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Biodiversity as an organizing principle in agroecosystem management: Case studies of holistic resource management practitioners in the USA

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Abstract

Holistic Resource Management (HRM) is a process of goal setting, decision making and monitoring which integrates social, ecological and economic factors. Biodiversity enhancement is a fundamental principle in HRM and students are taught that biodiversity is the foundation of sustainable profit. In the HRM process, practitioners develop a holistic goal which includes: (1) quality of life values, (2) forms of production to support those values, and (3) landscape planning, which should protect and enhance biodiversity and support ecosystem processes of succession, energy flow, hydrological and nutrient cycling. We present an overview of the HRM model and results of interviews with 25 HRM farmers and ranchers from across the USA in which perceptions and experiences with respect to the role of biodiversity in the sustainability of their operations were explored. An ethnographic approach and qualitative research methods were used in the interviews. While only 9% of the interviewees reported thinking about biodiversity in the context of their operations before being exposed to HRM, now all of them think biodiversity is important to the sustainability of their farms and ranches. Of the people interviewed, 95% perceived increases in biodiversity (particularly with respect to plants) and 80% perceived increase in profits from their land since HRM began influencing their decisions. In addition to perceiving increases in biodiversity, all of the interviewees reported observing indications of positive changes in some of the ecosystem processes on their farms or ranches. In addition, 91% of the interviewees reported improvements in their quality of life because of changes in their time budgets. Three of the interviewees who had quantitative data on changes in numbers of plant species and economic indicators are discussed in detail. We conclude that holistic management approaches like HRM are worthy of further study.

Keywords: Plant biodiversity; Sustainability; Holistic Resource Management; Profitability; Ecosystem processes; Qualitative research

1. Introduction

In the United States, current trends towards larger scale monoculture farming operations (C-FARE, 1994; Hamilton, 1994a,b; Heffernan, 1994) will likely result in decreases in both diversity of farming practices and biodiversity in agricultural landscapes. Although there are a number of agroecosystem management approaches which provide alternatives to these trends (e.g. Permaculture (Mollison, 1993), Bio-Dynamic Agriculture (Steiner, 1984), Fukuoka's Natural Farming (Fukuoka, 1978, 1985), organic

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agriculture (e.g. Wolf, 1977), 'alternative' agriculture (e.g. Natural Resource Council, 1989) 'sustainable' agriculture (e.g. Edwards et al., 1990), 'ecological' agriculture (e.g. Soule and Piper, 1992), Holistic Resource Management (HRM) (Savory, 1988, 1991, 1994; and Bingham and Savory, 1990) is of particular interest in the context of biodiversity issues because of its emphasis on biodiversity protection and enhancement as a central management principle. In Holistic Resource Management courses, students are encouraged to work with fundamental ecosystem processes and increase biodiversity on their farms or ranches to enhance profitable sustainability.

Savory builds his argument for greater biodiversity in agroecosystems on the debated hypothesis in ecology that stability is positively correlated with diversity in ecosystem function (e.g. Margalef, 1968; Woodwell and Smith, 1969; May, 1973; Van Doblen and Lowe-McConnell, 1975; McNaughton, 1978; and Odum, 1983). McNaughton's (1978) work in old fields, East African grasslands (McNaughton, 1976, 1979), and more recent work by Tilman (1996) and Moffat (1996) support Savory's contention. The fundamental ecological premise of HRM is that efficient nutrient cycling, hydrology, successional dynamics, and energy flow, with a strong biodiversity base both above and below ground, buffers managed ecosystems' responses to perturbations. Theoretically, by learning to work with and improve biodiversity and these ecological processes on their land, farmers and ranchers need less external inputs to sustain production, which then allows them to reduce their input costs, enhance their profitability and sustain their resource base for the long-term future. It is our idea that biodiversity, used as a management concept, could impact ecological processes at population, community and ecosystem levels. For example, while diversified cropping practices, in both space and time, can contribute to increased populations of natural enemies (e.g. Andow, 1983; Brust et al., 1986), the same practices offer opportunities to recycle nutrients within a farming system (e.g. Sattler and Wistinghausen, 1992) and, also, present opportunities to value add enterprises within a farm. Perhaps most fundamentally, a decision process such as HRM provides a framework that encompasses a diversity of practices, a range of options that a farmer can then best adapt to local environmental, economic and social conditions. For these reasons, we believe it is important to view biodiversity as a multi-function management tool.

We desired to learn how exposure to HRM influences attitudes toward biodiversity among farmers and whether the actual experiences of HRM practitioners support Savory's idea that biodiversity is the foundation of profitable sustainability in agriculture. We used a participatory ethnographic approach (Spradley, 1980) and qualitative research methods (Lincoln and Guba, 1985; Creswell, 1994; Rubin and Rubin, 1995) to explore the attitudes, perceptions, decision making, observations and experiences of a group of farmers and ranchers who had proven expertise in using HRM. Our data are based on the practical experience of these land mangers rather than experimental scientific data. Checkland (1981) and Bawden et al. (1984) describe two different approaches to agricultural research. The *scientia* approach is quantitative, focused, precise, slow, expensive and, if done in optimal conditions, so controlled as to be disassociated from the complexities of reality. It focuses on mechanisms and predictability. In contrast, the *praxis* approach is qualitative, rich in contextual information, relatively inexpensive, quick and highly confounded with complexities of the real world. While many agricultural scientists are accustomed to *scientia* information, a growing number are recognizing the value of the kind of information produced in *praxis* studies, which can provide critical insights into the context of a particular area of scientific inquiry (Bawden et al., 1984).

