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In This Issue:

[Paying the farm bill: U.S. agricultural policy and the transition to sustainable agriculture.](#)

[Cover crop management and nitrogen rate in relation to growth and yield of no-till corn.](#)

[Challenges of intercropping in citrus orchards.](#)

[Industrial agriculture and rural community degradation.](#)

[[Home](#) | [Search](#) | [Feedback](#)]

Summer 1991 (v2n3)

Paying the farm bill: U.S. agricultural policy and the transition to sustainable agriculture.

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This 70-page report is the first of its kind to develop quantifiable economic measures of sustainability. It is based on a systems analysis which links data from field, farm, region and nation. The potential for a win-win outcome (benefits to farmers, consumers, the federal government and the environment) is explored through analyses of two nine-year field experiments located at the Rodale Research Center in Kutztown, Pennsylvania, and the University of Nebraska at Mead. These experiments compared conventional farming systems relying on heavy inputs of fertilizers and pesticides, and alternative Systems which utilize crop rotations, legume green manures, biological pest control, and modified tillage practices.

Methodology

The analytical framework for this study combined several environmental and econometric models as shown in Figure 1. Soil erosion and degradation estimates were used to determine the costs associated with the long-term productivity of farmland and off-farm environmental damage. The authors identify government policy as a major constraint to adoption of resource-conserving production practices. Therefore, five different policy options were superimposed onto the field experiment results. These include:

1. Baseline Policy — The Food Security Act of 1985, served as the analytical starting point for both case studies.
2. Multilateral Decoupling — assumes that all major trading countries eliminate both import restrictions and export subsidies on agricultural products and divorce government payments to farmers from specific production levels or decisions; this scenario represents one of the goals of the U.S. government in the current GATT negotiations.
3. The Sustainable Agricultural Adjustment Act of 1989 — also known as the Jontz Bill, enables farmers to adopt "resource- conserving crop rotations" without sacrificing commodity support benefits; a version of this legislation was passed in the 1990 Farm Bill as the *Integrated Farm Management Program Option*.
4. Normal Crop Acreage — a 1990 Bush administration proposal that would allow farmers participating in government programs somewhat more flexibility in the choice of crops to be planted.
5. Chemical Input Tax — assumes that baseline policy remains intact, but fertilizer and pesticide costs are 25 percent higher, simulating the effects

of an input tax.

Each policy option was analyzed in terms of its financial impact on individual farmers and society as a whole (Accounting Model). The financial impact on farmers is called **net farm income**, and includes the farmer's gross operating margin receipts from commodity programs, as well as the value of changes in soil productivity. Since this value does not take into account the environmental costs borne by others, a second indicator called **net economic value** is also calculated. This latter measure includes off-farm damages, but ignores transfer payments under governmental support programs.

Market simulations based on econometric models developed by the Food and Agricultural Policy Research Institute (FAPRI) at Iowa State University were used to estimate the market prices that each policy option would generate. These price projections were used in conjunction with farm production models to assess farmers' optimal responses to alternative policies, given the potentialities of the alternative farming systems.

Results and Conclusions

Under current baseline policy, resource-conserving production systems in the case studies were economically superior to conventional systems in terms of net economic value. In the Pennsylvania case study, for example, sustainable agricultural practices cut production costs by 25 percent, eliminated inorganic fertilizer and pesticide use, reduced soil erosion by more than 50 percent, and increased yields after the transition from conventional systems had been completed. With reduced soil erosion and greater water retention, the alternative production system would cut off-site damages by more than \$30 an acre; it also would forestall a 30-year income loss (present worth \$124 an acre) by building soil productivity by 2 percent and preventing a 17 percent decline in soil productivity. "Consequently, when all resource costs associated with soil erosion are included, resource--conserving farming outperforms conventional approaches by almost a two-to-one margin in net economic value per acre."

However, the Pennsylvania study also documents the difficulties that farmers face while in transition to alternative production systems. During this transition, farmers may experience some short-term income loss, but over the long-term (after about four years) substantial financial gains are realized. At a minimal cost, government policy could support farmers during the transition, while still remaining far less expensive than current programs to taxpayers.

Once the possibilities under current baseline policy are understood, the effects of other policy options can be considered. The WRI study concludes that a policy of *multilateral decoupling* (option 2) would produce the greatest net economic value of any of the policy alternatives. This is true for alternative production systems in both the Pennsylvania and Nebraska case studies. Based on data from the Rodale experiment (post-transition), the net economic value of alternative rotations (cash grain and cash grain with fodder) would be double that of conventional corn-beans. At the same time, the government costs in support payments would be reduced by \$110 - \$152 per acre over five years.

Moreover, multilateral decoupling would result in higher net farm operating

income for farmers before commodity payments are taken into account. Using the Pennsylvania data, net farm income would increase by 22 - 224 percent for the different rotations and treatments. In Nebraska, net farm income would increase by 16 - 203 percent. The reason is that multi-lateral decoupling divorces income support payments from commodity production levels, allowing farmers to feel market signals directly and thus encouraging more efficient reproduction. In addition, opening markets and reducing supplies from high input producers would result in higher market prices.

