WILL THE PUBLIC RECOGNIZE THE ENVIRONMENTAL BENEFITS OF ALFALFA?

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ABSTRACT

Several important benefits have been described for alfalfa. These are its rich habitat for wildlife, soil improving characteristics, N_2 fixation, its abilities to trap sediments and prevent water and air pollution, take up nitrate pollutants, provide an insectary for diverse beneficial insects, as well as to provide open space for aesthetic reasons. Regions of the world impacted by row crop or specialty crop production would clearly benefit environmentally by introduction of a perennial legume such as alfalfa into the crop rotation. However it remains to be seen whether the public as a whole will develop an appreciation of crops such as alfalfa, which seems so far removed from their daily lives. The primary critiques of alfalfa concentrate on its economic value; that alfalfa has a 'low value' compared with its resource use. However, alfalfa receives no direct government subsidy and must compete for economic viability with a wide mix of crops, from subsidized grain crops to high-value specialty crops. The economic value of alfalfa nationally is third only to corn and soybeans. Several issues associated with pesticide use in alfalfa and water quality have become apparent in recent years, and are being addressed by the industry. However, alfalfa can claim a wide range of environmental benefits for wildlife and to the soil, air, and water that should be important in a future of increased population pressure.

Keywords: Environmental issues, pest management, wildlife, Chlorpyriphos, insecticides, herbicides, water quality, mitigation.

The Challenge. A profound public policy question as the world hurdles into the 21st Century is the relationship between agriculture and our burgeoning cities containing vast numbers of people who have virtually no idea about where their food comes from. This relationship contains several elements including a near complete alienation from the process of food production, rapid urban sprawl, in addition to a

Antelope graze an alfalfa field in Intermountain California. The rich vegetative cover of alfalfa attracts herbivores of all types, in turn attracting wildlife predators including hawks, eagles and foxes and many birds who feed on abundant insects.

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narrow view of the ‘value’ of agricultural land and of resources used in agriculture.

This is a tremendous challenge, especially as we witness the relentless conversion of agricultural land into urban uses all over the United States, and indeed the world. Loss of farm and rural lands in the United States totaled more than 17 million acres during the period from1992-1997. The rate of conversion of agricultural land to developed uses is about 1.2 million acres a year in the US (Table 1). Large agricultural states such as Florida, Texas and California saw the largest numerical increases, but the impact on states such as Pennsylvania, Maryland and other eastern states may be greater, given the smaller acreage in farmland and the rapid pace of urbanization. Unfortunately, development occurs most often on soils which are considered prime farmland, since cities have historically developed mostly near regions of agricultural wealth. About 56 percent of our food is reported to come from rapidly developing counties on the edge of urban centers, and more than 70% of prime farmland is threatened by sprawl (Biodiversity project, 2001).

Table. 1. Land acreage converted to developed use, and yearly rate of agricultural land loss to development, 1992-1997 for the United States and several selected US states. Number in parentheses is rank of state in loss of farmland as a percentage of state’s agricultural land. Average age of farmers, land in farms, and value for 2002 is given (data: Farmland Information Center: http://www.farmlandinfo.org/).

	1992-1997			**2002**		
	Land Converted to Developed Use		Rate of Loss	Age 55 or Older	Land in Farms	**Value of Agriculture**
	Agricultural	Rural	Agricultural			
State	acres	acres	acres/yr	%	(X 1,000)	**(X $1,000)**
California (22)	413,300	563,300	82,660	54	27,589	**$25,737,173**
Texas (31)	767,700	915,300	153,540	55	129,878	**$14,134,744**
Florida (4)	454,800	826,600	90,960	56	10,415	**$6,242,272**
Wisconsin (24)	126,100	196,300	25,220	42	15,742	**$5,623,275**
Pennsylvania (6)	244,500	549,100	48,900	44	7,745	**$4,256,959**
Michigan (17)	194,500	365,500	38,900	46	10,143	**$3.772,435**
U.S.	**6,172,800**	**11,392,400**	**1,234,560**	**50**	**938,279**	**$200,646,355**

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The Central Valley-Are we witnessing the ‘Los Angelezation’ of Agriculture?

