THE IMPORTANCE OF ALFALFA TO CROPPING SYSTEMS AND ENVIRONMENTAL GOALS

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ABSTRACT

Alfalfa production has been criticized for high water-use in relation to its economic value. However, such criticism overlooks the many other benefits of alfalfa which accrue to cropping landscapes, values which contribute significantly to broader societal goals. These include alfalfa's role as a nitrogen fixer, its improvement of soil tilth and soil organic matter, its mitigation of soil erosion, its value as an insectary for beneficial insects, its significant role as a habitat for many species of wildlife, and its fundamental value in sustainable cropping systems. These important contributions are in addition to its significant economic value in its own right, and the critical role alfalfa plays in dairy and other livestock industries, and the production of honey. Although steps should be taken to improve alfalfa's water-use efficiency, alfalfa and other perennial leguminous forages should be recognized for their diverse benefits, and for their fundamental contribution to the long-term sustainability of California agricultural systems.

INTRODUCTION

The economic importance of alfalfa to farms and ranches in California is well known in the agricultural sector. The crop's direct value in 1995 was estimated at close to $800 million (see introduction to this symposium). While returns per acre are not as high as some crops such as tomatoes or cut flowers, alfalfa pays many bills, and provides a source of steady income throughout the state. It is the most important crop in the Intermountain areas and the Imperial Valley; many ranches would fail without it.

Swainson's Hawk, a threatened species in California, is a frequent visitor to Central Valley alfalfa fields.

Beyond its direct monetary value, alfalfa plays a vital role in the dairy and livestock (including horse) industries, the state's number one agricultural industry. It is not an exaggeration to say that California is currently the number one dairy state in the U.S. due, in large part, to a ready supply of high-quality alfalfa. In fact, the state does not quite meet its own requirement for alfalfa and a significant portion is now

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imported from other states.

However, alfalfa's contribution to the human diet and to maintaining a low price of dairy products is not often appreciated beyond the farm gate. Alfalfa does not easily translate into a product of widely recognized value to the consumer, as do tomatoes, almonds, or vineyards. There are few ice cream lovers who would make the connection between a lush green alfalfa field and the ice cream cone they are enjoying. As a result of this disconnection, forages in general, and alfalfa in particular, are not widely valued by the society as a whole. Is it any wonder, then, that alfalfa and irrigated pasture are often targeted in the public press for their water use, use of pesticides, and other crimes?

THE ARGUMENT

> "I've singled out the four largest water users in California for special condemnation. The No. 1 water user in this state is irrigated alfalfa, No. 2 is irrigated pasture, No. 3 is irrigated cotton, No. 4 is irrigated rice."
> -Marc Reisner, (Author of Cadillac Desert, as quoted in Beard, 1994).

Alfalfa is categorized in some circles in California as being a "negative" when it comes to the environment. This is somewhat ironic, since alfalfa and other perennial forages have been promoted in the Corn Belt and elsewhere by both agronomists and environmentalists as a way to increase the sustainability and lessen the environmental impact of agriculture. However, there is a critique of irrigated alfalfa production in the West which goes something like this:

> Alfalfa uses a large amount of water per unit of dollar return. Therefore, water should be shifted from alfalfa and allocated to higher value crops, or allocated to environmental or urban uses which have broader societal value (eg. Gleick et al, 1995; Beard, 1994).

The proponents of such ideas rarely specify to what degree we can economically substitute such high value crops as cut flowers and grapes without saturating the market, nor what the economic and environmental implications of such a shift might be. Most high value crops require considerably more pesticides and fertilizers than the "low value" crops as small grains or alfalfa.

However this argument contains a number of implicit assumptions which can be challenged in their own right. One of the major assumptions in this argument is that there are few, if any, benefits to society as a whole of growing alfalfa, beyond its direct economic value. Another is that if water or land is allocated to alfalfa in a region, the environment is the automatic looser. This is a classic tussle between "environmental interests" and "agricultural interests" which is played out in courtrooms, legislative and regulatory bodies, and the press throughout California and other western states.

