Habitat Changes in Colombian Coffee Farms Under Increasing Management Intensification

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Abstract

I analyzed a set of environmental and vegetation variables in order to characterize an intensification gradient for coffee production agroecosystems. I measured 14 habitat variables within 12 Colombian farms classified into four management systems at the Risaralda region of Colombia: Forests, Polygeneric Shaded coffee, Monogeneric Shaded coffee and Sun coffee plantations. The habitat variables were categorized into three vertical levels: arboreal, shrubs and soil. Univariate and multivariate analyses showed that the habitat effect is driven mainly by drastic changes (i.e. elimination) in the arboreal level along the intensification gradient, although variables at other levels showed gradual and sometimes unexpected changes. I then adapted the management index developed by Mas and Dietsch (2003) to the coffee plantations in this study. The quantitatively supported management index showed a close correspondence to the initial qualitatively classification of the farms. I conclude that intensification of coffee production has clear measurable effects on habitat characteristics and that the management index reflects the gradient of intensification in the studied farms. The approach of using the management index could be highly valuable for the programs of shade coffee certification and conservation goals.

Cambios en el Habitat en Plantaciones Colombianas de Café Bajo un Incremento en la Intensificación de Manejo

Resumen

Analizé una serie de variables ambientales y de vegetación para caracterizar un gradiente de intensificación para agroecosistemas de producción de café. Medí 14 variables relacionadas a habitat en 12 plantaciones colombianas clasificadas en cuatro sistemas de manejo en la región de Risaralda en Colombia: bosque, café de sombra poligenérico, café de sombra monogenérico y plantaciones de café sin sombra (de sol). Las variables relacionadas a habitat fueron categorizadas en tres niveles verticales: arbóreo, arbustivo y suelo. Los análisis de una sola variable y de variables múltiples mostraron que el efecto del habitat es influenciado principalmente por cambios drásticos (esto es, eliminación) en el nivel arbóreo a lo largo del gradiente de intensificación, aunque las variables a otros niveles mostraron cambios graduales y en algunos casos cambios inesperados. Posteriormente adapté el índice de manejo desarrollado por Mas y Dietsch (2003) para plantaciones de café. El análisis a nivel cualitativo obtenido con el índice de manejo mostró una correspondencia cercana a la clasificación cualitativa inicial de plantaciones. Concluí que la intensificación de la producción de café tiene claros efectos medibles en las características del habitat y que el índice de manejo refleja el gradiente de intensificación en las plantaciones estudiadas. La técnica de usar el índice de manejo pudiera ser altamente valiosa en los programas de certificación y conservación de café de sombra.

Changements des Habitats dans les Fermes Colombiennes sous une Intensification de Gestion

Résumé

J'ai analysé un ensemble de variables environnementales et de végétation afin de caractériser un gradient d'intensification pour des agroécosystèmes de production de café. J'ai mesuré 14 variables d'habitat dans 12 fermes colombiennes classifiées dans quatre systèmes de gestion dans la région de Risaralda de la Colombie: Les forêts, des plantations café d'ombre polygenerique, des plantations café d'ombre monogenerique, et des plantations café du soleil. Les variables d'habitat ont été classées dans trois niveaux verticaux: arborescent, arbustes et sol. J'ai utilisé des analyses univariables et multivariables et ai constaté que l'effet d'habitat est conduit principalement par les changements énergiques (c.-à-d. élimination) de la végétation de niveau arborescent le long du gradient d'intensification, bien que les variables à d'autres niveaux aient montré les changements progressifs et parfois inattendus le long du gradient. Ensuite, j'ai adapté l'index de gestion développé par Mas et Dietsch (2003) aux plantations de café dans cet étude. L'index de gestion est quantitativement soutenu et a montré une bonne corrélation à la classification qualitatif originale des fermes. Je conclus que l'intensification de production de café a des effets clairement mesurables sur leur caractéristiques d'habitat et que l'index de gestion reflète le gradient de l'intensification dans les fermes étudiées. L'approche d'employer l'index de gestion peut être fortement valable pour les programmes avec les buts de certification et conservation de café d'ombre.

Introduction

Agricultural intensification has been defined as the patterns of land-use change with the common feature of increase resource use to augment agricultural production (Giller et al. 1997). It is generally associated with specialization, increasing mechanization and generalized use of agrochemicals and other external inputs (Giller et al. 1997; Decaens and Jimenez 2002). This intensification negatively impacts the agricultural land, which is usually the matrix among forest fragments and therefore valuable for conservation purposes (Vandermeer and Carvajal 2001, Perfecto and Vandermeer 2002). There is growing awareness in the literature that agroecosystems should be a priority in the biological conservation agenda (Paoletti et al. 1992; Pimentel et al. 1992; Vandermeer and Perfecto 1997; McNeely and Scherr 2003) due to growing evidence that some agroecosystems are repositories of high levels of biodiversity (Pimentel et al. 1992; Roth et al. 1994; Perfecto et al. 1996, 1997; Perfecto and Armbrecht 2003).

It has been well documented that agroecosystems with high planned biodiversity foster high levels of associated biodiversity and that the intensification of agriculture negatively affects associated biodiversity (Andow 1991; Pimentel et al. 1992; Decaens and Jimenez 2002; Perfecto and Armbrecht 2003). Swift et al. (1996) have hypothesized several predictions regarding alternative patterns in which associated biodiversity decreases with intensification of agriculture. However, testing mechanistic hypotheses first requires the quantification of intensification.

The coffee agroecosystem has received considerable attention over the last decade with regard to the effect of intensification on biodiversity (Nestel et al. 1993; Perfecto et al. 1996, 1997; Greenberg et al 1997a; Moguel and Toledo 1999; Dietsch 2003; Armbrecht and Perfecto 2003), but there is a need to quantify habitat changes for this particular case. There are two reasons that justify the need for a better quantification: first, coffee production occurs across a wide gradient of agricultural intensification, involving different levels and varieties of shade trees (Moguel and Toledo 1999; Perfecto et al. 1996, 1997; Johnson 2000); and second, this agroecosystem is now known to be important for conservation biology (Vandermeer and Perfecto 1997; Moguel and Toledo 1999; Rappole et al 2003; Perfecto and Armbrecht 2003).

Intensification of agriculture can be quantified through various indices, which consider the measurement of variables presumed to determine its degree at particular scales. Giller et al. (1997) proposed an index or "degree of intensification" which was further modified by Decaens and Jimenez (2002) and named "Agricultural Intensification Index" (AI). The Agricultural Intensification Index (AI) is the average of seven subindices, equally weighted, which range from 0-1: (1) LUI, the land use intensity, or the proportion of the year the system is cropped; (2) FF, the mean fire frequency or burnings/year; (3) TF, the mean tillage frequency/year; (4) MPF, the mean frequency of motorized practices/year; (5) SR, the mean annual stocking rate (International Animal Units/ha); (6) FR, the mean fertilization rate (kg of chemicals used per year); and (7) PCR, the mean pest control rate (kg of chemicals used per year).

The coffee agroforest poses additional challenges to researchers, since some of the intensification variables defined in the AI are not meaningful in this context (e.g., LUI, FF, TF) because coffee agroforests are not tilled, no fire is used (unless accidental), and coffee is a perennial crop (Beer 1998) standing for several decades (Willson 1999).

Despite the fact that new studies accounting for differences among shade regimes in coffee plantations have quantified independent variables related to the structure of vegetation and habitat changes (Babbar and Zak 1995; Perfecto and Vandermeer 1996; Greenberg et al. 1997a; Decaens and Jimenez 2002; Klein et al. 2002; Armbrecht and Perfecto 2003; Mas and Dietsch 2003), many studies focusing on different coffee management systems have not reported such variables (e.g., Borrero 1986; Greenberg et al. 1997b; Beer, 1998; Wunderle and Latta 1996; Ibarra-Núñez and García-Ballinas1998; Molina 2000; Sossa and Fernandez 2001; Ricketts et al. 2001; Rojas et al. 2001; Perfecto and Vandermeer 2002). The potential problems associated with the failure to quantitatively assess intensification have been highlighted by Rappole et al. (2003), who argued that any plantation, regardless of the diversity and density of shade, could be considered a "shade coffee" plantation. The lack of a rigorous definition for shade coffee may have serious practical implications since shade coffee has emerged in recent years as an important component of biodiversity conservation programs among several environmental organizations such as Conservation International, The Rainforest Alliance and Eco-OK (Perfecto and Armbrecht 2003; Dietsch 2003).

Mas and Dietsch (2003) developed an index of management intensity (management index, MI) for coffee agroecosystems in order to evaluate whether qualitative differences between shade coffee agroecosystems correspond to quantitative differences in vegetation and farm management. Their index used seven equally weighted vegetation variables, which they considered directly related to flying insects such as butterflies. This management index was then related to the richness of fruit feeding butterflies in differentially shaded coffee plantations of Chiapas, Mexico (Mas and Dietsch 2003). The MI can be flexibly adapted to different targeted taxa in biodiversity studies. The present study is intended to test the extent to which a subjective categorical classification of farms along a gradient of intensification corresponds to a quantitatively supported classification by applying a modified version of Mas and Dietsch's management index. Additionally, this study aims to quantify habitat changes among Colombian coffee farms under a strong intensification process and compare them to other related studies.

Study Site

The Andean mountains of Risaralda Department, Colombia (5º 08' N; 75º 56'W), where the Apía municipality is located, range between 1400-1900 m a.s.l. Annual temperature and annual precipitation average 20°C and 2,320 mm respectively, the latter having a bimodal distribution with peaks in May and December (raw data from IDEAM Meteorological Stations, Colombia, 2002). The Apía region has a rugged topography with scattered secondary forest fragments that become continuous at higher altitudes (~4000m elevation) at the "Tatamá Natural Reserve." The Apía was a typical, traditional shade coffee growing area for many decades. However, in the last 20 years, coffee crop cover has decreased by more than 700% (seven-fold) of the initial area covered (ANFCG, 2002), and 60-70% of the remaining tree cover is composed of plantains used as barriers (personal observation December 2002). During the last decade, many coffee plantations were converted into cattle pastures and other agricultural

Farm's name	Management code	Area (ha)	Elevation (m a.s.l.)	Percentage slope (%)	Use of pesticides (appl./year)
MonteverdeF	For1	15	1845	59.6	None
Playabonita	For2	2	1444	61.3	None
El Porvenir	For3	1.5	1605	39.3	None
La Playita-1	PS1	15	1490	48.3	None (organic)
La Esperanza	PS2	4	1500	34.6	None (not organic)
La Clarita	PS3	7.5	1550	43.8	None (organic)
Monteverde	MS1	4	1720	43	Low
Buenos Aires	MS2	6	1440	40	Low
El Convenio	MS3	4	1465	64.4	Low
La Felisa	Sun1	6	1480	32.5	Moderate
La Estrella	Sun2	14	1470	17.5	Moderate
La Maria	Sun3	3	1405	2.5	High

Table 1. Names and general characteristics of the 12 farms involved in the study at the Apía Municipality of Risaralda Department, Colombia. Use of pesticides high: is at least two applications/year (pesticides and herbicides), moderate: at least one application/year, low: less than one application/year.

uses, and the coffee plantations that still stand have suffered a dramatic intensification change. The changes involve variying degrees of elimination of shade trees including the complete elimination of any shade, which is concomitant with increasing application of agrochemicals for the control of the coffee berry borer and for weeds.

Twelve farms, grouped in four qualitatively classified management types were chosen haphazardly at the Apía municipality. Following Nestel and Altieri (1992), the four management types were: Forest (F), Organic Polygeneric Shade coffee (PS), Monogeneric Shade coffee (MS), and Coffee Monoculture or Sun Coffee ("Sun"). For simplicity, each farm was assigned a code (Table 1). Two sets of criteria were used to decide the qualitative classification of the farm management type: a) a visual assessment of presence and diversity of trees; and b) information that farmers provided about farm management with regard to number of agrochemical applications per year and shade management. With regard to the forest fragments, I determined that the three forest fragments appeared to be secondary natural dense vegetation, disturbed and isolated. The forests were located relatively close to the coffee plantations (the primary forests that exist many kilometers from the municipality did not fit for comparison purposes of this study). The Monogeneric Shaded coffee plantations (MS) were subjectively perceived to be dominated by trees belonging to the genus *Inga* or *Cordia*. The Polygeneric Shaded coffee farms were organic and their shade trees were apparently more varied than those in the MSs. Sun coffee plantations had few or no shade trees, although it was not possible to find 100% open plantations because farmers still allow some isolated valuable trees and plantains within their plots. Therefore, measurements on the existing plantains (or any isolated tree) within these sun coffee plantations were done even though the habitat by definition should not have arboreal vegetation. As part of the study site description, percentage slope was calculated by measuring both the vertical and horizontal components of the slope at four haphazardly chosen sites at each farm.

#	HABITAT VARIABLES	For1	For2	For3	PS1	PS2	PS3	MS1	MS2	MS3	Sun 1	Sun 2	Sun 3	P
1	Percentage canopy cover	96.1	96.7	90.5	69.0	80.9	86.9	36.9	74.3	77.4	25.3	24.2	36.9	<0.0001
2	Tree species richness	14	7.5	13.5	4.5	8	3.5	2	2	2	1.5	1	0.5	0.011
3	Tree density in 452 m^2 (#/circle)	24	14	30.5	12	23	6	9.5	5.5	5	1.5	1.5	1.5	0.012
4	% trees with epiphytes	10.7	18.8	28.2	41.7	27.1	72.9	5.6	10	40	25	25	0	NS
5	Total epiphytes	N/A	87	55	72	35	56	3	2	5	1	2	0	0.02
6	Average tree height (m)	8.5	7.3	9.0	6.2	7.7	7.9	10.4	8.0	9.5	7.3	4.0	3.7	0.032
7	%dominance of one shade tree	20.2	34.3	28.6	41.7	35.6	63.3	88.9	81.8	80.0	97.7	98.7	100	<0.0001
8	Average dbh, live trees	14.7	18.1	17.0	22.5	20.7	23.4	21.5	30.5	22.7	21.2	22.9	11.3	NS
9	Vertical Heterogeneity (H')	1.5*	1.4*	1.5*	1.2	1.4	1.5	1.2	1.4	1.3	0.9	0.6	0.7	<0.001
10	Number of coffee bushes (78.5m^2)	43.5*	45.5*	73.5*	36.0	22.0	50.0	39.5	42.5	57.5	59.0	66.5	71.5	<0.0001
11	Average coffee height (m)	9.0*	8.9*	8.5*	2.0	2.5	2.5	2.2	2.6	2.2	1.8	1.7	1.4	0.024
12	Average number of logs in 4m2	4.8	5.1	4.5	3.4	4.3	5.2	2.3	2.3	1.2	0.9	1.4	0.2	<0.001
13	Log diameter (cm)	5.3	9.	6.0	7.1	8.9	7	5.7	4.8	8.7	11.1	13.6	7.4	NS
14	Avg # of logged trees in 4m^2	0.5	0.5	7.5	3.5	3	13.5	1.5	1.5	1	1.5	1.5	0.5	NS

Table 2. Average values for each of the variables measured (based on two circles per plot) to characterize the habitat of nine coffee plantations and three forest fragments at Apía. Variables are averages at either the "circle" level (#2,3,4,6,7,8,10, 15) or the "site" level (#1,9,11,12,13,14) or at the farm level (#5). Values marked M— are for understory plants. Last column, P, indicates alpha probability for mixed model analysis of variance. Degrees of freedom are 3, 8 except for variables 10 and 11 where forest values were taken out.

Methods

The characterization of the habitat at the Apía region followed the protocol established by Mas and Dietsch (2003) for coffee farms under different management systems in Mexico. In this protocol, a "management index" quantifies the effects of the management intensification on the shade tree canopy. Seven variables, each varying from 0 (least intensive condition) to 1 (most intensive condition) were used in calculating this index. Although Mas and Dietsch's paper reports and statistically compares 13 vegetation variables among their seven farms, they actually used only seven of those variables to determine their management index. Not all of the variables used by Mas and Dietsch were measured in this study because they focused on fruit feeding butterflies (influenced by canopy structure) while I was seeking to develop a management index that would be applicable to the study of ground and leaf litter organisms such as ants. In the study, I obtained the following 14 habitat variables, which were grouped in three vertical strata: arboreal stratum, coffee bush stratum, and soil (low) stratum. The arboreal stratum included percentage canopy cover, tree species richness, tree density, percentage of trees with epiphytes, number of epiphytes, tree height, percentage dominance of one shade tree, and diameter at breast height (dbh) of live trees. The coffee bush stratum considered vertical heterogeneity (up to 5.4m), number of coffee bushes, and coffee height. The soil (low) stratum included the number of logs, log diameter, and number of logged trees.

All habitat variables were measured between November and December 2002 at the 12 farms. In each farm, two sampling sites (or "circles") separated by approximately 50-100m, were haphazardly selected. Each sampling site consisted of a circle of twelve-meter radius within which all trees greater than 8.13 cm diameter at breast height (dbh) were identified to species. Also a visual inventory of the tree species in each plot was made. Height, dbh, presence of epiphytes, fruit or flowers were recorded for each tree. All coffee bushes or understory plants in Forest sites between 2.5-8.1cm dbh were counted within a five-meter radius circle located at the center of the larger circle. These were the only trees recorded for the management index calculation, and additional visual search was done by a botanist at each of the plantation plots for an inventory of the trees. Canopy and soil sampling points were established at four-meter intervals along the north-south and east-west axis of the sampling location for a total of 13 sampling points. At each sampling point, a spherical densiometer (Forestry Suppliers, Biloxi, Mississippi) was used to obtain the percentage canopy cover; the diameter dead logs was measured and dead logs greater than 2.5cm were counted in a 2m x 2m area next to the sampling point. Vertical heterogeneity of the understory was measured using the Vertical Intercept Line technique (Mills et al. 1991). The technique uses a 5.4m aluminum tube labeled with tapes of two colors, one color defining nine vertical consecutive intervals of 60cm (A), and the other color defining 54 ten-centimeter intervals (B) in such a way that each of the large nine intervals contain six 10cm intervals. The tube was placed vertically between two coffee bushes. Any vegetation contact within an imaginary 1dm radius cylinder around each of the tube segment was registered. Shannon-Wiener index (Magurran 1988) was calculated by using large intervals as species and small intervals as abundances.

Data analyses: Means of the variables for the four management types were statistically compared by mixed model nested analyses of variance with circles nested within farms and farms nested within managements. Tests for assumptions of normality (Kolmorogov-Smirnov tests) and homogeneity of variances (Levene's tests) (Zar 1999) were carried out. Data not normally distributed were transformed (inverse of the square root) in order to meet this assumption (Zar 1999). Tukey post-hoc tests were performed whenever the statistical differences were detected. Multiple comparison post-hoc tests were Bonferroni corrected. All univariate analyses were performed using SPSS-10 for Windows (SPSS Inc©). Multivariate analyses involved cluster analyses (Ward linkage method and Euclidian distances) and principal component analyses as implemented by Statistica-5 for Windows, multivariate exploratory techniques (Statistica Inc. 2002, ©Copyright StatSoft, Inc.).

Management index: Mas and Dietch's management index (MI) weighs each of the variables equally along a scale from 0.0 to 1.0 (0.0 represents the least managed/most "natural" system). The standardized index values for the variables

#	MGMT INDICES	For1	For2	For3	PS1	PS2	PS3	MS1	MS2	MS3	Sun1	Sun2	Sun3
1	% canopy cover (0.0=100%, 1.0=0%)	0.04	0.03	0.09	0.31	0.19	0.13	0.63	0.26	0.23	0.75	0.76	0.63
2	Tree species richness (0.0=16 spp., 1.0=0species)	0.13	0.53	0.16	0.72	0.5	0.78	0.88	0.88	0.88	0.91	0.94	0.97
3	Tree density (0.0=48 trees, 1.0=0 trees)	0.27	0.58	0.08	0.64	0.303	0.818	0.71	0.83	0.85	0.97	0.97	0.97
7	Percentage dominance (0.0=20.2%; 1.0=100%)	0	0.18	0.11	0.27	0.19	0.54	0.86	0.77	0.75	0.97	0.98	1
9	Vertical Heterogeneity (H')(0.0=1.59; 1.0=0.6)	0.11	0.19	0.09	0.37	0.23	0.09	0.38	0.24	0.3	0.73	0.98	0.9
10	Number of coffee bushes (0.0=0 bushes, 1.0=77 bushes	N/A	N/A	N/A	0.47	0.29	0.65	0.51	0.55	0.75	0.77	0.86	0.93
11	Average coffee height (m) (0.0=2.7m, 1.35=1.0)	N/A	N/A	N/A	0.51	0.15	0.15	0.4	0.08	0.4	0.71	0.71	0.99
12	Average number of logs (0.0=6 logs, 1.0=0 logs)	0.21	0.15	0.25	0.44	0.29	0.14	0.62	0.62	0.81	0.86	0.78	0.97

Table 3. Standardized values for the variables included in the Management Index for each of the coffee farms and forests patches, according to Mas and Dietsch protocol (2003). The real values for most intensive condition (1) and least intensive condition (0.0) are shown in parenthesis in the first column, numbers in the first column refer to the variable numbers in Table 2. N/A: not applicable and treated as zero in the management index.

are then added together such that the number of variables included in the study constitute the maximum value possible reached by the MI. Thus, Mas and Dietsch's (2003) index ranges from 0.0 to a possible high of seven, since they used seven variables for their index.

Different variables were treated somewhat differently in the management index following Mas and Dietsch's (2003) protocol. For example, with variables such as tree species richness, which is assumed to decrease as intensification increases, the 0.0 value was based on the tree species richness for the richest circle in the richest forest. The assumption is that the expected tree species richness could vary depending on the native forest type present in the region. Therefore in this study, for each farm, the proportion of the average tree species richness with respect to the richest forest (Table 2) was calculated and then subtracted from 1.0, so that a higher value would reflect a higher intensification (e.g., the number of tree species in the second circle of F1 forest was 16 species). This procedure was used to obtain the following standardized values: tree species richness; tree abundance; number of logs; percentage canopy cover (assuming 100% is 0.0 value); and percentage trees with epiphytes.

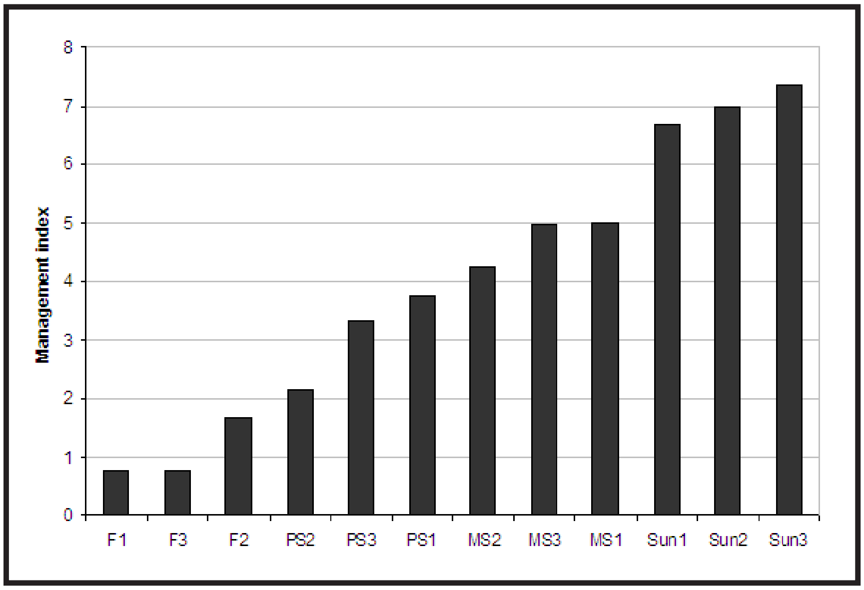


Figure 1. Total management index in each of the 12 farms, considering all of the habitat variables measured. The index may vary from 0.0 (least intense) to eight (most intense management). Since the Management Index value applies for the farm, and not for each circle, no error bars are presented.

