provenza, 2003a). Bob argues that the costs of riding are offset by the benefits from additional forage in uplands, improved herd care and health, better riparian areas, and enhanced diversity of plants and wildlife. Riding is less costly than fencing and more effective in the long run. Fencing addresses only the symptoms of animal-distribution problems. By relying on fences, managers reinforce undesirable behaviors. Riparian areas are often over-utilized, even in fenced pastures that contain both uplands and riparian areas. Riding, on the other hand, allows managers to use behavioral principles to train adults and their offspring to use upland forages and habitats, a long-term solution to the problem. Intimate knowledge of where different individuals and subgroups of animals live can be used to enhance dispersion across a landscape by culling animals that use sensitive areas and retaining animals that use different areas. Within any group, some individuals will never conform to management needs concerning food or habitat selection criteria while others will conform well. A rider also can identify cows and calves that consistently use riparian areas so that undesirable individuals can be culled.

Keeping it interesting: the importance of variety

Palatability is the interrelationship between flavor and feedback, as they are influenced by an animal's past experiences with food. But if that's all there is to palatability, then why do animals perform better when offered choices of different foods and why is the grass always greener on the other side of the fence? For example, why do sheep and cattle perform better when offered individual ingredients from a total mixed ration than when fed a total mixed ration formulated to meet their needs? Why do sheep prefer to eat clover in the morning and grass in the afternoon, even though clover is more digestible and higher in protein than grass? More generally, what is the value of variety in the diet?

Everybody is different

With the advent of statistics in the 20th century, great emphasis has been placed on assessing the response of the "average" animal to a treatment. While the discipline of statistics has advanced our ability to conduct experiments, it also has made variation among individuals an enemy to counteract rather than a friend to embrace. Scientific studies and management practices emphasize means and populations rather than individuals and variation, while nature and evolutionary processes do the opposite. For example, research and management strategies in nutrition determine needs and formulate diets for the "average" member of the herd, not for individuals. Yet, marked variation is common even among closely related animals in needs for nutrients and abilities to cope with secondary compounds common in plants.

Differences among individuals in food intake and preference depend on how animals are built morphologically, and how they function physiologically, and on their past experiences. When we unduly constrain individuals by mixing food to meet the needs of the "average" animal, by planting monocultures of forages on pastures, or by restricting the ability of animals to fully use pastures and rangelands, we may only meet the nutritional needs of a subset of individuals in a herd - and abuse landscapes in the process. Individuals can better meet their needs for nutrients and regulate their intake of toxins when offered a variety of foods that differ in nutrients and toxins than when constrained to a single food, even if the food is nutritionally balanced. Variety allows the uniqueness of the individual to be manifest.

The spice of life in confinement, on pastures and rangelands

Whether confined or foraging on pastures or rangelands, variety is the spice of life for herbivores. Like us, they satiate on foods and foraging locations and thrive on variety (Provenza, 1996; Bailey and

Provenza, 2008). That causes them to use different foods and foraging locations. Sheep and cattle prefer foods in different flavors in the same way eating maple-flavored oatmeal for breakfast every day causes people to prefer oatmeal in a different flavor. When sheep and cattle eat a food in one flavor, such as maple- or coconut-flavored grain or straw, they prefer food with the alternate flavor on the following day. (Early and Provenza, 1998; Scott and Provenza, 1998; Atwood et al., 2001a,b, 2006).

The satiety hypothesis attributes changes in palatability to transient food aversions due to flavors interacting with primary and secondary compounds along concentration gradients (Provenza 1995, 1996). Aversions typically are mild and below the level of conscious awareness. However, they become pronounced when foods contain too high levels of primary or secondary compounds or imbalances of these compounds. Aversions also arise when foods are deficient in nutrients or when amounts of nutrients required for detoxification are inadequate. Aversions occur even when a food is nutritionally adequate because satiety and surfeit are on a continuum. Thus, cyclic patterns of intake of different foods are due to eating any food too often or in too large an amount, and the less adequate a food is relative to an animal's needs, the greater and more persistent the aversion. The satiety hypothesis has implications for how animals are fed in confinement as well as on pastures and rangelands (Manteca et al., 2007)

For example, food intake and performance of steers fed barley, corn, alfalfa, and corn silage were compared with steers fed a chopped and mixed ration of those ingredients. Averaged throughout the trial, animals offered the mixed-ration ate slightly more food than animals given a choice but they did not gain at a faster rate. Gain per unit food consumed was similar for both groups. However, daily food costs were less for animals offered a choice than for those fed the mixed-ration ($1.36 per day vs. $1.58 per day) because animals offered a choice ate less, and they ate less grain. Cost/lb gain was less for the choice group than for the mixed-ration group ($0.68/lb vs. $0.84/lb). Collectively, these findings suggest that 1) animals can more efficiently meet their *individual* needs for macronutrients when offered a choice among dietary ingredients than when constrained to a single diet, even if it is nutritionally balanced; 2) transient food aversions compound the inefficiency of a single mixed diet by depressing intake even among animals suited to that nutritional profile; and 3) alternative feeding practices may allow producers to efficiently capitalize on the agency of animals, thus reducing illness and improving performance.

Variety is also important for animals foraging on pastures. Sheep satiate on clover in the morning and switch to grass in the afternoon (Newman et al., 1992; Parsons et al., 1994). In the morning, hungry sheep initially prefer clover because it is highly digestible compared with grass. As they continue to eat clover, however, they acquire a mild aversion to clover, likely due to the combined effects of nutrients like soluble carbohydrates and proteins, from the effects of toxic cyanide compounds, and from eating the same flavor. The mild aversion causes them to switch to grass in the afternoon. During the afternoon and evening, the sheep recuperate from eating clover, and the aversion subsides. By morning, they are ready for more clover. The combination of clover and grass likely enables sheep to eat more each day than if only one species were available. Sowing clover and grass in spatially separated strips can further enhance intake and performance compared to clover-grass mixtures (Chapman et al., 2007). When grass and clover are planted in distinct strips, as opposed to conventional intermixtures, dry matter intake of sheep increases by 25% (265 g/sheep/day) and milk production of dairy cows increases by 11% (2.4 kg/cow/day). The choice allows each animal to balance the mix of grass and clover, and the strip evidently minimizes time spent searching for the desired amounts of the different forages. Planting forages in strips overcomes many difficulties inherent in establishing and maintaining mixed pastures. It also mimics what happens naturally as different plant species aggregate in response to environment.

Finally herders in France use understanding of plant diversity to stimulate food intake and more fully use the range of plants available by herding in grazing circuits under extensive conditions on rangelands (Meuret et al., 1994). Daily grazing circuits are designed to stimulate and satisfy an animal's appetite for different nutrients, and they enable animals to maximize intake of nutrients and regulate intake of different secondary compounds. The circuits include a moderation phase, which provides sheep and goats access to plants that are abundant but not highly preferred to calm a hungry flock; the next phase is a main course for the bulk of the meal with plants of moderate abundance and preference; then comes a booster phase of highly preferred plants for added diversity; and finally a dessert phase of abundant and palatable plants that complement previously eaten forages.

Grazing management based on grazing circuits designed to stimulate and satisfy an animal's appetite for different nutrients, enable animals to maximize intake of nutrients and regulate intake of different toxins. The circuits also ensure all plants in a landscape get used, not just a subset of plants. Papachristou et al. (2007) provide evidence for the biochemical basis of grazing circuits, since they indicated that sheep ate more foods containing secondary compounds, and more nutritious food, when food with secondary compounds were offered in the morning as opposed to the afternoon. Moreover, lambs learned the benefits of mixing food with tannins, terpenes, and oxalates and continued to do so even when they subsequently had *ad libitum* access to nutritious foods. These findings have implications for managing animals on landscapes generally and for using domestic animals to control noxious weeds specifically. An integrated understanding of how plant biochemical diversity influences foraging by large mammalian herbivores at the landscape-level and what bearing this has on plant community dynamics will have profound implications for enhancing biodiversity of landscapes. Knowledge of foraging behavior can markedly influence and enhance ecological relationships among people, herbivores, plants and landscapes, and in the process, improve the quality of life for land and livestock managers as well as the integrity of the environment. Ultimately, there are likely to be thresholds of knowledge – for people and herbivores – and plant biochemical diversity above which diversity is likely to beget diversity and below which a lack of diversity leads inexorably to less diversity (Provenza, 2003b).