Such dichotomies of thinking are sometimes useful for political causes, for selling books, or for raising money, but they rarely represent the true picture. Several of the crops which are criticized clearly have benefits to the larger society beyond their ability to supply phenomenally cheap food and fiber. For example, rice, a crop targeted by Reisner as ill chosen for California, is now acknowledged to have an important role in the biology of waterfowl in the Sacramento Valley and the Pacific flyway (Beard, 1994). Alfalfa has many important characteristics which accrue benefits beyond its direct economic value, and beyond its important nutritional foundation for a large sector of California agriculture. However, for various reasons, the foremost of which may be the dispersed, non-centralized nature of the alfalfa industry, many of the environmental benefits of perennial forages such as alfalfa seem not to be well established in the public mind. In addition, the water-use characteristics of alfalfa are not so clearly negative.

THE WATER STORY

> "The main objective of this scenario is to eliminate the estimated annual overdraft in the year 2020 by reducing alfalfa and irrigated pasture acreage"
> - *California Water 2020,* Gleick et al., 1995.

This recommendation for solving California's water problem by eliminating "low value" crops such as alfalfa is commonly heard. This usually means that the crop is of low value to the one making the recommendation, and that their priorities (presumably of higher "value") would receive preference.

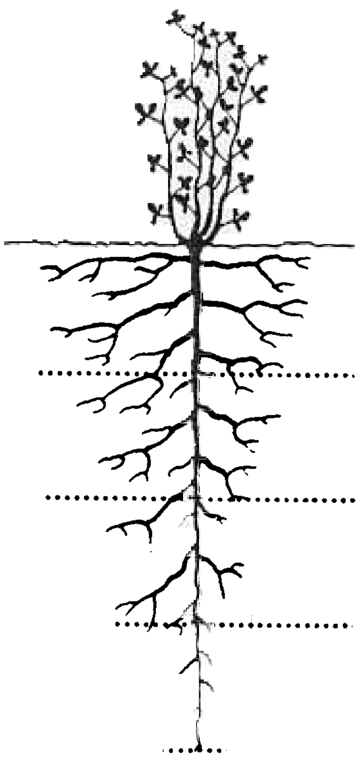
There is little doubt that there are crops which yield higher economic return per unit area than field crops (alfalfa shares this characteristic with other agronomic species: wheat, rice, sugarbeets, and corn). It is also true that a substantial amount of water is used to produce alfalfa. The consumptive water use of alfalfa varies considerably throughout California, and has been estimated to range from 41 inches to 81 inches/year, depending upon location (Marble, 1991).

Efficiency of Water-Use. However, this does not mean that alfalfa is inefficient. Those looking at total water-use in alfalfa should keep in mind that it is grown on nearly 1 million acres throughout the state, thereby increasing water-use compared with other crops of lower acreage. Alfalfa is also actively growing throughout the warm season, from 7-11 months a year in California. It is a very high-yielding crop, and the entire above-ground plant is harvested and used, unlike most field and horticultural crops. This season-long productivity means that yearly water-use is high, but also that the efficiency of conversion to useful plant material is fairly high.

Attempts at improving the water-use efficiency of alfalfa are ongoing; growers in many regions have made innovative attempts to improve irrigation methods. For example, "Bedded" alfalfa, which is common in the Imperial Valley, has the potential to save 15-20% of irrigation water compared with flood check irrigation (K. Bali, 1995, pers. comm.). A grower in San Joaquin County has experimented with buried drip irrigation. Reports at this symposium include the reuse of dairy lagoon water for alfalfa. "Summer dry-down" has been experimented with as a significant water saving measure in the Imperial Valley and the lower San Joaquin Valley.