Proportion of the relative difference was used to calculate the standardized values (Mas and Dietsch 2003) for six additional variables: percentage dominance of one tree species in the plantation, average tree height, average diameter of logs on soil, average coffee bush height, vertical heterogeneity, and live trees dbh. For example, for the average tree height, 1.0 was based on the circle with the lowest average tree height on the assumption that more intensive management includes regular pruning that produces a lower average tree height. The 0.0 value for average tree height (ATH) was based on the point with the overall highest value which was assumed to be the least intensive condition. The ATH value for each point was calculated as the proportion of overall lowest value, then subtracted from 1.0 (Index Value = 1-[point ATH – low ATH]/ [high ATH – low ATH]). For this study, the lowest ATH was three and the highest was 10.65m. This quantification procedure amplifies the range of variation of the index since a lower limit (above zero) is defined, so the standardized values for each variable determined in this way are relative to the Apía region. The standardized value management index for variables such as logged tree bases and number of coffee bushes was calculated as the proportion relative to the highest value found in any of the 26 circles. These two variables are assumed to increase with management intensification.

Summarizing, 14 variables were measured in all of the farms at Apía (Table 2), but only eight (Table 3, for reasons presented in the discussion section) were actually used to calculate the management index for each farm. Standardized values for all of the variables were calculated at the farm level, and not at the circle level.

Results

Most of the 14 habitat or vegetation variables exhibited increasing or decreasing trends throughout the intensification gradient of coffee agriculture (Tables 2, 3; Figures 1, 4), with the exception of five: percentage of trees with epiphytes, tree height, dbh of live trees, diameter of fallen logs, and number of logged trees. The five variables that did not show a clear trend were withdrawn from the total management index values (Table 3).

For further clarity, the variables were grouped into three strata or vertical levels: arboreal (variables #1-8); coffee bushes (variables #9-11); and soil (variables #12-14) (numbers in parenthesis refer to those variables numbers in Table 2). For the arboreal level, those habitat variables that visually impact an observer showed a gradual change along the gradient of agricultural intensification (Figure 2). For the coffee and soil levels, changes were frequently more obvious in the Sun coffee plantations than in the shaded ones (Figures 3 and 4). The "coffee bush" level variables showed that the density of coffee plants significantly increased in the Sun coffee plantations, while the vertical heterogeneity and coffee bush height decreased (Figure 3). The apparent contradiction between the trend of these last two variables is explained because bushes are smaller in Sun coffee, and thus have less altitudinal categories accounting for an increasing vertical heterogeneity. The average number of logs, the only soil-level variable that showed significant differences, also decreased gradually across the gradient (Figure 4).

The overall tree species richness across all the studied farms through the inventory was 71 species (Appendix A). Tree species richness values per circle were sometimes similar between Forests and Polygeneric Shaded coffee plantations (Table 2), although the identity of the trees was frequently different (Appendix A).

A cluster analysis incorporating the complete set of variables measured in the study (14 variables, Table 2) indicated two groups of farms separated by the highest distance (Figure 5). A first cluster contains all Sun and Monogeneric Shade, and both of these management systems are further separated into two groups. A second cluster involves the Forests and Polygeneric Shaded farms, but they are not separated further into discrete groups as happened in the first cluster. Principal component analysis's output (Figure 6) revealed that the first two principal components accounted for 69.25% and 23.78% of the total variance respectively, and in total for 93.03%. Variables such as tree species richness, tree density and percentage of trees with epiphytes were important for the first factor, while percentage dominance of one tree and the number of coffee bushes were important for the second factor.

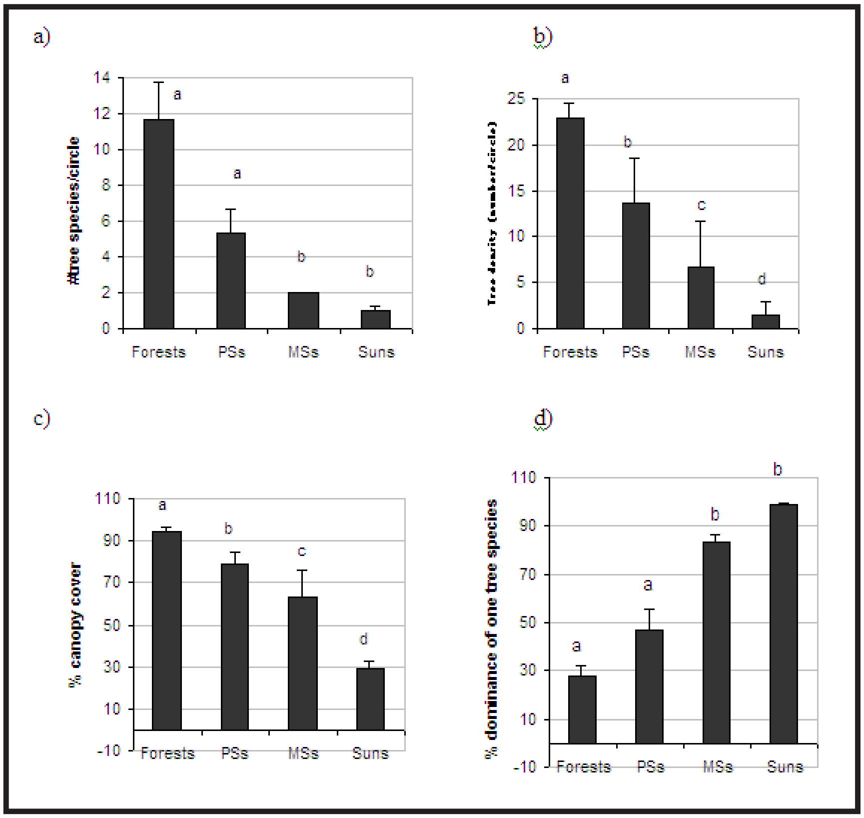


Figure 2. Means and standard errors of three habitat variables at the "tree" level. Number of trees (a); tree density or number of individual trees in 452m2 (b); percentage of canopy cover (or shade) (c); and percentage dominance of one tree species (proportion of individuals of the most abundant tree species by 100) (d). Plantains were the most abundant in sun coffee plantations. Forests (positive control) are the least managed systems in the coffee landscape. Bars labeled with different letters were statistically different at the 0.05 or lower level of significance.

Discussion

The results from this study showed that a qualitative classification of 12 farms into four management systems overall matched the quantitative analyses derived from 14 quantified habitat variables and the management index (Figure 1). The visual perception of management impact on the coffee farms is obvious at first glance. The qualitative classification in this study was based upon conspicuous arboreal characteristics within each farm, such as the overall appearance of the shade trees in terms of richness, density and level of shade. The information from farmers was a second important criterion to decide *a priori* classification of the farms. Cluster analysis and principal component analysis were consistent to the qualitative classification, uncovering the definition of discrete groups of farms according to the management intensification and the *a priori* classification, but most important, showing the similarities between Forest and Polygeneric Shaded coffee (Figures 5 and 6). The principal component analysis technique captures most of the variability of the system and the type of variation captured by the first principal component (PC) strongly dominates all other types of variation. My interpretation is that the first PC (responsible for 69% of the total variance) was driven by the arboreal component of the habitat variables. This interpretation is supported by the high loadings (>0.83) of the first PC in both Forests and Polygeneric Shade, while these loadings were extremely low in Suns (0.08-0.013) and in Monogeneric Shades (0.27-0.57) (Figure 6). The second PC probably captured most of the variability generated by soil and coffee bush vegetation variables, with extremely high loadings in Suns (0.96-0.98). These results suggest that other studies comparing coffee farms of contrasting management systems or shade levels classified qualitatively are reliable at the broad scale even without reporting habitat measurements (e.g., Borrero 1986; Ibarra-Núñez and García-Ballinas 1998; Ricketts et al. 2001; Rojas et al. 2001).

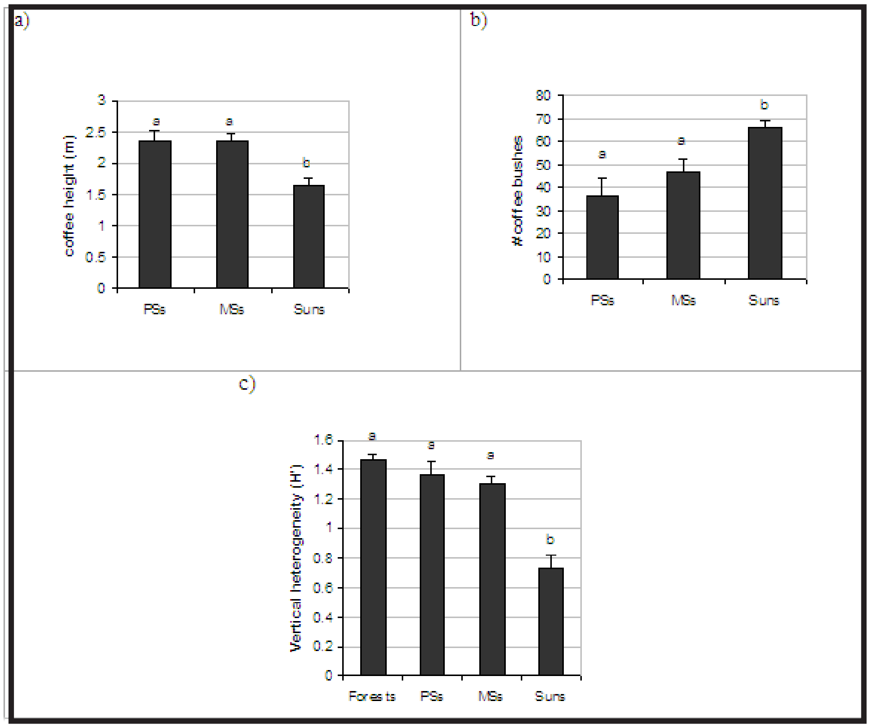


Figure 3. Means and standard errors of three habitat variables at the "coffee bush" level. Coffee height (a); density of coffee bushes in $78.5m^2$ (b); vertical heterogeneity (Shannon Index H') (c). Means labeled with different letters were statistically different at the 0.05 or lower level of significance.

The trends found in this study along the intensification gradient are consistent with changes found in the habitat by other studies. For example, the forest patches in Mas and Dietsch (2003) in Chiapas, Mexico were slightly richer in terms of tree species than the forest patches included in this study at Apía (12.9 and 11.67 tree species, respectively, in equivalent areas) and the same trend was found within the rustic coffee plantations of Chiapas, as compared to the Polygeneric Shaded coffee plantations of Apía (average 6.65 and 5.3 tree species respectively). Trees were taller (9.14m and 7.15m) but thinner (10.2 and 21.85cm dbh) in Chiapas than in Apía. In another study in Mexico, Soto-Pinto et al. (2002) reported an average tree height of 7.6m in shaded coffee plantations of Chilon, Mexico, which is consistent with the heights observed at Apía in this study (7.15m). Nevertheless, trees in Colombian plantations of Apía trees provided similar shade (canopy cover 78.9%) than the rustic plantations in Mas and Dietsch's study (73.3% average). However, canopy cover was unexpectedly lower in Soto-Pinto et al.'s (2002) traditional coffee plantations (46.6%) possibly because most of the trees in these coffee farms were planted fruit trees. The canopy cover measures in the intensified shaded system in this study were similar to both the values found by Mas and Dietsch (2003) (36.16%), and by Ambrecht and Perfecto (2003) (35%) (Figure 2). Armbrecht and Perfecto conducted their study in a different year in the same farms used by Mas and Dietsch, but despite the high dynamic (pruning) management in shaded coffee plantations, the values obtained in the two independent studies were extremely similar. In the present study, plantains (*Musa* x *paradisiaca* L.) planted in a barrier fashion provided 28.8% canopy cover in Sun coffee plantations. Canopy cover deserves special attention because it is likely to be influencing biological activities through physiological responses of the associated biota inside the farms (e.g., Kaspari and Weiser 2000).

Tree density found in this study is also consistent to Soto-Pinto et al. (2000): 463 shade trees/ha in traditional shaded coffee plantations of Chilon (Mexico) *versus* up to 508 trees/ha in the Polygeneric Shaded coffee plantations in this study (Table 2). The comparative discussion here points out that a categorical (subjective) classification is consistent with results obtained from direct measurements in coffee plantations of different countries and different studies. These results provide a basis for further reliable studies synthesizing information or making comparative analyses in literature reviews, and also for reliability of scientific assessment for Shade Coffee certification programs.

Although this study suggested overall consistency in habitat changes along the gradient of intensification of coffee production and across similar studies, it also showed some inconsistencies. Variables such as average tree height and percent epiphytes did not change the same way in Colombia as reported by Mas and Dietsch (2003) and two explanations are offered here. The first explanation is that the energy that the farmer invests in pruning can be directed differently depending on the type and age of the shade tree. For example, trees were thicker, smaller and provided more than double canopy cover in Monogeneric Shades planted with *Inga* spp. as compared to those planted with *Cordia allidora* (76% vs 37%) (Table 2). *C. allidora* is pruned laterally to stimulate straight vertical growth since its wood is highly valuable in the market and an additional source of income for farmers. A second possible explanation is that the percentage of

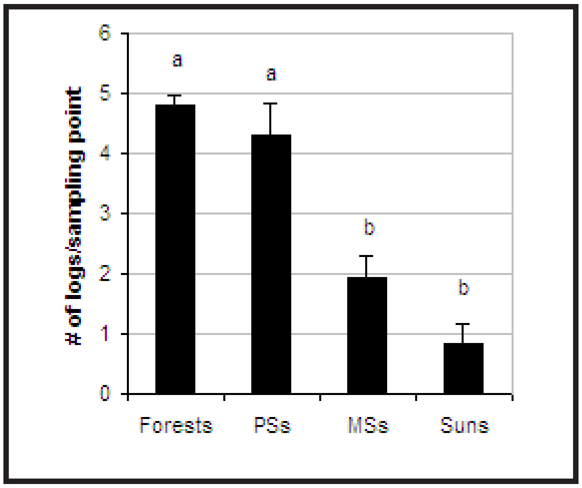


Figure 4. Means and standard error of one variable at the "soil level": number of logs per sampling point or $4m^2$ area. Errors are shown at the top of each bar and bars with different letters were statistically different at the 0.05 level.

trees with epiphytes was strongly influenced by the number of trees existing in the plantations. If there is only one isolated tree in Sun coffee and it happens to have an epiphyte it would represent 100%, therefore I propose the use of raw number of epiphytes instead (variable 5, Table 2). It is remarkable that none of the Monogeneric Shaded coffee farms contributed many epiphytes in the system as compared to the Polygeneric Shaded farms. The

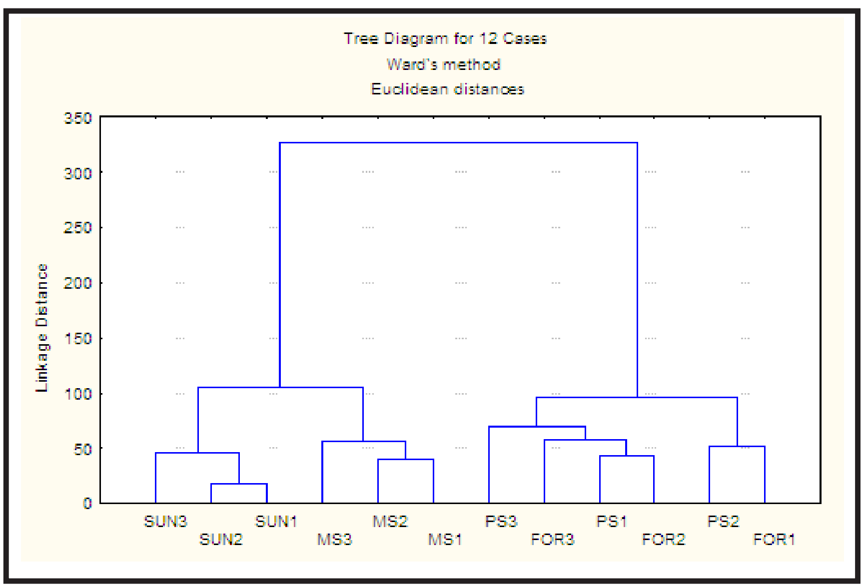


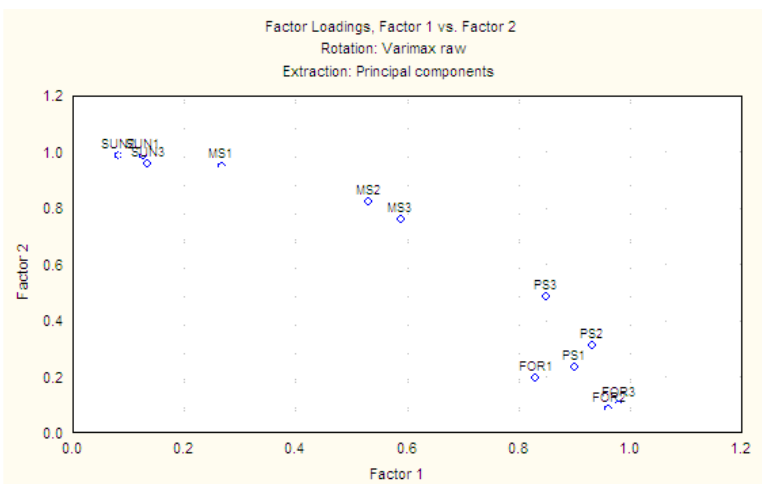
Figure 5. Cluster analysis output with data from all habitat variables. Ward's method for linkage and Euclidian distances were used in the analysis.

density of trees in Polygeneric Shaded coffee plantations doubled that in Monogeneric Shaded farms, but there were 54 times as many epiphytes (Table 2), a fact that cannot be easily explained as a sampling effect. The reason for this "overpopulation" of epiphytes could be related to epiphyte metapopulation dynamics as well as to the presence of seed dispersers related in turn to the diversity of "supporting" trees (Vandermeer and Carvajal 2001). Tree diameter at breast height (dbh) was also surprisingly higher in all shaded coffee systems than in forests (Table 2). This result is likely a consequence of tree age distribution in the successional process that takes place in these forests. The number of logged trees was unexpectedly high in one of the Polygeneric Shaded coffee plantations (Table 2) and this measurement suggests that this was a much more shaded and diverse rustic plantation before its conversion into organic production for coffee exportation.

Results from this study strongly suggest the importance of taking into account the "arboreal" stratum variables for the management index, since almost all of them were significantly different among management types (Figure 2, Table 2). Most importantly, the means of all arboreal variables for Polygeneric and Monogeneric Shaded coffee plantations in Figure 2 were significantly different, with a clear intensification gradient that distinguishes these two types of shaded coffee farms (Figure 1). These results confirm the great importance of providing a quantitative basis in the certification of shade grown coffee (e.g., Rainforest Alliance or Conservation International).

Several general conclusions emerged from this study. A high correspondence was detected between the initial qualitative classification and the results of quantifying habitat variables of 12 farms along an increasing gradient of Colombian coffee production. This high concordance was mainly a consequence of the presence, diversity and structure of the arboreal vegetation in the farms (first component PCA Figure 6). Most of the changes in vegetation variables detected in this study were consistent with other studies in coffee plantations (Soto-Pinto et al.2000; Armbrecht and Perfecto 2003; Mas and Dietsch 2003). Finally, Mas and Dietsch's management index proved to be useful in describing the intensification of coffee production.

The implications of this study are of high relevance to a recent debate regarding shaded coffee certification and conservation programs (e.g., http://www.eco-labels.org/home.cfm). Questions have been recently raised about the real benefits of promoting shade-grown coffee among consumers as valuable for conservation of biodiversity if no distinction is made regarding differently shaded coffee plantations (Rappole et al. 2003). If such a distinction needs to be made, this study provides an additional step toward this goal.



Extraction: Principal components				
		% total	Cumul.	Cumul.
	Eigenval	Variance	Eigenval	%
1	8.31041	69.25344	8.31041	69.25344
2	2.85423	23.78528	11.16465	93.03873

Figure 6. Principal component analysis output plot considering the variables involved in the calculation of the Management Index. The codes refer to the management systems and the farms. FOR: Forests; PS: Polygeneric Shaded coffee plantations; MS: Monogeneric Shaded coffee plantations; SUN: sun coffee plantations.

Appendix A. Identities of trees species at each of the 12 coffee farms studied at Apía, Risaralda. Farms codes are: F: Forests; P: Polygeneric Shaded coffee; M: Monogeneric Shaded coffee; S: Sun coffee (codes and farm names are in Table 1). Last right column refers to total individuals.

SCIENTIFIC NAME	F1	F2	F3	P1	P2	P3	M1	M2	M3	S1	S2	S3
Acacia melanoxylon R. Br.							1					
Acalypha macrostachya Jacquin		1										
Aegiphila mollis Moldenke												
Albizzia carbonaria Britton					1	1						
Alchornea glandulosa Endlicher & Poepp.			18	1								
A. grandiflora Muell. Arg.			2									
Allophylus occidentalis (Sw.) Radlk.		4	3									
Andira inermis (W. Wright) Kunth						1						
Boehmeria caudata Swartz		1										
Cecropia angustifolia Trecul			1	1								
Cedrela odorata L.			1		3	1				1		
Citrus sinensis L.		2			2					1	1	
Cordia acuta Pittier	1											
C. alliodora (R. et P.) Cham.			2				16					
Coussapoa villosa Poep. & Endlicher			3		1							
Cupania cinerea P. et. E.						1						
Duranta mutisii L. f.	1											
Erythrina rubrinervia Kunth												
Eucaliptus globulus						1						
Euphorbia neriifolia Linneaus	1											
Ficus andicola Standley					1							
F. glabrata Kunth			1									
Fraxinus chinensis Roxburgh									1			
Gliricidia sepium (Jacq.) Steud.					2							
Guadua angustifolia Kunth												
Guettarda sabiceoides Standley	1											
Heliconia griggsiana L. B. Smith			1									
Heliocarpus popayanensis Kunth	2											
Hyeronima scabrida (Tul.) Muell-Arg.	2											
Inga aff. *densiflora* Benth.					1							
I. densiflora Benth.			3	6	4							
I. edulis Mart.				4	5	7		9	8			
I. marginata (Vahl.) Willd.		3										
I. oerstediana Bentham	4											
Juglans neotropica Diels						1						
Lafoensia punicifolia DC.												
Leucaena leucocephala (Lam.) De Wit						1						
Macrocnemum roseum (Ruiz & Pavón) Weddell					2							
Mangifera indica L.						1						
Miconia caudata (Bonpl.) de Candolle					2						1	
Montanoa quadrangularis Schultz Bip.	10		10									
Musa x acuminata L.		1										
M. x balbisiana L.		1	4									
M. x paradisiaca L.		1		10	21	2	1	2		1		3
Myriocarpa stipitata Bentham		11										
Myrsine coriacea (Sw.) R. Brown	1		6									
Nectandra lineatifolia (R. & P.) Mez	4											
Ocotea smithiana O.C. Schmidt	1											
Ormosia colombiana Rudd.						1						
Palicourea acetosoides Wernham	8											
P. angustifolia Kunth	1											
P. ovalis Standley	2											
Persea americana Miller				2		2						
P. coerulea (R. & P.) Mez												
Poulsenia armata (Miq.) Standley												
Prunus integrifolia (C. Presl) Walp.			2									
Psidium guajava Linnaeus					1							
Samanea saman (Jacq.) Merrill						1						
Saurauia cuatrecasana R. E. Schultes	16											
Senna spectabilis (DC.) Irwin & Barneby var. spectabilis												
Siparuna aspera (R. & P.) A. DC.	1											
Solanum aphydodendron S. Knapp			1									
S. wrighti Bentham						1						
Tabebuia chrysantha (Jacq.) Nicholson									1			
Tetrorchidium rubrivenium Poepp. & Endlicher			1		1							
Toxicodendron striatum (Ruiz & Pavón) Kuntze	14		2									
Trema micrantha L.	2	1			1							
Trichantera gigantea (H. et B.) Nees					5							
Urera caracasana (Jacq.) Griseb.		6				1						
Verbesina arborea Kunth	5		1									
Viburnum cornifolium Killip & Smith	2											
Zanthoxylum rhoifolium Lam			1									
Number of individuals	79	32	63	24	53	23	18	11	10	3	2	3
# of species	20	11	19	6	16	15	3	2	3	3	2	1

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Can the Food Dollar Support Conservation?