Value of variety of secondary compounds in nutrition and health

All plants produce secondary compounds, even the plants we grow in our gardens, but until recently people thought secondary compounds were waste products of plant metabolism. We have learned much in the past 30 years about the roles of secondary compounds in the health of plants, including functions as diverse as attracting pollinators and seed dispersers, helping plants recover from injury, protecting plants from ultraviolet radiation, and defending plants against diseases, pathogens and herbivores (Rosenthal and Janzen, 1979; Rosenthal and Berenbaum, 1992). At the same time we were learning of the value of secondary compounds, we were reducing their concentrations through selection to maximize yields of crops and pastures that were inevitably more susceptible to environmental hardships. In their stead, we resorted to fossil fuel-based fertilizers, herbicides and insecticides to grow and protect plants in monocultures, antibiotics and anthelmintics to maintain the health of herbivores, and nutritional supplements and pharmaceuticals to sustain the wellbeing of humans. Such systems corrupt the health of soils, plants, herbivores and humans and gradually degrade the economic and environmental health of landscapes.

Ironically, we are now attempting to genetically engineer specific compounds with similar beneficial functions back into plants. Instead, we should be asking how and why nature grows plants in diverse mixtures with remarkable arrays of secondary compounds, and re-constructing pastures and grazing lands with assorted species that together enhance the fertility of soils, the health and nutrition of plants and herbivores and the health of humans (Provenza, 2007; Provenza et al., 2007).

Ecologists and agronomists alike have come to view secondary compounds as "plant defences" that negatively affect herbivores. This view ignores the fact that the effect of every compound depends on the dose -- at too high doses, nutrients are toxic, whereas at appropriate doses, plant secondary compounds may have health benefits (Engel, 2002; Provenza, 2003b; Provenza and Villalba, 2006; Athanasiadou et al., this volume) and protect dietary proteins against ruminal degradation, thus increase the flow of intestinal proteins (Ben Salem et al., 2005; Waghorn, in press). We are just beginning to realize the benefits of plant secondary compounds in human health and in the health of wild and domestic herbivores (see for example Provenza, 2003; Makkar, 2007; Provenza, 2008).

As case in point, tannins are increasingly recognized as compounds important in health and nutrition, though historically they were thought by agriculturalists and ecologists alike to adversely affect the health and nutrition of herbivores. Eating plants high in tannins is a way for herbivores to reduce internal parasites (Min and Hart, 2003), and tannins alleviate bloat by binding to proteins in the rumen (Waghorn, 1990). By making the protein unavailable for digestion and absorption until it reaches the more acidic abomasum, tannins also enhance nutrition by providing high-quality protein to the small intestines

(Barry et al., 2001). This high-quality-protein-bypass effect enhances immune responses and increases resistance to gastrointestinal nematodes (Niezen et al., 2002; Min et al., 2004). The resulting increase in essential and branched-chain amino acids improves reproduction efficiency in sheep (Min et al., 2001). Tannins in the diet are a natural way to reduce methane emission in ruminants (Woodward et al., 2004), which is an important issue regarding ongoing efforts to diminish the influence of livestock on global warming. Finally, tannins eaten in modest amounts by herbivores can improve the color and quality of meat for human consumption (Priolo et al., 2005). More generally, diverse assortments of secondary compounds in the diets of herbivores influence the flavor, color and quality of meat and milk for human consumption, often in ways that are positive (Vasta et al., 2007).

Complementarities among secondary compounds are an important but little understood area of plant-herbivore interactions (Freeland and Janzen, 1974; Provenza et al., 2003). Animals may be able to ingest more nutrients, or nutrients not encountered in "safe" plants, by ingesting a variety of plants with plant secondary compounds. In principle, herbivores can eat more of a combination of foods with different kinds of plant secondary compounds as different plant secondary compounds have different effects in the body and they are detoxified by different mechanisms (Freeland and Janzen, 1974).

Even less is known about how the sequences of eating plants with different secondary compounds affects foraging, though they appear to be very important for increasing intake. Sheep eat more food with terpenes when they first eat food with tannins (Mote et al., 2007). Cattle steadily decrease time eating high-alkaloid varieties of tall fescue from 40% to 15% when they first graze tall fescue alone for 30 minutes followed by high-tannin varieties of birdsfoot trefoil for 60 minutes; remarkably, when the sequence is reversed they forage actively on both trefoil and fescue throughout the 90-minute meal (Lyman et al., 2008a). These patterns of foraging are analogous with birdsfoot trefoil and high-alkaloid reed canarygrass (Lyman et al., 2008a). Sheep similarly decrease intake of tall fescue in a meal, unless they receive intraruminal infusions of tannins prior to the meal, in which case they eat tall fescue throughout the meal; conversely, they eat trefoil readily unless they receive intraruminal infusions of tannins prior to the meal in which case they eat less trefoil (Lisonbee et al., 2008). When sheep eat foods high in tannins or saponins along with foods high in alkaloids, the tannins and saponins bind with alkaloids reducing their adverse effects on animal health and nutrition (Lyman et al., 2008b).

For people and herbivores, the biochemical composition of the meals we eat has become more uniform as the variety of foods in our diets has declined, and we no longer experience the benefits of eating an array of plant-derived primary and secondary metabolites (Craig, 1999; Engel, 2002). That, in concert with eating the meat of animals from feedlots, means our intake of a various beneficial compounds is far lower than if we ate wild plants and herbivores reared on biochemically diverse forages (Dhiman et al., 2005; Pollan, 2006). In concert with lack of exercise, this may explain the current obesity crisis in many countries, which may get much worse unless we change our behavior. Indeed, fast-food generations may be the first to have shorter lives than their parents and grandparents due to obesity-related diseases. Certainly, many foods preferred by our ancestors are considered "unpalatable" by people today due to their lack of experience with secondary compounds. With ready access to processed foods high in sugar, carbohydrates, fat and salt, young people no longer acquire preferences for "unpalatable" foods as they lack the traditional cultural foundations to guide their selection of foods high in secondary compounds (Johns, 1994). On the other hand, hunter-gatherers who have maintained their traditional diets have far less cancer, heart disease, diabetes and osteoporosis than people who forage on fast foods, and it is not because hunter-gatherers die before these ills can develop (Logan and Dixon, 1994). The Masai of Africa, for instance, suffer much less heart disease and cancer, even with diets very high in meat and milk, evidently because they combine animal products including up to 28 antioxidant herbs added to each meat-based soup and 12 added to milk (Johns, 1994; Engel, 2002).

Issues of diet mixing and secondary compounds are just as relevant for the nutrition and health of herbivores. They are what they eat, as we are what they eat. Cindy Engel's (2002) book titled *Wild Health, How Animals Keep Themselves Well and What We Can Learn from Them* is a fascinating discussion of the roles of secondary compounds in the health and well-being of animals. With nutrients and secondary compounds alike, everything depends on the dose. Any compound, including water, is toxic in too high doses: The right dose differentiates a toxin from a remedy, and because every individual is different, it is critical to provide animals with the opportunity to regulate their intake of primary and secondary compounds by offering them a variety of plants. While we have much to learn about plant mixtures and interactions among primary and secondary compounds, it is becoming increasingly clear that offering animals a variety of foods that not only meet their needs for nutrients, but that also provide a variety of secondary compounds, can enhance nutrition and health.

Managing herbivores and landscapes

Generalist herbivores typically encounter several plant species during a meal and the frequency of food encounter influences diet selection. The dynamics of the diet selection process is also influenced by the sequence in which herbivores ingest the foods they encounter (Papachristou et al., 2007). The sequence of food ingestion within and between feeding bouts will be influenced by food patchiness. In turn, the way herbivores learn about foraging sequences in patchy environments may impact habitat partitioning in plant communities. Herbivore density is also likely to influence how herbivores learn about consuming foods in specific sequences (Provenza, 2003b). Many herbivores forage in herds of high densities, and the close proximity to other animals may limit selectivity (Augustine et al., 2003) and influence the temporal resolution of meal patterns.

Selective foraging influences plant assemblages (Augustine and McNaughton, 1998; Augustine et al., 2003), and certain associations among palatable and unpalatable plants may encourage herbivory, provided animals learn the nutritional and toxicological relationships among the plants. Experienced animals eat substantial amounts of foods with secondary compounds even though nutritious alternatives were available *ad libitum*. Thus, animals who learn to mix diets may achieve more uniform use of different species, which may enable palatable and less tolerant species to maintain their abundance, and may prevent unpalatable, chemically defended species from increasing in abundance. Conversely, when herbivores eat only a subset of plants, because of experiences or prevailing management regimens, chemically defended species may increase in abundance (Provenza, 2003b).