Nowhere is this trend more evident than in California's Great Central Valley, an important flashpoint for urbanization of farmland in America. The deep alluvial plain of the San Joaquin and Sacramento Rivers is sometimes called ‘the Disneyland of Agriculture’ since so many diverse crops are produced there. It is truly a powerhouse of food production; containing the largest irrigated agricultural area west of the Rocky Mountains, nearly half of the state's farmland, two-thirds of its cropland, nearly 75 percent of the irrigated land. Six of the nation's top 10 farm counties are located here. More than 90 percent of the nation's tomatoes and grapes, and all of its commercial almonds, dates, figs, olives, cling peaches, prunes and raisins are grown in the Central Valley, not to mention that it is a major center of dairy farming and alfalfa production (about 60% of California’s alfalfa is produced there). Tulare County would be the nation's 4th largest dairy state (if ranked as a state). As Americans sit each day for a meal, it is likely that some portion of it comes from California's Central Valley.

Traditionally, California's massive cities were confined to the coasts, but no more. The California Department of Conservation reported that the San Joaquin Valley ranked first in the state in conversion of irrigated farmland in the period between 1994 and 1996. The San Joaquin Valley counties grew faster than California as a whole (Figure 1). Fresno and Sacramento are ranked as the nation's 37th and 40th largest cities and grew by 21% and 10% from 1990 to 2000, respectively (US Census data), and are rapidly expanding into the neighboring, mostly agricultural regions.

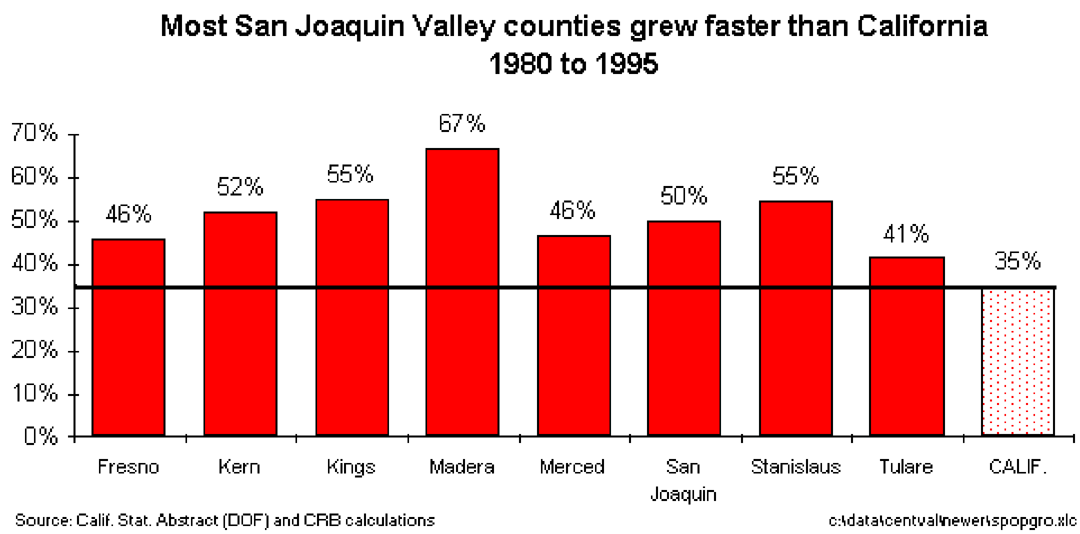


Figure 1. California population in San Joaquin Valley Counties and California as a whole. Such trends are also evident in other major US agricultural areas.