Although biodiversity may be viewed as a fundamental principle of sustainablity by many scientists and environmental activists, in our experience with farmers in Ohio, Missouri, Kansas, West Virginia and Vermont, at least, it is rarely taken into consideration. If we wish to develop more forms of agriculture which protect biodiversity, we need to understand the perspectives of the people who manage agricultural lands in general. However, in particular, understanding the perceptions and experiences of land managers who are committed to these principles can be a valuable step towards developing research and education for a wider audience. Other researchers working in a participatory mode with farmers throughout the world have found that indigenous experience and knowledge have provided an effective foundation for research and development of more sustainable agricultural practices (McCorkle, 1989; Kloppenburg, 1991; Williams and Muchena, 1991; Flora, 1992; DeWalt, 1994; Scoones and Thompson, 1994).

The Holistic Resource Management process is being used by farmers, ranchers, communities, government agencies and, increasingly, businesses, nationally and internationally (Bingham, 1990; Anonymous, 1993; Dagget, 1995; Sindelar et al., 1995). Holistic Resource Management evolved out of Savory's concern for the alarming rate of desertification he observed as a wildlife biologist in his native Zimbabwe and many other parts of the world. Savory equates desertification with loss of biodiversity. HRM students are taught that biodiversity is the source of prosperity and that loss of biodiversity can have far-ranging environmental and social effects. 'Biodiversity is not about rare and endangered species, it is about human survival' (Savory, 1994). Savory argues that the fundamental cause of biodiversity loss is the process of how management decisions are made and he offers the Holistic Resource Management Model (Fig. 1) as an alternative decision making process.

1.1. The holistic resource management process

The first step in the HRM process is to define the 'whole' being managed in terms of people, landbase and money. Once a clear assessment has been made in these terms, the people directly involved (both those who influence the decisions and those who are influenced most by the decisions) should work together to develop a holistic goal. This goal includes: (1) their quality of life values, (2) forms of production they must achieve from the land or other resource base to support each of their quality of life values, and (3) a vision of what they wish the land or resource base to look like in the future to sustain their production and that of future generations. In the future landscape description, HRM students are taught that it is important to understand and work with four ecological processes as foundation blocks

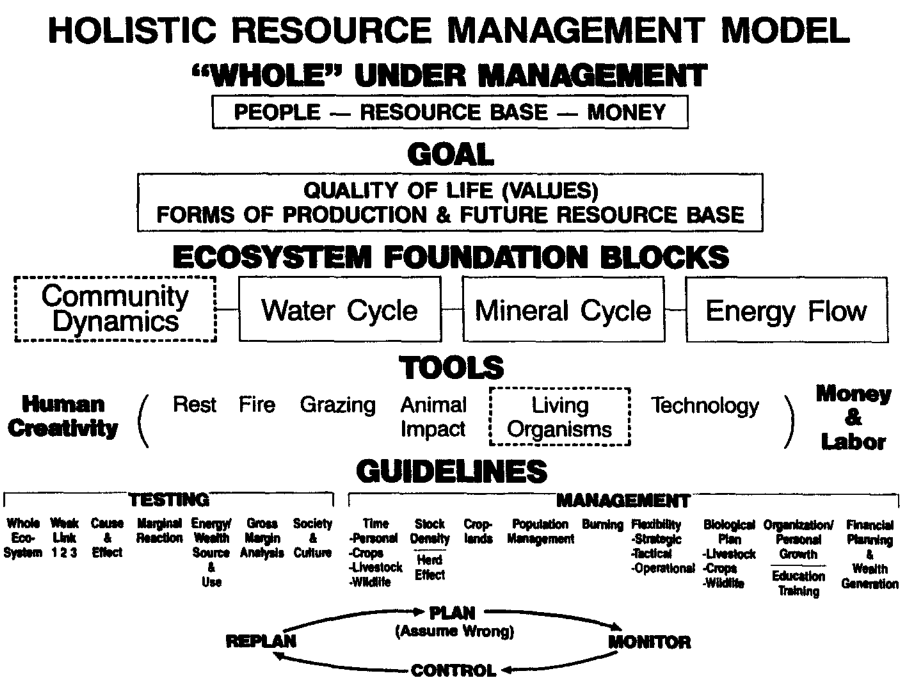

Fig. 1. Holistic Resource Management model.

– community dynamics (which includes ecological succession and human community dynamics), the water cycle, mineral or nutrient cycles, and energy flow (Fig. 1).

Only after this contextual groundwork has been laid do specific tools come into the HRM process. Although most people, and especially natural scientists, are much more comfortable discussing tools than quality of life values, it is tools that we most often argue about. Laying the context of a farm or ranch first can be a key to building unity in otherwise disparate groups of people in the whole. The tools used in the HRM model include: human creativity, money and labor, rest (e.g. allowing land to lay fallow), fire, grazing, animal impact (effect of short-term hoof action and concentrated fertilization when high densities of animals are bunched in a small area for a short period of time, as on the African savannas or the US Great Plains with the American Bison (*Bison bison*) during annual migrations), living organisms (e.g. using soil microorganisms to combat crop diseases), and technology (Fig. 1).

Creative brainstorming or idea generation is encouraged to produce a list of possible solutions to management challenges. These, then, are tested using seven testing guidelines in a pass or fail mode, against the established goal.

The first testing guideline, Whole Ecosystem (Fig. 1), asks how the proposed tool or enterprise will affect the four ecosystem processes; will they be enhanced or degraded and will it move these processes towards or away from the future landscape description?