In some communities, an increase in dominance by unpalatable species can increase species richness if palatable species gain "associational protection" by growing close to unpalatable neighbours (Atsatt and O'Dowd, 1976), with the costs of competition offset by the benefits of less herbivory (Hay, 1986). However, a multidimensional view, which considers biochemical interactions among foods and changes in herbivore behaviour due to experience, suggests unpalatable plants may not always protect palatable neighbours. Certain associations between palatable and unpalatable plants or among unpalatable plants may encourage herbivory, provided animals experience the benefits of nutritional and/or toxicological relationships among plants in those communities.

Herbivore density and plant chemistry can influence what animals learn about foods. Low to moderate herbivore densities encourage selective foraging, which may prevent learning about complementarities among less palatable foods (Provenza, 2003b). This effect may be exacerbated when the preferred plants in the community are accompanied by a variety of unpalatable species that advertise their toxicity by strong odour and taste (Eisner and Grant, 1980; Provenza et al., 2000). In contrast, high herbivore densities may encourage animals to learn complementary relationships among foods. Many herbivores forage in herds of high densities, which may limit selectivity and encourage diet mixing (Augustine and McNaughton, 1998; Augustine et al., 2003; Provenza, 2003b). Besides the short-term effect of preventing chemically defended species from increasing in dominance, animals that eat unpalatable plants and learn food complementarities will likely continue such behaviour even when high-quality alternatives are available. Importantly, once mixing patterns are learned, they are likely to be transmitted trans-generationally from mothers to offspring (Mirza and Provenza, 1990).

Conclusion

Scientists and managers often ignore the power of behavior to transform systems, despite compelling evidence for it. For those willing to understand how environment interacts with the genome to influence behavior, the potential is virtually unlimited. Once mastered, understanding of behavioral principles and processes become a part of the "infrastructure" of the person, so they can be transferred readily among situations and locales. Such knowledge can be used to improve economic viability and ecological integrity of confinement-, pasture-, and range-based enterprises;

to enhance and maintain biodiversity of rangelands; to restore pastures and rangelands dominated by weeds; to alleviate livestock abuse of riparian areas; to anticipate the influence of behavior on systems; and to improve our ability to manage complex adaptive systems. By understanding and applying behavioral principles to our lives and those of the creatures we manage, we can transform systems ecologically, culturally, and economically. But understanding isn't enough. We must also learn to behave with compassion toward others who have different beliefs and values. To do so challenges us all to embrace one another as we collaborate to change the world.

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Trends and Opportunities

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Introduction

We are living in a period of time that will likely be described by historians as the "age of uncertainty". Individuals, organizations, and entire industries are faced with an economic and social climate where the rules seem to be in a state of constant flux. Perspectives and strategies that served us well in the past are often less effective today. The production, processing, and distribution infrastructure undergoes continual shifts as we search for the most profitable means to meet consumer demand. Simultaneously, governmental regulations are superimposed over an already strained agricultural production system. Furthermore, there are three societal issues that will continue to have an impact on the beef industry – food safety, environmental impacts, and animal welfare. Failure to deal with these issues would be a serious strategic error by the leadership of the industry.

The landscape is changing

Perhaps the only statement of certainty is that the beef cattle industry and its' infrastructure are undergoing dramatic changes. Economic forces, consumer and societal demands, and the changing demographics of agricultural producers and rural communities drive these changes. Before information management can be adequately addressed, the environment in which information will be used must be described.

There is a great cartoon where a gigantic aardvark is sitting in the bed of a small pickup truck with a caption "Can you find the aardvark?" The "aardvark" in the back of the beef industry's truck is consolidation. Not a single sector of American agriculture has escaped the impact of consolidation. Consider the following data:

- The top 10 food retailers control 59% of sales (Wal-Mart Supercenters own 10%).
- 3% of cow-calf producers have more than 200 cows per herd but control 1/3 of the total beef cow inventory.
- The largest 15% of the feedyards account for nearly 70% of fed steer and heifer marketings.
- The four biggest packers harvest more than 80% of the total market steers and heifers.

Consolidation

The trend of consolidation in U.S. production agriculture, food distribution, retailing, and food service is a long-term significant shift in the playing field. Let there be no doubt about the reasons for this trend – meeting the needs of consumers for widely available, cheaper, more differentiated consumer goods. Tables 1 through 4 illustrate the consolidation occurring at the packing, feeding, cow-calf, and retail segments.

Table 1 Steer and Heifer Slaughter Concentration by the Top Four Firms

Year	Head (mil.)	Concentration (% of total slaughter)
1980	9.5	35.7
1985	14.1	50.2
1990	19.1	71.6
1995	22.8	79.3
1997	23.1	79.5
1999	24.2	81.4
2002	23.4	79.6
2006	22.4	80.9

Source: Packers and Stockyard, 2007

Table 2 Number of Feedlots and Cattle Marketed by Size of Feedlot (>1,000 hd), 2006

	1,000-8,000	8,000-16,000	16,000-32,000	>32,000	Total
Number of lots	1,751	195	139	120	2,205
Percent	79.4	8.8	6.3	5.4	100.0
Number of cattle marketed (1,000 hd)	4,243	2,958	4,757	11509	23,467
Percent	18.1	12.6	20.3	49.0	100.0

Source: USDA, 2007

Table 3. Cow-Calf Producers and Production by Various Herd Size

Number of Operations	Total (N)	Percent by Size Group 1-49	50-99	100-499	500+
1995	897,660	79.8	11.7	7.8	0.6
2000	830,880	78.6	12.1	8.6	0.7
2003	792,050	78.3	12.1	8.8	0.8
2007	760,000	77.0	12.0	10.0	1.0
January 1 Inventory—1,000 hd					
1995	35,190	31.2	19.2	35.3	14.3
2000	33,569	29.3	19.2	36.8	14.7
2003	32,983	29.2	18.9	37.5	14.4
2007	32,548	28.0	19.0	39.0	15.0

Source: USDA, 2007

Table 4. Top 10 Grocery Stores (sales)

Company	Stores Owned	Sales (Bil $)
Wal-Mart Stores, Inc. (AR)[a]	3,153	241
Kroger, Co. (OH)[b]	4,341	69
Safeway (CA)[c]	520	63
Albertson, Inc. ((ID)	2,486	44
Ahold USA (VA)	1,738	42
Delhaize America (NC)	925	23
Publix Super Markets (FL)	706	21
Winn-Dixie Stores (FL)	1,586	18
Supervalue, Inc. (MN)	181	14
Great A&P Tea Co.	310	13

[a] Also the largest food retailer in Canada and Mexico
[b]#1 in 1992
[c]#1 in 1982
Source: Progressive Grocer, 2008

While the harvest concentration occurring in the packing industry had largely been maximized by 1995, the number of federally inspected plants continues to decline as the infrastructure becomes outdated and as companies capture the available economies of size and scale by maintaining only the most efficient manufacturing facilities. The 80:20 rule is apparent in the feedlot sector as the largest 20% of the feeders market approximately 80% of the fed cattle in the U.S. This degree of consolidation in the future will be constrained at least to some extent by the growing level of federal and state environmental regulations.

At the cow-calf sector, the largest 10% of the producers control about 50% of the breeding cattle in the U.S. It is also important to notice that the number of farms maintaining beef cows has declined by about 100,000 in the past decade.

The escalation of concentration in the retail sector can be summarized in one word – "Wal-Mart". The rapid emergence of the Arkansas based retailer as North America's leading grocer has generated significant competition in the retail sector with an emphasis on case-ready meats, improved inventory control, and the use of post-harvest techniques to assure consistency of palatability. The net effect is continued pressure to develop lower cost supplies of protein. While a number of factors contribute to increased consolidation in the industry, the big three are the desire of consumers for lower priced food, the capture of economies of size and scale that accrue to larger organizations, and the competitive advantage of larger firms to deal with increasing levels of governmental regulation.

These trends are projected to increase in at least the near to mid-term. Increasing consolidation has been a source of frustration for many in the beef industry. Yet, these trends have occurred due to economic realities. For example, ranches with herd sizes of greater than 500 head have about one-half the production costs as compared to those enterprises with less than 50 head of cows. The same trends are evident at the feedyard, packer, retailer, and food service segments.

In addition to increasing consolidation, retailers have begun to favor a case-ready product approach to the meat counter. As such, the specifications for beef products have narrowed. The growing importance of the food service sector cannot be ignored. Just over one-half of the total value and tonnage of beef merchandising is accounted for by food service sales.