What does this nationwide trend of loss of farmland have to do with alfalfa? It is clear that in rapidly expanding urban regions like California, the public will increasingly ask questions about the economic value of farming, compared with alternative uses for land and water, both urban and environmental. And since alfalfa is considered a 'low value' crop by some, it is frequently singled out as an example of a land or water use that could be put to more beneficial use. This is particularly driven by development interests, but also hastened by stresses in agriculture (including too little profitability and too much regulation), and an aging farming population. However, it is also driven by some 'environmentalists' who single out alfalfa in particular as a poster child culprit in the conflicts over agricultural land and water use, and the environment.

THE CRITIQUE OF ALFALFA

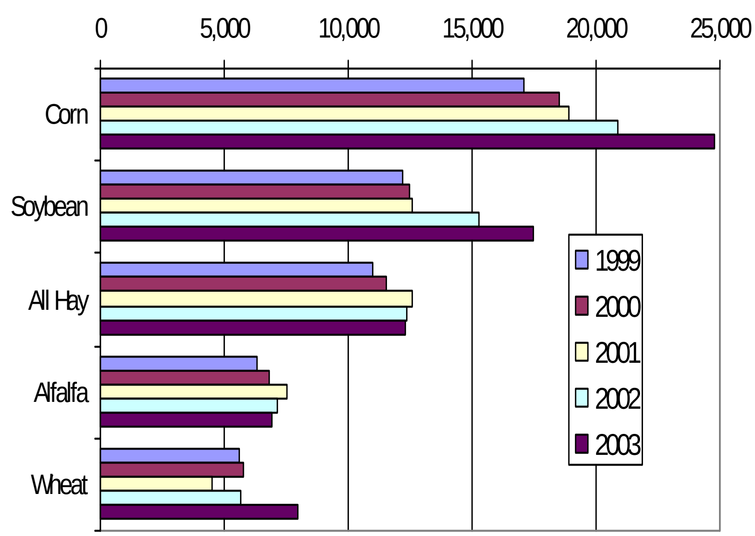
> *"An alfalfa farm using 240 acre-feet of water generates $60,000 in sales, while a semiconductor plant using the same amount of water generates 5,000 times that amount, or $300 million. (And while such a farm could function with as few as two workers, the semiconductor plant would employ 2,000.)"* -Natural Resources Defense Council, 2001

Most of the critics of alfalfa point to the supposedly low value of crop production in comparison with the water which could be used for other applications, such as semiconductor plants (see text box). If there were an encapsulated argument in favor of the urbanization of rural agricultural areas, it can be seen in this quotation.

There is no point in arguing this 'economic value' point, since it's essentially correct. This is indeed the crux of the urbanization problem. The quotation doesn't really have the economic values right. Economically, alfalfa is much more important than just farm-gate sales. It is the nation's third most important crop (see Figure 2) and has an economic value beyond its direct sales value. The dairy forage continuum is more important economically than any other single crop. However, the essential point is correct. In terms of income potential per unit land or water, how could an alfalfa field compete with a semiconductor plant? On second thought, even the 2,000 workers in a semiconductor plant have to eat!

Environmental Groups as promoters of Urbanization? It is indeed strange that some environmental groups would appear to promote the urbanization of rural areas, as this argument clearly does. Instead of considering the environmental impacts (both positive and negative) of agriculture on water, land, or wildlife habitat on their own merits, this view promotes essentially a rejection of agriculture in favor of urban development based upon economic comparisons. It ascribes the role of agriculture purely on economic terms and assigns no other values.

Figure 2. Economic Values of the top 4 crops in the US. 'All Hay' includes alfalfa. (1999-2002, USDA data, X $ 1 million)



The singling out of alfalfa doesn't make sense. The 'economic value' arguably applies to all of agriculture, whether or not they are labeled 'high value' or 'low value' crops. There are no agricultural enterprises (with the exception of 'boutique' agriculture or some nursery enterprises) that can compete for dollar returns per acre of land or drop of water with a housing development, a semiconductor plant or a strip mall. Alfalfa is no exception in this regard. Additionally, its water-use story is not as bad as it first seems.