In sum, WRI concludes that the apparent financial advantage to farmers of conventional over alternative farming systems is reversed when accounting methods are used that take into consideration soil depreciation (or appreciation). Current commodity and income support policies inhibit the adoption of resource-conserving practices by artificially making them less profitable to the farmer (lower net farm income). By removing these distortions, a policy of multilateral decoupling would increase farmers' incomes, reduce government costs, improve soil and water quality, and provide consumers food grown with fewer chemical inputs.

Reviewer's Comments

There is reason to believe that the results generated by the two case studies are generalizable to other regions of the U.S., including California. Although they were selected primarily because of the availability of the necessary long-term productivity data on alternative systems, Pennsylvania and Nebraska also represent regions with wide differences in soil, weather, cropping systems and level of on and off-farm environmental damage from soil erosion (as measured by the USDA's Erosion-Productivity Impact Calculator Model, EPIC). In Pennsylvania off-site damage from soil erosion is among the highest in the nation, while Nebraska ranks near the bottom. Yet even in Nebraska, resource-conserving production systems proved to be economically competitive.

If anything, the methods employed in this study actually underestimate the economic viability of sustainable practices when considered from a long-term environmental perspective. As the authors point out, their model does not include (because data are not as readily available) other costs often associated with conventional practices: groundwater depletion or contamination, loss of wildlife habitat, soil salinization or toxic build-up, and human health problems due to the use of toxics. To paint an accurate picture, any attempt to assess the comparative economic value of production systems in California would need to build on the model in this report, but also include data which measure the economic value of as many of these other concerns as possible.

Two issues raised in the study would have benefited from further elaboration. The first concerns the authors' unqualified endorsement of the Bush Administration position in the GATT negotiations. The endorsement is based solely on WRI's analysis of the benefits of multilateral decoupling. Yet the Bush Administration has many other goals in these negotiations, not all of which may prove as beneficial to farmers, consumers and the environment. A distinction between the specific goal of multilateral decoupling and the general package of policies being pursued in GATT negotiations would have been in order.

The second issue involves calculating the costs and benefits to consumers of the proposed policy changes, and more particularly, how those costs and benefits might be unequally distributed amongst the population. Specifically, multilateral decoupling offers some benefits to both farmers and consumers; but there is also the question of how a rise in market prices will affect the ability of the nation's poor to obtain nutritious food. This topic deserves attention in a report of this importance.

Copies of *Paying the Farm Bill* can be ordered (\$15.50 includes postage and handling) from: WRI Publications--Dept. PB, P.O. Box 4852, Hampden Station, Baltimore, MD 21211.

For more information write to: World Resources Institute, 1709 New York Ave. NW, Washington, DC 20006.

(DEC.301) *Contributed by Dave Campbell*

[[Back](#) | [Search](#) | [Feedback](#)]

Cover crop management and nitrogen rate in relation to growth and yield of no-till corn.

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Winter cover crops have been used mainly as green manures for controlling soil erosion and improving soil quality. More information is needed on how to use winter cover crops in minimum or no-till cropping systems, particularly in the areas of plant-soil-water relations and soil nitrogen dynamics. This study investigates the effects of cover crop management, timing of corn planting and nitrogen fertilizer rate in a non-tillage production system. Corn dry matter production, grain yield, and nitrogen uptake are used to evaluate the effect of different treatments.

Methods

In 1984 and 1985, four cover crop treatments, three desiccation/planting date combinations, and three nitrogen rates were replicated four times in a split-split plot design. Cover crop treatments included fallow, rye ('Wrens Abruzzi'), crimson clover ('Tibbee'), and hairy vetch ('Common'). Nitrogen rates were 0, 100 and 200 kg per ha. Dates of cover crop desiccation and corn planting were:

Treatment code	Cover crop desic.	Corn planted
1984		
EE ^{a/}	18 April	18 April
EL	18 April	1 May
LL	1 May	1 May
1985		
EE	19 April	19 April
EL	19 April	7 May
LL	7 May	7 May

^{a/} Corresponds to cover crop desiccation/corn planting combinations of early/early (EE), early/late (EL), late/late (LL).

Results and discussion

Cover crop composition and nitrogen release. A companion study (Waggoner, 1989) provided detailed information on how cover crops were affected by the time of desiccation. Averaged over the two years (1984,1985), late cover crop desiccation resulted in dry matter increases of 39, 41 and 61 percent for rye, crimson clover, and hairy vetch, respectively. The total nitrogen content of the respective cover crops increased 14, 23, and 41 percent. The corresponding C/N ratio, cellulose content and lignin content for each cover crop also increased between early and late desiccation times.

Each cover crop had its own distinct nitrogen release curve; these patterns differed sharply between 1984 and 1985 which had a relatively dryer growing season. Total nitrogen content for each cover crop (as determined by the micro-Kjeldahl procedure) and estimates for the *cumulative* cover crop-nitrogen released at various times during the two years is shown in Table 1.