A comparison of the water-use efficiency (which factors the component of the crop harvested) of several species showed alfalfa to be the highest in water-use efficiency of several species (Table

(Kurtz et al. 1984). Nitrogen fixation is a significant factor in this yield benefit, but other factors, such as soil tilth, are also implicated. Nitrogen stored in roots and above-ground plant matter can be made available to a subsequent crop through degradation after plowdown. Considerable N is removed at each cutting when the high N-containing forage is removed as a forage crop, but much of this is "renewable" through N fixation of subsequent regrowth. The amount of N provided to a crop following alfalfa is quite variable, and will depend upon a number of factors, primarily the stand, yield and stage of growth when the alfalfa is plowed down, and uptake of N by that crop. Nitrogen application to corn can often be reduced by 100-150 lb/acre if it is preceded by alfalfa or red clover (Miller and Heichel, 1995).



The deep, N_2-fixing characteristics of alfalfa roots provide a significant benefit to California soils and cropping systems.

Soil tilth and the value of deep-rooted perennials. The "rotation effect", which benefits crops grown after alfalfa, in not simply the result of the transfer of elemental N. This rotation effect is a result of complex causes of improved water-holding capacity, better soil tilth (improved structure), increased soil organic matter, and reduction of soil pathogens in addition to the N residues supplied (Barnes and Sheaffer, 1995). Alfalfa roots have been measured at a 39 meter depth and 8-11 meters is common (Sheaffer et al., 1988),. Alfalfa roots penetrate much more deeply than most grass species or annual field crops. Therefore, alfalfa roots create many channels in the soil which are used by subsequent crops to more fully explore the soil. In addition, there is a tremendous amount of biological activity in the alfalfa rhizosphere, and a number of organic acids are secreted by alfalfa roots which contributes to soil "tilth" - the crumbly soil structure which is so beneficial for plant growth.

In a recent study at the UC Davis campus, we plowed up an experimental plot which contained strips of 4-year old alfalfa, and 4-year old fallow strips. The difference in the soil structure was dramatic and obvious: blocky, tight clods in the fallow strips which were very difficult to cultivate, and crumbly, loose, well aerated soil in those areas occupied by alfalfa. Many growers have observed the differences in soil tilth and crop performance and value that contribution to subsequent crops.

Erosion protection. Although much of current concern about the environmental effects of agriculture focusses on the possible contamination and harmful effects of pesticides, soil erosion has always been a significant environmental hazard of agriculture. The development of the Soil Conservation Service received its impetus from the dust bowl days of the 1930s, with the recognition that soil is a non-renewable resource, and that steps were needed to reduce the degree of erosion in many cropping systems. One of the major thrusts of these efforts was to encourage the incorporation of leguminous cover crops and perennial forage crops which are far superior at preventing erosion than highly cultivated field or horticultural crops. Perennial legumes protect the soil in several ways: by reducing the amount of cultivation per year, by hold the soil in place through extensive rooting, and by providing a vigorous above-ground canopy which prevents rain droplets from loosening soil. Any cost-benefit analysis of alfalfa's role in the environment should incorporate these considerations.

Protection of groundwater, help with waste problems. The deep rooted characteristics of alfalfa have led soil scientists to look at alfalfa as an important crop in helping to "mop up" subsurface nitrate in the soil (Russelle, 1994). Nitrate contamination of groundwater (sometimes from N fertilizers) is a problem on some sensitive, sandy soil types. Alfalfa, due to its vigorous roots, is recognized as being important in mitigating groundwater pollution with nitrate. Additionally, scientists are looking at alfalfa to help with "bioremediation" of contaminated sites, and for helping in the disposal of municipal wastes. The robust biological characteristics of alfalfa have not escaped notice for these applications.

Alfalfa as a renewable fuel. As California faces a highly urbanized future, with its associated environmental pressures, development of renewable sources of energy should be an important broader societal goal. A project in Minnesota, initiated by the Northern States Power Company, has analyzed the potential of using alfalfa as a renewable source of energy (Martin and DeLong, 1995). This concept, which would benefit the environment, the consumer, and the dairy industry, is to use the high-lignin alfalfa stem for energy, and use the leaves, which are higher in feed value, as a high quality dairy feed. The major reason that alfalfa was examined (rather than the more ubiquitous corn) was the lack of energy requirement for fertilizers in alfalfa, and alfalfa's many benefits to the sustainability of cropping systems in the corn belt, as described above. While it remains to be seen whether all aspects of this program will be feasible, California may find it important to examine this option as a method of producing renewable energy in the future, a strategy which may benefit both urban and agricultural interests.