Economics, Water Use, and Efficiency. The fact that alfalfa is a major player in water and land use is undeniable. It is a major acreage crop in virtually all western states. In California, more water is applied to alfalfa than to any other crop. However, this issue is much more complex than what it might seem at first. Consider the following:

- Alfalfa is a large acreage crop (> 1 million acres), thus its high water use is due mostly to its acreage, not other factors.
- Alfalfa grows nearly all year long compared with some crops that are grown only for a few months, increasing its seasonal water use compared with other crops.
- Alfalfa's demand for water is generally not different from other herbaceous crop species during a growth period when both crops have full canopy.
- Alfalfa is high yielding and the entire crop is harvested for economic returns, therefore it has higher water use efficiency than many other crops.
- The perennial nature of alfalfa means that alfalfa does not have to be reestablished each year, thereby increasing water use efficiency. (For many annual crops, excess water beyond the crop's needs is applied each year to establish a new crop.)
- Because alfalfa is a deep-rooted perennial less water is usually lost below the root zone with alfalfa than with more shallow-rooted crops.
- The economic value of alfalfa is linked to many other enterprises—cheese production to ice cream and horseracing—and has a relatively large economic impact.
- Alfalfa prices are not subsidized so it must compete economically with any other crop that can be grown in a region, both in terms of water and land use.

Alfalfa is one of the more efficient uses of water in terms of production of harvested product per unit of water. The Water Use Efficiency of several crops in the Sacramento Valley shows that alfalfa is superior to several crop alternatives (Table 2). Many of the 'higher value' types of crops are fairly inefficient in terms of crop production (dry matter of harvestable product) per unit water.

Table 2. Water Use comparison of several crops in the Sacramento Valley of California

Crop	Duration	Applied Water	Biomass Yield	Economic Yield	Harvest Index	Water Use Efficiency
		(in)	Lb/acre	Lb/acre	(%)	Lbs/acre inch
Alfalfa	Mar-Oct	42	12,833	12,833	100	306
Corn Grain	Apr-Aug	35	19,194	9597	50	274
Wheat	Dec-Jun	19	10,055	4,525	45	238
Sugarbeet	Oct-Jun	43	18529	8,005	43	186
Rice	May-Oct	71	16,900	7,774	45	109
Dry Bean	May-Aug	28	4,382	1,753	40	63
Almonds	Mar-Oct	37	-	1,134	-	31

NOTES: Applied Water based upon median of a range of values from California Water Plan Update, DWR, 1994. Economic yields are based upon a 5 year mean from County Ag. Commissioner Reports for 9 counties in the Sacramento Valley. Sugarbeet economic yields based upon 15% sucrose. Harvest Index is percentage of harvested economic product based upon Cooperative Extension estimates. WUE is calculated as the DM economic yield per inch of applied irrigation water.

Economics and Risk Management. Dry matter production per unit water, however, is not the only measure of the efficient use of water. There is no question that it is desirable for growers to produce the highest value crops possible to maximize returns per unit water use and to increase efficiency of water use in agriculture. However, it is not true that alfalfa is somehow uniquely problematic in this respect. Although there is no question that irrigation practices for alfalfa can and should be improved, it is already a fairly water-use efficient crop (Table 2). Alfalfa does not receive any crop subsidy, must compete economically with a wide range of both high value specialty and subsidized crops for acreage. Additionally, from a risk-management point of view, it is not entirely sustainable for growers to convert entirely to high value crops, which by definition are higher risk (both biologically and economically) than so-called 'low value crops'. Additionally, from the public's perspective, 'low value' crops like rice, alfalfa, and pasture create values to the landscape that are often missing with the higher value crops.