Corn Dry Matter Production. Corn growth was measured in all zero-N treatments by harvesting a sample of above ground plant tissue at 4-week intervals beginning eight weeks after planting. A summary of the data for 1984 and 1985 is shown in Table 2.

1984. Eight weeks after planting, corn growth was greater for EL and LL treatments than for the EE treatment. This could partially be explained by the relatively cool temperatures which existed at planting time for EE management. Another explanation offered was that residual soil nitrogen during the early growth stages of EE corn was not readily available. As evidence of this, it was noted that between mid-April and mid-May, soil inorganic nitrogen for fallow plots increased five-fold. A similar pattern was observed 12 weeks after planting, but by maturity (16 weeks) results had reversed. Corn growth at this time was actually greater under EE management "indicating a differential pattern of cover crop N availability relative to cover management and corn demand for N."

The data suggest some of the difficulties in synchronizing nitrogen release by cover crops with periods of N uptake by the subsequent cash crop. This problem is compounded in areas where significant rainfall occurs during the growing season, as N released during cover crop decomposition is subject to leaching. As would be expected, corn growth for each sampling date following legume treatments was greater than corn growth following a rye cover crop. This was probably due to more rapid N release by the legumes and some N immobilization with rye because of its higher C/N ratio.

1985. The main finding during the 1985 growing season was a significant cover management x cover crop type interaction, particularly for the mid-season sampling dates. The differences in corn growth under various cover crop treatments and planting dates were attributed to the wide range of residue-N release between early and late desiccation dates. For example, rye nitrogen release rates eight weeks after planting were 33 kg N per ha for early desiccation and 8 kg N per ha for late desiccation. The differences between early and late desiccation for the legume cover crops were not as pronounced: 47 and 37 kg N per ha, for crimson clover; and 70 and 95 kg per ha for hairy vetch (see Table 1).

Corn Grain Yield. Yield of corn was evaluated for all nitrogen fertilizer treatments. For purposes of analysis, nitrogen application rates were grouped within cover crop type and nested within cover management. In general, grain yields following fallow and rye cover increased with the initial fertilizer application of 100 kg N per ha. Additional nitrogen to equal 200 kg per ha did not result in any further yield increases. In contrast, the yield response to applied nitrogen following a legume cover crop was quite limited. Because of poor weather, overall yields in 1985 were about 50 percent of those obtained in 1984.

Uptake of Residue Nitrogen. The nitrogen released by the cover crops and

taken up by the corn was estimated by taking the difference between nitrogen up-take at physiological maturity of corn (without applied nitrogen) in the fallow system and that in the cover crop treatments. Results showed a net immobilization of N in the rye cover crop system. The legume cover crop systems, on the other hand, showed varying degrees of nitrogen mineralization. Mean nitrogen recovery values following rye, crimson clover and hairy vetch were similar both years, averaging -25, 43, and 40 kg N per ha, respectively. "Although no attempt was made to delineate a nitrogen response curve over a wide range of applied N, and thereby establish a fertilizer nitrogen replacement value by the legumes, the 40 to 45 kg N per ha recovered by corn following crimson clover and hairy vetch represents approximately 38 and 35 percent in 1984, and M and 24 percent of the respective total N content of these legumes."

Table 1. Cover Crop N Content and Cumulative N Release During 1984 and 1985 Growing Seasons.						
Cover crop\ Desicc. time	Total N Content	Cumulative N release				
		2	4	8	12	16
1984		---- kg N per ha ----				
Rye/early	52	14	20	24	24	24
/late	66	12	20	26	29	29
C. clover/early	107	54	68	81	88	92
/late	131	27	47	73	88	95
H. vetch/early	114	57	81	96	99	99
/late	146	50	80	109	120	123
1985						
Rye/early	106	12	22	33	40	43
/late	114	3	5	8	10	12
C. clover/early	119	16	28	47	60	68
/late	147	12	22	37	47	54
H. vetch/early	154	23	42	70	88	101
/late	229	32	57	95	120	136

Source: Wagger, 1989.

Table 2. Corn Dry Matter Production in 1984 and 1985 as Affected by Cover Crop and Management at Zero Applied N.							
Mgmt.	Cover Crop	Weeks after Planting					
		1984			1985		
		8	12	16	8	12	16
		-- Dry matter, Mg/ha --					
EE	Rye	0.48	4.83	12.33	1.56	3.55	6.93
EE	Cr. clover	3.22	8.73	18.90	2.82	9.58	10.74
EE	Hairy vetch	3.61	9.39	18.44	2.71	8.71	11.30
EL	Rye	2.64	4.73	11.08	2.00	4.00	6.80
EL	Cr. clover	4.79	10.81	14.81	3.45	7.44	11.58
EL	Hairy vetch	5.97	10.84	15.80	2.60	8.36	11.18
LL	Rye	2.41	7.30	12.91	0.91	3.50	6.27
LL	Cr. clover	6.26	8.07	13.57	2.59	4.90	10.04
LL	Hairy vetch	6.64	11.57	16.28	3.44	6.69	10.98

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[[Back](#) | [Search](#) | [Feedback](#)]

Challenges of intercropping in citrus orchards.