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Abstract
Modern, industrial agriculture has undermined biological diversity at all levels – genetic diversity, viability of populations and species, as well as ecosystems and their services. Agriculture is the primary cause of habitat destruction and transformation worldwide. The impacts of the industrial food system on species, ecosystems, farmers, and rural communities provide the mandate for conservationists to support sustainable alternatives in agriculture. Five examples are presented of ecologically-informed farming or ranching: (1) shaded coffee farms in tropical forests, (2) non-lethal control of large livestock predators, (3) rotational grazing and restoration of riparian habitat, (4) farming with natural floodplain cycles, and (5) modeling the farm on native vegetation. The ecological-farming movement is protecting native biodiversity while providing rural livelihoods. In supporting this movement, conservationists are supporting their own interests.

Pueden los Dolares Invertidos en Comida Apoyar la Conservación?

Resumen

La agricultura industrial a decimado la diversidad biológica a todos los niveles- diversidad genética, viabilidad de poblaciones y especies, así como también los ecosistemas y los servicios que éstos prestan. La agricultura es la principal causa de la destrucción y transformación de habitats a nivel mundial. El impacto del sistema alimentario industrial en especies, ecosistemas, agricultores y comunidades rurales debe convencer a los conservacionistas a apoyar alternativas sustentables en la agricultura. En este artículo se presentan cinco ejemplos de prácticas agropecuarias basadas en conocimiento ecológico: (1) plantaciones de café de sombra en bosque tropical, (2) control no letal de depredadores de ganado, (3) pastoreo rotacional y restauración de habitats en rios, (4) cultivo de acuerdo a ciclos de inundación naturales y (5) parcelas establecidas en base a vegetación nativa. El movimiento ecológico en las áreas de cultivo protege la biodiversidad, al mismo tiempo que provee un modo de vida en comunidades rurales. Al apoyar este movimiento los conservacionistas están apoyando sus propios intereses.

Peut la Dollar Nourriture Assister à la Conservation?

Résumé

L'agriculture industrielle moderne a miné la diversité biologique à tous les niveaux: diversité génétique, viabilité des populations et espèces, aussi bien que des écosystèmes et leurs services. L'agriculture est la cause primaire de la destruction et de la transformation des habitats dans le monde entier. Les impactes du système industriel de nourriture sur les espèces, les écosystèmes, les fermiers, et les communautés rurales fournissent le mandat pour que les conservationistes soutiennent des alternatives agricoles durables. Cinq exemples de la cultivation ou de l'élevage écosensibles sont présentés; (1) fermes de café d'ombre dans les forêts tropicales; (2) contrôle non-mortelle de grands prédateurs de bétail; (3) pâturage rotationelle et restauration des habitats riveraines; (4) cultivation dans des plaines d'inondation avec des cycles normaux; et (5) modeler la ferme sur la végétation indigène. Le mouvement cultivateur-écologique protège la biodiversité indigène tout en fournissant des occupations rurales. En soutenant ce mouvement, les conservationistes soutiennent leurs propres intérêts.

Introduction

At the margins of conservation and agriculture is a movement involving conservation practitioners, academic ecologists, and sustainable farmers and ranchers at its core. Beyond the center lies a web of community gardeners, slow-food advocates, farmers-rights organizations, permaculturists, anti-globalization activists, and cultural-survival groups. Those active in this movement seek to enlarge, encourage, and reward the overlapping domains of conserving native biodiversity and producing food sustainably. The movement has a worldwide presence, since the problems facing farmers and conservationists are acute globally and often occur on the same lands. No single name or organization claims this movement. Aldo Leopold called ecologically-informed farming "biotic farming" (Flader and Callicott 1991). Today, agroecologists use the term "ecological farming" (Jackson and Jackson 2002). Wendell Berry (2002) offers "agrarianism" as a way of thought and practice based on the land. The newly-established Wild Farm Alliance (www.wildfarmalliance.org), gathering representatives of this movement in the United States, uses "farming with the wild" to express the alliance between advocates of wildlands and sustainable agriculture (Imhoff 2003). The movement's focus is expansion of the role of agricultural lands in preserving biodiversity at all levels, while providing viable livelihoods for farmers and ranchers. All participants recognize that healthy ecosystems and landscape-wide ecosystem services are as critical to agriculture as they are to wildlife conservation (Badgley in press).

Aldo Leopold referred to agricultural lands as "working landscapes." In his vision of the land ethic in practice, farming and ranching were as essential to conservation as to subsistence. Leopold understood that native biodiversity contributes in many ways to the health of working landscapes, and that farms and ranches must be a central part of conservation strategies. He wrote, "It is the individual farmer who must weave the greater part of the rug on which America stands" (Flader and Callicott 1991, p. 260). Thus, argued Leopold, conservationists must support sustainable forms of agriculture: "Conservation is our attempt to put human ecology on a permanent footing" (Flader and Callicott 1991, p. 298).

Why is Agriculture Critical to Conservation?

Many ecologists and evolutionary biologists argue that the early phase of a mass extinction of global biodiversity is underway (Pimm and Brooks 1997). Assessments of the causes of extinction and endangerment of species and ecosystems list habitat destruction as the foremost cause (e.g., World Conservation Union, Stein et al. 2000). The primary human activity behind habitat destruction is agriculture: current estimates for the amount of land involved in agriculture (cropland and pasture) range from ~1/3 to ~1/2 of the earth's ecologically productive land area (Wackernagel and Rees 1995; Vitousek et al. 1997). The dominant form of modern agriculture, industrial agriculture, has had ruinous impacts on biological diversity at all levels — genetic diversity, viability of populations and species, and ecosystems and ecological services (Kimbrell 2002). Industrial agriculture has narrowed the genetic diversity of cultivated plants and animals and has often replaced locally adapted crop and livestock varieties with more genetically uniform stocks. The enlargement of farms, along with elimination of shelter belts and woodlots, has endangered hundreds of local populations of plants and animals. Industrial methods of tillage and monoculture plantings have caused widespread erosion and degradation of soils. Excessive applications of fertilizers and the proliferation of synthetic pesticides have stunted the native soil biota and poisoned hundreds of streams, wetlands, and wells. The world's dead zones at sea are largely the consequence of agricultural runoff. Withdrawals of freshwater for irrigation have dried out downstream rivers and riparian areas, eliminating habitats for aquatic plants and animals and altering local climates. Dams have impeded the natural migrations of fish and altered water temperatures upstream and downstream. Factory farming of livestock animals has led to increased routine use of antibiotics, contributing to the evolution of antibiotic resistance. Many species introductions have occurred via agriculture, both intentionally and unintentionally. In most of the world's biodiversity hotspots, agricultural activities are continuing to reduce the viability of native species and ecosystems.

In the face of such a dire indictment of the consequences of modern agriculture, it is easy to conclude that farming and ranching are the enemy of conservation. In fact, both agribusiness executives and some conservationists support further industrial intensification of food production, including the widespread adoption of transgenic crops, so as to produce more food on less land, thereby making more land available for wildlife (Jackson 2002b). This approach would divide rural lands into "ecological sacrifice zones" and protected areas. But in both theory and practice, this is an impossible strategy. The land areas needed for food production would still be immense. They would become even less permeable than they are now to wide-ranging species. The impacts on non-target species and habitats would intensify, and the requirement for synthetic inputs would remain high. Moreover, global warming is predicted to change most local climates, leading to range shifts of many species and areas optimal for agriculture.

Ironically, the industrialization of agriculture during the twentieth century has neither fed the human population adequately nor provided a reliable livelihood for most of the world's farmers (Kimbrell 2002). While more than enough calories are produced annually to feed every person well, about one-fifth of the world's population is chronically undernourished because of poverty and political oppression (Lappé et al. 1998). Farmers are squeezed economically between the rising costs of agricultural inputs and declining prices for food, owing to the overproduction of the major agricultural commodities. As a result, small family farms have steadily declined over several decades in the United States, leading to the collapse of many rural communities. Free-trade policies have permitted artificially cheap food commodities in developed countries to flood the markets of developing countries, causing the local prices to drop, with ruinous consequences for peasant farmers around the world (International Forum on Globalization 2002). The recent rebellion of developing nations at the September 2003 meeting of the World Trade Organization arose over this practice.

These economic pressures on farmers also have harmful consequences for biodiversity. When farmers either quit or become bankrupt, farms are sold either to neighboring farms or to developers. Increase in farm size leads to expanded application of industrial practices, while development transforms farmland into suburban or industrial uses. Both outcomes represent further loss of habitats for native species. Most farmers and conservationists face common enemies — the abuses of land and local economies resulting from the corporate control of food production, the alliances between corporations and government policies, and the influences of corporations on international trade policies (Korten 2001). The "wild farming" movement has arisen in opposition to these forces.

The Conservation Benefits of Farming with Nature

Fortunately, for farmers, consumers, and conservationists, alternatives to industrial agriculture are numerous and increasing (Pretty, 2002). A wide range of farming and ranching practices supports high levels of native biodiversity. These include intercropping, cover cropping, no-till, biological control of pests, pasture-feeding of livestock, non-lethal control of vertebrate predators, as well as maintenance of patches of native habitat on farms and ranches. Such methods may qualify as organic, biodynamic, or low-input production. Most of these practices have direct benefits for conservation. Five examples illustrate this point.

(1) Shaded coffee farms in Latin America. In tropical countries of four continents, coffee is grown as an export crop in areas considered "megadiverse" by Conservation International (Perfecto and Ambrecht 2002). The indigenous method of coffee production is to raise coffee shrubs under a forest canopy of either planted or native forest (shaded coffee). The modern, intensive method of coffee production involves a monoculture of coffee shrubs in full sun, managed with synthetic fertilizers and pesticides (sun coffee). Shaded coffee farms house high numbers of native arthropods and vertebrates. In addition, these farms provide erosion control on mountain slopes, carbon sequestration, and dispersal routes for native species between patches of undisturbed forest. Most animal groups studied thus far show lower species richness and more uniform distribution in sun-coffee monocultures. In some parts of Latin America, shade-coffee farms provide most of the remaining forest habitat. For example, El Salvador has lost more than 90% of its original forests, and 80% of its remaining forests are shade-coffee farms. However, coffee yields are lower in shaded coffee farms, so these farmers face greater financial risk, especially now with the global decline in coffee prices. In this example, shade-coffee farms are critical to the persistence of native biodiversity in hotspot regions where economic pressures to clear forests are high.

(2) Predator control with guard animals. One of the long-term casualties of livestock production has been wide-ranging vertebrate predators, such as the wolf, grizzly, cougar, and some birds of prey. These species have been the targets of predator-control programs for over a century in many parts of the world. Consequently, these species are absent or rare over much of their former geographic ranges. Populations of mesopredators, including foxes, skunks, and raccoons, have increased resulting in more intensive predation upon ground-nesting birds and mammals. Populations of wild ungulates have also increased to the point that they are considered pests in many rural and urban areas. Programs to reintroduce wolves and grizzlies have been vigorously opposed by most ranchers. But some ranchers with an ecological vision have supported the restoration of these native predators. These ranchers guard their livestock with animals, including llamas, burros, and guard dogs (Weed 1999, see figure 1). A special certification program provides the ranchers to sell meat, hides, and wool as "predator-friendly." The ranchers have assumed the risk of living with large predators in order to receive premium prices for their livestock and to promote the top-down ecological effects of large native carnivores on the larger ecosystem.

Figure 1. Cyrus the llama stands guard over the sheep at Thirteen Mile Ranch, Belgrade, Montana. Photograph courtesy of Becky Weed and William Campbell.

(3) Rotational grazing and restoration of riparian habitat. The pasturing of livestock is notorious as a cause of overgrazing and destruction of riparian areas, especially in naturally arid and semi-arid landscapes. These effects

may occur even when stocking rates are within recommended limits. Overgrazing results in increased soil erosion, loss of native plants and extirpation of aquatic species from degraded streams and ponds (Wuerthner and Matteson 2002). Rotational grazing involves confining the livestock herd to small areas at any one time and switching the location of the grazing area as often as every few days. The result is that the pasture is more evenly grazed for a much shorter fraction of the year. The forage remains healthier, fewer weeds are present, the ground is covered, and riparian areas are protected. Water quality improves and native fishes and aquatic insects may return to the streams. DeVore (2002) describes the transformation of the pastures, stream quality, and farmers themselves as a group of them converted from conventional to rotational grazing in southeastern Minnesota.

(4) Farming with floodplain cycles. Many of the world's floodplains are dominated by agriculture. Often the rivers are highly managed by dams, canals, and diversion routes that suppress the seasonal flood cycle. In parts of the Central Valley of California, heavily modified for intensive agricultural production, farmers and conservationists have collaborated to restore flooding in winter fields to support migratory waterfowl as well as aquatic insects and fishes. The California Nature Conservancy's Cosumnes River Preserve includes both fully protected areas, active farms purchased by The Nature Conservancy, and privately owned farms with conservation easements (Imhoff 2003). Some of the farms have adapted their cultivation of rice, corn, and vegetables to the flood cycle, and utilize the winter floods to provide habitat for the seasonal aquatic biota. Waterfowl and fishes eat crop residue and insects, while adding fertility to the fields for the next growing season.

(5) Modeling the farm after the native vegetation. One of the important themes in the sustainable-agriculture movement of the last two decades is "farming in nature's image" (Soule and Piper 1992). This phrase refers to designing the farm or ranch to model the structure and ecological interactions of the native ecosystem. While many indigenous farmers are experts at this practice, it is being rediscovered in the lands of industrial monocultures. The domestic prairies of The Land Institute in Salina, Kansas, are experimental agroecosystems based on the hardiness and resilience of native prairie vegetation (Soule and Piper 1992). Mixtures of warm-season grasses, cool-season grasses, legumes, and composites are designed to maintain soil fertility, resist diseases and pests, and provide grains, oil-seeds, and livestock forage. This long-term experiment under the leadership of Wes Jackson is providing an ecological model for grain-based agriculture (see www.landinstitute.org). In a different biome, a visionary farmer and educator Paul Gallimore has created a "food forest" at the Long Branch Environmental Education Center in the Appalachian uplands of North Carolina, located within one of the premier biodiversity hotspots of the United States (Imhoff 2003). Designed to mimic the eastern deciduous forest, the farm contains hundreds of fruit and nut trees, including a grove of nut-bearing American chestnut hybrids. Interspersed with the orchards are a few acres of open land devoted to perennial and annual crops and a trout pond. The farm provides vegetables, fruits, nuts, fish, herbs, firewood, and construction wood. In both examples, the farm relies heavily on perennials grown in mixtures—which minimize soil erosion and take advantage of mutualistic as well as competitive ecological interactions.

In these examples, the ecologically beneficial farming methods rely on and promote the ecological services of healthy ecosystems. These are not just isolated examples either. Recent books that feature ecological farming (e.g., Joannides et al. 2001, Jackson and Jackson 2002b, Pretty 2002, Imhoff 2003) present similar examples in many agricultural regions of the world, includ-

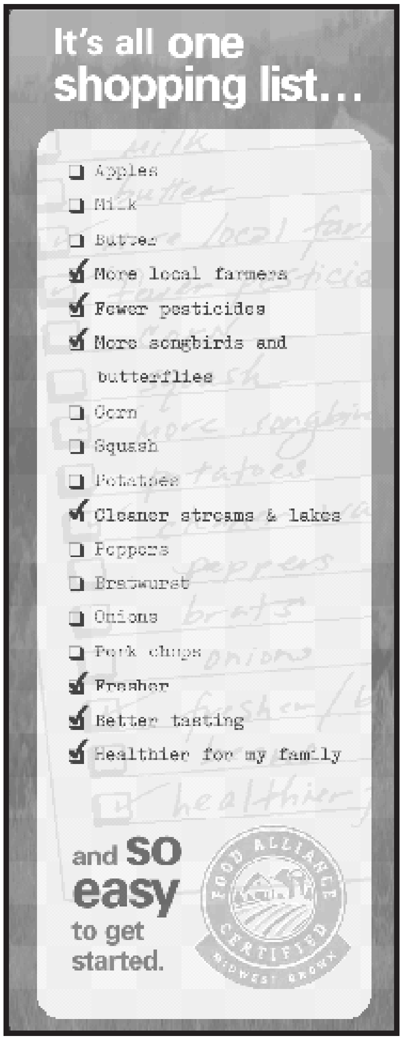

Figure 2. Part of a brochure advocating purchase of local, environmentally friendly, and socially responsible farms in the upper Midwest. Produced by the Land Stewardship Project. (www.landstewardshipproject.org).

ing hotspots of biodiversity. These farming practices share an increase in biodiversity (often with native species), within the agroecosystem, substitution of ecological interactions for chemical inputs, and attention to the impacts of the farm at the landscape level. Many of these ecological farms have an educational mission as well.

How Conservationists Can Support Sustainable Agriculture

Changes needed in the food system to support more biodiversity in rural landscapes require consumers to understand the impacts of the industrial food system on species, ecosystems, and rural communities and to support the alternatives. Despite the growth in popularity of organically-grown food, farmers markets, and community-supported agriculture in the last 20 years, most small-scale farmers engaged in these efforts struggle for economic viability. At the same time, large food corporations are moving into the organic market on an industrial scale (Pollan 2001). Support of farmers and ranchers who practice with an ecological view of the land must come not only from individual consumers but also from politically active movements, including environmental groups. Dana Jackson of the Land Stewardship Project in Minnesota argues persuasively that wildlands advocates and conservation organizations should lead the social demand for sustainable food and sustainable agriculture. "The message about buying food produced by sustainable methods could become just as pervasive as the message about recycling if consistently and repeatedly communicated through magazines, newsletters, web sites, and meetings" (Jackson 2002a, p. 258-259; see figure 2). Conservation organizations can quicken the pace of cultural change in food purchasing and eating habits to promote ecologically sensitive, regional food systems and can advocate changes in the agricultural policies that prop up the industrial food system to the disadvantage of consumers and ecosystems alike.

Biodiversity-friendly agriculture has the potential to reverse much of the ecological degradation that has occurred in the name of progress in agriculture. The ecological farming movement, or farming with the wild, is protecting native biodiversity and ecosystem services, while providing livelihoods and reviving rural cultures. In supporting this movement, conservationists are supporting their own interests.

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Opinion

Conservation Biology and the Need of a Different Ecological Framework for Agriculture

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Abstract

The application of ecological principles is fundamental in the design of agricultural practices aimed to protect the natural environment and conserve biodiversity. Central to current ecological frameworks for agriculture is the agroecosystem concept. A great deal of progress in our ecological understanding of agricultural systems has been achieved using such framework. However, if we are going to further our understanding of agriculture dynamics in the context of landscapes or watersheds, it is necessary to use a different paradigm. The implications of considering patch dynamics theory as the base of a new ecological framework for agriculture are briefly discussed.

La Biología de la Conservación y la Necesidad de un Marco Ecológico Diferente para la Agricultura

Resumen

La aplicación de principios ecológicos es fundamental en el diseño de prácticas agrícolas encaminadas a proteger el medio ambiente natural y conservar la biodiversidad. Central en varios de los marcos de referencia ecológicos que existen para la agricultura es el concepto de agroecosistema. Un gran progreso se ha logrado en nuestro entendimiento ecológico de sistemas agrícolas utilizando dicho marco de referencia. Sin embargo, si hemos de avanzar nuestro entendimiento ecológico de la dinámica de la agricultura dentro del contexto de paisajes o cuencas hidrológicas, es necesario usar un paradigma diferente. Las implicaciones de considerar la teoría de la dinámica de parches como la base de un nuevo marco de referencia ecológico se discuten brevemente.

La Biologie de Conservation et le Besoin d'un Cadre Ecologique Différent pour l'Agriculture

Résumé

L'application des principes écologiques est fondamentale dans la conception des pratiques agricoles visées à protéger l'environnement naturel et conserver la biodiversité. Le concept d'agroécosystème est central aux cadres écologiques courants pour l'agriculture. Beaucoup de progrès dans notre compréhension écologique des systèmes agricoles a été réalisé en utilisant de tels cadres. Cependant, si nous allons améliorer autre notre compréhension de la dynamique d'agriculture dans le contexte des paysages ou des bassins hydrographiques, il est nécessaire d'employer un paradigme différent. Les implications de considérer la théorie des dynamiques spatiales comme base d'un nouveau cadre écologique pour l'agriculture sont brièvement discutées.

Conciliating the needs of other species with the needs of our society is one of the major challenges in the management of human-dominated landscapes. This requires us to increase our understanding of how ecological systems work and to find ways to apply ecological principles in the design of managed systems. Agriculture during the second half of the last century was a prime example of how the lack of ecological understanding can be very detrimental. Intensive and highly mechanized agricultural practices negatively affected soil, water bodies, and wildlife. Ultimately, negative effects were felt on agriculture itself (i.e. pesticide resistance, reduction of soil quality). To alleviate these problems, it became necessary to develop and implement ecologically based agricultural practices. Fundamental in this process was the view of farms as ecosystems (agroecosystems), a paradigm aimed at reestablishing in the farm processes such as energy flow, biogeochemical cycles, and trophic interactions in accordance with ecological principles observed in natural systems. A lot of progress has been achieved in our understanding of agricultural ecology, however, to move forward, we need to realize that agricultural systems are intrinsically different from natural ecosystems. The gradients of disturbance observed in agricultural systems and their interactions with their surrounding landscape suggest that it is time to change our current ecological framework that considers farms as ecosystems.

Different succession stages in a forest ecosystem (Photograph Manuel Colunga-Garcia).

For an agricultural field to exist, the original vegetation had to be removed at some time. This removal of the vegetation has a name in ecology: disturbance. Ecologists (and weed scientists) have long recognized this fact, but somehow, they have not followed up on its ramifications. Basically, this means that when studying agricultural fields, we are dealing with disturbed patches rather than with ecosystems. The dynamics of a disturbance patch is a known and common phenomenon in natural ecosystems. Periodically, landscapes are affected by disturbances such as flood, fire, insects, and diseases, creating disturbed patches. Disturbance processes are then followed by recovery processes where the vegetation is usually restored. Agriculture is a special case of disturbance in which patches (agricultural fields) are chronically disturbed and recovery processes are not allowed to take place until those fields are abandoned. Therefore, patch dynamics theory should provide a better ecological framework for agriculture by considering agricultural fields as disturbance patches.