In the second testing guideline, Weak Link (Fig. 1), the user determines the weakest link in their operation. Is there a lack of knowledge or information that is holding back progress toward the goal? Is the weakest link in personnel or financial problems, inadequate or poor land? Where is the weakest link in the energy conversion chain from sun to plants, to products that can be marketed? Is there a problem organism involved? If so, where is the weakest link in the life cycle of the organism?

In the third testing guideline, Cause and Effect (Fig. 1), the user considers whether the proposed action will treat a cause or symptom.

The fourth testing guideline, Marginal Reaction (Fig. 1), is one of the economic guidelines and is used only when comparing more than one option. It asks which option will provide the biggest return for the money or time invested in moving the operation towards the goal.

The fifth testing guideline, Energy/Wealth – Source and Use (Fig. 1) asks: Will the proposed tool require the use of finite sources of energy and will such use have to be repeated? The fifth testing guideline asks also: What is the source of money required – paper dollars (bank loans), mineral dollars (money from non renewable resources) or solar dollars (money generated from renewable sources of energy)?

The sixth guideline, Society and Culture (Fig. 1), asks how the proposed tool or action will affect the culture and society. Will it help strengthen the community?

The seventh and final testing guideline, Gross Margin Analysis (Fig. 1), is another economic test and, like Marginal Reaction, compares several options. Using the approach of British economists, Wallace and Burr (1963), in which only variable costs are figured, this guideline helps determine which forms of production are most profitable.

If used conscientiously, this decision making process gives the decision maker a consistent and objective evaluation of the soundness of the decision and helps insure that any decision is optimized between environmental, economic and social considerations. Savory argues that it is this conscious optimization process that sets HRM decision making apart from decision making that humans have been using throughout our history as a species and regardless of culture.

The Management Guidelines part of the model (Fig. 1) deals with specific and more advanced aspects of Holistic Resource Management. See Savory (1988) and Bingham and Savory (1990) for additional information. In the last part of the model – Control, Test – Assume Wrong, Early Warning Criteria, Monitor, etc. (Fig. 1), the user assumes the decision is wrong and watches for the earliest sign of deviation from the plan, be this economically, ecologically or with respect to quality of life. This approach creates a different psychology from that in conventional decision making in which a carefully researched decision generally is assumed to be right.

2. Methods

The names and contacts of committed Holistic Research Management practitioners were requested from established certified HRM educators and the Center for Holistic Resource Management in Albuquerque, New Mexico. We wanted to interview a range of HRM practitioners with respect to several parameters: (i) length of time using Holistic Management, (ii) different climatic regions or position on the 'brittleness scale' (Savory's (1988) description for amount and distribution of moisture for a geographic

Table 1
Interview questions asked of Holistic Resource Management practitioners

1. When did HRM start influencing your decisions?
2. What led you to HRM? What attracted you? What allowed you to accept HRM? How did you get started?
3. Before HRM started influencing your decisions, how did you measure success? What economic indicators did you use?
(e.g. $/A?, $/unit?, cash flow?) What quality of life indicators did you use? (e.g. time?)
What biological, chemical, or ecological indicators did you use? (e.g. soil tests?)
4. Now that you are using HRM, how do you measure success and what quality of life, economic and ecological indicators do you use?
How has HRM influenced your use of time?
5. What is your three-part (holistic) goal?
6. What is your definition of biodiversity? How important was biodiversity to you before HRM compared to now?
7. Have you observed or monitored changes in biodiversity on your farm/ranch since you began using HRM?
If so what changes have you seen and how have they been monitored?
8. What consequences of changes in biodiversity have you observed on your farm/ranch ecologically and economically?
9. If biodiversity has increased since you began HRM, have you seen increase in profit or overall wealth? How much in percentages?
10. Has thinking and learning about biodiversity through HRM changed your practices as a farmer/rancher?
Are your decisions different from before HRM? What are your thoughts for the future with respect to biodiversity?
11. What advice would you give to other farmers just beginning?
12. How have you adapted HRM indicators to your area with respect to the brittleness scale? (*This question is especially for eastern farmers*)
13. How has HRM affected your interactions within your community? Has networking been important to you and if so, in what ways?

Fig. 2. Map showing locations of interviewees.

Table 2
Summary data from interviews with Holistic Resource Management practitioners. Cases are presented from east to west across the USA. case numbers are shown on map in Fig. 2

Case [a]	Location	Enterprises [b]	Scale (ha)	Yrs. HRM	Perceived changes in					
					Biodiversity [c]	Profit (%) [d]	Community dynamics	Mineral cycle	Water cycle	Energy flow
1	VT	S. dairy sheep/ horses (G)	80	1.5	+	+	+	+	+	+
2	VT	Organic vegetables	7.3	1.5	0	+100–200	0	+	0	+
3	WV	Sheep/beef (G)	82	2	+	+	+	+	+	+
4 *	WV	Sheep/goats beef/poultry	32	5	+	+500	+	+	+	+
5	OH	Sheep/beef (G)	56	2	+	+250–300	+	+	+	+
6	OH	Dairy (G)	120	2	+	0 *	+	+	0	+
7	MN	S. dairy (G)	140	5	+	+ *	+	+	+	+
8	MN	Dairy (G)/ maize soybean/hay	120	5	+	+	+	+	+	+
9	IA	Beef/chickens sheep (TG)/ maize soybean	144	2	+	+	+	+	+	+
10	IA	Beef/hogs sheep/chickens dairy heifers (G) maize/soybean)		4	+	+	+	+	+	+
11	IA	Hogs/beef (G) agroforestry maize/soybean		3		0 *	+	+	+	+
12	MO	Beef (G)	360	7	+	+	+	+	+	+
13	MO	Beef (G)	116	2	+	+	+	+	+	+
14	MO	Beef (G)		3	+	+	+	+	+	+
15	MO	Beef (G)	116	3	+	+	+	+	+	+
16	TX	Beef (G)	8800	9	+	+60	+	+	+	+
17	OK	Beef (G)	1200	9	+	+	+	+	+	+
18	OK	Beef (G)	5600	7.5	+	+200	+	+	+	+
19 *	OK	Beef (G)	1040	8	+	+200	+	+	+	+
20	OK	Beef/chickens goats (G)	400	5	+	0 *	+	+	+	+
21	KS	S. dairy beef (G)	120	5	+	0	+	+	+	+
22	ND	Beef (G)/ oats wheat/millet lentils/flax	100	10	+	+	+	+	+	+
23 *	NM	Beef (G)	4800	9	+	+300	+	+	+	+
24	UT	Beef (G)	90000	17	+	+1400	+	+	+	+
25	WA	Beef (G)	+1520	10	+	+	+	+	+	+