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Article written for Components. 1991

Editor's note: Contamination of groundwater by herbicides and nitrates is an increasing concern for citrus growers in California. New management strategies including the use of cover crops may help prevent this problem. These management strategies will be addressed in a SAREP publication on managing citrus orchards to prevent groundwater contamination, scheduled to be released in 1992.

Cultivated species of *Citrus* originated in the understories of tropical rain forests in southeast Asia. Adaptation to a shaded, moist environment is evident from such morphological traits such as broad, flat leaves with few barriers to transpiration, naked flower buds, and weak root-hair development (Webber, 1943). The most intriguing intercrops for California citrus may be overstory trees with compatible root systems. As with other crops domesticated from the forest understory (e.g., coffee, cacao), proper species selection and planting design can enhance the productivity of the cash crop, and buffer the growing environment against environmental stress. Citrus produced under dates (*Phoenix dactylifera*) in southern California suffered considerably less in the 1937 freeze than did citrus planted alone (Webber, 1943). Overstories of jujube (*Zizyphus jujube*) in India protect citrus orchards from heat and drying winds (Bonavia, 1883). Taprooted overstory trees can recover water that moves below the reach of superficial citrus roots and recycle the nitrates that now leach into groundwater. Inclusion of overstory species as intercrops is probably not feasible in the near term for many Californian citrus districts.

Understory cover cropping can provide some important benefits to citrus, but nonetheless presents some challenges. Until the middle of this century, cover crops were widely grown in California citrus orchards. During 1916-17, cover crops (mostly sour clover [*Melilotus indica*]) were grown on about 95,000 acres of citrus (Anon., 1917). Today's floor management practices are far different from those of the early part of this century; complete non-tillage management with herbicides is practiced in over 90 percent of California's citrus orchards (Pehrson, 1988). However, the potential loss of pre-emergence herbicides due to groundwater contamination has caused growers and researchers to reconsider using cover crops.

Cover crops are important in sustainable tree and vine husbandry because they can reduce soil erosion, improve soil fertility and structure, increase water infiltration, increase soil organic matter content and biological activity, reduce orchard temperatures in the summer, suppress weeds, and promote beneficial arthropods.

Problems related to citrus arise because: 1) cover crops predispose for radiation

frosts; 2) citrus trees produce year-round shade which may inhibit cover crops; 3) tillage associated with cover-crop management may damage citrus roots, cause compaction, and reduce water infiltration; and 4) cover crops may compete with shallow-rooted citrus trees for water. Here we explore these issues.

Frosts

Citrus trees are evergreen, and susceptible to frost. Irrigation, wind machines, helicopters, and orchard heaters may be used for protection on still, clear, winter nights. Adequate nitrogen and potassium reduce the threat of damage, but nitrogen management practices should not promote lush foliar growth during autumn.

Cover crops can predispose orchards to radiation frosts. Dense stands of cover crops reduce the amount of solar radiation reaching the soil during daylight hours, and lead to slightly lower air temperatures on cold, clear nights (Young, 1922, 1925; Pehrson, 1989). This is because bare ground is usually better than living foliage at storing and later re-radiating solar heat. However, orchards with closely-mowed cover crops and moist soil may be only slightly colder than the optimal soil which is bare, firm, and moist. It is important to note that cover cropping is not likely to exacerbate severe advective freezes like the catastrophic cold spell that occurred during the winter of 1990-91.

It is not clear which cover crops provide the most "open" stands (i.e., the most exposed ground) upon mowing, yet retain the capacity to regenerate by late spring. Various clovers (*Trifolium* spp.) and medics (*Medicago* spp.) tolerate mowing well, but some of these may require "scalping" (very close mowing) in order to substantially reduce vegetational cover. Sub-terranean clovers (*Trifolium subterraneum*) are able to regenerate rapidly after such mowing. Vetches (*Vicia* spp.), on the other hand, appear to be less suitable in frost-prone areas since they must be mowed relatively high in order to ensure regeneration. Mowing may not be feasible if the soil is too wet, although waterlogged soil is less likely in orchards that have been cover cropped for several years.

An alternative or complement to mowing is to seed an annual cover crop later than normally recommended. In California, the standard recommendation is that cool-season annual cover crops should be seeded by mid-October to ensure rapid establishment and growth. This may not be desirable in the citrus system. Some growers in the southern San Joaquin Valley seed mixtures of oats (*Avena sativa*), vetches, and winter peas (*Pisum sativum arvense*) during late November or early December, so that the cover crop is no more than a few centimeters high and affords little vegetational cover during the time of principal frost danger (January and February). This strategy may also aid in cover crop establishment in orchards with low-volume irrigation systems because rainfall is more likely in November or December than in October. If plowed down at peak flower, the mixture of oats, vetches, and peas will require yearly replanting. Clearly, the idea of late seeding is not a management option with a self-reseeding or perennial cover crop.