What are the implications of using patch dynamics theory in our understanding of agricultural ecology? First, the role of ecologists in the development of sustainable agriculture practices will become crucial. It is clear that if agriculture is a disturbance, then the phrase "sustainable disturbance" does not make much sense. Ecologists will help to focus the discussion on the sustainability of the place (the landscape) rather than on the sustainability of the activity (agriculture). It is the structure and function of the landscape that should be sustainable and the target of ecologically based agricultural practices.

Second, the idea of what a good agricultural practice consists of will be clarified. All types of agriculture disturb the landscape, however, some practices cause more disturbance than others. Thus we should aim for agricultural practices that minimize the impact of that disturbance.

Third, the need for a regional analysis of agriculture will become evident. Disturbance patches at different stages of recovery are normal sights in natural landscapes. However, if we have too many patches under chronic disturbance we may end up with a disturbed landscape. Disturbed landscapes may begin in turn to impact larger and larger regions (e.g., watersheds) in a hierarchical fashion. Therefore, we need to understand the consequences of having entire landscapes or watersheds under cultivation (i.e. disturbance). The corn-belt in the U.S., for instance, is constituted of watersheds largely covered by cropland. We need to evaluate the function of landscapes and watersheds and assess how agricultural practices have altered such functions.

Fourth, a framework will be established for scientists in other areas of ecology to bring their expertise in the study of the management of agricultural systems. Landscape and restoration ecologists that study the processes conducive to the recovery of disturbed patches would help to address challenging issues in agricultural ecology. For instance, they could address the question of how to disturb constantly the landscape/watershed while at the same time minimizing the negative impact on their function. Land abandonment models may become common tools to assess the current status of the landscape/watershed, by helping to address the question of what would come out if agriculture ceased in a given area… a forest, a shrubland, or a desert type of vegetation. The resulting vegetation would give an indication of the degree of stress that the landscape is currently under.

Fifth, patch dynamics theory will facilitate the study of landscape or watershed level interactions between agricultural and urban systems. The relationship between agriculture, disturbance, and watershed function has been described above. Additionally, the establishment (and subsequent metabolism) of cities has likely impacted the function of landscapes and watersheds. In regions where the dominant land use types are cropland and build-up, the potential synergism between the disturbance caused by agricultural systems and urban systems needs to be investigated.

Most discussions about agriculture and conservation of species deal primarily with the need to provide refuges for organisms (almost as a concession to them). This is in part due to an underlying assumption that we are substituting one system (forest, grassland) with other (agricultural field), and thus we are just replacing groups of species with new ones. Thus, anything that we can do to preserve as many species as we can of the original system is a gain. We need to appreciate that agriculture is disturbing a landscape or watershed whose function depends on the organisms it contains. Minimizing such disturbance requires more than just leaving some patches of uncultivated habitats. It requires a thorough understanding of the function of a landscape/watershed, an assessment on how agriculture would interfere with such function, and how best to design farming systems (i.e. configuration, type, etc) to minimize their impact.

The agroecosystem concept appears to bring a sense of naturalness to agriculture and also seems to make humans an integral part of the system. Some may argue that agriculture transforms, rather than disturbs, landscapes. I argue that given our current ecological knowledge, the disturbance paradigm should prevail until we decide whether we - as humans - disturb or transform our environment. This will take some time since ecology is still an evolving discipline that has yet to figure out what to do with humans.

Conservation in the Human Landscape

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Abstract

Much of our conservation efforts have focused on preservation of wilderness to the detriment of our ability to see the need for conservation efforts in our more human dominated landscapes, the places we work, farm, and live. Agricultural landscapes comprise nearly 46% of total land area. Isolated islands of conserved ecosystems cannot meet our conservation goals if surrounded by biological deserts of industrial agriculture. There must be a shift in how conservationists and the public view the value of conservation in agricultural and other human influenced landscapes. There is also a need for a shift in the agricultural community among both farmers and researchers from viewing farming as an industrial process to understanding and managing agroecosystems as complex living biotic systems. Collaboration between conservationists, ecologist, agronomists, and farmers is necessary in order to create sustainable agroecosystems that protect biodiversity and provide connectivity to other conserved lands. Our efforts to protect biodiversity and ecosystems cannot succeed without increased conservation efforts in working rural landscapes.

Conservación en el Paisaje Humano

Resumen
Una gran parte de los esfuerzos de conservación se han enfocado a la preservación de lugares silvestres en perjuicio de nuestra habilidad para entender la necesidad de conservar paisajes con un componente humano importante, esto es, los lugares en los que trabajamos, cultivamos la tierra y vivimos. Los paisajes agrícolas abarcan cerca del 46% del área total de tierra existente. Islas aisladas de ecosistemas protegidos no cumplirán nuestras metas de conservación si se encuentran rodeados por los desiertos biológicos de la agricultura industrial. Debe existir un cambio en cómo los medio ambientalistas y el público en general perciben el valor de conservar tierras agrícolas y otros paisajes con influencia humana. Existe también la necesidad de un cambio en la comunidad agrícola, desde productores hasta investigadores, de dejar de ver el cultivo de la tierra como un proceso industrial y manejar los agroecosistemas como sistemas biológicos complejos. Es necesaria la colaboración entre medio ambientalistas, ecológos, agrónomos y agricultores para poder crear agroecosistemas sustentables que protejan la biodiversidad y provean conectividad con otras áreas naturales protegidas. Nuestros esfuerzos en proteger la biodiversidad y los ecosistemas no pueden ser exitosos sin un incremento en los esfuerzos por conservar el paisaje rural.

Conservation Dans le Paysage Humain

Résumé
Beaucoup de nos efforts de conservation se sont concentrés sur la conservation de régions sauvages au détriment de notre capacité de voir le besoin d'efforts de conservation dans nos paysages humains, les endroits où nous travaillons, cultivons, et vivent. Les paysages agricoles comportent presque 46% du secteur total de terre. Les écosystèmes conservés qui sont des îles isolés ne peuvent pas réalizer nos buts de conservation s'ils sont entouré par les déserts biologiques de l'agriculture industrielle. Il doit y avoir un changement dans la façon dont les conservationnistes et la publique considérent la valeur de la conservation dans paysages agricoles et humains. Il y a également un besoin d'un changement dans la communauté agricole parmi les fermiers et des chercheurs qui considérent la cultivation comme processus industriel pour la compréhension et gestion des systèmes agro-écologiques en tant que systèmes biotiques vivants et complexes. La collaboration entre les conservationnistes, les écologistes, les agronomes, et les fermiers est nécessaire afin de créer les systèmes agro-écologiques durables qui protègent la biodiversité et fournissent la connectivité à d'autres terres conservées. Nos efforts de protéger la biodiversité et les écosystèmes ne peuvent pas réussir sans une augmentation des efforts de conservation dans les paysages travaillés dans les régions ruraux.

Ninety five percent of the land on this planet is under human management with just under 10% in protected areas (Western and Pearl 1989; Pimentel et. al. 1992; World Conservation Monitoring Centre 2000). Fifty five percent of the world's major protected areas (29% in terms total hectares) occur in landscapes where agriculture is also practiced. Agriculture occupies more than 30% of the land cover in 17% of protected land area (Sebastian 2001). Nearly 46% of total global land area is in some type of agricultural management. This management ranges from intensive grain, livestock and vegetable production (e.g. the central valley of California, Midwest United States, and Europe), to extensive grazing (e.g. Western US, Central Asia, and South America), and traditional polyculture-agroforestry systems (e.g. some traditional systems in Latin America) (Wood, Sebastian, and Scherr 2000; McNeely and Scherr 2003). It is clear that if we wish to conserve biodiversity and ecosystems, we must realize the value and necessity of increasing conservation efforts and sustainable farming practices in agricultural landscapes.

There is a damaging perspective in much of the conservation community that views agricultural and other human dominated landscapes as sacrificial land of no conservation interest. According to this view, one also popular amongst environmentalists, our conservation/preservation efforts should be concentrated on protecting "wild" or "natural" places, "untouched" or "unspoiled" by human influence. Most importantly, this concept of wilderness conservation shapes our interactions with all other landscapes. This conception furthers the false mental construct that humans are separate from the environment and the ecosystem processes that sustain us and all the other inhabitants of this planet. It defines "nature" as without human presence or influence and allows us to conceive of "nature" as separate from ourselves and in turn facilitates our mismanagement and destruction of the ecosystems in which we farm, work, and live. The continued prevalence of this belief will lead to the failure of our isolated conservation efforts and of the ecosystems on which we depend for our survival.

Conservation biology has shown that isolated populations or habitat patches experience increased extinction rates. Isolated areas of wilderness cannot function for conservation when surrounded by biological deserts of industrial agriculture. Likewise, agricultural production cannot be sustained using production techniques that ignore the fact that the agroecosystem is just that, an ecosystem, dependant on complex biological interactions, and not an industrial manufacturing process. More and more ecologists, agronomists, conservationists, and farmers are coming to realize the interdependence of agriculture and conservation. Research continues to be conducted on the effect of landscape diversity and connectivity in agricultural areas on conservation of biodiversity, and ecosystem functions, as well as conservation of biological control agents for agricultural pests. (See *The conservation of beneficial arthropods in agricultural landscapes* by E. Silva in this issue.)

In the U.S., organizations like the Land Institute, Rodale Institute, Association of Temperate Agroforestry, and several university researchers are working towards furthering the research necessary to create diverse sustainable agricultural systems are able to produce food and fiber while preserving ecosystem functions and serving conservation goals. The Natural Resources Conservation Service (NRCS), a branch of the United States Department of Agriculture, conducts research and provides free technical assistance for creation and implementation of conservation plans by private landowners and farmers. These types of efforts need more intellectual and financial support in order to impact the necessary changes in agriculture and conservation. In the immediate term, the sustainability of agriculture and its conservation benefits could be increased by implementing NRCS promoted practices such as filter strips, field borders, cover crops, windbreaks/hedgerows, and agroforestry on a mass scale in combination with collaborative regional land-use and landscape planning. Currently, implementation of such practices is voluntary. Therefore, there is a great need for increased education amongst farmers, landowners, and conservationists about the benefits of these practices in order to increase their use and impact.

The 2002 farm bill provides cost shares on implementation of conservation practices to farmers through programs such as CRP (conservation reserve program), WRP (wetland reserve program), EQIP (environmental quality incentive program), WHIP (wildlife habitat incentive program), and CSP (conservation security program). These programs incorporate incentives for use of native plant species, restoration of rare or diminishing ecosystems, protection of air and water resources, increased landscape connectivity, wildlife habitat creation, and habitat provisions for threatened or endangered species. These types of programs and payments need to be expanded. Subsidies for conservation and sustainable agriculture practices should replace current production subsidies that ensure overproduction and high levels of associated negative externalities such as soil loss, ground and surface water contamination, air contamination, and habitat and species loss.

We need a shift in how environmentalists, conservationists, and the general public view the relationship between conservation and agriculture. In order for conservation efforts to be successful and sustainable they must work with the human influenced landscape that makes up the vast majority of the land, to make it a more suitable matrix for conservation of biological diversity and connectivity for protected areas. We need to see conservation as necessary not only for wilderness, but for the very places in which we live and derive our sustenance. Creation of sustainable agricultural systems that are based on ecological knowledge and conservation principles is a necessary part of our conservation efforts. This sustainable agriculture must ensure in perpetuity the productivity and ecological health of farmlands, local and global food security, a reasonable economic return to farmers, and vitality of rural communities, while fostering and protecting ecosystems for a great diversity of biota, including humans. It is imperative that we see the inextricable link between conservation and sustainable agriculture and manage our human influenced landscapes with the insights of this knowledge. If any of our conservation endeavors are to succeed we need a landscape of functioning diverse ecosystems not just to study or visit, but also in which to live and farm.

For more information on the relationships between agriculture and conservation several recent books have been published: *Ecoagriculture: Strategies to Feed the World and Save Wild Biodiversity*, Island Press 2003; *Farming with the Wild: Enhancing Biodiversity on Farms and Ranches*, Watershed Media 2003; *The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems*, Island Press 2002; *Biodiversity in Agroecosystems*, CRC Press 1999; and Biotic *Diversity in Agroecosystems*, Elsevier 1990.

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Can the Food Dollar Support Conservation?

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Abstract

Modern, industrial agriculture has undermined biological diversity at all levels – genetic diversity, viability of populations and species, as well as ecosystems and their services. Agriculture is the primary cause of habitat destruction and transformation worldwide. The impacts of the industrial food system on species, ecosystems, farmers, and rural communities provide the mandate for conservationists to support sustainable alternatives in agriculture. Five examples are presented of ecologically-informed farming or ranching: (1) shaded coffee farms in tropical forests, (2) non-lethal control of large livestock predators, (3) rotational grazing and restoration of riparian habitat, (4) farming with natural floodplain cycles, and (5) modeling the farm on native vegetation. The ecological-farming movement is protecting native biodiversity while providing rural livelihoods. In supporting this movement, conservationists are supporting their own interests.

Pueden los Dolares Invertidos en Comida Apoyar la Conservación?

Resumen

La agricultura industrial a decimado la diversidad biológica a todos los niveles- diversidad genética, viabilidad de poblaciones y especies, así como también los ecosistemas y los servicios que éstos prestan. La agricultura es la principal causa de la destrucción y transformación de habitats a nivel mundial. El impacto del sistema alimentario industrial en especies, ecosistemas, agricultores y comunidades rurales debe convencer a los conservacionistas a apoyar alternativas sustentables en la agricultura. En este artículo se presentan cinco ejemplos de prácticas agropecuarias basadas en conocimiento ecológico: (1) plantaciones de café de sombra en bosque tropical, (2) control no letal de depredadores de ganado, (3) pastoreo rotacional y restauración de habitats en rios, (4) cultivo de acuerdo a ciclos de inundación naturales y (5) parcelas establecidas en base a vegetación nativa. El movimiento ecológico en las áreas de cultivo protege la biodiversidad, al mismo tiempo que provee un modo de vida en comunidades rurales. Al apoyar este movimiento los conservacionistas están apoyando sus propios intereses.

Peut la Dollar Nourriture Assister à la Conservation?

Résumé

L'agriculture industrielle moderne a miné la diversité biologique à tous les niveaux: diversité génétique, viabilité des populations et espèces, aussi bien que des écosystèmes et leurs services. L'agriculture est la cause primaire de la destruction et de la transformation des habitats dans le monde entier. Les impactes du système industriel de nourriture sur les espèces, les écosystèmes, les fermiers, et les communautés rurales fournissent le mandat pour que les conservationistes soutiennent des alternatives agricoles durables. Cinq exemples de la cultivation ou de l'élevage écosensibles sont présentés; (1) fermes de café d'ombre dans les forêts tropicales; (2) contrôle non-mortelle de grands prédateurs de bétail; (3) pâturage rotationelle et restauration des habitats riveraines; (4) cultivation dans des plaines d'inondation avec des cycles normaux; et (5) modeler la ferme sur la végétation indigène. Le mouvement cultivateur-écologique protège la biodiversité indigène tout en fournissant des occupations rurales. En soutenant ce mouvement, les conservationistes soutiennent leurs propres intérêts.

Introduction

At the margins of conservation and agriculture is a movement involving conservation practitioners, academic ecologists, and sustainable farmers and ranchers at its core. Beyond the center lies a web of community gardeners, slow-food advocates, farmers-rights organizations, permaculturists, anti-globalization activists, and cultural-survival groups. Those active in this movement seek to enlarge, encourage, and reward the overlapping domains of conserving native biodiversity and producing food sustainably. The movement has a worldwide presence, since the problems facing farmers and conservationists are acute globally and often occur on the same lands. No single name or organization claims this movement. Aldo Leopold called ecologically-informed farming "biotic farming" (Flader and Callicott 1991). Today, agroecologists use the term "ecological farming" (Jackson and Jackson 2002). Wendell Berry (2002) offers "agrarianism" as a way of thought and practice based on the land. The newly-established Wild Farm Alliance (www.wildfarmalliance.org), gathering representatives of this movement in the United States, uses "farming with the wild" to express the alliance between advocates of wildlands and sustainable agriculture (Imhoff 2003). The movement's focus is expansion of the role of agricultural lands in preserving biodiversity at all levels, while providing viable livelihoods for farmers and ranchers. All participants recognize that healthy ecosystems and landscape-wide ecosystem services are as critical to agriculture as they are to wildlife conservation (Badgley in press).

Aldo Leopold referred to agricultural lands as "working landscapes." In his vision of the land ethic in practice, farming and ranching were as essential to conservation as to subsistence. Leopold understood that native biodiversity contributes in many ways to the health of working landscapes, and that farms and ranches must be a central part of conservation strategies. He wrote, "It is the individual farmer who must weave the greater part of the rug on which America stands" (Flader and Callicott 1991, p. 260). Thus, argued Leopold, conservationists must support sustainable forms of agriculture: "Conservation is our attempt to put human ecology on a permanent footing" (Flader and Callicott 1991, p. 298).

Why is Agriculture Critical to Conservation?

Many ecologists and evolutionary biologists argue that the early phase of a mass extinction of global biodiversity is underway (Pimm and Brooks 1997). Assessments of the causes of extinction and endangerment of species and ecosystems list habitat destruction as the foremost cause (e.g., World Conservation Union, Stein et al. 2000). The primary human activity behind habitat destruction is agriculture: current estimates for the amount of land involved in agriculture (cropland and pasture) range from ~1/3 to ~1/2 of the earth's ecologically productive land area (Wackernagel and Rees 1995; Vitousek et al. 1997). The dominant form of modern agriculture, industrial agriculture, has had ruinous impacts on biological diversity at all levels — genetic diversity, viability of populations and species, and ecosystems and ecological services (Kimbrell 2002). Industrial agriculture has narrowed the genetic diversity of cultivated plants and animals and has often replaced locally adapted crop and livestock varieties with more genetically uniform stocks. The enlargement of farms, along with elimination of shelter belts and woodlots, has endangered hundreds of local populations of plants and animals. Industrial methods of tillage and monoculture plantings have caused widespread erosion and degradation of soils. Excessive applications of fertilizers and the proliferation of synthetic pesticides have stunted the native soil biota and poisoned hundreds of streams, wetlands, and wells. The world's dead zones at sea are largely the consequence of agricultural runoff. Withdrawals of freshwater for irrigation have dried out downstream rivers and riparian areas, eliminating habitats for aquatic plants and animals and altering local climates. Dams have impeded the natural migrations of fish and altered water temperatures upstream and downstream. Factory farming of livestock animals has led to increased routine use of antibiotics, contributing to the evolution of antibiotic resistance. Many species introductions have occurred via agriculture, both intentionally and unintentionally. In most of the world's biodiversity hotspots, agricultural activities are continuing to reduce the viability of native species and ecosystems.

In the face of such a dire indictment of the consequences of modern agriculture, it is easy to conclude that farming and ranching are the enemy of conservation. In fact, both agribusiness executives and some conservationists support further industrial intensification of food production, including the widespread adoption of transgenic crops, so as to produce more food on less land, thereby making more land available for wildlife (Jackson 2002b). This approach would divide rural lands into "ecological sacrifice zones" and protected areas. But in both theory and practice, this is an impossible strategy. The land areas needed for food production would still be immense. They would become even less permeable than they are now to wide-ranging species. The impacts on non-target species and habitats would intensify, and the requirement for synthetic inputs would remain high. Moreover, global warming is predicted to change most local climates, leading to range shifts of many species and areas optimal for agriculture.

Ironically, the industrialization of agriculture during the twentieth century has neither fed the human population adequately nor provided a reliable livelihood for most of the world's farmers (Kimbrell 2002). While more than enough calories are produced annually to feed every person well, about one-fifth of the world's population is chronically undernourished because of poverty and political oppression (Lappé et al. 1998). Farmers are squeezed economically between the rising costs of agricultural inputs and declining prices for food, owing to the overproduction of the major agricultural commodities. As a result, small family farms have steadily declined over several decades in the United States, leading to the collapse of many rural communities. Free-trade policies have permitted artificially cheap food commodities in developed countries to flood the markets of developing countries, causing the local prices to drop, with ruinous consequences for peasant farmers around the world (International Forum on Globalization 2002). The recent rebellion of developing nations at the September 2003 meeting of the World Trade Organization arose over this practice.

These economic pressures on farmers also have harmful consequences for biodiversity. When farmers either quit or become bankrupt, farms are sold either to neighboring farms or to developers. Increase in farm size leads to expanded application of industrial practices, while development transforms farmland into suburban or industrial uses. Both outcomes represent further loss of habitats for native species. Most farmers and conservationists face common enemies — the abuses of land and local economies resulting from the corporate control of food production, the alliances between corporations and government policies, and the influences of corporations on international trade policies (Korten 2001). The "wild farming" movement has arisen in opposition to these forces.

The Conservation Benefits of Farming with Nature

Fortunately, for farmers, consumers, and conservationists, alternatives to industrial agriculture are numerous and increasing (Pretty, 2002). A wide range of farming and ranching practices supports high levels of native biodiversity. These include intercropping, cover cropping, no-till, biological control of pests, pasture-feeding of livestock, non-lethal control of vertebrate predators, as well as maintenance of patches of native habitat on farms and ranches. Such methods may qualify as organic, biodynamic, or low-input production. Most of these practices have direct benefits for conservation. Five examples illustrate this point.

(1) Shaded coffee farms in Latin America. In tropical countries of four continents, coffee is grown as an export crop in areas considered "megadiverse" by Conservation International (Perfecto and Ambrecht 2002). The indigenous method of coffee production is to raise coffee shrubs under a forest canopy of either planted or native forest (shaded coffee). The modern, intensive method of coffee production involves a monoculture of coffee shrubs in full sun, managed with synthetic fertilizers and pesticides (sun coffee). Shaded coffee farms house high numbers of native arthropods and vertebrates. In addition, these farms provide erosion control on mountain slopes, carbon sequestration, and dispersal routes for native species between patches of undisturbed forest. Most animal groups studied thus far show lower species richness and more uniform distribution in sun-coffee monocultures. In some parts of Latin America, shade-coffee farms provide most of the remaining forest habitat. For example, El Salvador has lost more than 90% of its original forests, and 80% of its remaining forests are shade-coffee farms. However, coffee yields are lower in shaded coffee farms, so these farmers face greater financial risk, especially now with the global decline in coffee prices. In this example, shade-coffee farms are critical to the persistence of native biodiversity in hotspot regions where economic pressures to clear forests are high.

(2) Predator control with guard animals. One of the long-term casualties of livestock production has been wide-ranging vertebrate predators, such as the wolf, grizzly, cougar, and some birds of prey. These species have been the targets of predator-control programs for over a century in many parts of the world. Consequently, these species are absent or rare over much of their former geographic ranges. Populations of mesopredators, including foxes, skunks, and raccoons, have increased resulting in more intensive predation upon ground-nesting birds and mammals. Populations of wild ungulates have also increased to the point that they are considered pests in many rural and urban areas. Programs to reintroduce wolves and grizzlies have been vigorously opposed by most ranchers. But some ranchers with an ecological vision have supported the restoration of these native predators. These ranchers guard their livestock with animals, including llamas, burros, and guard dogs (Weed 1999, see figure 1). A special certification program provides the ranchers to sell meat, hides, and wool as "predator-friendly." The ranchers have assumed the risk of living with large predators in order to receive premium prices for their livestock and to promote the top-down ecological effects of large native carnivores on the larger ecosystem.

Figure 1. Cyrus the llama stands guard over the sheep at Thirteen Mile Ranch, Belgrade, Montana. Photograph courtesy of Becky Weed and William Campbell.