[a] Asterisk * Indicates farms or ranches from which more quantitative data was provided and is presented in Tables 4, 6 and 8.
[b] S = Seasonal; G = Planned intensive grazing; TG = Transitionl planned intensive grazing from cropping.
[c] + Indicates that the interviewee observed increases in biodiversity of plant species and sometimes in birds and wildlife. See text for further explanation.
[d] + Indicates that farm profits reportedly increased since beginning HRM. + * indicates that the farm/ranch was operating at a loss before HRM was implemented and is now breaking even. 0 * indicates that increased profits have not been observed yet, but that the interviewee was confident that profits will increase. 0 indicates no change in profits. Percentage increases are shown where the interviewee provided that information.

area on an annual basis), (iii) scale of operation, and (iv) enterprises. A set of questions was agreed upon (Table 1). Potential interviewees were contacted by correspondence and given the opportunity to think about the questions before being called and interviewed. A few of the interviewees chose to respond in written form and four individuals were interviewed in person, but the majority were interviewed by telephone. The interviews took an average of one hour to conduct. Twenty-five practitioners were interviewed from locations shown in Fig. 2.

Biological monitoring is the part of Holistic Resource Management which detects early warning signs of ecological problems. Savory (1988) and Bingham and Savory (1990) present methods in which attributes concerning plant cover, density and species composition and soil surface conditions are measured on fixed transects. Instead of direct statistical analysis, the data are related to the HRM model for interpretation (Bingham and Savory, 1990). In addition to providing information on changes in plant community composition over time, this monitoring offers the manager a relatively simple and inexpensive means (in comparison with *scientia* research methods) of assessing feedback on parameters associated with all the ecosystem foundation blocks in the model. Random sampling points are determined along fixed starting point transects using a dart thrown over the shoulder. Sampling is to be done at the same time of the year each year by the same person. Less than 5% of the people interviewed were doing the full scale biological monitoring recommended by Savory and co-workers. Most of them relied on less time-consuming methods of monitoring their land ecologically, which included walking their land and getting down to ground level and observing soil and plants.

Information from all the interviews is summarized and presented in Table 2 according to methods in Miles and Huberman (1994). This is followed by much more detailed case studies developed according to Stake (1995) for three of the interviewees who had quantitative data from the biological monitoring described above. These three case studies cross an environmental range in brittleness, a factor of interest because Savory stresses that brittle environments respond differently to management tools than non-brittle environments. In Table 2, changes in biodiversity are based on interviewees' observations of changes in species numbers (particularly plants) over the time they have been practicing Holistic Resource Management. For changes in profit from the farm or ranch since beginning HRM, percentages are presented where that information was shared, otherwise we show reported positive, negative or zero trends. For information on the ecosystem processes, changes in biodiversity were taken as an indication of changes in community dynamics or succession.

Observations of faster decomposition of manure piles, more earthworms and other soil macro-fauna, and changes in organic matter or soil tilth, for example, were viewed as indications of changes in nutrient cycles. Many interviewees reported observing changes in soil erosion and hydrological cycles, such as springs and streams running where none had run for many years and clear instead of murky water in ponds. Another indication used for changes in the water cycle was both resistance and resilience to drought. Finally, for changes in energy flow, we used reported increases in plant biomass and increase in stocking rates of livestock. Stocking rates of livestock on a unit of land was a parameter reported by numerous interviewees and was viewed as a direct indicator of profitability (although price fluctuations confound this) in addition to an indirect indicator of energy flow. Stocking rates are the amount of land required to support one animal for a specified period of time, usually a year (see Bingham and Savory, 1990, for further discussion of stocking rates).

3. Results

3.1. Summary of all interviews

The scale of operations ranged from 7.3 ha to 90 000 ha and the time practicing HRM 1.5–17 years with an average of 5.6 years. The cases were characterized by wide range of farm/ranch types (Table 2). All but one of the cases (#2, Table 2) were using planned intensive grazing (Voisin, 1961) on some of their land, if not all. Interviewees typically defined biodiversity as all the different species of plants and animals, including micro-organisms in the soil, and their quantities as biomass or numbers. In addition, habitat diversity and genetic diversity within agricultural species were often mentioned. One interviewee included diversity of human ideas in his definition of biodiversity. Nine percent of the interviewees thought about biodiversity in the context of their operations before being exposed to HRM. Now, 100% of them think biodiversity is important to the ecological and economic well-being of their farms or ranches. 'Biodiversity is the true wealth to sustain the world. It is the only true source of capital for enterprises. I was not aware of biodiversity before HRM', said one of the interviewees in response to question 6 (Table 1). All but one interviewee reported observing increases in biodiversity since they began using HRM. With respect to changes in profit, 80% reported increases from their land since HRM began influencing their decisions. Of these, 40% provided actual percentage increases which ranged from 60% to 1400% and averaged 386% (median 238%). Sixteen percent reported no or little increase in profits yet, but were optimistic about future increased profitability.