Shading by Citrus Trees

The evergreen habit of citrus presents another problem. Closely-spaced, large trees cast year-round shade over much of the orchard floor. Winter cover crops

may receive little direct sunlight in orchards with east-west row orientation and hedgerow pruning. Shade tolerance of cover crops may therefore be important. None of the currently-available cover crops appears to tolerate the deep shade immediately beneath mature citrus trees, although several varieties of white clover (*Trifolium repens*) are somewhat shade tolerant. Fertilization with phosphorus has been shown to improve the shade tolerance of berseem clover (*Trifolium alexandrinum*) (Hazra and Tripathi, 1986).

Between trees, the orchard floor may present a pattern of dappled sun and shadow that shifts during the season as well as during the day. Mixtures of cover crops with varying thermal and shade optima and tolerances might be most productive in such a variable environment. This idea remains to be formally tested, but with these issues in mind, mixtures of shade-tolerant white clover and heat-tolerant 'Salina' strawberry clover (*Trifolium fragiferum*), both of which are perennials, are now being used as permanent cover crops in some southern Californian citrus orchards.

Tillage

In order to ensure the most rapid availability of nitrogen and other nutrients contained in cover crops, they should be tilled under; sometimes prior mowing is advisable. Tillage can also be useful for disposing of prunings. However, citrus roots are abundant near the soil surface, rendering them susceptible to direct damage or soil compaction caused by disking (Kimball, 1951; Jones and Embleton, 1973). Spring-tooth and spike-tooth harrows compact the soil less than the disk harrow; other innovative tillage implements may also be available.

Reducing or eliminating tillage would probably lead to improved water infiltration (Jones and Embleton, 1973), but a reduced availability of nitrogen (Janzen and McGinn, 1991). The use of mowing alone for resident vegetation discourages tall-growing, upright species and selects for low-growing, spreading species. Within a few years, such management can lead to a solid stand of bermuda grass (*Cynodon dactylon*) (Fischer and Jordan, 1984). However, a dense stand of a cool-season cover crop can, upon dying in the spring, suppress weed seed germination or growth of bermuda grass through much of the summer.

Water Issues

Given the concerns over water availability in much of California and the extensive use of low volume irrigation, many growers question whether cover crops can or should be grown. All plants need water to grow, but cover crops which grow during winter months can utilize winter rainfall and have relatively little impact on soil moisture available to associated trees.

Cover crops can improve infiltration and reduce runoff of rainwater, and thereby retain more rainfall and irrigation water. This effect has been shown repeatedly. Jones and Embleton (1973) stated that cover cropping leads to improved soil structure and water infiltration in citrus orchards. Grimes and Goldhamer (1989) found that the annual grass 'Blando' brome (*Bromus mollis*) could greatly improve the water intake for vineyard soils in the eastern San Joaquin Valley, and improve the efficiency of irrigation. Cover crops can improve available water storage capacity of orchard soils, but this is most likely on heavier soils, as noted by Lanini et al. (1988). Those authors also

reviewed several studies that showed that soil moisture was highest in orchards with organic mulch, followed by bare soil, minimal cultivation, grass sod, legume sward, and continuous cultivation. Winter- annual grasses and legumes were not considered.

Plant materials. Some winter-annual cover crops, such as burr medic (*Medicago polymorpha*), are deep-rooted and drought resistant. Deep-rooted cover crops may be more efficient at water use because they are able to continue growth by tapping water from deep in the soil profile after surface supplies are cut off. However, such a mechanism would lead to depletion of soil moisture at depth, and suggests potential competition with associated trees and vines.

In orchards employing mini-sprinklers or other forms of surface irrigation, perennial warm-season legumes such as white clover, 'Sauna' strawberry clover, and birdsfoot trefoil (*Lotus corniculatis*) can persist within the irrigated areas. Cover crops can potentially block microsprinkler emitters; this can be a problem with both cool-season annuals and warm-season perennials. The low risers that typify misters and other mini-sprinklers may dictate the use of low-growing clovers rather than twining, climbing vetches. On the other hand, recent advances in mowing technology may include implements that can mow around sprinklers without damaging them.

When self-reseeding annual cover crops are desired in areas with erratic rainfall, early maturation, hardseededness, and embryo dormancy may be important traits to keep in mind. Early-maturing varieties of cool-season cover crops will not require spring rains in order to reseed (Graves et al., 1987). Early-maturing varieties of burclover, crimson clover (*Trifolium incarnate*), rose clover (*Trifolium hirtum*), and subterranean clover are commercially available. Hard seed will not germinate until the impermeable seedcoats have been physically abraded or biologically degraded. Hardseededness or embryo dormancy can ensure that a substantial portion of the seed bank will be held in reserve for subsequent years. Rose clovers produce high proportions of hard seed (Williams and Elliott, 1960), as do some varieties of subterranean clover (Graves et al., 1987) and crimson clover (Baltensperger et al., 1987).