(3) Rotational grazing and restoration of riparian habitat. The pasturing of livestock is notorious as a cause of overgrazing and destruction of riparian areas, especially in naturally arid and semi-arid landscapes. These effects

may occur even when stocking rates are within recommended limits. Overgrazing results in increased soil erosion, loss of native plants and extirpation of aquatic species from degraded streams and ponds (Wuerthner and Matteson 2002). Rotational grazing involves confining the livestock herd to small areas at any one time and switching the location of the grazing area as often as every few days. The result is that the pasture is more evenly grazed for a much shorter fraction of the year. The forage remains healthier, fewer weeds are present, the ground is covered, and riparian areas are protected. Water quality improves and native fishes and aquatic insects may return to the streams. DeVore (2002) describes the transformation of the pastures, stream quality, and farmers themselves as a group of them converted from conventional to rotational grazing in southeastern Minnesota.

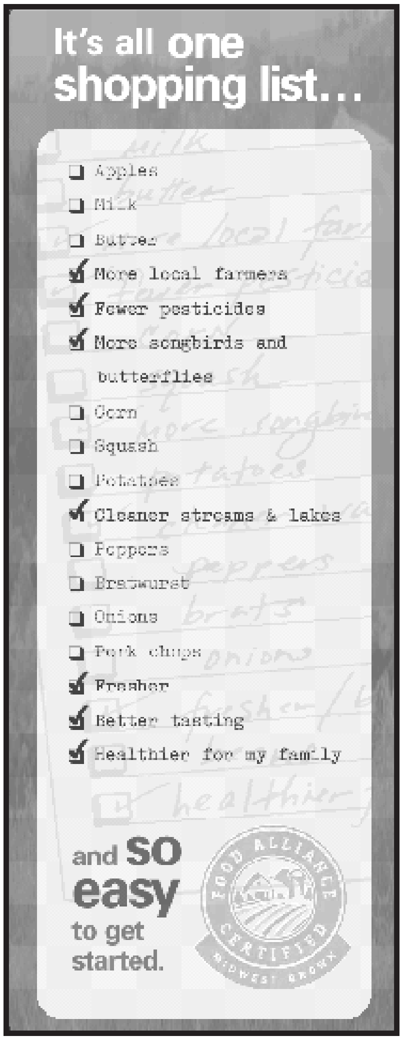

Figure 2. Part of a brochure advocating purchase of local, environmentally friendly, and socially responsible farms in the upper Midwest. Produced by the Land Stewardship Project. (www.landstewardshipproject.org).

(4) Farming with floodplain cycles. Many of the world's floodplains are dominated by agriculture. Often the rivers are highly managed by dams, canals, and diversion routes that suppress the seasonal flood cycle. In parts of the Central Valley of California, heavily modified for intensive agricultural production, farmers and conservationists have collaborated to restore flooding in winter fields to support migratory waterfowl as well as aquatic insects and fishes. The California Nature Conservancy's Cosumnes River Preserve includes both fully protected areas, active farms purchased by The Nature Conservancy, and privately owned farms with conservation easements (Imhoff 2003). Some of the farms have adapted their cultivation of rice, corn, and vegetables to the flood cycle, and utilize the winter floods to provide habitat for the seasonal aquatic biota. Waterfowl and fishes eat crop residue and insects, while adding fertility to the fields for the next growing season.

(5) Modeling the farm after the native vegetation. One of the important themes in the sustainable-agriculture movement of the last two decades is "farming in nature's image" (Soule and Piper 1992). This phrase refers to designing the farm or ranch to model the structure and ecological interactions of the native ecosystem. While many indigenous farmers are experts at this practice, it is being rediscovered in the lands of industrial monocultures. The domestic prairies of The Land Institute in Salina, Kansas, are experimental agroecosystems based on the hardiness and resilience of native prairie vegetation (Soule and Piper 1992). Mixtures of warm-season grasses, cool-season grasses, legumes, and composites are designed to maintain soil fertility, resist diseases and pests, and provide grains, oil-seeds, and livestock forage. This long-term experiment under the leadership of Wes Jackson is providing an ecological model for grain-based agriculture (see www.landinstitute.org). In a different biome, a visionary farmer and educator Paul Gallimore has created a "food forest" at the Long Branch Environmental Education Center in the Appalachian uplands of North Carolina, located within one of the premier biodiversity hotspots of the United States (Imhoff 2003). Designed to mimic the eastern deciduous forest, the farm contains hundreds of fruit and nut trees, including a grove of nut-bearing American chestnut hybrids. Interspersed with the orchards are a few acres of open land devoted to perennial and annual crops and a trout pond. The farm provides vegetables, fruits, nuts, fish, herbs, firewood, and construction wood. In both examples, the farm relies heavily on perennials grown in mixtures—which minimize soil erosion and take advantage of mutualistic as well as competitive ecological interactions.

In these examples, the ecologically beneficial farming methods rely on and promote the ecological services of healthy ecosystems. These are not just isolated examples either. Recent books that feature ecological farming (e.g., Joannides et al. 2001, Jackson and Jackson 2002b, Pretty 2002, Imhoff 2003) present similar examples in many agricultural regions of the world, including hotspots of biodiversity. These farming practices share an increase in biodiversity (often with native species), within the agroecosystem, substitution of ecological interactions for chemical inputs, and attention to the impacts of the farm at the landscape level. Many of these ecological farms have an educational mission as well.

How Conservationists Can Support Sustainable Agriculture

Changes needed in the food system to support more biodiversity in rural landscapes require consumers to understand the impacts of the industrial food system on species, ecosystems, and rural communities and to support the alternatives. Despite the growth in popularity of organically-grown food, farmers markets, and community-supported agriculture in the last 20 years, most small-scale farmers engaged in these efforts struggle for economic viability. At the same time, large food corporations are moving into the organic market on an industrial scale (Pollan 2001). Support of farmers and ranchers who practice with an ecological view of the land must come not only from individual consumers but also from politically active movements, including environmental groups. Dana Jackson of the Land Stewardship Project in Minnesota argues persuasively that wildlands advocates and conservation organizations should lead the social demand for sustainable food and sustainable agriculture. "The message about buying food produced by sustainable methods could become just as pervasive as the message about recycling if consistently and repeatedly communicated through magazines, newsletters, web sites, and meetings" (Jackson 2002a, p. 258-259; see figure 2). Conservation organizations can quicken the pace of cultural change in food purchasing and eating habits to promote ecologically sensitive, regional food systems and can advocate changes in the agricultural policies that prop up the industrial food system to the disadvantage of consumers and ecosystems alike.

Biodiversity-friendly agriculture has the potential to reverse much of the ecological degradation that has occurred in the name of progress in agriculture. The ecological farming movement, or farming with the wild, is protecting native biodiversity and ecosystem services, while providing livelihoods and reviving rural cultures. In supporting this movement, conservationists are supporting their own interests.

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Conservation Biology and Agroecology: *De un Pájaro las dos Alas*[1,2]

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Abstract

One of the strategies used by conservation agencies and governments to curb biodiversity loss has been to establish priority areas where species richness and levels of endemism are high. The strategy to purchase land and protect it has been based primarily on the idea that the conversion to agriculture is the main cause of habitat loss for wildlife and on the assumption that local people and their livelihood practices constitute the most important threat to biodiversity conservation. However, over the last decade, it has become obvious that these efforts to reduce the loss of biodiversity are not working and that the assumptions on which the main conservation efforts are based ignore the role of external factors related to political economy, as well as the vast array of livelihood practices that maintain and even increase biodiversity at the landscape level. In this paper, I propose various reasons to explain the failed strategy. The importance of agriculture for the conservation of biodiversity has three main components: 1) the matrix that surrounds protected areas is composed primarily of a mosaic of agricultural and other managed systems (this means that particularly in a fragmented landscape, migration to and from "natural" habitat fragments must take place within the agricultural matrix), 2) agroecosystems *per se* can be important habitat for wildlife, and 3) human communities inside and outside protected areas engage in productive activities that can not be ignored when the protected area is established. The "problem" with agriculture is not agriculture *per se*, but rather the intensification of agricultural and livestock systems. The major drop in biodiversity occurs with the "intensification" of agriculture, not with its initiation. The main challenge for the new generation of conservationists is to incorporate agriculture and other managed systems as an integral part of conservation policies, and *vice versa*, to integrate biodiversity conservation into the development of agricultural policies. Part of the challenge ahead is the recognition that agroecology and conservation biology are both essential components of an integrated policy and that they are, metaphorically speaking, the two wings of the biodiversity conservation bird.

[1] The subtitle of this article is translated as "Two Wings of a Bird." It is derived from a poem by the Cuban writer José Martí.
[2] This paper is based on a talk given at the XVII Congress of the Sociedad Mesoamericana para la Biología y la Conservación, in Tuxtla Gutierrez, México, November 4-7, 2003.

Biología de la Conservación y Agroecología: *De un Pájaro las dos Alas*[1,2]

Resumen

Una de las estrategias usadas por agencias de conservación y gobiernos para reducir la pérdida de biodiversidad ha sido el establecimiento de áreas prioritarias en las que la riqueza de especies y los niveles de endemismo son altos. La estrategia de comprar tierra y protegerla se ha basado primariamente en la idea de que la conversión agrícola es la principal causa de la pérdida de hábitat para vida silvestre y bajo el supuesto de que las comunidades locales y sus prácticas cotidianas constituyen la más importante amenaza para la conservación de la biodiversidad. Sin embargo, en la última década ha llegado a ser obvio que los esfuerzos para reducir la pérdida de biodiversidad no han sido exitosos y que los supuestos en los cuales los esfuerzos de conservación están basados, ignoran el rol de factores externos relacionados a la política económica, así como también la vasta diversidad de prácticas llevadas a cabo por las comunidades locales que mantienen, y en algunos casos, incrementan la biodiversidad al nivel del paisaje. En este artículo propongo diversas razones para explicar el fracaso de la estrategia para la conservación. La importancia de la agricultura para la conservación de la biodiversidad tiene tres componentes principales: 1) la matriz que rodea las áreas protegidas está compuesta primariamente de un mosaico agrícola y otros sistemas manejados por el hombre (esto significa que, particularmente en un paisaje fragmentado, la migración hacia y desde fragmentos de hábitat "naturales" debe llevarse a cabo en la matriz agrícola), 2) los agroecosistemas *per se* pueden ser hábitats importantes para la vida silvestre, y 3) las comunidades humanas dentro y fuera de las áreas protegidas están involucradas en actividades productivas que no pueden ser ignoradas cuando se establece una área protegida. El "problema" con la agricultura no es la agricultura *per se*, sino más bien la intensificación de los sistemas agrícolas y ganaderos. La mayor pérdida de biodiversidad ocurre con la "intensificación" de la agricultura, no con su inicio. El mayor reto para la nueva generación de medio ambientalistas es incorporar la agricultura y otros sistemas manejados por el hombre como una parte integral de las políticas de conservación y viceversa, integrar la conservación de la biodiversidad en las políticas de desarrollo agrícola. Parte de este reto en el futuro será el reconocimiento de que tanto la agroecología como la biología de la conservación son componentes esenciales de una política integral y que son, metafóricamente hablando, las dos alas del ave de la conservación de la biodiversidad.

[1] El subtítulo de este artículo proviene de un poema del escritor cubano José Martí.

[2] Este artículo está basado en la plática dada en el XVII Congreso de la Sociedad Mesoamericana para la Biología y la Conservación, en Tuxtla Gutiérrez, México, Noviembre 4-7, 2003.

La Biologie de Conservation et Agroécologie: ***De un Pájaro las dos Alas***[1,2]

Résumé

Un des stratégies employées par des agences de conservation et des gouvernements pour limiter la perte de biodiversité est dû à l'établissement des aires prioritaires où la richesse des espèces et les niveaux de l'endémisme sont hauts. La stratégie d'acheter la terre et de la protéger a été basée principalement sur l'idée que la conversion en agriculture est la cause principale de la perte des habitats de la faune et sur la prétention que la peuple locale et leur moyens de subsistance constituent la menace la plus importante à la conservation de biodiversité. Cependant, pendant la dernière décennie il est évident que ces efforts de réduire la perte de biodiversité ne fonctionnent pas et que les prétentions sur lesquelles les efforts principaux de conservation sont basés ignorent le rôle des facteurs externes liés à l'économie politique, aussi bien que le vaste choix des moyens de subsistance qui maintiennent et même augmentent la biodiversité au niveau du paysage. Dans cet article je propose de diverses raisons pour expliquer la stratégie échouée. L'importance de l'agriculture pour la conservation de la biodiversité a quatre composants principaux: 1) la matrice qui entoure les aires protégées se compose principalement d'une mosaïque d'agriculture et d'autres systèmes contrôlés (ceci signifie que la migration entre les paysages fragmentés et les habitats "naturelles" doit avoir lieu dans la matrice agricole); 2) les agroécosystèmes intrinsèquement peuvent être les habitats importants pour la faune; et 3) les communautés humaines dans et hors des aires protégées s'engagent dans les activités productives qui ne peuvent pas être ignorées quand l'aire protégée est établie. Le "problème" avec l'agriculture n'est pas agriculture intrinsèquement, mais plutôt l'intensification des systèmes agricoles et de bétail. La baisse principale dans la biodiversité se produit avec l'intensification de l'agriculture, pas avec son commencement. Le défi principal pour la nouvelle génération des conservationistes est d'incorporer l'agriculture et d'autres systèmes contrôlés comme partie intégrale dans la politique de la conservation, et vice versa, d'intégrer la conservation de biodiversité dans la formulation des politiques agricoles. Ce défi reconnaît que la biologie d'agroécologie et de conservation sont les deux composants essentiels d'une politique intégrée.

[1] Le sous-titre de cet article est traduit comme "Deux ailles d'un oiseau." Il est dérivé de un poem par le cubain José Martí.

[2] Cet article est basé sur un exposé présenté au XVII Congrès du Sociedad Mesoamericana para la Biología y la Conservación, au Tuxtla Gutierrez, Mexique, le 4 - 7 novembre 2003.

The loss of biodiversity became front-page news more than ten years ago at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil. Heads of states of more than 182 nations signed the United Nations Convention on Biological Diversity (UNCED) to confront the crisis. Ten years later, the possibility of mass extinctions without precedence is still front-page news, with little evidence that progress has been made. In 2002, for the anniversary of the UNCED, newscasts at CNN, BBC, and others covered the lack of progress on curbing biodiversity loss. According to a recent survey of 400 scientists commissioned by the American Museum of Natural History, the majority of the nation's biologists are convinced that a "mass extinction" of plants and animals is underway and agree that the loss of biodiversity is one of the most pressing environmental problems facing us in the new millennium (American Museum of Natural History 2003).

One of the strategies used by conservation agencies and governments to curb biodiversity loss has been to establish priority areas where species richness and levels of endemism are high, the so-called "hot spots of biodiversity" (Myers 1988; Cincota and Endelman 2000). The focus within these areas has been to purchase land and set it aside through the establishment of protected areas. The establishment of protected areas is hardly a new concept, with examples of sacred groves and recreational areas established throughout history and in all areas of the world. In India for example, sacred groves were established millennia ago for the protection of wildlife (Gadgil and Ramachandra 1993) and local farming communities in Mexico routinely set aside nature reserves for watershed protection and recreation. However, the first time that a protected area was created by national decree was Yellowstone National Park in 1872 (Merchant 1993). Yellowstone became a model for the establishment of reserves and national parks all over the world. In Brazil, the first protected nature reserve was established in 1911, and the first National Park, in 1930. Since then, 35 national parks, 23 biological reserves and six ecological reserves have been created in Brazil, covering 15 million hectares of land protected at the national level. Similarly, in Mexico, the first National park, Parque Nacional Desierto de los Leones, was established in 1917. During the presidency of Lázaro Cardenas (1934-1940), who's populist development agenda was based partially on conservation of natural resources, 32 national parks were established in Mexico (Simonian 1995). Today, there are 93 protected areas, including more than 50 National Parks, with 11.7 million hectares representing six percent of the land under protection (Simonian 1995; Vargas Marquez 1984). Worldwide, there are approximately 17,000 nature reserves covering nearly ten percent of the earth's land surface, and with the establishment of private reserve, this amount is increasing (McNeely and Scherr 2003; World Conservation Monitoring Center 2000). However, over the last decade, it has become obvious that these efforts to reduce the loss of biodiversity are not working. In this paper, I propose various reasons to explain the failed strategy. Unlike some main stream conservationists, who argue that we need to expand protected areas and protect them by whatever means necessary (Terborgh 1999; Oates 1999), I argue that the failure is precisely because of the strategy of establishing reserves and the particular focus that these efforts have taken.

The Failed Strategy: Creating Nature Reserves

The strategy to purchase land and protect it has been based primarily on the idea that the conversion to agriculture is the main cause of habitat loss for wildlife. The focus of this conservation strategy has been on charismatic megafauna and on so-called "pristine" habitats. Such a focus is unfortunate since it effectively ignores everything outside of the protected areas, including people, their productive systems and all the biodiversity contained within managed ecosystems. Although many conservation organizations have realized this since the mid eighties and have responded with the implementation of so-called Integrated Conservation and Development Projects (ICDP), the assumptions of most ICDP programs have not really deviated from the underlying assumption that local people and their livelihood practices constitute the most important threat to biodiversity conservation (Hughes and Flintan 2001). This assumption ignores the role of external factors related to political economy (such as pressures to pay external debt, construction of roads, and transmigration programs), as well as the vast array of livelihood practices that maintain and even increase biodiversity at the landscape level, to say nothing of recent advances in the science of ecology associated with mechanisms of extinction and metapopulation theory.

The Focus on Charismatic Megafauna

All of us are familiar with the beautiful poster and the campaigns to protect pandas, elephants, gorillas, tigers, jaguars, and other charismatic organisms. If the interest is to conserve the diversity of life on our planet, the focus on mammals and other vertebrates is quite misguided. Based on conservative estimates of actual numbers of species, all the vertebrates on our planet represent only 0.4% of all the diversity of life (Groombridge 1992). Even plants, which were thought to be quite diverse, represent at most 14% of all the described species, with some estimates putting the figure closer to 2.4% (based on the rate of encountering new species). On the other hand, arthropods represent at least 50% of all species, with beetles alone accounting for 25% of all estimated species (Groombridge 1992). The British biologist, J. B. S. Haldane, when asked what he had been able to learn about God during all his years of studying nature, responded, "the creator, if he exists, has an inordinate fondness for beetles."

Recently, in efforts to call attention to the need to protect biodiversity, ecologists have pointed out the link between biodiversity and ecosystem function. Interestingly, few of these studies even mention charismatic fauna, and most point to the role of soil micro and macro organisms, soil ecosystems being the new frontier in biodiversity studies. Recent studies have documented more than 10,000 different types of fungi and bacteria and 100 to 1000 species of invertebrates in one squared meter of soil (Giller et al. 1997; Shaefer and Schauermann 1990; Torsvik et al. 1994).

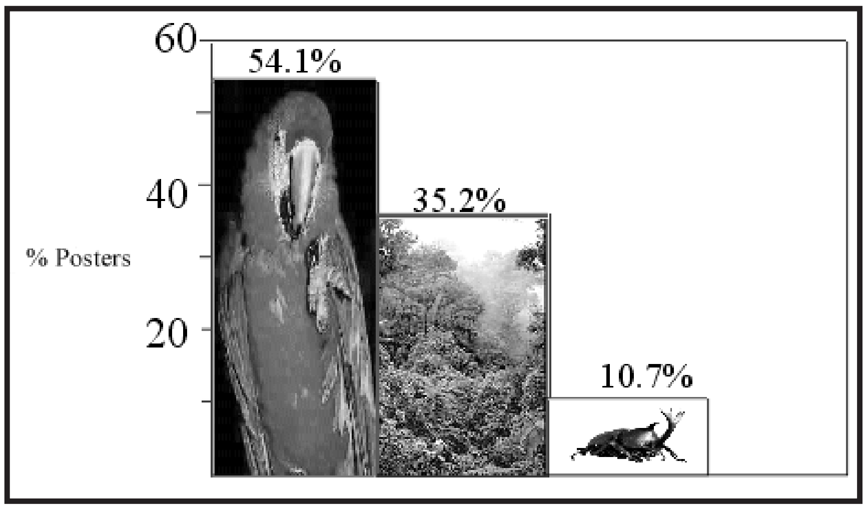

Figure 1. Results of an informal survey of the posters presented at the VII Meetings of the Mesoamerican Association of Biology and Conservation, November, 2003, Tuxtla Gutierrez, Mexico.

A quick tally of the posters presented at the XVII Meetings of the Mesoamerican Society for Biology and Conservation in Tuxtla Gutierrez in November 2003 revealed that the bias toward large charismatic organisms has been transmitted to the new generation of scientist (most of the posters presented were by undergraduate and graduate students from Mexico and Central America.). Out of 159 posters examined, 54.1 % were on vertebrates, mainly mammals and birds; 35.2% were on plants and forest ecosystems, and only 10.7 percent were on invertebrates, mainly insects (Figure 1).

The focus on charismatic organisms has been defended on two fronts. First it is assumed that, since most of these organisms need large areas to maintain viable populations, protecting them will effectively protect everything else that lives in the same area. Second, it is argued that people identify more with these organisms and therefore would support programs for their protection. However, evidence from several studies suggest that these assumptions are not always true. It seems that most large mammal species need areas that are considerably bigger than the areas that are already available (Redford and Robinson 1991; Bierregaard et al. 1992; Armbruster and Lande 1993; Wilkie et al. 2000), suggesting that it is necessary to think of areas far more expansive than current nature preserves. Furthermore, with some exceptions, most of the flagship wildlife does not absolutely require pristine habitat to maintain viable populations. What they need are simply areas where they can find food and shelter and not get shot. On the other hand, there is clear evidence that a focus on "poster species," something charismatic to draw attention when placed on a poster, has been effective politically, regardless of its truth value (the Oak forest at Colonial Point, near Pellston Michigan, was protected based on the proposition that it was a pristine forest, which in fact was false).

Table 1. Percentage of land surface on managed systems (Modified from McNeely and Scheer, 2003).

SYSTEM	PERCENTAGE
Agriculture*	10
Mixed Agriculture**	17
Savannas or Pastures	17.5
Tree plantations	1.4
Urban areas	7
Total	52.9

* Landscapes with at least 60% agriculture.

** Landscapes with a mixture of pastures, forest patches and agriculture, where agriculture represents at least 30%.

Table 1. Percentage of land surface on managed systems (Modified from McNeely and Scheer, 2003).

The Focus on Pristine Ecosystems

We now have considerable evidence that very little, if any, of the wild lands on Earth are pristine. Even in very remote areas of the Amazon, scientists have found evidence of agriculture and human settlements (Roosevelt et al. 1996; Goulding et al. 1996; Heckenberger et al. 2003). It seems that at some point in time since the invention of agriculture 10,000 years ago, humans have occupied almost every corner of our planet. Nevertheless, land conversion to agriculture over the last 100 years has been responsible for the unprecedented loss of forest habitat, and in particular rain forests, where a large percentage of the world's biodiversity is found. This has lead conservation organizations and governments to place most of their resources in the establishment of reserves and protected areas in what are considered "pristine" forests, in attempts to protect what is left of these ecosystems and their biota. Unfortunately, the protection of the "pristine" habitats has been done at the expense of all areas that have already been converted to agriculture or some other managed system, under the false assumption that it is the conversion from natural habitat to managed habitat that is the critical factor in biodiversity loss. As I shall demonstrate below, there is now substantial evidence indicating that this assumption is false in many, if not most, cases.