In addition to reported increased biodiversity on their farms and ranches and concomitant reported increases in profitability, almost all of the interviewees reported observing improvements in ecosystem processes since they began using HRM (Table 2). For example, a farmer/rancher in North Dakota with 10 years' experience practicing HRM, related increases in soil permeability and infiltration from 5 cm to 50 cm. All of the ranchers west of the Mississippi River reported changes in plant species composition to a greater frequency of perennials and the return of many native tall and short grass prairie species. On the human community side, most of the interviewees relayed that they were considered odd by their immediate neighbors, but many of them are sought after speakers for national meetings and even internationally. Networks with other HRM practitioners were considered critical to the success of most of the interviewees.

With respect to quality of life issues, 91% of the interviewees reported that HRM has influenced some aspect of time management in their operations and lives in general. Of this group, 29% reported no change in total labor, but that how that time is allocated has changed. 'I don't know that the amount of time we spend has changed, but how we spend it has', said one of the interviewees. 'We are no longer doing a lot of things we do not like to do', reported another.

Fifty-two percent (especially the ranchers), reported decreases of up to 40%–60% in labor requirements in their operations, in spite of the extra planning and monitoring required by HRM. 'Not only do I have time to go out to eat with my family one night a week now, but I can pick which night', one of the ranchers (7 years HRM) told a group of HRM workshop participants. Another rancher (9 years HRM) reported, 'I have time to be a dilettante'.

All of the ranchers interviewed on the original tall and short grass prairies of the USA reported the return of native species in their intensively managed grazing cells and reported that their cattle were doing well on the native forage. Ecologically, this is very interesting, in that it was agriculture that caused degradation of the American prairies and on these HRM managed lands at least, agriculture is helping to restore the native ecological communities. These ranchers believe that their investments of time and money to upgrade their land is netting increased profits in higher carrying capacity and lower production costs.

3.2. *Detailed case studies of three farms / ranches*

These three operations offer a range along Savory's brittleness scale, with the farm in West Virginia in the humid southeastern part of the USA (#4, Fig. 2) being in the least brittle environment, followed by the Oklahoma Coffey Ranch (#19, Fig. 2), and the New Mexico ranch in the arid southwestern part of the USA in the most brittle environment (#23, Fig. 2).

3.2.1. *Windy slope farm, Leon, West Virginia*

The Fichtner family moved to this 32 ha (8 ha pasture and 24 ha woodlands) hillside farm (#4, Fig. 2) in 1981. At that time, Fichtner reported that the farm was almost overrun with multiflora rose (*Rosa multiflora* Thumb) and its soils (Gilpin, Muskingham and Uptsure) were classified as severely eroded and very severely eroded. It had been plowed for maize production in the 1930s and then put into sod in the 1940s or 1950s and the land supported a few horses and beef cattle since the 1950s. The farm is located in an area which was fire-maintained savanna grazed by the Eastern Woodland Bison (*Bison athaabascae*) before European settlement (Smith, 1989). The Fichtners began intensive grazing in 1989 and discovered HRM at an intensive grazing conference. The husband and wife took their first HRM classes in 1990 and 1991, respectively. Both had off-farm jobs at that time. See Table 3 for their goal statement. With their goal and the principles and tools of HRM they began to reclaim their land.

A great diversity of animals (Saaenen dairy goats, Suffolk, Suffolk X, Chevlot, Romney × Liecester, Perendale × sheep, Scottish Highlander cattle, Jersey dairy heifers, donkeys, hogs, chickens, quineas, geese, Muscovy ducks and turkeys) are used as tools, each with their own role. For example, the hogs break up and compost manure in the barn and the Muscovy ducks control flies. The Scottish Highlander cattle are very rugged and excellent browsers, clearing brush efficiently. The donkeys keep coyotes (*Canis latrans*) at bay. The cattle graze after the sheep, helping to break the parasitic cycle, as well as harvest the plants their predecessors passed over. Lambs are pasture born in the spring. The Fichtners began controlled grazing in 1990 on a small scale with seven paddocks, a few sheep and electric net on a 0.2 ha field. Now they have one 12 ha cell with 12 permanent paddocks, which they further subdivide into 40 or 50 or even more temporary paddocks depending on the conditions (Massey, 1993, and interview). In this time, profits from the farm rose enough that the wife was able to quit her off-farm job. The family's short-term goal is to have a seasonal dairy by 1997. They have 20 Jersey heifers as a foundation for their future dairy herd; a clear statement of the pasture improvements that have been made on this farm. Concomitantly with these changes, the Fichtners reported improvements in the organic matter, and observed more humus and tilth in their soils and increases in plant biodiversity in their pastures (Table 4).

Table 4
Plant biodiversity, stocking rate and net profit data from the 32 ha Windy Slope Farm in West Virginia

	Number of pasture plant species [a]	Stocking rate/yr. [b]	Net profit/ha [c]
1990	8	1:2	< $40
1995	32	1:0.4	$200

[a] Change reflects colonization of non-cultivated plants
[b] One animal unit: number of hectares required to carry that animal
[c] Profit from farm only, no off-farm incomes included.

A summary of reported changes in stocking rates, number of non-cultivated pasture plant species and net profit per hectare from 1990 to 1995 from the Fichtner farm are shown in Table 4. All variables reportedly increased fivefold in those five years. The Fichtners believe that improvements in the ecosystem foundation blocks were integral to their increased profitability. Their observed increase in pasture plant diversity was reported to be in the direction of higher successional species (especially perennials), indicating changes in community dynamics.