In citrus, cover crops of perennial grasses might be appropriate in pack rows (usually about one alley in five) to facilitate the vehicular traffic that accompanies harvesting during the wet winter months. A drawback of perennial grasses (especially warm-season perennials) is that they compete with trees for nitrogen and water (Forshey, 1986). However, an off-setting advantage is that perennial grasses enhance soil structure better than do other plants (Goldstein, 1989). Grasses produce masses of fine roots and stimulate soil microorganisms that exude gums; in turn, these gums help to aggregate soil particles. Annual grain crops produce only 11-16 percent as much root biomass as do some perennial grasses. The residual effect of improved water infiltration following perennial sod can endure 6 years after the sod is plowed.

Cool-season perennials (e.g., native bunchgrasses) may prove useful in any portions of the understory outside the coverage of the irrigation. These plants use water primarily during the winter and spring and most species cease growth during the warm season. However, seasons of growth and dormancy vary both within and among species. In many years even these cover crops require irrigation to establish the seedlings. Examples of potentially useful cool-season

perennial grasses include the following California natives: blue wildrye (*Elymus glaucus*), meadow barley (*Hordeum brachyantherum*), creeping red fescue (*Festuca rubra*), and California brome (*Bromus carinatus*). Perennial ryegrass (*Lolium perenne*), a non-native, may also be useful.

Cover crop management. Cover crops require care and water. Despite the economy gained by main reliance on winter rains, it is generally recommended that, when possible, cool-season annual and perennial cover crops should be irrigated lightly but frequently to ensure prompt establishment. While furrow or sprinkler irrigation systems are suitable for such a purpose, most San Joaquin Valley citrus orchards have low volume irrigation systems that wet only a small portion of the orchard floor. The options with such systems include using dragline sprinklers during the period of establishment or relying on fall rains for germination. The latter practice may be the only alternative, but may produce unreliable results since fall rains are sometimes insufficient or too sporadic to establish the cover crop.

Cool-season cover crops can be used to provide a mulch during the summer, thus reducing evaporation of water from the soil. This practice can be viewed as "investing" some water in the autumn in order to conserve water during spring and summer. In a study of cover crops in almond orchards, Prichard et al. (1989) showed that 'Blando' brome used water during the early season, but after mowing led to reduced water use during June and July. Total seasonal water use for this cover was similar to that of the residual herbicide and chemical mowing treatments.

Conclusion

Various factors preclude simply adopting the cover cropping practices of decades past. As our knowledge progresses we may be able to prescribe cover cropping regimes to suit specific site requirements.

Table 1. Summary of characteristics and uses of potential cover crop species for citrus.			
Cover Crop Species	Reliably Self-Reseeding?	Tolerates Close Mowing During Winter?	Comments
Winter-Annual Legumes			
Austrian Winter Pea <i>Pisum sativum arvense</i>	No	No	Useful in mixes where frosts are not a major problem.
Barrel Medics <i>Medicago truncatula</i>	Yes	Yes	Drought-resistant; thrive on high-pH soils
Burr Medics (Burclover) <i>Medicago polymorpha</i>	Yes	Yes	Drought-resistant; thrive on high-pH soils.
Clovers (<i>Trifolium</i> spp.)			
Crimson Clover <i>T. incarnatum</i>	Yes	Yes	Early maturing/reseeding var. available ('Dixie')
Rose Clover <i>T. hirtum</i>	Yes	Yes	Early maturing/reseeding varieties available.

Subterranean Clover <i>T. subterraneum</i>	Yes	Yes	Early-maturing/reseeding varieties available.
Sour Clover <i>Melilotus indica</i>	Yes	Yes	Used much until 1950's; erect plant with woody stalk.
Vetches <i>Vicia spp.</i>	Yes	No	Produce much biomass; useful in mixes.
Winter-Annual Grasses			
'Blando' Brome <i>Bromus mollis</i>	Yes	Yes	Clippings can conserve soil soil moisture.
Oats <i>Avena sativa</i>	Yes	Yes	Work well with legumes.
Perennials			
Birdsfoot Trefoil <i>Lotus corniculatus</i>	Yes	Yes	Tolerant of waterlogging and drought.
'Salina' Strawberry Clover <i>T. fragiferum</i>	Yes	Yes	Can be used with white clover; may become invasive
White Clover <i>T. repens</i>	Yes	Yes	Has some shade tolerance.
Perennial Grasses	Yes	Yes	Can compete with trees; cool-season spp. may work well.

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Industrial agriculture and rural community degradation.

MacCannell, Dean

In Swanson, L.E. (ed.) **Agriculture and Community Change in the U.S.: The Congressional Research Reports**. pp.15-75, 325-355. Westview Press, Boulder, CO. 1988

Reviewers note: This study, done for the US. Office of Technology Assessment looks at the social conditions in rural communities in four Sunbelt states: California, Arizona, Texas and Florida. It was conducted by the UC Davis Macrosocial Accounting Project, following up on earlier work in California (see references) and examines, on a statistical level the negative relationship between the trend toward increasing farm size and the social conditions in rural communities. This study uses macrosocial accounting (MSA) methods for data collection and analyses which are similar to methods used in agricultural economics. However, instead of modeling costs and benefits of different policies and practices at the level of the firm, MSA describes regional social structure. In this study, MSA is used to examine the relationship between agricultural variables and rural community conditions to determine the social costs and benefits of differences in farm structure.