According to Western and Pearl (1989), 90% of the Earth's land surface is in some sort of managed ecosystem. Although this is an inflated figure that assumes that all lands outside of established reserves have already been transformed somehow, it still points out the fundamental problem of focusing on the so-called "pristine" habitats — we are ignoring a large percentage of the surface of our planet. More conservative estimates based on satellite images revealed that humans actively manage at least half of the Earth's surface and a large percentage of the rest is under some sort of human influence (Table 1). These data alone underscore the importance of incorporating managed ecosystems into our conservation policies (McNeely and Scherr 2003).

The Importance of Agriculture for Biodiversity Conservation

The need to incorporate agriculture into conservation policies has become clear in recent years due, in part, to the failure of many conservation programs that focus exclusively on protecting habitat for wildlife. However, even the attempts to incorporate rural people into conservation efforts (e.g., ICDPs and related structures), have suffered from the perception that agriculture is the main culprit of biodiversity loss (Hughes and Flintan 2001). The importance of agriculture for the conservation of biodiversity has three main components: 1) the matrix that surrounds protected areas is composed primarily of a mosaic of agricultural and other managed systems (this means that particularly in a fragmented landscape, migration to and from "natural" habitat fragments must take place within the agricultural matrix), 2) agroecosystems *per se* can be important habitat for wildlife, and 3) human communities inside and outside protected areas engage in productive activities that can not be ignored when the protected area is established.

The Quality of the Matrix

In the last 20 years, one of the most debated issues in conservation biology has been the size and number of protected areas needed to effectively protect biodiversity, the so-called "SLOSS" (Single Large versus Several Small) debate (Wilkox and Murphy 1985), based on the theory of island biogeography (McArthur and Wilson 1967). The main idea is that the equilibrium number of species on an island (or, by extension, in a habitat fragment) is the result of two processes, extinction and migration. The rate of extinction on an island is related to the size of the island, with larger islands having lower extinction rates, and the migration rate is related to the distance from the mainland, with more distant or isolated island having lower migration rates. This theory was developed for physical islands and assumes that the matrix surrounding the island is inhospitable.

The theory of island biogeography has also been used to explain the loss of species within small isolated nature preserves, which are, of course, habitat islands (Diamond 1975; Whittaker 1998). For example, since its establishment in 1883 the 164-hectare Bukit Timah Nature Preserve in Singapore has lost 50% of the tree species that were present when the reserve was established. This is not surprising, since the reserve is small and is completely isolated and surrounded by Singapore's urban center. In this case, the quality of the matrix within which the nature preserve is embedded is very poor.

Extinctions have not only occurred in small reserves but also in large national parks. A study of 14 North America national parks revealed that extinctions have occurred in all except the largest National Parks (Newark 1995). Although some of the reported extinctions could have resulted from invasive species out competing native ones, the quality of the matrix within which these parks are embedded may also be implicated. If a protected area is embedded within a matrix of industrial agriculture or other inhospitable habitat, the rate of migration will be greatly reduced, and, according to the elementary theory of island biogeography, generate a level of extinction commensurate with that lowered migration rate.

An alternative to the theory of island biogeography that has been applied to fragmented habitats is the concept of metapopulations (Levins 1969; Hanski and Simberloff 1997). In a fragmented habitat, populations may be maintained as metapopulations, which is to say, subpopulations within fragments may go extinct but are recolonized from other fragments, thus providing for the entire collection of subpopulations (which is the "metapopulation") to persist even though each of them periodically goes extinct. The role of migration in preventing permanent extinction is evident in both of these theoretical formulations. What has been lacking from these theories and the empirical studies that have followed is the incorporation of the quality of the matrix in determining the rate of migration (Perfecto and Vandermeer 2002; Vandermeer and Carvajal 2001).

In the tropics, most of the remaining forests are highly fragmented (Laurence and Bierregaard 1997). The ability of these patches of forests to maintain biodiversity will depend to a great extent on the quality of the matrix within which they are embedded. For example, in the Sarapiqui area of Costa Rica, the La Selva Biological Reserve is surrounded by a number of forest patches scattered throughout the landscape. However, the matrix that surrounds those patches is frequently composed of tens of thousands of hectares of banana plantations or pastures (Figure 2a). The low quality matrix could reduce or even halt migration of certain organisms from patch to patch, dooming them to extinction within patches. On the other hand, when the matrix is of sufficient quality for migration to occur, local extinctions could be prevented. For example, in the Soconusco area of Mexico, El Triunfo Biosphere Reserve is embedded within a matrix of shaded coffee plantations (Figure 2b). Many smaller patches of forests have been maintained in areas that are too difficult to convert to coffee cultivation. The ability of these smaller patches to maintain forest species depend on the ability of organisms to migrate from patch to patch or from the large reserve to the smaller patches. The shaded coffee plantations provide a high quality matrix through which forest organisms can move (Perfecto and Vandermeer 2002). However, if these plantations are technified and converted to sun coffee (Figure 2c), the migration of some organisms would likely be reduced or halted and local extinctions could occur.

Figure 2a. Different types of agricultural matrices: Banana plantation in Costa Rica

In summary, the quality of the matrix matters! With a low-quality matrix, rates of migration will be low and species extinction is more likely to occur within fragments, even large ones. The factors that determine the quality of the matrix are going to be different for different groups of organisms. However, some educated guesses can be made. For example, for frugivorous forest bird species, a diverse canopy cover that provides fruits will be important. Agroforestry systems that contain diverse fruit trees could represent a matrix of enough quality to allow migration. Our studies in coffee plantations in Chiapas, Mexico, demonstrate that for ground-foraging ant species, a diverse plantation with more than 50% shade cover represented a high quality matrix while a less diverse shade with less than 20% shade cover was a low-quality matrix. These and other studies strongly suggest that the agroecological matrix should be an essential component of any conservation program design to conserve biodiversity.

Agroecosystems as Habitat for Biodiversity

When we talk about agroecosystems we are referring to a very broad range of agricultural systems and practices all of which have differential impact on biodiversity. A large monoculture of wheat with intensive use of agrochemicals and heavy machinery will have less biodiversity than a mosaic of small diverse organic farms (Vandermeer et al. 1998). Some managed ecosystems, and in particular some tropical agroeforestry systems, have been found to contain very high levels of biodiversity, sometimes comparable to adjacent undisturbed natural systems (Pimentel et al. 1992).

The importance of agricultural landscapes for biodiversity conservation has received significant attention in Europe, where most ecosystems have been altered and transformed to manage systems for millennia. In spite of the fact that agricultural landscapes are the dominant landscapes in Western Europe, the continent has experienced low levels of extinction and most biodiversity seems to have adapted to managed systems. In the UK, where more than 70% of the land surface is farmed, farmland conservation has become one of the main strategies for the conservation of wildlife (DEFRA 2002). However, as traditional farming practices and extensive livestock husbandry are transformed to more intensive systems or are abandoned, these important farmland habitats are disappearing, threatening many species. In the UK, several species of birds are threatened because of the loss of farmland (Gregory et al. 2002), while pesticides have been implicated in the reduction of the populations of others (Campbell and Cooke 1997). According to "Working with the Grain of Nature: A Biodiversity Strategy for England," the main concerns for biodiversity associated with agriculture are related to "the abandonment of traditional practices and the intensification of agriculture" (DEFRA 2002).

In Spain, the dehesa grazing system contain 30% of the vascular plants found in the entire Iberian Peninsula (Pineda and Montalvo 1995), and 135 species have been reported in a 0.1 hectare plot in a dehesa in Andalucia (Marañon 1985). In addition, there are a number of vulnerable and rare bird species whose population viability depends entirely in the structural integrity if this grazing system. However, this system is changing from a pastoral system to a ranching economy threatening the long-term stability of the system and the wild biodiversity that has been maintained for hundreds of years of traditional management (Plieninger and Wilbrand 2001).

In the neotropics an extensive literature has accumulated on the role of diverse shaded coffee and cacao plantations for biodiversity conservation (Perfecto et al. 1996; Moguel and Toledo 1999). However, as in Europe, these traditional systems are being transformed to more intensive farms where the diversity and density of shade is reduced or eliminated altogether (Figure 1c), with dramatic impact on biodiversity (Perfecto et al. 1996; Perfecto and Armbrecht 2003).

It is obvious that the "problem" with agriculture is not agriculture *per se*, but rather the intensification of agricultural and livestock systems, specifically the intensification that results from the specialization in a few species and varieties of crops and animals, and the substitution of biological processes with agrochemicals. From a variety of studies, it is now evident that the assumption that the main drop in biodiversity occurs at the moment of transformation of the non-managed system to a managed one is false. In a variety of well-substantiated cases the major drop in biodiversity occurs with the intensification of agriculture, not

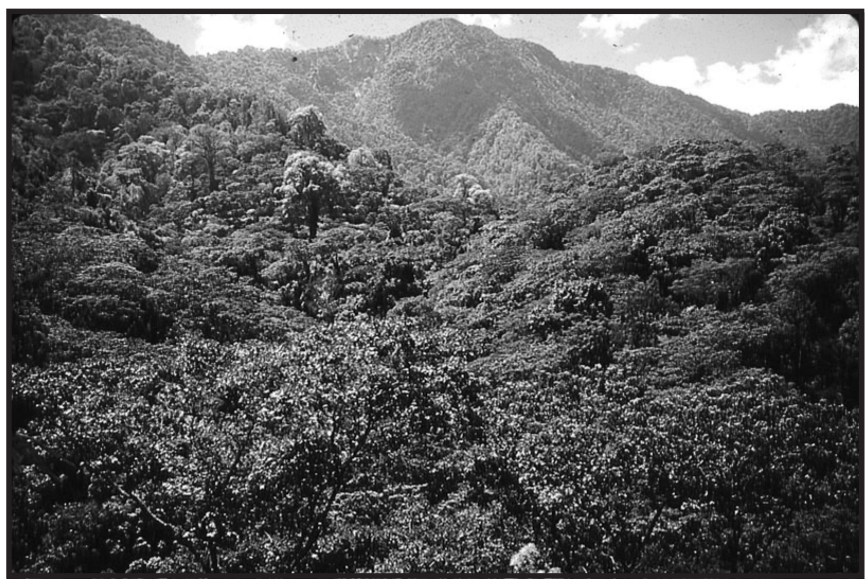

Figure 2b. Different types of agricultural matrices: Shaded coffee plantation in Mexico (with the El Triunfo Biosphere Reserve in the background).

with its initiation (Vandermeer et al. 1998). The community garden and associated areas of fallow land of an Amazonian indigenous community is likely to contain much the same biodiversity as the native forest from which it was carved. But the cattle pasture that replaced those indigenous peoples' farming system probably contains far less biodiversity and, more importantly, represents a matrix of such low quality that interhabitat migration among remaining fragments of natural forest is significantly reduced.

Unfortunately, conservation biologists tend to think of agricultural systems as biological deserts and therefore, the enemy of biodiversity conservation (Vandermeer 2003a). This mainly North American bias has been unfortunate because it has created a protected area/managed ecosystem dichotomy that results in almost opposite goals and strategies for both types of areas. Furthermore, different disciplines are involved in the technical aspects of managing these areas – conservation biologists provide insights for the management of protected areas and agronomists provide insights about managing agricultural areas (Vandermeer 2003a). The dichotomy between the "pristine" and the "managed" reinforce the separation of people from nature (i.e. a romantic notion of nature) and creates barriers for the development of integrated conservation and agricultural policies.

Figure 2c. Different types of agricultural matrices: Sun coffee plantation (coffee monoculture) in Costa Rica.

Protected Areas and People

The separation of nature from people has created a philosophical divide between those who do research on biodiversity conservation and those who do research on agroecosystems. Many conservationists still believe that the best way to protect biodiversity is buying land, relocating communities that have traditionally lived and used these areas and fencing it (Terborgh 1999; Oates 1999). However, the last 20 years of failure of this conservation strategy demonstrate that it does not work. Most academic studies conclude that rural communities need to be engaged in conservation strategies and not alienated from them if they are to have a chance to succeed (Wilshusen et al. 2002). There are many examples of rural communities managing their productive systems in ways that conserve or even increase biodiversity at the landscape level (Halladay and Gilmour 1995; Collins and Qualset 1999; Vandermeer 2003b). In particular in the tropics, it is essential to address the problem of land tenure and the lack of access to productive land for the rural poor (Colchester 1994; Vandermeer and Perfecto 1995).

Conclusion

Agriculture should be an integral part of biodiversity conservation, not only because some agroecosystems contain high levels of biodiversity and their intensification represents a significant threat for biodiversity, but also because the conservation of biodiversity within protected areas and fragments of natural habitats depend to a great extent on the quality of the agroecological matrix. In incorporating agriculture into conservation policies careful attention should be paid to the managers of agroecosystems and external forces that push for the intensification of agriculture.

The main challenge for the new generation of conservationists is to incorporate agriculture and other managed systems as an integral part of conservation policies, and *vice versa*, to integrate biodiversity conservation into the development of agricultural policies. This is already happening to a certain extent in the European Union, but concerns are growing on the potential negative impacts of trade liberalization policies. Part of the challenge ahead is the recognition that agroecology and conservation biology are both essential components of an integrated policy that should be developed with environmental and social justice as guiding principles. They are, metaphorically speaking, the two wings of the biodiversity conservation bird.

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Book Review
The Failure of Modern Agriculture and Hope for the Future

Fatal Harvest: The Tragedy of Industrial Agriculture
Andrew Kimbrell, editor.
Island Press 2002

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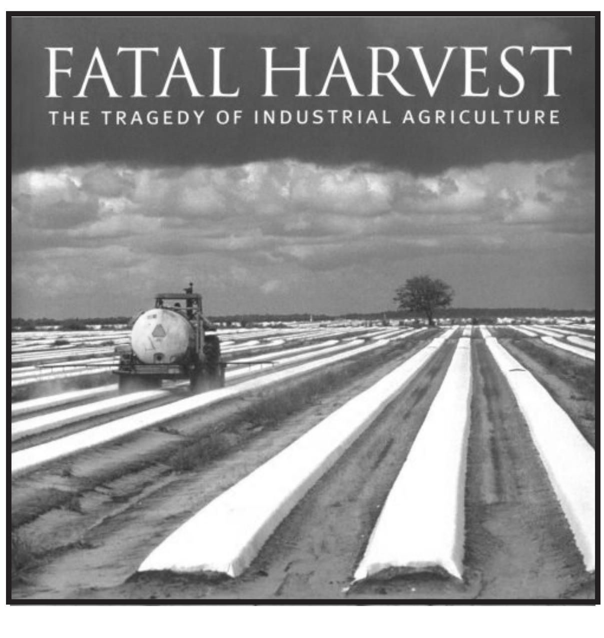
Abstract
Fatal Harvest is an extraordinary book for teachers, agronomists, ecologists, conservation biologists, or antiglobalization activists. The authors discuss in a comprehensive manner the biological, social, and economic implications of industrial agriculture. *Fatal Harvest* includes impressive photographs that convey the negative impacts of industrial agriculture on human health, rural society and biodiversity in contrast to the positive promises of organic and local agriculture. *Fatal Harvest* destroys the myths of industrial agriculture explaining in detail famine, pesticide use, monocultures, risks in the use of biotechnology, and the control of the modern agriculture by multinational corporations and institutions such as the World Trade Organization. The authors also present alternatives such as organic agriculture and the complementarity between conservation and sustainable agricultural systems. A shortfall of the book is the lack of discussion of industrial agriculture in the developing countries. In general, *Fatal Harvest* is an excellent book that achieves the authors' goals, creating a visual guide with an intelligent text that help readers understand the economic interconnections and the political power involved in the present global agricultural system.



Crítica de libros
El Fracaso de la Agricultura Moderna y la Esperanza para el Futuro
Cosecha Fatal: La Tragedia de la Agricultura Industrial
Andrew Kimbrell, editor
Island Press 2002

Resumen
Fatal Harvest es un libro extraordinario y propicio para el uso de maestros, agrónomos, ecólogos, biólogos de la conservación, o globalifóbicos. Los autores y editores de este libro discuten un panorama amplio de las implicaciones biológicas, sociales y económicas de la agricultura industrial. El libro incluye fotografías impresionantes que ayudan al entendimiento de los impactos negativos de la agricultura industrial en la sociedad rural, la salud y la biodiversidad en contraste con las promesas de la agricultura orgánica y local. Acabando con el mito de la agricultura industrial – de que ésta es necesaria para alimentar al mundo con una selección de productos baratos, eficientes, saludables, y seguros – *Fatal Harvest* explica los detalles reales del hambre, plaguicidas, monocultivos, riesgos de la biotecnología, y el control de la agricultura moderna por corporaciones multinacionales y grupos como la Organización Mundial de Comercio. También, el libro sugiere alternativas como la agricultura orgánica y un intercambio entre las áreas de conservación y agricultura para un futuro sustentable. El libro carece de una discusión amplia de los temas de la agricultura industrial en el mundo en vías de desarollo. Por lo general, *Fatal Harvest* es un libro excelente que logra el objectivo principal de los autores, creando una guía visual con texto inteligente para entender las "interconecciones" económicas y el poder político involucrado en nuestro sistema de agricultura global.

Revue
L'Echec de l'Agriculture Moderne et l'Espoir pour le Futur
Moisson Mortelle: La Tragédie de l'Agriculture Industrielle
Andrew Kimbrell, editeur
Island Press, 2002

Résumé

Moisson Mortelle est un livre extraordinaire pour n'importe quel professeur, agronome, écologiste, biologiste de conservation, ou activiste d'antiglobalization. Les auteurs discutent dans une façon complète les implications biologiques, sociales, et économiques de l'agriculture industrielle. *Moisson Mortelle* inclut les photographies impressionnantes qui améliorent la compréhension des impacts négatifs de l'agriculture industrielle sur la santé humaine, la société rurale, et la biodiversité, contrairement aux promesses positives de l'agriculture organique et locale. Détruire le mithology derrière l'agriculture industrielle, *Moisson Mortelle* détruit le mythe derrière l'agriculture industrielle, expliquant en détail la famine, l'utilisation des pesticides, les monocultures, les risques dans l'utilisation de la biotechnologie, et la commande de l'agriculture moderne par des sociétés multinationales et des organisations internationales tels que l'Organisation Mondial de Commerce. Les auteurs présentent également des alternatives telles que l'agriculture organique et la complémentarité entre la conservation et les systèmes agricoles durables. Un déficit du livre est le manque d'une discussion d'agriculture industrielle dans les pays en voie de développement, mais en général, *Moisson Mortelle* est un excellent livre qui réalise les buts des auteurs, créant un guide visuel avec un texte intelligent qui aide dans la compréhension des liens économiques et la puissance politique impliquée dans le système agricole global actuel.

Fatal Harvest is an extraordinary new book, a welcomed addition to the shelves of teachers, agricultural scientists, ecologists, conservation biologists, or anti-globalization activists. The authors discuss a wide array of topics covering the biological, social, and economic implications of industrial agriculture. Additionally, the vivid and breathtaking photos make it suitable for any coffee table. Although filled with fascinating facts, one almost does not have to read the chapters to understand the negative impacts that industrial agriculture has had on American rural society, health, and biodiversity, or to envision the promise that locally-controlled organic agriculture holds for creating an alternative. The authors have achieved their primary goal of creating a "visual guide and a compelling textbook with which to understand better the interconnections, the mind-set, and the economic and political power involved in our globalized food production system."

Fatal Harvest covers many aspects of industrial agriculture. In the second section, the authors outline its myths— namely that industrial agriculture will feed the world with a diverse selection of healthy, safe, cheap, and efficiently produced food, and that unaccomplished advances will soon be met by biotechnology- and provides detailed explanations that effectively dispell these myths. The authors discuss hunger and its root causes that stem not from lack of food, but from the inability of the worlds' poor to produce or buy it. They provide examples of the millions of pounds of pesticides (over 53 known to be carcinogenic) applied to virtually all crops including strawberries, cotton, and tomatoes, and recount the more than 25 million farm workers worldwide who are poisoned by its application each year. They also show the real costs of industrial agriculture – breast cancer, water pollution, and soil erosion – not the subsidized supermarket price tags. Particularly striking photos show the loss of plant diversity associated with industrialized agriculture. One page illustrates today's production focuses — iceberg lettuce, red delicious apples, and McDonald's-like French fries contrasted with pages full of examples of the 5000 + known potato varieties like red thumb and French fingerling, as well as apple and lettuce varieties such as spygold and belle de boskoop apples and red Batavian cardina and Samantha lettuce.

Several chapters present the threats of biotechnology and genetically engineered (GE) foods, especially in the context of corporate control. Apparently consumers once believed that "DDT is good for me" and that post wartime insecticides such as "Ambush" and "Force" were the solution to agricultural problems. Now, however, skeptical American consumers (up to 90 percent) support labeling for GE foods, choose to buy non-GE food. Furthermore, despite the assurances of companies like Monsanto, use of herbicides has not decreased in herbicide-resistant crops, and the poster-child of GE, vitamin A enriched rice, only provides 1.32 % of daily recommended values per serving to malnourished children. The authors also clearly outline how multinational corporations and organizations like the World Trade Organization have gained control of most sectors of agriculture from pesticide dependence to seed control, and from ownership of agricultural lands to large influences over elected officials. One chapter warns of the danger in involving corporations in the organic movement and provides strategies to remain independent.

Although the impacts of industrial agriculture seem depressing, thankfully the authors consistently present hopeful alternatives through organic agriculture, or the agrarian approach. One particularly clever section uses photos and industrial and agrarian "eyes" to again and again contrast modern, industrial agriculture with organic and other alternative techniques. In bleak pictures, we are shown what industrial agriculture looks like – eroded barren areas, dead birds, and endless expanses of GE corn. But for each one of these images, we are shown beautiful intercropped organic fields to assure us that a different future is possible. One section of the book focuses on alternatives to industrial agriculture such as community sponsored agriculture, urban gardens, natural systems agriculture and ecologically friendly labels. Some authors even begin to address the important links between agriculture and biodiversity conservation.

As with any book, there are a few shortcomings. The primary focus of this book is on agricultural production within the continental United States. Although the authors discuss some global issues such as hunger and pesticide poisoning, and accurately describe their root causes, little suggestion is made on how to begin to solve problems more unique to the developing world. Although organic farming in the global South is an excellent goal, corrupt governments and little access to transportation make access to foods difficult without massive land reform programs for peasant farmers. Furthermore, the authors do not address the problems associated with massive export crops such as coffee or bananas, usually grown under the same industrial model with the same disastrous effects, but without contributing to local consumption. Perhaps, however, these issues are best left for books focusing on food production in the developing world. Lastly, the authors discuss the overlap between organic and sustainable agriculture and wildlife and biodiversity only in the last pages of the text. I would have liked to see more discussion of how to bridge the gap between conservation and agriculture throughout the text.

In conclusion, *Fatal Harvest* is an excellent book that reminds consumers and citizens about the disastrous ecological consequences of industrial agriculture reported in 1962 Rachel Carson's *Silent Spring*. However, many people assume that industrial agriculture today is safer than it was forty years ago and that its practices are necessary to feed the world. The fact that so many people believe these myths makes me wonder what impact a book like *Fatal Harvest* will have when faced with the TV campaigns of agribusiness corporations. Hopefully the vivid imagery presented in the book will make it a useful tool for convincing those who are not already supporters of the growing organic and alternative movement to change their habits to be so.