Table 3
Holistic goal statement for the Fichtner's of Windy Slope Farm in West Virginia

Quality of life: A lifestyle that requires minimal material goods and allows for plenty of time to enjoy life with family and friends.
A lifestyle that is in harmony with nature and contributes to the community, and one in which the children can grow, learn, develop and be happy productive individuals.

Forms of production: Many different species of:
(A) Livestock and poultry to harvest forage produced by the sun's energy.
(B) A form of production that is sustainable and relies little on external inputs.
(C) A form of production that poses little health risk and lots of enjoyment to all involved with the operation.
(D) A diversity of enterprises is desirable. In addition to livestock, we would make use of the forest – wood products, raise fruits, nuts, and vegetables.
(E) Forms of production that would allow our children to earn a livelihood for them and their children, if so desired.

Future landscape: A landscape with character. Lush green fertile pastures free of erosion bordered by woodlands that are rich in diversity of healthy plant and animal species, both wild and domestic. Clean water sources that can be used for production purposes as well as recreation and wildlife habitat.

Higher stocking rates indicated more efficient solar energy conversion with its resulting increased carrying capacity. The Fichtners perceive reduced erosion on their farm with the increased plant productivity and more earthworms (Lumbridicidae) and other soil macrofauna (e.g. Coleoptera) involved in nutrient

Table 5
Goal statement for the Coffey Ranch, Marietta, Oklahoma (Altom, 1992)

I. *Quality of life*
A. To carry out the mandate of the Coffey will
B. To develop a good community/neighbor relationship
C. Develop a positive impact among neighbors, community, and other agricultural agencies by sharing information in field days, tours and publications.
D. Develop economical, physical, mental and spiritual well-being of all persons involved by using a team approach and being collaborative in establishing ranch policies and research and demonstration needs.
E. Find a high degree of satisfaction and pride in work for staff and families and perform at a high level of productivity.
F. Improve the ecosystem of the ranch (soils, grass-forbs, wildlife, etc.).

II. *Production and education*
A. Develop desired landscape using management systems that require limited expenditures for inputs.
B. Demonstrate the use of a cow herd for producing income and changing the landscape.
C. Demonstrate wildlife and fisheries management and recreational leasing on a cattle ranch.
D. Demonstrate value of crops, timber, minerals, and aesthetics on a ranch.
E. Monitor and access
  1. People
  2. Finances
  3. Land
  4. Plants and animals
F. Identify and initiate needed research.

III. *Landscape* – The major goal is to develop and/or maintain a wide diversity of plants to support livestock and wildlife, reduce erosion, and create a positive water cycle. The ranch has been divided into plant communities and soil areas for description and monitoring.
A. Woody plant communities
  1. Bottomland
    a. Loamy bottomland goal description: Grasses 15–50% frequency, grasslikes 0–10% frequency, forbs 10–25% frequency, and woody plants 85% canopy cover. (A specific list of desired plants has been written, but is not listed here).
    b. Blackclay prairie
    c. Sandy
  2. Upland
    a. Blackclay prairie
    b. Loamy prairie
    c. Sandy savanna
    d. Very shallow
B. Herbaceous plant communities
  1. Bottomland native
    a. Loamy
    b. Sandy
  2. Upland native
    a. Blackclay prairie goal description: Grasses 80–90% frequency, grasslikes 0–5% frequency, forbs 10–25% frequency, woody plants 0–5% canopy cover. (A specific list of desired plants has been developed, but is not listed here).
    b. Loamy prairie
    c. Sandy savanna
    d. Very shallow
  3. Planted
    a. Bermudagrass
    b. Mixed grass
C. Wetland – ponds, streams, and marshes.

cycling and faster decomposition of manure piles. The shorter and denser forage species present now grow longer and better in hot dry weather than those present in 1990. The Fichtner's reported having a longer growing season now (early March–December) than they did before (mid April–late October). Also, they are able to get more grazing rotations on a particular paddock per year now (three to six) than in 1990 (one or two).

3.2.2. Noble Foundation / D. Joyce Coffey Resource Management and Demonstration Ranch, Marietta, Oklahoma

This 1053 ha ranch (#19, Fig. 2) was a privately owned and operated ranch until 1981, when its owner died and willed its management to the Noble Foundation to be operated as a model ranch. Historically, this ranch was similar to much of southern Okalahoma, with crops planted on open land and livestock continuously grazed on rough and wooded land. The Coffey family moved to the ranch in 1949 and focused on cattle and forages, establishing improved grasses in some areas in the 1960s and 1970s (Altom, 1992). Today, the ranch contains 506 ha of open herbaceous plant community and the remaining streams and wooded vegetation (Griffith and Stevens, 1992). Major soils on the ranch are: Breaks – -alluvial land, Denton, Durant, Gowen, Labette, Lincoln, Lula, Minco, Norwood, Rocky broken land, Stephenville, Shidler-Steedman Complex, Tarrant, Teller, and Windthorst. Some of the upland soils are slightly to severely eroded (Altom, 1992). Currently, the ranch is managed by a team of specialists in crops and forages, economics, livestock, soils and soil fertility, and wildlife and fisheries, plus the ranch manager. This management team initiated HRM on the ranch in 1987. We interviewed Charles Griffith, the forage specialist, and in addition to the interview material, he provided us with written research and field day reports. This operation had the most complete quantitative data on changes in plant biodiversity of our interviewee group. The annual stocking rate had decreased from 300 to 67 animal units per year when the HRM team began. The distribution of plant species on the degraded rangeland was characterized by a mixture of 60% low seral species (species associated with early successional stages, usually 'weedy' annuals that may be of low forage quality and often are considered undesirable), 12% mid seral species and 22% high seral species (these are species associated with the native or climax plant community of the area) when HRM began being applied (Griffith and Stevens, 1992).