VALUES OF ALFALFA TO THE LANDSCAPE

While it is true that agriculture has a large impact on the landscape, and sometimes this impact is negative, this is not always the case. Agriculture interacts in a much more complex way with the environment than, say a factory or a waste treatment plant. In fact, as many parts of our crowded world are realizing, farms have intrinsic value beyond just their importance in producing food and fiber. Europe and Japan, for example, have a number of public policies that favor farming landscapes as a vital component of the culture and environment. Is it possible to think that some components of agriculture could actually be solutions to environmental problems, to urban sprawl and environmental impacts, rather than be seen as problems themselves?

Alfalfa has several characteristics that produce value to landscapes that should be considered in their own right. There are several negatives associated with alfalfa production as well, which must be considered. Thus, the development of an 'environmental balance sheet' seems appropriate for agricultural enterprises (see text box, end of article). No practice or enterprise may be conceived of as entirely positive or negative—all technologies typically have both negative and positive impacts. For example, the substitution of herbicides in favor of greater tillage to control weeds may reduce total pesticide

Alfalfa produces a very vigorous root and canopy structure, which protects soil, air, and filters particulates.

use, but allow greater air pollution and erosion of soils, a known hazard of tillage.

Benefits of Alfalfa. Alfalfa growers, through organizations such as the California Alfalfa & Forage Association have taken a lead on this issue through the publication of 'Alfalfa, Wildlife, and the Environment' (Putnam, et al., 2001), a booklet which describes in detail the benefits of alfalfa to the environment. Growers have taken tremendous leadership in making sure that the positive side of the alfalfa story was told. However, this analysis should also require a candid assessment of some of the environmental negatives associated with alfalfa, and descriptions of efforts to address these.

The principle benefits of alfalfa include:

White Faced Ibis feeds in an alfalfa field

Protecting the Soil. The deep- rooted characteristics of alfalfa and vigorous year-round canopy help prevent soil erosion and sustain soils for the future.

Protecting the Air. Alfalfa fields hold soils in place and prevent air pollution from the dust that commonly comes from tillage.

Protecting Waterways from sedimentation. Soils commonly do not move off of alfalfa fields. Alfalfa acts as a 'filter', protecting streams from sedimentation (see Figure 3).

Taking up Nitrates. Alfalfa is an excellent crop for taking up nitrates that may leak from agricultural fields into groundwater.

Nitrogen Fixation. Alfalfa needs no N fertilizers since it fixes its N from the atmosphere. This saves energy that is used to make fertilizers for grain crops.

Rotation Benefits. Alfalfa leaves the soil in excellent condition for other crops, with good soil 'tilth' and residual 'free' nitrogen for crop production.

CO_2 Sequestration. Alfalfa, as a perennial crop, sequesters CO_2 in its crown and roots as well as the soil rhizosphere.

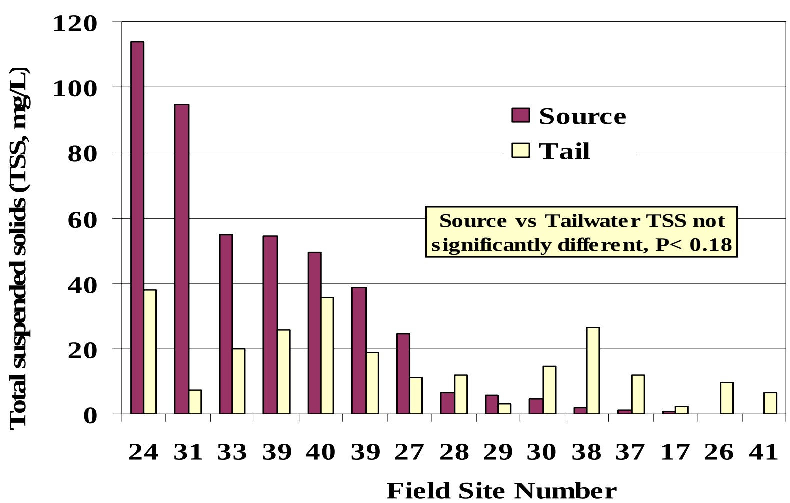


Figure. 3. Total Dissolved Solids (particulates) measured in tailwater from alfalfa fields in the Sacramento Valley. When solids in source water were high, tail-water solids were always less than source water (Long et al., 2002).