The Conservation of Beneficial Arthropods in Agricultural Landscapes: a Challenge for the Success of Sustainable Agriculture

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Abstract

In the past, agricultural landscapes were a mosaic of crops, hedgerows, field margins, woodlands, wetlands and fallow fields. It is unfortunate that the current trend toward agriculture intensification is based on the replacement of diverse landscapes by contiguous large-scale monocultures. One of the consequences of this trend is the reduction of the total area of suitable habitats for wildlife, including arthropods that act as natural enemies of crop pests. This process has important implications to the use of biological control as a means to making agriculture sustainable. Extensive monocultures fail to provide key resources for natural enemies, such as nectar, pollen, over-wintering sites, refuges and alternative prey, offering almost no conditions for the survival and persistence of natural enemies in the long term. This problem can become a serious limitation to the application of biological control strategies based on the conservation of natural enemies of insect pests. Therefore, it is necessary to develop farming approaches for sustainable agriculture that seek to incorporate more biodiversity in agricultural landscapes in order to restore the vital resources required for the conservation of beneficial arthropods. Some authors have suggested that managing the structure of agricultural landscapes can facilitate a more ecologically based approach to integrated pest management. This paper discusses supporting evidence from a temperate agriculture perspective, the factors constraining the adoption of this approach by farmers, and the actions needed to overcome these constraints.

La Conservación de Artrópodos Benéficos en el Paisaje Agrícola: Un Reto Para el Exito de la Agricultura Sustentable

Resumen

En el pasado, los paisajes agrícolas eran un moisaco de cultivos diversos, cercas vivas, márgenes de áreas de cultivo, zonas boscosas, ciénagas y áreas de cultivo en descanso. Desafortunadamente la tendencia actual a la intensificación de la agricultura está basada en el reemplazo de paisajes diversos por monocultivos contiguos a gran escala. Una de las consecuencias de esta tendencia es la reducción del área total de habitats en buenas condiciones para la vida silvestre, incluyendo artrópodos que actúan como enemigos naturales de las plagas de cultivos. Este proceso tiene importantes implicaciones para el uso de control biológico como una forma de lograr una agricultura sustentable. Los monocultivos extensivos no proveen los recursos vitales tales como néctar, polen, sitios de hibernación, refugios y presas alternativas para los enemigos naturales, lo que ofrece condiciones casi inexistentes para la sobrevivencia y persistencia de los enemigos naturales a largo plazo. Este problema puede llegar a ser una seria limitación en la aplicación de estrategias de control biológico basadas en la conservación de enemigos naturales de plagas agrícolas. Por lo tanto, es necesario desarrollar recomendaciones para una agricultura sustentable que busquen incorporan una mayor biodiversidad en los paisajes agrícolas para restaurar los recursos vitales requeridos para la conservación de artrópodos benéficos. Algunos autores sugieren que manejando la estructura de los paisajes agrícolas podemos facilitar propuestas con fundamentos ecológicos en el manejo integrado de plagas. Este artículo discute la evidencia que apoya esta idea desde la perspectiva de la agricultura de zonas templadas, además de discutir los factores que restringen la adopción de esta alternativa de manejo por los agricultores y las acciones necesarias para poder resolver estas restricciones.

La Conservation des Arthropodes Bénéfiques Dans des Paysages Agricoles: un Défi pour le Succès d'Agriculture Durable

Résumé

Dans le passé, les paysages agricoles étaient une mosaïque des champs de récoltes des rangées de haie, des talus, des régions boisées, des marais et des jachères. Malheureusement, la tendance actuellement est pour une intensification d'agriculture basée sur le remplacement des paysages diversifiés par des grandes monocultures contiguës. Un des conséquences de cette tendance est la réduction de la surface totale des habitats convenables pour la faune, y compris les arthropodes qui sont les ennemis naturelles des parasites de récolte. Ce processus a des implications importantes à l'utilisation de la contrôle biologique en tant que des moyens à rendre l'agriculture durable. Les monocultures étendues ne fournissent pas les ressources principales pour les ennemis naturelles, tels que le nectar, le pollen, hivernement des emplacements, les refuges et les proies alternative, n'offrant presque aucune condition pour la survie et la persistance des ennemis naturelles dans le long terme. Ce problème peut devenir une limitation sérieuse à la mise en œuvre des stratégies de la contrôle biologique basées sur la conservation des ennemis naturelles des insectes nuisibles. Par conséquent, il est nécessaire de développer des méthodes agricoles pour une agriculture durable, en cherchant à incorporer plus de biodiversité dans des paysages agricoles afin de reconstituer les ressources essentielles exigées pour la conservation des arthropodes bénéfiques. Certaines auteurs ont proposé que la gestion de la structure des paysages agricoles puisse faciliter une approche plus écologiquement basée à la gestion intégrée des parasites. Cet article discute les données obtenues d'une perspective d'agriculture des regions tempérées, des facteurs contraignant l'adoption de cette approche par des fermiers, et des actions requises pour surmonter ces contraintes.

Introduction

In the past, agricultural landscapes were a mosaic of crop fields, hedgerows, field margins, woodlands, wetlands and fallow fields. It is unfortunate that the current trend toward agriculture intensification is based on the replacement of diverse landscapes by contiguous large-scale monocultures. One of the consequences of this trend is the reduction of the total area of suitable habitats for wildlife, including arthropods that act as natural enemies of crop pests.

This process has serious implications to the use of biological control as a means to making agriculture sustainable. Extensive monocultures fail to provide key resources for natural enemies, such as nectar, pollen, overwintering sites, refuges and alternative preys, offering almost no conditions for the survival and persistence of natural enemies in the long term (Altieri 1994). This problem can become a serious limitation to the application of biological control strategies based on the conservation of natural enemies of insect pests. Therefore, it is necessary to develop farming approaches for sustainable agriculture that seek to incorporate more biodiversity in agricultural landscapes in order to restore the vital resources required for the conservation of beneficial arthropods.

Some authors have suggested that managing the structure of agricultural landscapes can facilitate a more ecologically based approach to integrated pest management. This paper discusses supporting evidence from a temperate agriculture perspective, the factors constraining the adoption of this approach by farmers, and the actions needed to overcome these constraints.

Diverse Landscapes Increase the Diversity of Beneficial Arthropods: Evidence from Research

Since Dambach's studies (Dambach 1948) it is known that, if well managed, the vegetation surrounding crop fields and orchards can play an important role in the conservation of natural enemies that migrate into crop fields during the spring and regulate pest populations over the growing season. A study carried out by the United States Office of Technology Assessment (OTA) found that regions with relatively small agricultural holdings and a variety of crops frequently provided a landscape able to support natural enemies of crop pests and a greater likelihood of supporting species and varieties resisting disease outbreaks (OTA 1987).

In the last decades, some studies on landscape ecology and biological control have shown that there is a relationship between landscape heterogeneity and the abundance, diversity, and activity of natural enemies of insect pests. In South Dakota, Elliot et al. (1998) found that the overall abundance and species richness of aphidophagous predators in cereal fields increased with the increasing amount of noncrop land and increasing patchiness in the surrounding landscape. A similar result was obtained for aphidophagous predators in alfalfa fields (Elliot et al. 2002). Parasitism rates of rape pollen beetles in Germany were higher and crop damage were lower in heterogeneous (high percentage of noncrop areas) than in homogeneous landscapes (high percentage of crop areas) (Thies and Tscharntke 1999). In California, Landis and Menalled (1998) studied what type of habitat would conserve maximum community richness of parasitoids associated to lepidopteran pests on corn, soybean, wheat, and alfalfa in the Midwestern region of the United States. Generalist species dominated the parasitoid assemblage and it was found that over 60% of the herbivores that are alternate hosts of these generalist parasitoids feed on trees and shrubs, a type of vegetation found only on stable, late-successional habitats. They concluded that the conservation of species-rich parasitoid communities of the lepidopteran pest complex requires the inclusion of late-successional habitats (e.g., woodlots interconnected by hedgerows). In another study in Michigan, Marino and Landis (1996) found that parasitism rates of true armyworm *Pseudaletia unipunctata* were higher in a complex landscape (comprised of abundant and highly interconnected woodlots and fencerows) than in a simple landscape (where woodlots and fencerows were less abundant and interconnected). Noncrop areas are also important to ameliorate adverse abiotic factors such as high temperatures. Adult parasitoids have tiny bodies and are very vulnerable to death by dehydration if temperatures are very high within crop fields. In Michigan, parasitoids of the European corn borer were more abundant in herbaceous-edge and wooded-edge than in the interior of corn fields, probably seeking sugar sources and a more suitable microclimate (Dyer and Landis 1997).

In spite of this empirical evidence, the response of natural enemies to landscape structure varies from context to context and generalizations are not applicable to all agroecosystems. The effective conservation of natural enemies through landscape management depends on the potential interactions among crops, arthropods and noncrop habitats as well as on the composition of plant communities in the noncrop habitats. For instance, it is more appropriate to have woody plants in hedgerows adjacent to grain, leguminous and forage crops instead of having grasses and herbaceous plants botanically related to the crops (Altieri 1994). In apple orchards, windbreaks with single tree species like *Populus* spp, *Salix* spp, *Pinus* spp and *Alnus* spp have become an alternative to hedgerows with multiple species because the former are not significant sources of insects and mites that could attack apple trees (Solomon 1981).

While planting field margins to provide nectar to natural enemies, it is important to look at the interactions between flower architecture and insect morphology. For example, some flowers have corolla apertures varying in width, turning the nectar glands to be exposed, partially exposed or hidden. Parasitic wasps, lacewings and lady bird beetles can access the nectar in the flowers only if their head width fits the width of corolla apertures (Patt et al. 1997). Therefore, it is the type of diversity and not the diversity *per se* that will ultimately define the success or failure of biological control strategies based on the management of noncrop areas in agricultural landscapes.

Managing Landscapes, Managing Pests: Perspectives of Implementation

Deciding whether and how innovative techniques in pest control will be used becomes a complex question for the farmer. The adoption of innovative technologies is accepted only if the decision maker is sure of obtaining good results. Assessment of risk, faith in new technology, income, education, age, size of farm operation, impacts on personal time and implications for other parts of the operation are major factors governing change of practices (Perkins and Garcia 1999).

In recent years there has been an accumulation of research on pest management based on two ecological approaches: *conservation biological control* and *habitat manipulation* (Barbosa 1998; Landis et al. 2000). According to Gurr et al. (2000), both approaches are used interchangeably but are not synonymous. Conservation biological control combines the provision of key resources and habitats to natural enemies with the reduction of pesticide induced mortality. Habitat manipulation combines the provision of key resources and habitats to natural enemies with the disruption of pest behavior using plant diversity within crop fields.

This accumulation of research has not resulted yet in the implementation of conservation biological control and habitat manipulation over large acreage areas. According to Kogan (1998), the amount of agricultural land (field and vegetable crops only) in the United States under pest management practices based on habitat manipulation tactics is less than 0.1%. Although habitat manipulation through vegetation diversification is a common practice among small scale organic farmers all over the world, there are few cases of large scale adoption of habitat manipulation for pest control. The exceptions are the adoption of weed-strip management (Nentwig 1998) and beetle banks in Europe (Thomas et al. 1991), cotton-wheat relay intercropping (Xia 1994) and cover crops in citrus orchards in China (Liang and Huang 1994) and Australia (Smith and Papacek 1991).

What forces limit a widespread implementation of ecologically based pest management? The lack of scientific knowledge might be the primary constraint, because the knowledge to be applied must be appropriate to local or regional contexts. The current background on pest management has a very limited ecological foundation. Biological control through habitat manipulation will require changes in the research agenda of the land grant universities system. Agricultural colleges will have to include in their research agenda the development of pest management strategies that are gentle to the environment, generate appropriate income to farmers and look after laborers' and consumers' health (which I would call a *food production* view). This action is needed to counterbalance the current emphasis on intensive use of capital and chemicals to produce commodities (*commodity production* view).

Unfortunately, in the field of biological control, there is a trend toward a research agenda that supports the commoditization view. An exemplary case of this trend is the dismantling of the Division of Biological Control at the University of California at Berkeley. In summary (see Jennings 1999 for details), this unit had a holistic research orientation to pest management based on ecological knowledge, reduction in pesticide use, environmental health and respect of laborers' rights. Also, faculty members were outspoken advocates of increased participation by non-agribusinesses constituents (e.g., farmers and environmentalist NGO's) in defining research priorities.

Of course, this orientation challenged the interests of conventional pest management supporters in academia as well as the interests of agro-chemical corporations. Despite the division's success in developing biological control programs that use arthropods beneficial to the environment, the unit has experienced a dismantling process. The remaining UC system prioritizes the inclusion of molecular biology and biotechnology in the research agenda of its Natural Resources and Agriculture colleges. According to Jennings (1999), the reality is not different in other American universities.

In this scenario, it is impossible to expect a shift in the research agenda from modernization (intensive use of chemicals, capital and biotechnology) toward an ecological approach based on landscape diversification. The great challenge for constituents supporting ecologically based pest management and sustainable agriculture is to make sure that this field of inquiry will survive the modernization wave that is sweeping through the agricultural research system, especially in developed countries.

Other factors might also limit the adoption of habitat/landscape management in pest management. This approach to pest management does not generate marketable products like biological control techniques based on mass rearing and releases of commercially produced parasitoids and predators. Therefore, this technology or knowledge will not be available to farmers unless it is strongly supported by the public sector (Jennings 1999). Another limitation is the reductionist education received by many entomologists. As pointed out by Ehler (1998) biological control based on the conservation of natural enemies is holistic in nature and "we can not afford to train a cadre of narrow reductionists and ask them to implement holistic approaches to agroecosystem management." The success of habitat management for biological control will depend also on better training of entomologists with a holistic curriculum.

Restrictions in the use of machinery after the redesign of agricultural fields can be another limiting factor. In

England, Perrin (1980) suggested the redesign of the cereal/rape system on a regional scale and the manipulation of landscape diversity in a coordinate manner by all stakeholders involved. The conflicts and dilemmas among social actors in England were so huge that the debate on hedgerow management took the direction of antagonism between the "production" and "conservation" views. On the one hand, the removal of hedges would increase the efficiency of farming practices with machinery, but on the other hand it would decrease the conservation of wildlife.

When these types of cases occur, the best approach is to ensure that economic, socio-cultural and environmental goals will be discussed by the local community, especially in communities looking for the implementation of low-input technologies to harmonize environmental conservation, economic growth and social development (democratic participation included). Nonetheless, as pointed out by Landis et al. (2000), habitat management may not always demand radical change in farm practices and some of the tactics for conservation of beneficial arthropods can be packaged in an agronomically acceptable form.

Conclusion

The conservation of beneficial arthropods in agricultural landscapes faces the same challenges posed to wildlife conservation. As well pointed out by Letourneau (1998), this means that perceiving the theoretical and applied aspects of community ecology, endangered species' life history and their interactions with ecosystems is not always enough to conserve threatened species and habitats. Most of the time, the success or failure in conservation programs depends on political forces, legal procedures, policy decisions and economic pressures. Though, it is reasonable to assume that these same barriers apply to the conservation of beneficial arthropods.

The implementation of habitat/landscape management for biological control has an incredible potential to foster the development of sustainable agriculture. The transformation of this potential onto reality will depend on the adoption of some actions in different fronts of intervention:

-Inclusion of more ecologically based pest control strategies in the agricultural research agenda;

-More holistic training for agronomists and entomologists;

-Search for solutions to pack ecologically based pest management technologies in an agronomically acceptable fashion;

-Support of government agencies to make conservation biological control and habitat manipulation technologies available to farmers;

-Coalition building among environmentalists, farmers, policy-makers and agroecologists pursuing the development of economic policies that promote sustainability, as well as cooperation at the regional level to design and implement multiple land use management; and

-Creation of funds to provide incentives to farmers when land is taken out of agricultural production for conservation purposes.

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Mr. Cloyd's Road: The Discourse of Subsidies in Agriculture

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Abstract

The international scheme of heavily subsidized commodities and overproduction in the developed countries, which has maintained low commodity prices, and forced small producers out of business in developed as well as developing countries, was one of the main issues involved in the collapse of the World Trade Organization talks in Cancun, Mexico in the Fall of 2003. This article addresses the two disparate perspectives of subsidies for the developed and developing countries, and how the supply management arrangement was quietly substituted by the principles of "free market" due to the interests of the politically powerful agribusinesses. Overproduction and the consequent fall of prices for farmers seem to have the modern agricultural system on the brink of disaster and it is an implicit cause of the failure of local governments in the developing world. Worldwide, this unfair economic arrangement might cause the emergence of unusual political upheaval.

El Camino de Don Cloyd: La Raciocinación de Subsidios en la Agricultura

Resumen

El esquema internacional de productos agrícolas y la sobreproducción en los países desarrollados, lo que ha mantenido precios bajos de estos productos y forzado la bancarrota de pequeños productores tanto en los países desarrollados como en los países en vías de desarrollo, fue uno de las controversias principales involucradas en el colapso de las negociaciones de la Organización Mundial de Comercio en Cancún, México en el otoño del 2003. Este artículo se enfoca en las dos perspectivas contradictorias acerca de subsidios para los países desarrollados y en vías de desarrollo, y como el arreglo de manejo del abastecimiento fue subrepticiamente sustiuido por los principios de "libre mercado" debido a los intereses de las políticamente poderosas compañías agroindustriales. La sobreproducción y la consecuente caída de precios para los agricultores parece tener al sistema agrícola moderno al borde del desastre y es la causa implícita de la falla de gobiernos locales en el mundo subdesarrollado. A nivel mundial, este arreglo económico injusto podría causar la aparición de disturbios políticos inusuales.

La Route de M. Cloyd: Le Discours des Subventions Dans l'Agriculture

Résumé

Le schéma international des produits fortement subventionnés et de la surproduction dans les pays développés, lequel a maintenu de bas cours de matières, et lequel a forcé de petits producteurs hors des affaires dans les pays développé comme ceux en voie de développement, était un des points principales impliqués dans l'effondrement des entretiens de l'Organisation Mondial du Commerce au Cancun, Mexique en automne de 2003. Cet article adresse les deux perspectives différentes des subventions pour les pays développés et ceux en voie de développement, et comment l'arrangement en matière d'approvisionnement a été tranquillement substitué par les principes du marché libre-échange en raison des intérêts des entreprises agricoles politiquement puissants. Pour les fermiers, la surproduction et la chute conséquente des prix semblent avoir mise le système agricole moderne sur le point du désastre et c'est une cause implicite de l'échec des gouvernements locaux dans les pays en voie de développement. Dans le monde entier, cet arrangement économique injuste pourrait causer l'apparition d'une bouleversement politique peu commun.

The WTO negotiations of 2003 in Cancún Mexico brought a surprise for pundits in the Developed World. Their rhetoric had come back to haunt them. Why, asked the Underdeveloped World, do you pay your farmers to be inefficient and then dump their heavily subsidized products into the poorer countries, thus undercutting the ability of local farmers to survive? It seems that there has been, for quite some time now, welfare recipients (and even welfare cheats) in the boardrooms of the very agribusinesses that preach so evangelically about The Free Market (piously capitalized here to reflect the proper genuflexic attitude). There is, of course, a delicious irony to all of this. Scrambling to develop a plausible excuse, economists and "economics journalists" have gone to all sorts of extremes to convince a properly skeptical world public that it is economically rational to provide massive subsidies to rich corporate farms in the United States, Europe, and Japan, but would be antithetical to rationality itself to provide such subsidies to poor farmers in the Third World – that would be a Trade Barrier (again the capitals, this time for Satan). It is difficult not to revert to that overused metaphor of the emperor's new clothes – the world public apparently is beginning to notice the nakedness.

As comical as all of this is, it nevertheless opens a door to some reflection on the underlying assumptions involved in such icons as Free Trade, Trade Barrier, The Market (or rather THE Market). And the particular question of subsidies (I mean, Subsidies) is a possible Rosetta stone. What, precisely, do we mean when we say subsidies? In any productive enterprise, modern accounting methods account for assets and liabilities, and ignore things that are "off the books," or external to the accounting system. In a simple-minded way, the liabilities that we are not obligated to pay are subsidies. But, let's be honest about it, certain things are not normally thought of as subsidies, and different cultures normally have different norms as to what is or is not a subsidy.

A friend of mine is a farmer in Nicaragua. His name is Mr. Cloyd Williams, and all his friends simply refer to him as Mr. Cloyd. Mr. Cloyd works harder than anyone I know in the United States, and is also poorer than anyone I know in the United States. His farm is what is referred to as a silvopastoral system, and has cattle (mainly for milk) and citrus trees. Mr. Cloyd's oranges are the most delicious oranges I have ever eaten – even more delicious than the organic oranges I get from the People's Food Coop in Ann Arbor Michigan, if you could imagine such a thing. The town nearest to his farm is Pearl Lagoon. The walk to Mr. Cloyd's farm from Pearl Lagoon takes about four hours (at least for me), and I am told can be done in a little more than two hours on horseback. That walk is on a dirt road, a very muddy dirt road. One of the reasons it takes so long is the condition of the road. You can hardly walk on it in the rainy season, slipping and sliding and falling in the mud for all those hours. Mules and horses seem to do better. But driving a truck over it is difficult at best and then only in the dry season. And here is one of Mr. Cloyd's problems. His market is in small town known as Pearl Lagoon and his connection to the market is this road. If the road could be paved, he could move his oranges to Pearl Lagoon in about a half an hour, rather than the approximately four hours it takes by mule, which is the way he does it now.

What could Mr. Cloyd do about this predicament? He could take some money out of his profits and pay someone to pave the road. That, of course, would have to be counted on his accounting balance sheets as a liability, because he would really have to pay for it. Actually, he sort of did something like that, although not really paving. He got his neighbors together (for there are some dozen or so neighbor farmers in the same predicament) two years ago and they cleared the brush on the side of the road, effectively making a new pathway to the side of the mud-drenched road normally used.

This provided them with a slightly dryer road for a couple of years, but not to the extent that trucks could use it. Just a little easier for mules and people to walk on. And Mr. Cloyd and his neighbors clearly understand that the price of road improvement was something they had to personally incur. A cost of production. A liability on their balance sheet.

Somewhere in South Florida there is another farmer. I do not know him, but I know he exists, and I know he grows oranges. Let's call him Mr. Golden. He actually does not work very hard, depending on how you describe work. Mr. Golden is a farmer only in the technical sense of the word, in that he owns a farm, a really big farm. That is the way it normally is for citrus farmers in Florida. But he regards himself more as a businessman than a farmer, rightly so. Now I ask you to imagine the process of getting oranges to market in these two cases. If Mr. Cloyd could get a "subsidy" from the local government in the form of a paved road, he could make his enterprise far more profitable (he currently lives close to the edge of existence). But Mr. Golden already has that paved road. Indeed before he ever started his business he knew the paved road would be there. As we all know, there is much more to the question of subsidies for Florida citrus growers than paved roads. However, for the purpose of pondering the principles involved here, let's just consider the question of the paved road. If the local government where Mr. Cloyd lives decides to help Mr. Cloyd and pave his road, would this be a "subsidy?" Since the lack of the paved road reduces production efficiency, providing that paved road clearly increases it, and would almost certainly increase Mr. Cloyd's profits. So, formally speaking, it would be a subsidy, and it would not take a great deal of argument to convince an agricultural economist that this was a form of subsidy. But if Mr. Cloyd's road is a subsidy, why is Mr. Golden's not?

The point of all this is, I hope, clear. We live in a social world. We are a social species. One person's activities in that world are inevitably and intricately involved with the activities of others. If I produce trinkets for you, everything about you and those trinkets derives from the social world in which we live. To suggest that our combined assumptions about the way we should organize the world (the government) do not determine everything about those trinkets would be denying the obvious. In effect, it is all subsidies. Mr. Golden's produce probably travels on an interstate highway which is a social good (a nice term for the same thing that is called a subsidy when economists do not like it). How could we make a level playing field on which Mr. Cloyd could, at least theoretically, compete evenly with Mr. Golden? Should the government of Nicaragua pave Mr. Cloyd's road? Or would that be a "subsidy" and even a "trade barrier."