The growing importance of the food-service sector suggests that those in the beef industry should carefully evaluate the wants and needs of the food-service sector:

1. The consumer is the king. Eating out as an experience and convenience are demand drivers.
2. New formats will dominate with an emphasis on "food on the go".
3. Consolidation will continue.
4. Low cost, just-in-time delivery, and accurate invoicing are table stakes (requirements) for supply chains to compete.
5. The labor pool for food service staffing will shrink by 30%. Thus product development becomes an important core strategy.
6. Brand equity in the future will be defined as families of brands and distribution alliances.
7. Growth opportunities lie in the ability to deliver custom products at mass market prices.
8. Innovation must become a way of business rather than a breakthrough event.
9. Technology will increasingly be viewed as a competitive advantage.
10. Organizational structures are going to change: quick results are going to be favored and as such analytical, customer-driven, flexible, multi-task skilled people will thrive.

Adapted from W. P. Mason (2002).

Furthermore, with an increasing emphasis on food safety, animal welfare, and environmental impacts, retailers and food service operators have moved towards a supply chain mentality where expectations are clearly stated and only those producers who are willing to adapt their management strategies to these stated expectations gain access to the market. The movement of the industry towards a supply-chain approach will increasingly put information capture, assimilation, and utilization on the forefront. What do these changes really mean to producers? Essentially, a new game is emerging and in this new game, score keeping will be more precise, we won't be allowed to call our own fouls, and only those with appropriate commitment and skills will be asked to join a team.

What to do in times of uncertainty?

"Lord, just give us one more oil boom; I promise I won't blow it all this time." Bumper Sticker

There is no sure-fire formula that is guaranteed to be effective when the future is unclear. Nonetheless, there are options. The first step is to define the wants and needs of the most immediate customer as well as the desires of the final consumer. Organizational objectives can then be created within the framework as described by customers.

However, even this process may not yield a perfectly clear vision. One approach to deal with uncertainty is to clearly identify those factors or issues of concern, to determine what can be done about them under our sphere of influence, to choose the best of the alternative actions, and to then establish a timeline that defines when the action(s) will be implemented. The key is to read the situation, to develop an action plan, and to then put the plan to work.

There has never been a more critical time in the history of the cattle business for individuals and firms to thoughtfully outline and detail their strategic direction. Good business plans describe four critical components of the enterprise:

1. Who – the people involved in the day-to-day operations; outside participants who provide goods, services, or resources; and the people providing the financing
2. Opportunity – a brief sketch of the business (products, services, market targets, anticipated growth) and SWOTs (strengths, weaknesses, opportunities, and threats)
3. Context – a description of the macro conditions (regulatory challenges, interest rates, other factors beyond the control of management)
4. Risk and reward – assess the best and worst case scenarios and projected responses by the management team to each (Sahlman, Harvard Business School, 1997)

Furthermore, good business plans are simple, fair, trust-oriented, they remain functional even when reality deviates from the plan, not based on incentives that cause destructive behavior by participants, and written on a stack of paper not thicker than 1.5 inches (Sahlman, 1997). The goal is to write a concise, focused plan that clearly directs the energy of people and the available resources towards the attainment of a definitive objective.

Staying customer-driven

"The only valid definition of business purpose is a satisfied customer." Peter Drucker

Of course, a business plan must be keenly focused on the needs of customers. And therein lies the challenge for traditional commodity oriented businesses. The production, fabrication, and merchandising processes of the beef industry are not seamless and as such allow a fair bit of "noise" into the system. This "noise" makes it more difficult to clearly define the wants and needs of customers. Nonetheless, creating a system of communication that filters the static and allows all supply chain participants to clearly share information about expectations and performance is of critical importance.

A survey of participants in the U.S. pork industry provides interesting insight into the issue of information transfer (Pork-Chain Communication Gap Survey, 2001). Nearly 90 percent of respondents expressed a desire for more communication about pork-chain business operations and opportunities. The expected benefits of improved communication included 1) a more loyal customer base, 2) increased sales volume, 3) market expansion opportunities, 4) increased efficiencies throughout the chain (limit wastage of time, money, and resources), and 5) opportunities to become more responsive to change. When asked about the key components required for the pork industry to achieve its maximum market potential, respondents stated the following needs:

- Better understanding of consumer needs (72%)
- More consistent information sharing (49%)
- Creation of alliances within the chain (29%)
- Certified-production systems (25%)
- Increased sharing of financial information (20%)
- Identity preservation (16%)

Survey participants were also asked to identify the reasons that communication breakdowns occur, the top four responses were 1) hard to find time (39%), 2) no one asks for information (37%), don't know what others need (30%), and the lack of established relationships (29%). These results suggest that animal agriculture industries have some serious challenges in terms of managing information in the context of working relationships required by supply chains.

Supply chains, process verification, and source verification

The increasing and varied demands from consumers, activists, and regulators combine to create an environment favoring the development of supply chains specifically designed to meet these issues. Source verification or the ability to trace a product to the farm of origin and process verification or the ability to document the management and handling of beef at specified stages of the production and fabrication process are two approaches to providing assurances for consumer niches that demand more information about food.

The development of a supply chain mentality is driven by the specific criteria established by branded product alliances and even traditional commodity systems (Table 5) oriented to meeting the needs of a particular market target. As targets become even more defined and as the specifications narrow (Table 6), the management protocols and genetic selection systems employed by individual beef cattle producers require additional levels of precision.

TABLE 5. Carcass Specifications to Meet Consumer Demand

	Specifications by Market Segment[a]		
Trait	Retail Store	Lean	High Palatability
Live weight (lb)	1,100-1,350	1,200-1,400	1,050-1,300
Carcass weight (lb)	700-850	750-900	650-850
Fat thickness (in)	0.2-0.5	Maximum of 0.3	Maximum of 0.8
Ribeye area (sq in)	12.0-16.0	13.0-16.0	12.0-14.0
Yield grade	1.5-3.5	1.5-2.9	2.5-3.9
Quality grade	Select/low choice; Min. 100 days on feed	Select and up	Average choice or Higher

[a] There is some overlap between the market segments.

Table 6. The Current and Projected Supply Needs of the Retail and Food Service Market

Quality Grade	Current Supply (%)	Seller	Needed Supply (%)
Prime	1-2	Upscale food service	4-6
Premium Choice	16-18	Restaurant International – (ends) Retail	25-30
Low Choice	34-36	Food service Retail	35-40
Select	45	Retail	25-30

Source: Certified Angus Beef Supply Development

During the 1980s, branded beef products made their appearance primarily because consumer demand for beef appeared to be slipping and the beef industry was emphasizing the need for improvements in marketing. Several branded products were marketed to consumers who were looking for: (1) "lite beef" with less fat and cholesterol (e.g., Laura's Lean), (2) organic or natural beef from cattle not fed antibiotics or growth stimulants (e.g., Coleman Natural Beef, Maverick Ranch Natural Lite), and (3) high palatability beef (e.g., Certified Angus Beef, Certified Hereford Beef). In 1988, when the major packers and retailers began trimming fat, many of the "lite beef" markets were lost. Thus, most name brands featuring less fat were abandoned or became less significant as their distinctiveness was lost compared with commodity beef. However, products such as Laura's Lean have carved out a sustainable market niche. Natural product companies such as Coleman Natural Beef, Maverick Ranch, Oregon Country Beef and Bradley-3R Meats have also found sustained success. The current market appears to have three primary target segments – "white table cloth" where superior marbling and tenderness are critical attributes, "calorie conscious – lifestyle" characterized by demand for tenderness coupled with specific lean yield parameters, and "retail" where a balance of quality and yield must be managed.

Because consumers are increasingly mindful of the management and production practices employed in the production of food, some beef companies are moving towards process-verified programs that document production practices such as health history, breed of origin, feeding protocols, unique fabrication processes, and proof of not using antibiotics or hormonal growth promotants. The use of electronic identification systems and intensive data management are critical components of these systems. The process verified approval protocol involves the following seven steps: document program, operate and test, conduct an adequacy audit, conduct a compliance audit, receive product approval, begin marketing, and submit to USDA monitoring.