Significant Wildlife Habitat. Alfalfa provides a landscape for many types of wild species. 162 (27%) of the wild species in California use alfalfa for habitat (see details, Putnam et al., 2001)

Insectary. Alfalfa is a rich insectary, containing hundreds of species of insects. Many of these are beneficial, helping to control insect pests in other crops.

Aesthetics/Open Spaces. Alfalfa provides an oasis of green which is aesthetically pleasing in an ever-urbanizing world, and is also important to wildlife.

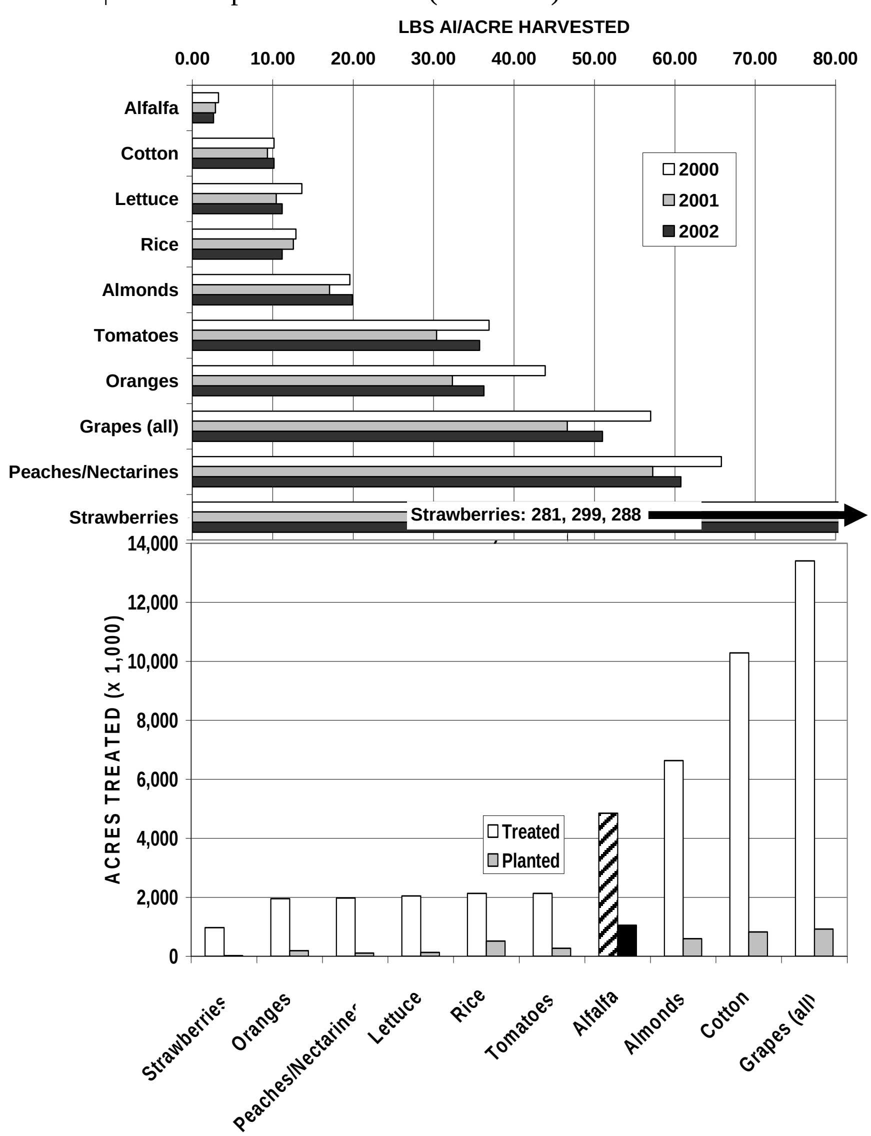
These benefits of alfalfa on landscapes have been known for thousands of years by agriculturalists and by those who observe carefully the interactions of cropland with the environment. Some of these characteristics of alfalfa may become more important as societies become more concerned about the sustainability of agricultural landscapes.