MacCannell draws two primary conclusions from this study on the social conditions in rural communities of four Sunbelt states-- California, Arizona, Texas and Florida: 1) An advanced, industrial-type agriculture is now well established in the U.S. Sunbelt; and 2) Evidence suggests that this new form of agriculture is associated with substantial deterioration of human living conditions in nearby rural communities. These conclusions challenge the assumptions that have previously informed agricultural and rural policy, i.e. that agricultural economic development generally benefits workers and communities. Acceptance of MacCannell's conclusions will require rethinking policies that have encouraged the dominance of an industrial agriculture in the Sunbelt and/or those policies that will address the social and environmental damage associated with this industrial type of agriculture.

Development of Industrial Agriculture in the Sunbelt

To put this study into perspective, MacCannell reviews the development of industrial agriculture in the Sunbelt and its relation to the existence of the family farm. Despite global industrialization, the family farm continues to be the dominant form of agriculture worldwide, and persists in many parts of the U.S. and California. It was only after World War II that a unique set of circumstances in the U.S. Sunbelt developed and led to the establishment of industrial agriculture on a regional basis. These factors include:

- A historical pattern of large sized farms
- State/Federal water projects and subsidized irrigation
- Low paid, unorganized foreign labor
- Harvest mechanization and other uses of high technology

The confluence of these preconditions allowed industrial agriculture to flourish in the U.S. Sunbelt. The largest farm operators in this region were able to exploit their natural, historical and political advantages by combining government support programs, irrigation systems, foreign labor and new technologies to become preeminent in the national and global agricultural economies. Conventional wisdom suggests that the rapid pace of economic development which occurred in this agricultural sector should improve the economic and social conditions in surrounding rural communities. Yet, this study shows just the opposite. "...it is in exactly those areas where farming is the most modern, rational and economically profitable that the worst general social conditions are found." (p. 17) Although industrialization has brought benefits in terms of better technology and economic profitability to farm owners, it is associated with poverty for the workers and the community. For example, in the most productive agricultural tracts in the study area, poverty rates were from 5 to 40 percentage points higher than in other rural areas of the U.S.

Methodology

Agricultural counties in the four Sunbelt states are the units used in this MSA analysis. Ninety-eight counties were selected based on their ranking in the top 100 counties in agricultural sales nationwide or on their ratio of agricultural sales to population (at least \$2000 a year per capita). Most of these counties were dominated by agriculture and mainly rural. Data from these counties were used for descriptive statements as well as for regression analyses of the relationship of industrial farm structure and rural community conditions.

Description of Community Social Conditions

Before describing his regression analyses, MacCannell gives some background descriptive information about social conditions in selected counties in the study area. Some counties and tracts were selected for closer observation if 20 percent of the labor force was classified as "farm laborers" in 1970 and/or 15 percent or more was classified as workers in "farming, fisheries and forestry" (the closest category to farm laborer in the 1980 census) in 1980. Both field observations and tract-level data were gathered for these tracts and counties. The table below summarizes some of MacCannell's findings for California:

Social Conditions in Selected Counties in California			
Indicators	CA Total	Fresno Co.	Imperial Co.
Population	23,668,000	514,600	92,100
Labor force			
% employed	93.0	91.0	90.0
Quality of Housing			
Percent families			
w/o plumbing	0.2	2.0	4.0
>5 per room	0.5	1.0	4.0
Poverty			
Percent families			
at or below			
fed. level	8.7	11.4	12.7
Income			
Percent families			

earn > \$10,000	82.0	77.0	67.0
Mean income	\$25,800	\$22,300	\$18,800

As the table shows, housing conditions (using lack of plumbing as an indicator) were worse in the selected counties than the state average. For example, in Imperial County, lack of plumbing is 20 times higher than in the state. The same general pattern emerges from the data on crowding (as measured by percent families living in a house with more than five persons/room). Communities in Fresno and Imperial counties tended to have more families living in crowded conditions compared to the state average.

Average family incomes are 14 percent and 27 percent lower than the California average in Fresno and Imperial counties, respectively. In fact, poverty affects a much larger segment of the population in these areas as the figures show. It is interesting to note that despite the fact that poverty is higher in these counties, employment remains relatively high.

The Regression Analysis

Based on descriptive analyses of rural community conditions in areas of industrialized agriculture (of which the above discussion is just a small part), as well as previous work of the Macrosocial Accounting Project, MacCannell has built his "industrialization-degradation" hypothesis. This hypothesis asserts that increasing rural community degradation is positively correlated with increasing agricultural industrialization. To test this hypothesis, MacCannell uses regression analyses in which farm structure and agricultural technology indicators are entered as independent variables and measures of social conditions in rural communities are entered as dependent variables. The independent and dependent variables are described below.