The goal statement developed by the management team for the Coffey Ranch is shown in Table 5. In general, the landscape goal was to reverse the successional trend back to a mixture of low, medium and high seral species, with high seral species occupying as much as 50% of the plant communities, and to stop all forms of soil erosion. It was determined that this landscape could support the production goal of high profitability in livestock and lease hunting (Griffith and Stevens, 1992). Management tools used to realize the landscape goal included: grazing, based on time control, stock density and proper plant rest periods; fire and animal impact. Herbaceous plant composition was monitored annually on five random transects. Annual fixed point photographs were used to monitor soil erosion, and wildlife populations were monitored with spotlight surveys, harvest records and incidental sightings (Griffith and Stevens, 1992).

Monitored changes in plant communities and annual stocking rates from 1987 to 1991 and then to 1994 are shown in Table 6. From 1987 to 1991, there was no change in frequency rate of high seral species at 5%, but low seral species declined from 60% to 32% frequency rate and mid seral species increased from 12% to 43% as a result of grazing management, with a concomitant increase in annual stocking rate of 30% (Table 6). Exposed soils containing varying degrees of erosion were completely covered with growing plants and the white-tailed

Table 6
Changes in biodiversity and profit indicators on the Coffey Ranch, Marietta, Oklahoma 1987–1994 [a]

	1987	1991	1994
Changes in forage type (% frequency)			
Low-seral [b]	60	32	25
Mid-seral	25	27	27
High-seral	5	5	25
Stocking rate/yr.	110	140	200

[a] Sources of data Griffith and Stevens (1992) and Newport (1995).
[b] Seral stages refer to early, mid and late successional species of grasses and forbs.

deer (*Odocoileus virginianus*) had increased 100% (Griffith and Stevens, 1992). By 1994, high seral species had risen to 25%, low seral species had declined further to 25%, mid seral species had dropped back down to 27%, and stocking rates had increased 100%, from 110 animal units per annum in 1987 to 200 (Table 6, Newport, 1995). In addition, Griffith and Stevens reported sightings of golden eagles (*Aquila chrysaetos*), but no quantitative monitoring of their populations has been done.

Other ecosystem processes besides succession have changed on the Coffey Ranch since implementation of HRM also. In the interview, Griffith reported that improvements in the water cycle were the first changes observed with respect to erosion. Ponds which had high turbidity now have low turbidity and two springs which had dried up now run in the spring of the year. Nutrient cycles have changed, resulting in much faster decomposition of manure piles from 2–3 years in 1987 to 5 days now, according to Griffith. The higher stocking rates are indicative of improved energy flow and conversion on the land. Labor is another factor that has been dramatically altered on the Coffey Ranch by HRM according to Griffith in the interview. In 1987 it took four people and two horses all day to gather the cattle, now, because of planned grazing and the cattle being trained to that, it takes one person and no horses five minutes to move the animals. Animal sales doubled since 1987 after a three-year threshold was crossed. However, 'if our knowledge had been there, the increases could have come almost immediately' Griffith said in retrospect in the interview.

3.2.3. Rafter F Ranch, San Jon, New Mexico

This 4800 ha ranch in northeastern New Mexico (#23, Fig. 2) is in the most brittle environment of our three detailed case studies with an average of 40.6 cm of rainfall a year, 70% of which comes in the summer months. However, 1994 and 1995 were exceptionally dry with 12.7 cm and 17.8 cm, respectively. The ranch was first homesteaded in the early 1900s by the current owner's parents. In the interview, Roger Bowe said that the land was originally farmed and 'blew away in the 1930s' (soil erosion via wind). Rolling hills with sandy loam soils and sod-bound grama grass (*Bouteloua* spp.) and valleys with clay flats, tobosa grass (*Hilaria mutica*) and gradual encroachment of mesquite trees (*Prosopis glandulosa*) characterized the land (Bowe, 1987; Butterfield, 1992). It is all range land. Bowe and his parents were motivated to take their first HRM course in 1983 to halt their ranch's falling productivity. They admit that they made many mistakes the first couple of years, in particular because they spent more time and energy on fencing, land and biological planning than on goal setting (interview and Bowe, 1987). A second HRM course in 1986 was critical in helping them with their goal (Table 7) and they began to move forward (interview and Bowe, 1987). The parents have since retired, but Bowe and his wife have been joined by his brother and his family.

They used three tools, primarily, to reach their goal: grazing, animal impact and technology in the form of fencing. Several days of planning are required each year to establish the grazing plan for the following year, both in checking on forage quality to determine how much will be needed to feed one cow one day in all 56 paddocks, and in computer and evaluation time. Biological monitoring is done on five transects once a year after the growing season when the plants have seed heads for ease in identification (Butterfield, 1992). Results of this monitoring are shown in Table 8. From 1984 to 1991 the number of perennial species of grasses tripled and

Table 7
Goal statement for the Rafter F Ranch, San Jon, New Mexico

Quality of life	A long-term business that is prosperous and stable and can provide for two families without anyone having to work away from the business, closer family ties, time for leisure, time for working in a strong community, school and church, and a good education for the children.
Forms of production	Profits from livestock and wildlife.
Future resource base	Higher successional grassland with scattered brush, increased biodiversity in both livestock and plants, a watershed that is no longer eroding and high water quality.