ALFALFA - AN "INCREDIBLE" INSECTARY

A fieldside view of an alfalfa field may show little apparent activity - simply a mass of green. However, each successive regrowth of alfalfa creates an environment which teems with insect life. The numbers and kind of insects that inhabit alfalfa have been described as "incredible" (Manglitz and Ratcliffe, 1988). A count of 591 species was recorded in a field near Ithaca, NY (Pimental and Wheeler, 1973). Insects are so abundant in alfalfa fields that university entomology classes can often be found sweeping in alfalfa fields to study the diversity of insects to be found there.

Important host for beneficial insects. Some of these insects, of course feed on alfalfa, but there are many beneficial insects as well. These 'beneficials' prey on herbivorous or sucking insect pests of alfalfa. Dozens of predacious and parasitic insects occur in alfalfa, and several "work horses" of biological control are especially abundant (Leigh, 1991). Bigeyed bugs (*Geocoris pallens* and *G. puncitipes*), damsel bugs (*Nabis americoferus*), and minute pirate bugs (*Orius tristicolor*), are some of the major predators. Lady beetles (*Hippodamia* spp.) have long been recognized to control many types of aphids, and are often abundant in alfalfa fields. A parasitic wasp (*Lysiphlebus testaceipes*) is of importance in aphid control in alfalfa, and several other wasps help control beet armyworms, and other lepidopterous pests of cotton, alfalfa and other field crops.

The role of beneficial insect pests in helping to reduce crop damage in an alfalfa integrated pest management (IPM) program has been understood for some time. However, several of the species present in alfalfa also effect a number of other crops where they may greatly reduce the threat of pest damage (Leigh, 1991). Efforts are underway to better understand how to fully exploit this potential. Due to its reservoir of insects, planting alfalfa in strips with other crops was proposed to help distribute and nurture beneficial insects (Leigh, 1991). A reduction in the need for insecticides has been observed when this technique was applied to cotton (Stern, 1969).

Production of Honey. Alfalfa is also the primary honey crop in the US. It accounts for about one-third of the annual honey production in the US (Barnes and Sheaffer, 1988). This is a "spin-off" industry of seed production in some areas, particularly western Fresno County, and benefits both alfalfa and the consumer.

The contribution of alfalfa to biological diversity and for the nurturing of beneficial insects for other species often goes unrecognized, and can be considered an important environmental benefit of incorporating alfalfa into a cropping system.

ALFALFA ATTRACTS WILDLIFE

While it is true that production of irrigated field crops in Western ecosystems often represents a significant change from the naturally occurring flora and fauna, it is not true that wildlife are automatically loosers in this tradeoff. Agricultural activities interact significantly with wildlife on several different levels, and many forms of wildlife adapt, adjust, or even thrive within and alongside agriculture.

Since alfalfa is a productive insectary, it provides an important food source for many types of birds which inhabit nearby areas. There is also considerable below-ground biological activity in alfalfa fields. Since it is a perennial, gophers, ground squirrels, voles and other rodents often abound in alfalfa, and in some areas are important pests, along with rabbits and other herbivores. This biological activity, sometimes the bane of growers, has its positive side - providing an important habitat for wildlife.

Wildlife aggregates in alfalfa. In extensive surveys conducted in the Sacramento Valley, many species of wildlife were found to be present in alfalfa fields. Furthermore, many of these wildlife species show a strong preference for alfalfa (Table 1). Alfalfa has been found to be visited by 18 times the number of species than would be expected by chance (Smallwood and Geng, 1993). Predators of small mammals and ground-dwelling invertebrates were most selective for alfalfa. These include several migratory Hawks, Falcons, the Great Blue Heron, White-faced Ibis, Killdeer, Dunlin, Brewer's Blackbirds, American Crows, Yellow-billed Magpies, and European Starlings (Table 1).