The branded product leader is Certified Angus Beef (CAB). The Certified Angus Beef program is based on a set of live animal and carcass specifications designed to assure palatability. Trends in acceptance percentage and total sales volume are outlined in Table 8. To expand its appeal to a broader market, a natural product line was added to the Certified Angus Beef family of products in 2004. The new product line will meet the original carcass standards established by the company and will be process-verified under USDA guidelines for adherence to production practices that eliminate the use of hormone-based growth promotants, antibiotics, and animal byproducts in the ration. The licensed packer for the CAB Natural product pays a $10/cwt premium for cattle managed under the all-natural product criteria of no implants, antibiotics, or feeding of animal by-products.

Through these efforts, prices for Angus and Angus-cross feeder calves have risen relative to the total supply. Premiums were reported to range from $3.04/cwt to $2.39/cwt for Angus steer and heifer calves respectively during spring sales of 2004. Black-hided beef cattle also frequently receive at least some premium regardless of breed.

One of the keys in branded beef markets is to assure delivery of a product that meets or exceeds consumer expectations while connecting the product and producers to the needs of consumers. The family ranchers who produce Oregon Country Beef describe their product as follows:

"Our product is more than beef. It's the smell of sage after a summer thunderstorm, the cool shade of a Ponderosa Pine forest. Its 80-year-old weathered hands saddling a horse in the Blue Mountains, the future of a 6 year old in a one room school in the High Desert. It's a trout in a beaver build pond; haystacks on an Aspen framed meadow. It's the hardy quail running to join the cattle for a meal, the welcome ring of a dinner bell at dusk."

Shifting beef products from commodities to uniquely identified products that resonate with the deepest needs of consumers is the key to the future of the beef industry.

Information

"Leaders do not need to know all the answers. They do need to know the right questions." Ronald Heifetz, Harvard School of Business

Information management is one of the most discussed and cussed subjects by leaders of almost all forms of business and industry and as Dr. Heifetz points out, the critical first step is asking the right questions. In the past five years, the battle cry in the economy has been to build information-based companies where knowledge could effectively function as the centerpiece of value. There have been wild promises and a multitude of failed efforts that have surrounded this transition Tom Peters calls "moving the economy from brawn-based to brain-based". It would be safe to say that the least enviable job in any company would be that of vice-president of information technology. Despite these challenges, the need for collection of meaningful data and the creation of useful information as an aid to decision-making has not been diminished.

It is not an easy task to create meaningful information from the vast expanse of data that can be collected within the industry or even a single stocker enterprise. Thomas Davenport and John Glaser (2002) outline four fundamentals to assuring that information is successfully integrated into the management decisions:

- Assure that the knowledge base is up-to-date and founded on expert information.
- Prioritize processes by directing focus in the most critical areas in which information will be utilized and valued.

- Establish an organizational culture of measurement. Information systems will only work in a culture of commitment.
- Train people to collect and utilize the information.

We have all heard the TQM message that "you can only manage what you measure." In essence Deming was correct in this philosophy. Only when we develop a disciplined and objective approach to assessing performance against a stated objective or goal is there any real opportunity to sustain improvement. What Deming failed to say was that there is a second rule – what gets paid for gets done more. Keeping both rules in mind suggests that we should only measure the important stuff – those components of the business that contribute to profitability in both the short and the long term.

Nonetheless, there have been tremendous shortcomings in the beef industry's ability to capture data, transform that data into information, transfer the information through the system, and to apply it to decision making. We cannot hope to turn beef demand and industry profitability in a favorable direction without access to and use of meaningful information. Simply put, the game cannot be won without knowing the score and how much time is left on the clock.

What do customers want?

The first step is to determine what information customers want. This question should be asked directly to those who buy products/services from you. The answers then must be evaluated in the context of the ultimate consumer marketplace. A snapshot evaluation can be obtained by analyzing the results of a survey conducted by Colorado State University and Certified Angus Beef. Feedlot managers were asked to provide information as to the current level of knowledge they had about the cattle coming to their feedyards, their preferred level of knowledge about the cattle they were feeding, and their willingness to pay for desired information.

The average level of information available on cattle fed by these respondents was surprisingly low (Table 7). As importantly, there was tremendous variation in the level of information known about the cattle with ranges of responses from 0 to 100 percent and thus the associated high standard deviations (Table 7).

Only vaccination schedule and single versus multiple herd sources were known for just over one-half of the cattle currently being fed (Table 7). In general information was more available for health and management history than for genetic origin or herd history for feedlot and carcass performance.

However, these managers were interested in knowing considerably more (Table 8). Those traits in which 90 percent or more of respondents desired more information included yield grade (100%), nutritional management, quality grade, feedlot gain (96.8%); breed composition, vaccination schedule, implant history (93.5%); morbidity/mortality and brand of health products used (90.3%); and out or non-conformance history (90%). Only age of castration (66.7%), weaning age (74.2%), and cost of gain (74.2%) fell below the 80 percent mark. Clearly these managers desired access to more information about the cattle they feed.

In an attempt to determine the general attitudes of respondents in terms of their willingness to pay for access to information the survey included a question about which traits would be worthy of premiums should the performance of the cattle fit the purchase criterion? The top seven traits upon which these respondents were willing to pay premiums were vaccination schedule (83.3%), quality grade (80%), sire and associated performance data (79.3%), feedlot gain (76.7%), breed composition (72.4%), yield grade (70%), and implant history (66.7%). All other traits were below 55 percent in terms of respondent's willingness to pay premiums (Table 9).

Table 7. Percent of cattle currently being fed where information is known relative to each trait

Trait	Information is known (%)	S.D.
GENETIC ORIGIN		
Breed composition	49.3	34.9
Sire and associated performance data	31.1	34.7
Seedstock supplier	31.5	34.8
HEALTH/MANAGEMENT		
Vaccination schedule	55.5	35.7
Health products used (brands)	45.3	38.2
Implant history	48.7	35.5
Age of castration	31.8	41.3
Single vs. multiple herd	50.8	39.4
Weaning age	37.7	34.6
Nutritional Management	46.0	32.5
HERD HISTORY –FEEDLOT AND CARCASS		
Feedlot gain	36.6	33.4
Morbidity/mortality	25.1	31.2
Cost of gain	29.9	31.8
Quality Grade	29.5	31.1
Yield Grade	30.1	31.5
Dressing Percent	29.7	33.7
Outs	28.8	34.3

Source: Locke, Field and Conway, 2001.

Table 8. Percent of feed yard managers who would like to have information about various traits relative to the cattle they feed.

Trait	Yes (%)	No (%)	Maybe (%)
GENETIC ORIGIN			
Breed composition	93.5	6.5	0.0
Sire and associated performance data			
	87.1	12.9	
Seedstock supplier	83.9	16.1	0.0
HEALTH/MANAGEMENT			
Vaccination schedule	93.5	6.5	0.0
Health products used (brands)	90.3	9.7	0.0
Implant history	93.5	6.5	0.0
Age of castration[1]	66.7	30.0	3.3
Single vs. multiple herd	80.7	19.3	0.0
Weaning age	74.2	22.6	3.2
Nutritional Management	96.8	3.2	0.0
HERD HISTORY – FEEDLOT AND CARCASS			
Feedlot gain	96.8	3.2	0.0
Morbidity/mortality	90.3	9.7	0.0
Cost of gain	74.2	25.8	0.0
Quality Grade	96.8	3.2	0.0
Yield Grade	100.0	0.0	0.0
Dressing Percent[1]	83.3	16.7	0.0
Outs[1]	90.0	10.0	0.0

[1] Only 30 of 31 participants responded to these questions.

Source: Locke, Field and Conway, 2001

Table 9. Percent of respondents who would pay more for cattle if information were known and fit desired criteria.

Trait	Yes (%)	No (%)	Maybe (%)
GENETIC ORIGIN			
Breed composition[2]	72.4	20.7	6.9
Sire and associated performance data[2]	79.3	17.2	3.5
Seedstock supplier[2]	34.5	62.0	3.5
HEALTH/MANAGEMENT			
Vaccination schedule[1]	83.3	13.4	3.3
Health products used (brands) [1]	40.0	56.7	3.3
Implant history[1]	53.4	43.3	3.3
Age of castration[2]	17.8	79.3	6.9
Single vs. multiple herd[1]	36.7	56.7	6.6
Weaning age[1]	23.3	70.0	6.7
Nutritional Management[1]	53.3	46.7	0.0
HERD HISTORY – FEEDLOT AND CARCASS			
Feedlot gain[1]	76.7	20.0	3.3
Morbidity/mortality[1]	66.7	30.0	3.3
Cost of gain[1]	40.0	53.3	6.7
Quality Grade[1]	80.0	13.3	6.7
Yield Grade[1]	70.0	23.3	6.7
Dressing Percent[2]	44.8	51.7	3.5
Outs[3]	44.4	51.9	3.7

[1] Only 30 of 31 participants responded to these questions.
[2] Only 29 of 31 participants responded to these questions.
[3] Only 27 of 31 participants responded to these questions.