NEGATIVE ASPECTS OF ALFALFA AND THE ENVIRONMENT

Although there are many positive features of alfalfa environmentally (Putnam, et al., 2001), there are several important areas where alfalfa's impact on the environment can be improved. These can be grouped into two major areas, Off-site Pesticide Movement and Water Supply, and a few minor areas.

Offsite Pesticide Movement. While pesticides are not the only aspects of crop impacts upon the environment, they are frequently the subject of public debate. Of the major crops in California, alfalfa is one of the least pesticide-intensive crops (Figure 4). The multiple insect and disease resistance of alfalfa varieties, as well as a plethora of beneficial insects helps growers avoid sprays. However, there are several

Figure 4. Pesticide Intensity (lbs/a), top graph, and acres treated, bottom graph, of alfalfa compared with several other crops in California. (DPR data)



insects and weeds for which effective non-chemical control has proved elusive. The number of acres treated to control pests in alfalfa is larger than some crops simply due to the crop's acreage (the acreage on Figure 4 reflects multiple sprays per year).

Insecticide use in alfalfa exceeds that of herbicides. The majority of the insecticides used in alfalfa are in the Organophosphate class, which includes chlorpyrifos. The alfalfa weevil, a reliable pest each spring in most alfalfa fields in California, a complex of aphid species populations, and summer and fall worm species are the most common causes of insecticide sprays in California (see UC IPM website). Fungicides are rarely used in alfalfa. Herbicides are primarily used during stand establishment and to control of winter and summer annual weeds in established alfalfa. The pesticides used in alfalfa which are of environmental concern primarily fall into two categories: OP insecticides used for control of insects, and herbicides used for winter weed control in alfalfa.

Insecticides. Organophosphate (OP) insecticides used in alfalfa (as well as prominently in orchard sprays and in several other crops), such as chlorpyriphos (Lorsban or Lock-on) and diazonon have been detected in spikes in the San Joaquin delta at levels sufficient to be toxic to test aquatic organisms. These levels are in violation of toxicity objectives of the Central Valley Regional Water Quality Control Board. Under the Federal Clean Water Act, the San Joaquin River and associated delta/estuary have been listed as an impaired waterway due to these detections, although it must be emphasized that it is not at all clear what the sources of these OP sprays are (alfalfa, orchards, urban, other sources). However, when test organisms were exposed to the tail water from 27 alfalfa fields in the Sacramento Valley to which OP insecticides were applied, the organisms died even when the tail water was evaluated 3-6 weeks after pesticide applications. Thus, it is clear that alfalfa may be a contributor.

The alfalfa growers and University scientists have initiated project proposals to address this issue. We have proposed a series of mitigation measures for solving these problems (Putnam, 2003). It is important for alfalfa growers who farm near natural waterways or whose farms drain into impacted waters to avoid using these sprays, or to look for ways of preventing off-site water movement in the months following application.

Herbicides. Several years ago, herbicides commonly used in alfalfa (for example hexazinone or Velpar) were detected in a few wells in the upper San Joaquin Valley. Research by UC Cooperative Extension and DPR has examined the fate of herbicides used alfalfa fields for control of winter weeds (Prichard et al., 2004). It was found that there was no significant movement of these herbicides through the soil profile. Instead, pesticides were present in water that ran off the fields and collected in ditches and collection ponds at the ends of the fields. It is obvious from this study that it is critical that these ponds be properly designed to prevent groundwater contamination from the ponds themselves. Growers have initiated steps to recirculate water to prevent contamination of wells from these catchment basins, and projects are ongoing to address this issue.