Measuring Agricultural Industrialization. Mac-Cannell uses nine variables as indicators of "agricultural industrialization" to predict social variation. These include:

- the percent of farms in the county organized as corporations farm size in acres
- the percent of farms in the county having more than \$40,000 in sales
- percent of farms with full-time hired labor
- cost of hired labor per farm
- cost of contract labor per farm
- value of machinery per farm
- cost of fertilizers per farm
- costs of other chemicals per farm

A correlation matrix of all of these variables shows that, except for size in acres, all measures of industrialization are strongly and positively correlated, suggesting a "single, system-wide pattern of industrial agriculture." (p.37) Correlations between the nine variables and their rates of change between 1970 and 1980 are generally significant and negative, suggesting that the least industrialized of the counties underwent the most rapid change in percentage terms. Mac-Cannell suggests this trend would lead to a more uniform industrial agricultural system throughout the area.

Measuring Social Conditions in Small Communities. About 1,000

communities, averaging 5,000 population were identified within the 98-county study area. Indicators of community social conditions, the dependent variables, included the following:

- population (percent urban, rural farm and rural non-farm)
- median family income
- unemployment (percent unemployed)
- poverty level (percent of families and individuals living below the federal poverty standard)
- local government taxes
- per capita expenditures by local government
- retail sales per 1,000 persons
- percent employed in services
- percent employed in manufacture

Relationship between variables. The relationship between agricultural industrialization and community conditions was measured in several ways. Regression models were used to test: 1) the static relationship between agricultural structure in 1980 and social conditions in 1980; and 2) the dynamic relationship between agricultural structure in 1970 and the rate of change in social conditions from 1970 to 1980. All nine independent agricultural variables were used originally, but only those measures which significantly and independently predicted variation in the social variables were retained in the final analysis. The following discussion highlights a few of the relationships Mac-Cannell found.

Income. Farm size was the strongest negative predictor of median family income in the static relationship. The number of hired workers (150 + days) also significantly (and positively) predicted median family income. The only 1970 agricultural variable that predicted the rate of change in family income from 1970 to 1980 was percent farms in the county with annual sales greater than \$40,000 (negative relationship).

Unemployment. Unemployment is negatively associated with both farm size and mechanization. It is positively associated with both number of hired workers (150 + days) and percent of farms w/\$100K in annual sales. MacCannell concludes from this that large, industrialized farms are major employers of unskilled workers earning low wages. He suggests that job training programs are not the answer to employment problems in these areas, but wages, working conditions and the job mix must instead be targeted for policy changes.

Poverty. In the regression analysis, 10 percent of the variation in families living below the federal poverty standard and 14 percent of the variation in individuals living below the standard is predicted by this regression model. Average farm size is the strongest, positive predictor for both variables. The pattern is even stronger when looking at the change in poverty from 1970 to 1980. "Twenty-four percent of the variation in change in individual poverty between 1970 and 1980 is accounted for by the operation of a single industrialization variable: average farm size in 1970." (p.61) The percentage of families below poverty in 1980 is also negatively predicted by the number of hired workers (150+ days). Individuals living below the poverty level in 1980 is also negatively predicted by the percent of farms corporately owned in 1980.

Farm Size Debate

The debate about the effect of farm size or scale on rural communities was first revealed in a controversial study by Walter Goldschmidt in 1944. Goldschmidt found a number of negative social effects associated with large-scale agriculture in California's Central Valley. It has been difficult for other researchers to validate Goldschmidt's findings until recently. The reason for this is that these earlier studies assumed a linear relationship between farm size and community conditions. MacCannell's study casts the farm size debate into a new light by suggesting that this relationship is curvilinear--like an inverted "J" curve--under certain assumptions about farm management and structure. He hypothesizes that community conditions remain unchanged or improve as farm size increases up to about 300 acres under conventional family management, but then decrease precipitously with further increases in size under an "industrial management" model. Goldschmidt tapped into the downward part of this curve in his study because he included one of the first communities in the Sunbelt (Arvin) in which agriculture was practiced using an "industrial management model." MacCannell suggests that his results agree with Goldschmidt's, that as the degree of agricultural industrialization increases, social conditions in the rural communities become worse.

Conclusions and Recommendations

One of the primary conclusions from this study is that the farm size debate must be reframed. "The distinction that we should be making for policy purposes is not between moderate and large-scale farming but between super-sized industrial farms...and the small- to large-sized farms...The strongest policy recommendation to be derived from these findings is the need for a policy focus on 'farms' which are much larger than those currently labeled as large farms--the super-farms." MacCannell makes the following recommendations based on this research and much of the other work of the Macrosocial Accounting Project.

- The federal government should define and move to separate super-scale farming operations from other farms which operate as small businesses
- The social responsibility of super-scale farms should be spelled out
- Special taxes on super-scale farms based on volume or profits should be considered in order to finance community development work to repair social damage
- The Reclamation Law should be strictly enforced
- Current laws against hiring illegal aliens should be enforced
- Minimum-wage laws for all workers should be enforced
- The land grant university system should be responsible for adapting and delivering all new technologies to small to moderate-scale farms
- Commodity programs should continue to be sales volume-sensitive up to the threshold of super-scale farms and then all support should come off.

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