Source: Behrends, Field and Conway, 2001

While these results are constrained to the sampled population, it is important for cow-calf and stocker operators to recognize the growing value of information in the marketplace. As marketing specifications are more precisely defined, information is likely to become even more critical in price determination.

As producers evaluate their management and marketing plans for the future, they are advised to consider the need to collect and disseminate additional information about the genetics, management, and previous performance of cattle from their herds. Every attempt should be made to communicate with direct customers about the desired levels of performance and information. Those with information are likely to have more power in the marketing process.

What do consumers want?

"Every company connected with the world's food supply chain will eventually have to embrace traceability or find it difficult to stay in business. The facts are uncompromising and the pressures continue to mount from consumers and from the media, retailers and numerous government regulatory agencies." Food Processing, Feb. 2002

The issue of traceability is not going to go away nor is its importance to consumers going to be diminished. Developing systems that allow tracking of a final product back through the marketing, processing, and production chain is of value for the following reasons:

- Improve public health protection
- Avoid total product recalls that are costly and create media sensationalism
- Facilitate increased consumer confidence
- Facilitate improved management and communication
- Serve as a barrier to widespread disease outbreaks

There are a variety of viewpoints as to how to develop a trace back system. Some suggest that a coordinated individual identification system is the best approach. Others see the use of a coordinated identification system as a means to improve the capture and flow of meaningful data throughout the system. Regardless of how we view a trace back system, there is growing agreement that standardized individual animal identification is not a question of if but rather of when. Whether or not such a system will be mandated is yet to be seen but there is already evidence that participation will serve as a barrier to at least some if not many marketing channels in the beef industry.

The beef industry has been moving towards a market-target driven approach and as such a brand or brand-like mindset must be in place. To deliver on the promise of a brand and to capture the full value of a brand then life cycle management must be instituted in the industry.

Financial information

Space limitations prohibit a complete discussion of the role of financial information. However, trying to make any decision in the beef cattle enterprise without access to the costs and benefits would be the equivalent of flying blind.

Direct expenses, overhead expenses, quantity of production units, productivity per unit, value of each unit, and the enterprise mix affect profitability. Therefore, capturing data for each of these components is of potential value in helping managers make better decisions. However the interactions among these components must also be carefully assessed. For example, direct expenses can be lowered but excessive emphasis on this objective may reduce productivity per unit, lower the value of any one unit, or lead to unexpected overhead costs.

Sound financial information is the foundation for enterprise planning. Describing the breakeven price and the profit goals are critical to decision making. Because of the cyclic nature of beef cattle prices, it is appropriate to base projections on a ten-year average price. The planning and budgeting process should account for projected capital asset replacement based on realistic costs.

Without good financial information, it is virtually impossible to make the right marketing decision. Understanding breakeven price puts a producer at a position of strength in price negotiations and in the process of determining the most profitable marketing alternative. It is also critical to seek outside input into the process. You are fortunate to have access to one of the premier extension agri-business and animal science groups in the nation at Kansas State. I would urge you to call upon them to provide information and service.

The Human Factor

"Some men have thousands of reasons why *they cannot do* what *they want to, when* all *they need is one reason why they can." Mary Frances Berry.*

No system will ever work without the commitment and dedication of people. People are the key to the development, implementation, and effective utilization of an information system. Creating a culture of measurement, accountability, and communication is not an easy task. Therefore, as you design information management plans keep in mind the needs of those who will have to use the system. Always ask the questions – "is this necessary? Is it user-friendly? How much training will be required? Have the people in my enterprise had an opportunity for input? Does it ask the right questions?"

A quick study of other industries suggests that even the best information technologies are rendered useless when the people in the organization lack the training, the desire, or the time to make them work. Remember, people are the key. Even good ideas cannot change themselves.

Nobody knows nothing for sure

"Do what *you love, love* what *you do and deliver more than you promise." Harvey Mackay.*

In the final analysis, the honest truth is that we don't fully understand the information management and the role of information technology in our industry. At Colorado State University we are currently building an information system to link three ranches representing some 1000 head of cows together with our research feedyard in an attempt to better answer questions about the cost and benefit of hitting specific market targets, to determine which questions ought to be asked and the data requirements to answer those questions, and to provide an open-to-the-world demonstration of a coordinated production system. What we have learned so far is that nobody knows anything for sure.

There are no easy solutions or quick fixes. Even though information management is not a perfect science, we simply cannot afford to ignore its importance. As we seek the answers there are several key philosophies to keep in mind (Graham, 2002):

- If information is to be used as a value-added strategy then make sure that the definition of value is accomplished according to the wants and needs of customers.
- There are no silver bullets. Take your time and continuously evaluate the cost and benefit.
- Be careful of the NIKE slogan – "Just do it". While the action orientation makes sense to get the initiative moving, it isn't enough by itself. Without a plan, a functional process, and system-wide accountability, the effort is doomed to fail.
- Don't get trapped into a commodity mindset unless you are willing to take the lowest price possible for your product.

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Farm Service Agency Overview

USDA Farm Service Agency (FSA)

The Farm Service Agency (FSA) administers and manages farm commodity, conservation, disaster and agricultural loan programs authorized by Federal legislation through a network of local offices in Hawaii. FSA offices are located in Hawaii, Honolulu, Kauai and Maui County. FSA also has an office in Guam, which serves the Territory of Guam and the Commonwealth of the Northern Mariana Islands (CNMI) and an office in American Samoa.

FSA offices are supervised by a farmer-elected County Committee. These offices certify farmers for farm programs and pay out farm subsidies and disaster payments. Committee members are the local authorities responsible for fairly and equitably resolving local issues while remaining dually and directly accountable to the Secretary of Agriculture and local producers though the election process. They operate within official regulations designed to carry out Federal laws and provide a necessary and important voice in Federal decisions affecting their counties and communities.

Committee members make decisions affecting which FSA programs are implemented county-wide, the establishment of allotment and yields, commodity price support loans and payments, conservation programs, incentive, indemnity, and disaster payments for commodities, and other farm disaster assistance.

The mission of the Farm Service Agency is to equitably serve all farmers, ranchers, and agricultural partners through the delivery of effective, efficient agricultural programs for all Americans.

Noninsured Crop Disaster Assistance Program (NAP)

NAP provides financial assistance to producers of non-insurable crops when low yields, loss of inventory, or prevented planting occur due to natural disasters. Eligible crops must be commercially produced and grown for food or livestock consumption. They include: most fruits and vegetables, forage, honey, aquaculture, floriculture and ornamental nursery. Producers must apply for coverage and pay the applicable service fees by the application closing date. The service fee for 2009 coverage has increased to $250 per crop per county or $750 per producer per county. To remain eligible for NAP assistance, producers must provide acreage and production information annually. Failure to report may result in a loss of program benefits. When a crop is affected by a natural disaster, NAP producers must notify the local FSA office within 15 days of the disaster occurrence or the date damage to the crop becomes apparent. NAP covers the amount of loss greater than 50% of the expected production, based on the approved yield and reported acreage.

Conservation Reserve Program (CRP)

CRP helps agricultural producers safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource-conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. Producers can only offer land for CRP during designated sign-up periods. Offers are subject to competitive bidding. An accepted offer will result in a 10 to 15 year contract. In return for establishing long-term, resource-conserving covers, FSA provides annual rental payments to participants. These rental rates are based on the relative productivity of the soils within each county and the average dry land cash rent or cash-rent equivalent. Annual rental payments may also include additional maintenance incentive payments. Besides annual rental payments, FSA provides cost-share assistance to participants who establish approved cover on eligible cropland. The cost-share assistance can be an amount not more than 50 percent of the participants' costs in establishing approved practices.

Conservation Reserve Program-Continuous

Eligible land may be enrolled in CRP at any time under continuous CRP sign-up. Offers for continuous sign-ups are not subject to competitive bidding. They are automatically accepted provided the land and producer meet certain eligibility requirements. Continuous CRP provides annual rental payments and cost-share assistance to participants who establish approved cover on eligible cropland. The cost-share assistance can be an amount not more than 50 percent of the participants' costs in establishing approved practices. As a part of annual rental payments, FSA offers financial incentives of up to 20 percent of the soil rental rate for field windbreaks, grass waterways, filter strips, and riparian buffers. A per acre payment rate may also be added for maintenance of eligible practices. Additional incentives include: An up front signing incentive payment (CRP-SIP) of $100 to $150 per acre and a practice incentive payment (CRP-PIP) equal to 40 percent of the eligible installation costs for eligible participants who enroll certain practices.