From this point of view arises the inevitable and obvious point that it is never a question of subsidies or not — it is a question of which subsidies are allowable, who gets them and who has the right to decide who gets them. In short, it is a question of how we come to manage the socioeconomic world in which we live.

Despite their position between monopolized suppliers and monopsonized buyers, United States farmers wielded considerable political clout through various farmers organizations by the beginning of the twentieth century. As in virtually every industry in the capitalist world, the management of supply through various political arrangements has been a constant, if underreported, feature of the system. Whether by government largesse or vertical integration and monopoly control, supplies of commodities are carefully regulated so as to maintain profits at targeted levels. Agriculture has never been any different. Turn-of-the-twentieth-century farmers transformed their considerable political clout into policy, and the well-known principle of supply management became law. Based on prior production, each farmer was allocated a certain amount of land to put into production, thus maintaining supplies at sufficiently low levels to insure prices adequate to meet production costs and insure a reasonable profit. The whole arrangement was referred to as "supply management" and was one of those sociopolitical arrangements that was so obviously beneficial to everyone involved that it hardly merited popular debate.

But political power is a dynamic variable, and as the century proceeded, the power of monopolized and monopsonized agribusinesses grew exponentially. Concomitantly, political pressures changed. Basic assumptions of supply management were quietly altered in the interests of the politically powerful. The business planners of giants like Cargill and Campbell's Soup and Kraft and Kellogg, realized that supply management for the farmer's meant fair prices to those same farmers. "Subsidies" they argued! Would it not be more in line with the principles of the free market if the government got out of the business of organizing production? Did it not constitute an "unfair" business practice for the farmers to get together in a "Cartel" (demonic capitalization) to keep prices high? Would floating prices in a "free market" not allocate farm outputs more efficiently? From a disinterested vantage point such arguments of course seem silly, but certainly they are self-serving for anyone who would profit from the elimination of supply management.

The political clout that comes from large size and monopoly control was able to change the discourse, eliminating the subsidy structure that encouraged supply management, eventually encouraging each individual farmer to produce as much as possible. Consequently each farmer was obligated to plant fence row to fence row, and markets became oversaturated. Commodity prices fell accordingly and farmers reached a point where they were forced to sell below production costs, receiving direct government subsidies to make up for the shortfall. But the basic goals of the change in supply management were clearly met in that the large monopsonized grain and canning companies were purchasing commodities at rock bottom prices. This has become one of the chief problems of agriculture today, overproduction. And it arises from a different form of supply management – from above. The supply is still "managed" but mainly in the form of maintaining commodity prices at rock bottom to serve the interests of monopolized giants like Cargill and Kellogg. But have there been long editorials about the subsidies offered Cargill and Kraft, effected through the encouragement of farmers to plant fencerow to fencerow?

Farmers in the Global South have been especially hard hit by this socially engineered overproduction in the North. Grain from the Developed World, heavily subsidized by managing supply at high levels to insure low commodity prices, now enters markets in the South, forcing many basic grain producers out of business. Here, the basic disarticulated economies of the underdeveloped world have functioned exactly as planned. Grain companies, purchasing grain at rock bottom prices — at this point even below the cost of production — need market outlets, and there is simply too much food for the demand that exists in the developed world. The South has provided an excellent escape valve for developing those markets. Frequently with economic incentives from the developed world, underdeveloped countries one by one have been converted into net importers of basic grain. This basic arrangement was one of the major issues involved in the collapse of the WTO talks in Cancún in the Fall of 2003.

But all is not as rosy as it may seem for Corporate America. While the economies of the Global South do not make for economic growth, neither do they make for political stability, at least not over the long run. Consequently loans, credits, and gifts from the developed world are routinely doled out to the underdeveloped regions of the globe, most frequently for projects based on the "modernization" of agriculture. Such loans and credits are an important part of the huge debt that has been accumulated by many countries in the Global South. Furthermore, in many cases the failure of the modern agricultural model is an implicit cause of the failure of the local governments to be able to keep up with their credit obligations. One might even predict that unusual political upheavals might emerge from such blatantly and obviously unfair economic arrangements. Perhaps we can already see the beginnings.

Overproduction and the consequent fall in product prices for farmers in the developed world, coupled with the ever increasing price of inputs and continuing tendency for the industrial system to dominate both the supply of agricultural inputs and the purchase of farm products, bodes poorly for farmers the world over. Already their numbers have dwindled to the point that in countries where they suffer from little political power (such as the United States), they are hardly recognized as a force at all — in the 1996 census in the United States, "farmer" was not even recognized as a category under "occupation," there are simply too few of them. The problems are different in the Global South, but no less serious — lack of secure land tenure and disappearing markets. Couple these socioeconomic problems with the well-known problems of environmental deterioration and health risks, and the modern agricultural system indeed seems on the brink of disaster, and principally because of how subsidies are allocated.

Mr. Cloyd still gets few subsidies and his road remains unpaved. Mr. Golden continues to get massive subsidies and does not even think about where the interstate highway comes from. They both sell oranges.

Book Review

The Fateful Dialectic: Agriculture and Conservation

Ecoagriculture: Strategies to Feed the World and Save Wild Biodiversity

J. A. McNeely, and S. J. Sherr
Island Press 2003

The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems.

D. L. Jackson, and L. L. Jackson
Island Press 2003

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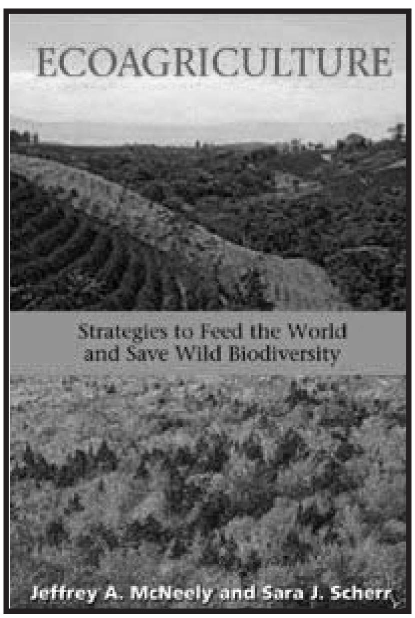
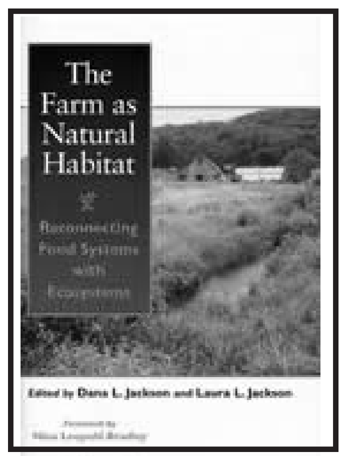
These two new offerings from the venerable Island Press have a similar underlying purpose described quite adequately by their titles. Designed to bridge the gap between conservation and sustainable agriculture, both books offer an introduction to this emerging field. However, neither book fully achieves this laudable objective. The Jackson and Jackson edited volume is a welcome addition to the growing appreciation of the mistake of separating agricultural production from conservation goals in terrestrial ecosystems, but the book suffers from a narrow geographic focus (the Midwest), and also from a short scope in its analysis. For example, there is little evaluation of the market beyond a few ominous words on the growing influence of corporate agriculture in the organic movement. There is, furthermore, a curious myopia about clear precedents to their viewpoint, and an inexplicable lack of attention to the concept of "natural agriculture systems."

The McNeely and Sherr volume is a sadly superficial book with some good parts. To their credit, and contrary to the Jacksons' volume, McNeely and Sherr delve into the difficult questions surrounding the economics and policy needs for encouraging and sustaining a biodiversity friendly agricultural movement. They acknowledge that food needs to be produced and biodiversity needs to be conserved, and they reject the anachronistic assumption of separation of agriculture and conservation. But their analysis of agricultural production falls directly in line with the more recent Malthusian assumptions that we must somehow intensify agricultural production. They would diverge from the simplistic notions of these analysts and argue for intensification based on more ecologically sound agricultural practices, but they nevertheless accept the wrong underlying assumptions of food shortage. Also, the superficial treatment of almost all subjects, we fear, may give ammunition to those who seek to discredit the move towards a more rational agriculture that takes conservation into account. Furthermore, a whole series of issues are almost completely ignored. Nothing is said of land reform, probably the most important issue in the move towards more ecologically sound agriculture in the tropics. We found that the rest of the book seems to suffer from similar problems. The shortcomings of these two books are really a shame, since the basic vision is one that we not only agree with, but one that we are certain is ultimately correct.





Crítica de Libros
La Dialéctica Fatídica: Agricultura y Conservación
Ecoagricultura: Estrategias para Alimentar al Mundo y Salvar la Biodiversidad Silvestre
J. A. McNeely, and S. J. Sherr
Island Press 2003
La Granja Agrícola como un Habitat Natural: Reconectando los Sistemas de Producción de Alimentos con los Ecosistemas
D. L. Jackson, and L. L. Jackson
Island Press 2003

Resumen

Estos dos libros recientes de la respetable casa editorial Island Press tienen un propósito fundamental semejante que los títulos describen adecuadamente. Designados para romper la brecha entre la conservación y la agricultura sustentable, ambos libros ofrecen una introducción a este nuevo campo. Sin embargo, ninguno de los libros logra este loable objetivo. El volumen editado por Jackson y Jackson es una grata adición a la creciente apreciación del error de separar la producción agrícola de los objetivos de conservación en ecosistemas terrestres, pero el libro adolece de un enfoque geográfico limitado (el Oeste Central de los Estados Unidos) y también de un ámbito limitado en su análisis. Por ejemplo, el libro presenta poca evaluación del mercado mas allá de algunas palabras ominosas sobre la creciente influencia de las corporaciones agrícolas en el movimiento orgánico. Es más, existe una curiosa miopía acerca de los claros precedentes a los puntos de vista expuestos en el libro, y una carencia inexplicable de atención al concepto de "sistemas agrícolas naturales."

El volumen de McNeely y Sherr es tristemente un libro superficial con algunas buenas partes. A su favor, en contraste con el volumen de los Jackson, McNeely y Sherr ahondan en las cuestiones difíciles en torno a la economía y la necesidad de una política para impulsar y mantener un movimiento agrícola que favorezca la biodiversidad. McNeely y Sheer reconocen que existe una necesidad de producir alimentos así como también una necesidad de conservar la biodiversidad y rechazan el supuesto anacrónico de la separación entre agricultura y conservación. Pero su análisis de la producción agrícola cae en la misma línea de los más recientes supuestos maltusianos, de que debemos de una forma u otra intensificar la producción agrícola. El análisis diverge de las mas simplistas nociones de los análisis maltusianos y discute en favor de una intensificación basada en prácticas ecológicas, sin embargo, McNeely y Sherr aceptan las erróneas suposiciones subyacentes de la carencia de alimentos. Creemos que el tratamiento superficial de casi todos los temas puede dar nuevos argumentos a aquellos que buscan desacreditar el movimiento hacia una agricultura mas racional que toma en cuenta la conservación. Además, una serie completa de temas son completamente ignorados. No se toca nada en cuanto a la reforma en la tenencia de la tierra, probablemente el asunto más importante en el movimiento hacia una agricultura mas ecológica en los trópicos. Encontramos que el resto del libro parece tener problemas similares. Las omisiones de estos dos libros son realmente una pena, ya que no sólo concordamos con su visión fundamental, sino que creemos que esta visión es en esencia correcta.

Revue

La Dialectique Fatidique: Agriculture et Conservation

McNeely, J. A. and S. J. Sherr. Eco-agriculture: Strategies to Feed the World and Save Wild Biodiversity. Island Press, 2003.

Jackson, D. L. and L. L. Jackson. The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems. Island Press 2003.

Résumé

Ces deux nouvelles offres en provenance de la vénérable Island Press ont un but fondamental semblable, bien décrit par leurs titres. Conçus pour établir le lien entre la conservation et l'agriculture durable, ces deux titres offrent une introduction à ce domaine naissant. Cependant, ni l'un ni l'autre livre n'atteignent entièrement cet objectif louable. Le titre édité par Jackson et Jackson est une addition bienvenue à l'appréciation croissante de la mauvaise stratégie de séparer la production agricole des buts de conservation dans des écosystèmes terrestres, mais le livre souffre d'un intérêt géographiquement étroit (le Midwest), et également d'une portée courte dans son analyse. Par exemple, il y a peu d'évaluation du marché au-delà de quelques mots sinistres sur l'influence croissante des affaires corporatifs d'agriculture dans le mouvement des produits organiques. Il y a d'ailleurs une myopie curieuse au sujet des précédents clairs à leur point de vue, et un manque d'attention inexplicable au concept des systèmes agricoles naturels.

Le volume de McNeely et de Sherr est tristement superficiel avec quelques bonnes parties. À leur crédit, et contrairement au volume de Jackson et Jackson, McNeely et Scherr fouillez dans les questions difficiles entourant les sciences économiques et les besoins politiques pour encourager et soutenir un mouvement agricole amical á la biodiversité. Ils reconnaissent que la nourriture doit être produite et la biodiversité doit être conservée, et ils rejettent la présomption anachronique de la séparation de l'agriculture et de la conservation. Mais leur analyse de la production agricole se trouve directement en conformité avec les prétentions Malthuses plus récentes que nous devons d'une façon ou d'autre intensifier la production agricole. Ils divergeraient des notions simples de ces analystes et plaideraient pour une intensification basée sur des pratiques agricoles plus écologiquement saines, mais néanmoins ils acceptent des présomptions fondamentales du manque de nourriture qui sont fausses. En outre, le traitement superficiel de presque tous les sujets, nous craignons, pouvons donner des munitions à ceux qui cherchent à critiquer le mouvement vers une agriculture plus raisonnable qui tient compte de la conservation. Egalement, une série de sujets presque est entièrement ignorée. Il n'y a pas la moindre discussion sur la réformation des terrains, un sujet probablement le plus important dans le mouvement en ce qui concerne la marche vers une agriculture écologiquement saine dans les tropiques. Nous avons constaté que le reste du livre semble souffrir des problèmes semblables. Les défauts de ces deux livres sont vraiment une décevantes, surtout parce que la vision fondamentale est non seulement une avec laquelle nous sommes d'accord, mais une que nous sommes certains est finalement correcte.

These two new offerings from the venerable Island Press have a similar underlying purpose described quite adequately by their titles. Designed to bridge the gap between conservation and sustainable agriculture, both books offer an introduction to this emerging field. However, neither book fully achieves this laudable objective. One is a very good book that suffers from a narrow geographic focus, while the other is a sadly superficial book with some good parts. Let us begin with the good book.

The Jackson and Jackson edited volume is a welcome addition to the growing appreciation that the separation of agricultural production from conservation goals in terrestrial ecosystems has been at best a fool's game, and at worst a Faustian bargain for both sides. Both conservation biologists and agricultural scientists have shared in a kind of unannounced agreement about how to manage landscapes – "give me my biological preserve and I won't notice how you're screwing up the world," and "don't say anything about how I'm screwing up the world and I will allow you your biological preserve." This unholy alliance has been devastating for both conservation and agriculture as has been extensively documented in recent years. The Jackson's volume speaks to this issue in a series of invited chapters, and can be summed up by the authors' own introductory statement "… we maintain that the trend toward sterile, industrialized agricultural (sic) is an unacceptable, unaffordable sacrifice, that it is far from necessary, and that we can help farmers reverse it to benefit nature conservation, rural communities, farm families, urban residents, and consumers."

Laura Jackson's chapter in particular provides a wonderful overview of the problem from the point of view of the Midwestern farmer and conservationist. "Conservation of biological diversity across the entire landscape and from creek to ocean will not be accomplished by simply planting a few patches of shrubs and grasses on farms for 'wildlife habitat.' It will mean changing the face of agriculture itself." We could not agree more, and find her arguments compelling. Furthermore, unlike many books of this type, Jackson does not shirk some of the more "delicate" issues such as property rights, and the absurd claim, made repeatedly by agroindustry that the problem is to feed the world (it has long been known that there is far more than enough food produced to feed many more people than currently exist, or even than are projected to exist – the problem is not the lack of food, but the lack of money that would allow the hungry to buy even a small part of the world's current oversupply of food). She likens the current agroindustrial system to an elephant in the living room, an apt and potent metaphor.

Having said all that, it must be mentioned that we did find some things wrong with the book. As with any multi-authored volume, it would be unusual if reviewers did not find one or another chapter with which they found fault. Such is the case here, but for the sake of space we simply note that most chapters are interesting, readable and within the same basic paradigm set out by the editors. Indeed it is an excellent job of putting together a single vision with multiple perspectives.

On the other hand, we find some fault with the scope of their analysis. For the Jackson's their fine analysis about how to integrate ecosystems into food systems seems to end with the harvest. There is little evaluation of the market beyond a few ominous words on the growing influence of corporate agriculture in the organic movement. A few pages are devoted to listing some cooperative marketing and labeling efforts, but this does not provide convincing evidence for their claim that "most people who wish to provide a sustainable table in their homes now have opportunities to purchase appropriate foods." Neither book provides a resource guide, even for the programs they mention, that might help consumers educate themselves or to reach biodiversity-friendly products. This is particularly needed for consumers and producers who live outside university towns and other hubs of progressive thought, where the bulk of agriculture is grown and consumed.

Additionally, their geographic scope is narrow. Clearly the Jackson's is Midwest (as they say in their introduction) and the images they conger, the examples they offer, the analysis they seek, all are conditioned by this location. One chapter is about California and one about Great Britain, but only passing reference is made to the Third World, where, let us admit it, the problems they address are most severe. There is, furthermore, a curious myopia about clear precedents to their viewpoint, at best short shrift is given the work of Miguel Altierri, of Peter Rosset, of Steve Gliessman to say nothing of many Third World authors (Latin Americans and Indians particularly come to mind). And most inexplicable is the lack of attention given to the concept of "natural systems agriculture," an idea pioneered by Wes Jackson, someone who we understand has deep connections with both editors.

The McNeely and Sherr volume is quite a different ballgame. The authors are policy advisors to IUCN-Conservation Union (McNeely) and Forest Trends (Scheer). And the book reflects those positions. It seems that they were assigned by superiors the task of writing a policy report on "ecoagriculture," spent a few months collecting relevant documents, and churned out a report that smacks of a policy statement, not a well-reasoned document. We say this with great sadness, because the underlying goal of their project is one with which we have great sympathy. Though perhaps useful as an introduction, the book is not something we would recommend as a serious academic treatment of the subject matter.

To their credit, and contrary to the Jackson's volume, McNeely and Scherr delve into the difficult questions surrounding the economics and policy needs for encouraging and sustaining a biodiversity friendly agricultural movement. They acknowledge that food needs to be produced and biodiversity needs to be conserved, and they reject the anachronistic assumption of separation of agriculture and conservation. They call for new, more ecologically friendly, methods of agricultural production and for the incorporation of conservation goals into agricultural planning. All of that is, from a basic values perspective, and from the perspective of where both conservation biology and agricultural ecology have arrived in recent years, consistent with what we regard as the correct paradigm. The problem is not with their underlying goal, but with the details.

While not as crude as some of the extreme neoMalthusians, their analysis of agricultural production falls directly in line with the more recent Malthusian assumptions. Sure, they say, most of the problem right now is that people cannot afford to buy what is admittedly an overabundant supply of food, but note approvingly that "some experts suggest that in thirty years we will need at least 50 to 60 percent more food than we produce now, in order to meet global food demand…" Then the basic underlying assumption promoted by every one from the director of the Missouri Botanical Gardens to Archer Daniels Midland to George W. Bush is that we must somehow intensify agricultural production. They would diverge from the simplistic notions of these analysts and argue for intensification based on more ecologically sound agricultural practices, but they nevertheless accept the underlying assumptions, which are wrong. We currently produce far more food than the world requires and will do so for as far into the future as anyone can imagine (short of war or other catastrophic events). Indeed, as attested by any farmer or agricultural economist, the main problem in agriculture today is low prices paid to farmers because of world-wide over production, not a scarcity of food. Furthermore, analyzing the United Nations Food and Agriculture Organization (FAO) statistics on farm size and productivity the world over, Rosset obtained the striking result that on a per hectare basis, the smaller farms are generally more productive than the larger ones. Indeed, if increasing production is your goal, breaking up large farms and giving the land to small producers would be the best short term solution.

The details of the book are especially annoying. Almost every chapter suffers from the superficiality that one expects from a World Bank report. Consider just a single example, the coffee agroecosystem, with which we are both intimately familiar. This ecosystem is included as one of six examples of "enhancing habitat value." Two paragraphs are devoted to this ecosystem, the first to simply describing the system, the second to note a single study that attempted to incorporate timber trees in coffee farms (published in an obscure policy wonk report) and a couple of certification programs. The major work on biodiversity in coffee has been done by Russell Greenberg and Robert Rice, of the Smithsonian Migratory Bird Center, Ivette Perfecto of the University of Michigan, and Victor Toledo of the National Autonomous University of Mexico, all of whom have published in major journals. With the exception of one fairly obscure paper by Perfecto, the authors completely ignore, and are perhaps unaware of these researchers. And their presentation of the issue ignores even the simplest and most evident complications: the major problem that currently exists in the world coffee market of overproduction that has depressed coffee prices to catastrophically low levels, created by an international development bank program in Vietnam; the technical problems associated with developing certification criteria for biodiversity-friendly coffee; the problem of unifying the three currently existing certification programs (fair trade, organic, and biodiversity-friendly); to mention a few. They also fail to mention the inaugural shade-grown coffee program, the Smithsonian Migratory Bird Center's bird-friendly coffee, which links organic and biodiversity-friendly certification efforts. In short, their treatment ignores the key documentation that might lead the reader to the appropriate literature, oversimplifies the technical aspects, and completely ignores the sociopolitical issues.

This superficiality is particularly disappointing because coffee is such an important test case for ecoagriculture. After nearly ten years of experience, shade-grown coffee certifiers have dealt with many of the issues associated with bringing biodiversity friendly products into the marketplace. Each certifier has different objectives and approaches to achieve those goals. Some programs have clearly measurable and verifiable criteria, while others, such as Conservation International's Conservation Coffee program with Starbucks, have yet to publish specific criteria. A deeper analysis of this and the longer organic experience would have greatly enhanced the discussion of market incentives for these products. For the authors, association with a conservation organization seems to be adequate proof of a certification program's efficacy. They have missed an opportunity to discuss the standards and levels of enforcement that actually go into real certification programs. As vendors and advertisers begin to latch onto the language of green marketing, consumers will need guidance to help them distinguish between certification approaches to support programs with the most conservation potential. Not all certification programs are created equal.

We found that the rest of the book seems to suffer from similar problems. The superficial treatment of almost all subjects, we fear, may give ammunition to those who seek to discredit the move towards a more rational agriculture that takes conservation into account. Furthermore, a whole series of issues are almost completely ignored. Nothing is said of land reform, probably the most important issue in the move towards more ecologically-sound agriculture in the tropics. The basic bourgeois assumptions about property rights are simply assumed (in contrast to the Jackson's volume). The question of maintaining premiums for organic produce in the face of capitalism's hegemony is seemingly not even appreciated as a problem. And the really basic issues of whole system accounting (i.e. those who produce pesticides, for example, need to pay all the costs of production, including cleaning up their chemical waste dumps), the precautionary principle which has become a standard in all of the environment movement, the spread of genetically modified organisms (GMOs), are either ignored or only touched on lightly.

It is really a shame, since, as we said at the outset, the basic vision is one that we not only agree with, but one that we are certain is ultimately correct.