Water supply. The fact that alfalfa consumes substantial quantities of water each year is an inescapable fact of life for alfalfa in western states, and an important component of its environmental impact. While it is clear that alfalfa is one of the more efficient users of water, it is also clear that efforts to improve the water-use efficiency of alfalfa will be important for the future. Since improved water management is also critical to water quality, it seems reasonable to place efficiency of water management at the top of the list of mitigating measures with regards to alfalfa's impact upon the environment. However, efforts to improve water use efficiency should be tempered with a realistic understanding of just how much water is required for plants and for crop production—a dimension rarely understood by critics of agriculture.

In addition to methods to improve water management efficiency during the growth of the crop, strategies which may influence the flexibility of water use in alfalfa are needed. Drought is not an every-year occurrence. Some years we have plenty of water for agriculture, cities, and the environment, while other years are very difficult. The perennial nature of alfalfa is generally an advantage with regards to water use. Since alfalfa starts growth right away in the spring, it can effectively use residual water from rainfall without irrigation, and can use water from deep in the soil due to its deep roots. However, alfalfa's perennial nature commits a farmer to continual irrigation, regardless of whether drought conditions exist or not. Over the past years, research has been conducted to study the agronomic feasibility of temporarily drying down alfalfa to allow for voluntary (economic) water transfers (Orloff & Putnam, 2003). This could make possible greater flexibility to allow other temporary uses for the water previously used on alfalfa. This could benefit the farmer who would keep farming, and benefit the communities that depend upon farming.

Phosphorus and Nitrates. This is not a large issue for alfalfa (alfalfa is excellent at taking up nitrate from contaminated soils). However, we should not dismiss this, since some growers continue with the practice of water-running nitrogen, opening the possibility that nitrate could become a problem in tailwater (there has been no evidence of this to date). Phosphorus, however, has been identified as a key water quality issue for desert soils. Phosphorus fertilizer practices are important for maintaining high yields on desert soils. However, high P levels in surface waters contribute to the eutrification of lakes, particularly for the Salton Sea. Fertilization practices which conserve P, and irrigation practices which minimize soil erosion from fields, ditches and water systems is important to prevent P contamination of surface waters.

Energy Use. All modern crop production methods require some subsidy of energy (typically from fossil fuels) for crop production. Alfalfa, with its frequent harvests, bulky transportation needs, and requirement for irrigation water (often from pumping) contributes its share to energy demand from agriculture. On the other hand, the energy saved from the use of a productive nitrogen-fixing crop such as alfalfa saves large amounts of fossil fuel for protein production each year (we estimate that over 9 trillion BTUs of energy for N fertilizers would be required each year to equal the protein produced from alfalfa, should that protein be produced through a non-legume that required N fertilization). There is a need to search for opportunities for improved energy efficiency in alfalfa production.

CONCLUSIONS

The case can be made that growers need to be proactive when it comes to environmental issues, since alfalfa has an important story to tell—one that is largely lost in public discourse. It is important to continually remind the public, and regulators specifically, about the multiple benefits of alfalfa to the landscape, particularly those characteristics that will work to solve public problems such as nitrate pollution, sedimentation, air pollution, and loss of habitat. At the same time, it is important to actively work towards mitigation of the pollution problems that are caused by (or perceived to be caused by) alfalfa growers. Although there are remaining technical questions about the nature, mechanism, intensity, and scope of these problems, there is a general consensus that in principle it is desirable to prevent the movement of pesticides off alfalfa production fields, and to improve water management in general.

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An Environmental Balance Sheet for Alfalfa

Key Positive Attributes

- A 'filter strip' to stop sedimentation of water and soil erosion
- Prevents air pollution through dust control
- Reduces nitrate contamination
- N_2 fixation saves fossil fuels
- Sequestration of carbon.
- Important wildlife habitat

Key Challenges

- Lack of recognition of forages as a food crop
- Water supply impacts on habitat, endangered species, other uses
- Off-site movement of some pesticides
- Groundwater contamination with some herbicides
- Energy use