Emergency Conservation Program (ECP)

Provides emergency funding for farmers and ranchers to rehabilitate farmland damaged by excessive wind, floods, hurricanes, or other natural disasters, and for carrying out emergency water conservation measures during periods of severe drought. The natural disaster must create new conservation problems, which, if not treated, would: 1) impair or endanger the land; 2) materially affect the productive capacity of the land; 3) represent unusual damage which is not the type likely to recur frequently in the same area (3 times within 25 years); and 4) be so costly to repair that federal assistance is or will be required to return the land to productive agricultural use. Cost-share levels up to 75 percent are set by county FSA committees. Emergency practices to rehabilitate farmland may include debris removal, providing water for livestock, fence restoration, grading and shaping of farmland, restoring conservation structures, and water conservation measures.

2009 Crop Year Buy-In for Disaster Assistance Programs

The 2008 Farm Bill enacted numerous disaster assistance programs covering losses to crops, forage, trees, vines, bushes and other commodities due to adverse weather. These programs require the crops planted, grown or produced to have been covered by federal crop insurance or FSA's Noninsured Crop Disaster Assistance Program (NAP). All crops on all acreage must be covered, not only the crops suffering the losses.

Due to the late passage of the Farm Bill, producers will be given an opportunity to "buy-in" to the disaster program by paying a catastrophic crop insurance (CAT) fee or NAP administrative fee for any 2008 crops that are not already covered by crop insurance or NAP. The deadline to "buy-in" is September 16, 2008.

The Farm Bill created five new disaster assistance programs. They are:

- Emergency Assistance for Livestock, Honey Bees, and Farm-Raised Fish (ELAP)
- Livestock Forage Disaster Program (LFP)
- Livestock Indemnity Program (LIP)
- Supplemental Revenue Assistance Payments Program (SURE)
- Tree Assistance Program (TAP)

Farm Loans

FSA makes direct and guaranteed farm ownership (FO) and operating loans (OL) to family-size farmers and ranchers who cannot obtain commercial credit from a bank, Farm Credit System institution, or other lender. FSA direct loans can be used to purchase land, livestock, equipment, feed, seed, and supplies. FSA guaranteed loans provide conventional agricultural lenders with a 90 percent guarantee of the principal loan amount. The lender is responsible for servicing a borrower's account for the life of the loan. FSA makes and services direct FO and OL loans. Direct loan customers are provided with credit counseling and loan supervision so they have a better chance of success in their farming operation. To qualify for a direct loan, the applicant must be able to show sufficient repayment ability and pledge enough collateral to fully secure the loan. Eligible applicants may obtain direct loans up to a maximum indebtedness of $300,000. The maximum repayment term is 40 years for both direct and guaranteed farm ownership loans (FO). In general, FO loan funds may be used to purchase farm real estate, enlarge an existing farm, construct new farm buildings and/or improve structures, and improve the environmental soundness of the farm. Direct and guaranteed farm operating loans (OL) are also available. The repayment term may vary, but typically it will not normally exceed 7 years for intermediate-term purposes. Annual operating loans are generally repaid within 12 months or when the commodities produced are sold. In general, OL loan funds may be used for normal operating expenses, machinery and equipment purchases, limited real estate repairs, and refinancing debt.

For more information regarding FSA programs you may visit our web site at http://www.fsa.usda.gov or contact your local office at:

Hawaii County FSA Office
PO Box 845
Hilo, HI 96721
Phone (808) 933-8340
Fax (808) 933-8345

Kauai County FSA Office
4334 Rice Street, Room 103
Lihue, HI 96766
Phone (808) 245-9014 Ext. 353
Fax (808) 246-4639

Honolulu County FSA Office
99-193 Aiea Heights Drive, Suite 114
Aiea, HI 96701
Phone (808) 483-8600 Ext. 353
Fax (808) 483-8615

Maui County FSA Office
77 Ho'okele Street, Suite 201
Kahului, HI 96732
Phone (808) 871-5500 Ext. 353
Fax (808) 873-6183

Carcass Quality and Meat Tenderness of Hawaii Pasture-Finished Cattle and Hawaii-Originated, Mainland Feedlot-Finished Cattle

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Summary

Interest in finishing cattle on pasture has increased among rancher and consumers in Hawaii. The objective of this study was to compare the carcass quality and meat tenderness of Hawaii cattle finished on pasture with that of mainland feedlot-finished cattle that were shipped from Hawaii after weaning. Ribeye steak samples were collected from 30 feedlot-finished cattle harvested at a slaughter house in Pasco, WA and from 13 pasture-finished cattle harvested at a local slaughter house in Hawaii, then shipped to a HNFAS laboratory, UH Manoa. Samples were aged for 2 weeks at 4°C and frozen for later proximate analysis and meat tenderness measurement. Feedlot-finished cattle had heavier carcass weight (778 vs 639 lb) and more backfat thickness (0.53 vs 0.26 inch), but no significant difference was observed in ribeye area between the two groups. Marbling score (Small) and USDA quality grade (Choice) of the pasture-finished beef were not significantly different from those of feedlot-finished beef. The shear force value of pasture-finished beef (5.18 kg) tended to be higher than that of feedlot-finished beef (4.40 kg), indicating that pasture-finished cattle produce less tender beef than feedlot-finished cattle. In conclusion, results of this study suggest that Hawaii cattle finished on pasture can produce as high quality carcass as mainland feedlot-finished cattle.

Introduction

Hawaii has been shipping most of its feeder calves to the US mainland and Canada and has imported feedlot-finished beef for consumption in the state. Recently, finishing cattle on pasture has drawn a lot of interest among ranchers and end users, such as restaurants and supermarkets, as a sustainable alternative to feedlot-finishing of cattle.

Some studies, however, have indicated that pasture-finished beef is generally less tender and less palatable than feedlot-finished beef (Melton 1983, Kim 1995, Fukumoto et al. 1999). To address the potential quality issues associated with pasture-finished beef produced in Hawaii, we have examined the carcass and meat quality characteristics of pasture-finished beef produced in Hawaii in a series of expreriments (Fukumoto et al., 1995, 1999, 2007[a,b] and Kim et al., 2007[a,b]). Our studies have demonstrated that meat tenderness of pasture-finished beef is somewhat variable, but a substantial proportion of pasture-finished beef produced in Hawaii is as tender as the imported feedlot-finihsed beef. Our study also showed that application of electrical stimulation and management practices such as controlling slaughter age and breed selection could improve the meat tenderness characteristics of pasture-finished beef. Furthermore, we have also shown that pasture-finished beef in general, as compared to feedlot-finished beef, has a much lower amount of intramuscular fat and higher amounts of omega-3 fatty acids, unsaturated fatty acid, indicating the potentials of attracting today's health-concious consumers. In fact, we have seen a steady increase in online mechandising of grass-fed, natural beef, and advertisement of pasture-finished beef appearing in mainstream media these days.

While we have compared the meat quality characteristics of pasture finished beef produced in Hawaii to those of mailand feedlot-finished beef, we did not have a chance to compare the carcass and meat quality characteristics of Hawaii pasture-finished beef to those of Hawaii-originated, mainland feedlot-finished beef. Therefore, the objective of this study was to examine the carcass quality and meat tenderness of Hawaii pasture-finished beef and Hawaii-originated, mainland feedlot-finished beef.

Procedures

Sample Collection

Two ribeye steak samples from the 12th rib were obtained from 30 feedlot-finished Angus cross breed cattle harvested at a slaughter house in Pasco, Washington in December, 2007. The cattle slaughtered in Pasco were from the Mealani Agricultural Research Station and shipped to Oregon after weaning for growing and finishing in an Idaho feedlot for 3 months before slaughter. The ribeye steaks were vacuum-packaged and shipped in a refrigerated condition to a HNFAS laboratory, UH Manoa. Fat thickness, rib eye area and marbling score of the steaks were determined upon arrival, then the steaks were aged in a refrigerator for 2 weeks (from the slaughter) before they were stored at -20°C for later proximate analysis of ribeye muscle and shear force measurement of cooked steak.