Table 8
Changes in biodiversity and profitability indicators on the Rafter F Ranch in northeastern New Mexico [a]

	1984 [b]	1991 [b]
Number of perennial grass species	6	18
% Bare soil	46	30
Distance between plants (cm)	3.25	1.75
	1983	1991
Stocking rate	1:17	1:6.7
Kg. of beef produced/ha	66	171
Cost/kg of beef	$1.36	$0.66

[a] Data from Butterfield (1992).
[b] Data from the two oldest transects.

ground cover increased. Concomitantly, from 1984 to 1991 the stocking rate of beef almost tripled and the cost of production dropped by half (Table 8). Bowe reported that net returns per acre tripled over this period (Butterfield, 1992). One weed, snakeweed (*Gutierrezia sarothrae.*), which covered 11% of one grazing cell in 1986 and which the Bowes had failed to eradicate, was reduced to 1% cover by 1990 and nine perennial species were recorded with grazing and animal impact (Butterfield, 1992). In the interview, Roger discussed the presence of two new plant species, indiangrass (*Sorghastrum nutans*, which the cattle love) and Canadian wild rye (*Elymus canadensis*) which normally occur at much higher altitudes than his land. In addition to increased plant biodiversity, Bowe reported increases in earthworms (Bowe, 1987) and wildlife.

Like most of the interviewees, the Bowes have observed numerous improvements in other ecological processes besides succession. Bowe reported that his water table has risen 3 m (which he thinks may explain the presence of the above rare species for his area). An old dry well now has 3 m of water in it. Springs have appeared. He told the story of an archaeological site on his land where there were signs of a Native American settlement in the form of tipi rings, which could not be explained because there was no water nearby. However, after the water table began rising, they discovered a spring near the site. There is much less erosion now than before, a function of the greater number of perennial grass species. However, Bowe feels there is potential for a lot more biodiversity on their ranch. 'When I see a new grass species, clear water in my stock ponds, minerals cycling through living organisms and my banker becoming a stranger, that's my (*positive*) feedback' (Butterfield, 1992).

4. Discussion

Our interviews indicated that the majority of the farmers and ranchers perceived biodiversity as playing a key role in economic and ecological sustainability of their operations. However, we cannot state with scientific certainty that a relationship exists between biodiversity and profitability from our qualitative data base. 'I see a direct link between biodiversity and money, but it will be hard to prove. You just know', said one of the interviewees. We suggest that our findings indicate further research is appropriate. More evidence that there are different approaches to decision making in agricultural management which can enhance not only profit, quality of life for farm or ranch families, but also biodiversity and the environment could be an effective tool to assist in developing new agricultural policies which support sustainable agriculture nationally and internationally. Farmers and ranchers like the ones in this study, especially those with many years of experience using biodiversity as a management principle, could serve as mentors not only to other farmers (many of them already do), but also to scientists (see Kramer et al., 1992) on case #22, Table 2).

However, while an approach like HRM appears promising and worthy of further research, there are limitations. For example, although the HRM model is not exclusive of any practice (e.g. the vegetable producer in case #2, Table 2), the process is supported with proportionately high numbers of farmers with livestock and ranchers. Keeping permanent sod cover in a healthy state is an effective means of enhancing the four ecosystem processes used in the model. As a result, ranchers and diversified crop and livestock farmers attracted to intensive grazing are inherently predisposed to be receptive to HRM, which is why our group of interviewees was skewed in that direction. A significant obstacle to widespread adoption of HRM or similar approaches is the paradigm shift required. 'The whole thing takes place in your mind', reported one of the interviewees. Another interviewee said, 'we must forget everything we've been taught and learn how to observe'. The paradigm that HRM is based upon, in which humans learn to work consciously with ecological processes to rebuild biodiversity and ecological integrity on their land, is fundamentally and radically different from the paradigm that dominates conventional agriculture, which places relatively little emphasis on ecological processes and biodiversity. However, numerous federal and private research and education grants involving HRM are extending HRM knowledge and practice among farmers/ranchers, research scientists, extension specialists and other government agency personnel in the USA (and other parts of the world). For example, in Ohio, federal funding supports much of our participatory research and education in sustainable agriculture with a diversity of farmers in which we are using an HRM approach in whole farm planning. As the number of HRM practitioners grow, so will opportunities for further research.

Although the HRM movement is growing nationally and internationally, it represents a very small percentage of the people currently making decisions about how to manage agricultural lands. Furthermore, there is a commitment problem among some people who take HRM workshops, as evidenced in a recent *Center for Holistic Resource Management Quarterly* devoted to the issue of maintaining commitment (Holistic Resource Management Quarterly, 1995). It appears that HRM involves more planning and monitoring than many farmers and ranchers are accustomed, or willing, to do. The learning is slow at first for most people. We found that there can be a considerable time lag before benefits return and managers can report, like this one with 10 years of HRM experience, 'HRM was mind boggling at first, but so simple now'.

Global agriculture is at a critical cross roads today. In the USA, independent farmers and ranchers with limited resources are becoming increasingly vulnerable to foreclosure or offers from transnational companies, with decreasing options for management (Hamilton, 1994a,b; Heffernan, 1994). A decision making process like HRM can help to empower individual farmers and farm communities. If Savory (1994) is correct in contributing the failure of past civilizations to loss of biodiversity, ultimately, this is an issue of considerable importance not only for farmers and ranchers and the rural communities they live in, but for all of us. The practical experiences of the farmers and ranchers interviewed in this study suggest that there are viable alternative management approaches which can support biodiversity, profitability, ecosystem function and quality of life.

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