Samples for pasture-finished beef were obtained from 13 cattle that were raised in the Mealani Agricultural Research Station and harvested at a local slaughter house on Hawaii Island in November, 2007. Two ribeye steak samples from the 12th rib were shipped to the same HNFAS laboratory, and samples were handled in the same manner as the feedlot-finished steaks until analysis

Information on animal age, carcass weight and sex was obtained during sample collection from the slaughter houses. Data on USDA quality grade for the feedlot-finished beef were obtained from the Pasco slaughter house and USDA quality grade score for the pasture-finished beef was determined based on the U.S. Department of Agriculture beef quality grading system.

Sample Analysis

Proximate Analysis

Ribeye muscles were removed without subcutaneous fat, then ground three times using meat grinder for proximate analysis. Moisture and lipid contents were determined according to AOAC methods (1980). Ash content was determined as the residue after combustion at 600ºC for six hours. Protein concentration was estimated by the difference between the weight of moisture, ash and lipid and the total sample weight.

Cooking and Shear Force Measurement

Steak samples were thawed overnight in a refrigerator, and then the steak slices were trimmed to less than 2 mm of subcutaneous fat, weighed, packed, and vacuum-sealed in Kapak pouches (Kapak Corporation, Minneapolis, MN). The packages were heated in a water bath at 70°C for one hour, and then cooled at room temperature for one hour. The pouches were unwrapped and cooked steaks were gently dried with paper towels. For shear force measurement, 6 core samples (1.3 cm diameter) were taken from the slice after cooking. Each core sample was cut at a speed of 180 mm/min with a Warner-Bratzler blade attached to a TA.XT2 Texture Analyzer (Texture Technologies Group, Scarsdale, New York). The shear force value was the mean of the maximum forces required to shear each set of core samples.

Data analyses

Data were analyzed by the GLM procedure using JMP software (SA Institute, Cary, NC).

Results and Discussion

Growth Traits of Pasture-finished and Feedlot-finished Cattle

Table 1 summarizes the growth traits of pasture- and feedlot-finished cattle. The mean slaughter weight of pasture finished cattle of Hawaii was lower than that of feedlot-finished cattle (1202.8 lbs vs. 1275.5 lbs). The lower slaughter weight of Hawaii pasture-finished cattle than that of feedlot-finished cattle was probably due to combination of the lower energy content of pasture than that of feedlot ration and shorter growing period of the pasture-finished cattle (583 days vs 606 days). Daily weight gain of the pasture-finished cattle was also lower than that of feedlot-finished cattle (1.90 lbs vs 1.99 lbs).

Table 1. Growth traits of pasture-finished and feedlot-finished cattle

Traits	Pasture-finished cattle (n=13)	Feedlot-finished cattle (n=30)
Birth wt, lb	91.6 ± 3.04	79.6** ± 2.00
Weaning wt, lb	504.2 ± 14.52	491.5 ± 9.56
Days to wean	223 ± 3.27	203** ± 2.15
Slaughter wt, lb	1202.8 ± 25.23	1275.5* ± 16.6
Days to slaughter	583 ± 3.9	606** ± 2.6
Daily wt gain, lb	1.90 ± 0.04	1.99* ± 0.02

Data are means ±SEM. **, P<0.01; *, P<0.05
Pasture-finished cattle are composed of all steers, and feedlot-finished cattle are composed of 6 steers and 24 heifers.

Table 2. Carcass traits of pasture-finished and feedlot-finished cattle

Traits	Pasture-finished cattle (n=13)	Feedlot-finished cattle (n=30)
Slaughter wt, lb	1202.8 ± 25.23	1275.5* ± 16.6
Carcass wt, lb	638.6 ± 16.43	777.6** ± 10.86
Dressing %	53.1 ± 0.44	60.9** ± 0.28
Backfat thickness, in	0.26 ± 0.037	0.53** ± 0.024
Ribeye area, in^2	11.96 ± 0.426	12.77 ± 0.269
Marbling score[a]	11.2 ± 0.68	12.0 ± 0.45
USDA quality grade[c]	7.0 ± 0.29	7.4 ± 0.19

Data are means ± SEM. **, P<0.01; *, P<0.05; †, P<0.1.
[a]Practically devoid (-, o and +) –1,2 and 3; Trace (-, o and +) – 4,5 and 6; Slight (-, o and +) -7,8 and 9; Small (-, o and +) -10,11, and 12; Modest (-, o and +)-13,14 and 15; Moderate (-, o and +)-16,17 and 18; Slightly abundant-19; Moderately abundant-20; Abundant-21
[b]Standard (-, o and +) -1,2 and 3; Select (-, o and +)-4,5 and 6; Choice (-, o and +) – 7,8 and 9; Prime (-, o and +) – 10, 11 and 12

Carcass Traits of Pasture-finished and Feedlot-finished Cattle

Table 2 summarizes the carcass traits of pasture- and feedlot-finished cattle. Pasture-finished cattle have lower carcass weight (638.6 lbs vs. 777.6 lbs), dressing %(53.1 lbs vs. 60.9 lbs) and backfat thickness (0.26 inch vs. 0.53 inch) compared to feedlot-finished cattle. Ribeye area was not significantly different between the pasture- and feedlot-finished beef. The mean marbling score of pasture-finished beef was small minus while the mean marbling score of feedlot-finished beef was small plus, but the difference was not statistically significant. The mean USDA quality grade of pasture-finished beef was low choice while the USDA quality grade of feedlot-finished beef was medium choice, but the difference was not statistically significant.

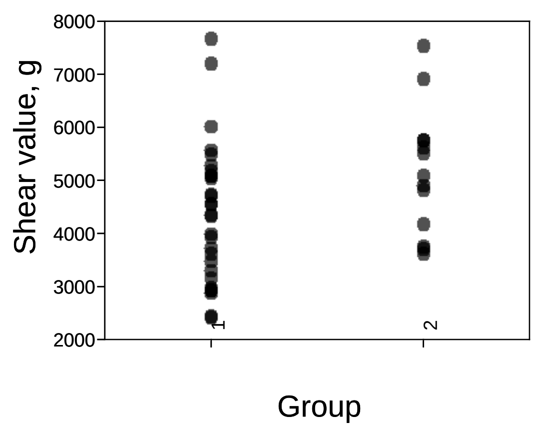
Proximate Analysis and pH of Ribeye Muscle and Cooked Meat Shear Force Value of Pasture- and Feedlot-finished Beef

Results of proximate analysis and pH of ribeye muscle and cooked meat shear force value of pasture- and feedlot-finished beef are summarized in Table 3. Pasture-finished beef had more moisture (73.0 vs. 71.8 %), but less intramuscular fat content (3.33 vs. 4.49 %) in the ribeye muscle compared to feedlot-finished beef. No difference in muscle pH was observed between the two groups, indicating that postmortem glycolysis process was not much different between the pasture- and feedlot-finished beef. The shear force value of pasture-finished beef ranged from 7.5 to 3.6 kg with a mean of 5.18 kg and the shear force value of feedlot-finished beef ranged from 7.6 to 2.4 kg, indicating that finishing cattle in a feedlot tends to produce more tender beef compared to finishing cattle on pasture only. While the mean shear force value of the pasture-finished beef was slightly higher than that of feedlot-finished beef, the distribution of shear force value of pasture-finished beef (Figure 1) suggests that cattle can be finished in Hawaii pasture with quality high enough to satisfy consumer's beef-eating experience.

Table 3. Proximate analysis, pH and shear force value of ribeye muscle of pasture- and feedlot-finished cattle

	Pasture-finished cattle (n=13)	**Feedlot-finished cattle (n=30)**
Moisture, %	72.9 ± 0.33	71.8** ± 0.22
Fat, %	3.33 ± 0.423	4.49* ± 0.278
Protein, %	22.7 ± 0.44	22.6 ± 0.12
Ash, %	1.04 ± 0.049	1.11 ± 0.032
pH	5.72 ± 0.030	5.72 ± 0.020
Shear value	5.18 ± 0.351	4.40† ± 0.231

Figure 1, Distribution of Shear Force Value (1, feedlot-finished beef; 2, pasture-finished beef)



Conclusion

- Pasture-finished beef tended to have less tender meat, but their overall carcass qualities were as good as feedlot-finished cattle.
- Pasture-finished cattle had less amount of intramuscular fat compared to feedlot-finished cattle.
- Considering that Hawaii pasture-finished beef is produced without growth-promoting agents on pasture, Hawaii pasture-finished beef has a potential to attract today's consumer seeking natural products.

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