Table 1. Listing of types of wildlife observed in alfalfa fields. Asterisks indicate species which have a preference (*) or a strong preference (**) for alfalfa based upon transect studies of the Sacramento Valley and personal observations. Lack of asterisks indicates no preference or unknown.

Species	Food	Species	Food	Species	Food
Killdeer**	I	Ring-necked Pheasant*	G	Ash Throated Flycatcher*	I
Dunlin**	I	Great Blue Heron*	V	Scrub Jay	
Red-Tailed Hawk*	V	Great Egret*	V,I	Common Raven*	G
Swainson's Hawk**	V,I	Snowy Egret*	I,V	American Robin	I
Ferruginous Hawk**	V	Black-crowned Heron*	I,V	Cliff Swallow	I
Rough-legged Hawk*	V	White-faced Ibis**	I,V	Valley Quail	I,P
Northern Harrier**	V,I	Cattle Egret*	I,V	Coyote	V
White-tailed Kite**	V,I	American Avocet	I	Desert Cottontail**	
Prairie Falcon*	I,V	Brewer's Blackbird**	I	Blacktailed Jackrabbit*	
American Kestrel*	I,V	Redwinged Blackbird	G	Gray Fox*	
Turkey Vulture	S	Rock Dove	P	Striped Skunk	I,V
Yellow-billed Magpie*	G	Mourning Dove	P	Racoon	
American Crow*	G	Golden Eagle*	V	CA Ground Squirrel*	
Loggerhead Shrike*	I	Western Meadowlark	I	Pocket Gopher**	
Western Kingbird*	I	Merlin*	I,V	CA Vole**	
European Starling*	I	Long-billed Curlew**	I	W. Fence Lizard	I
California Gull*	G	Mallard Duck*	G	Gopher and Racer Snakes*	V,I

* Indicates species has preference for alfalfa (population is 1.3 to 3 x the population to be expected by chance), ** indicates species has strong preference for alfalfa (greater than 3 x the population expected by chance). Designations are a mixture of transect study designations and subjective evaluation (Smallwood, 1995, pers. comm.). Data collected and reported by Smallwood and Geng, 1993, Erichsen et al., 1996, and Smallwood, 1995 pers. comm.)
Food Source: V = vertebrate animals, I = invertebrate animals and insects, S = scavengers of dead animals, P = plant matter, G = general, D = causes some damage to alfalfa.

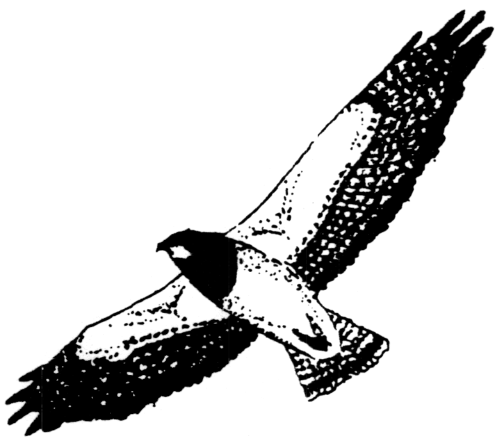
Alfalfa - Important for threatened species. Several species which have been classified as "threatened" or "special concern" show strong preference for alfalfa habitats. The Swainson's

Hawk is a state-listed threatened species and a candidate for federal threatened species list. It travels 11,000-17,000 miles yearly from S. America (Kemper, 1995), and visits alfalfa fields 10 times the number of times expected by chance (Smallwood, 1993). Alfalfa is also strongly selected by the Norther Harrier and White-faced Ibis, which are state-listed species of special concern. Other state-listed species which have a preference for alfalfa are the California Gull, Golden Eagle, Merlin and Prairie Falcon.

Food for large vertebrates. The characteristics which make alfalfa the premier dairy forage also are quite attractive to wild species. In many parts of California and the US, deer and antelope are a significant factor in alfalfa production. It is difficult to maintain fences around alfalfa fields, and deer and other large herbivores can be commonly found there. In certain areas of the northwestern US, elk are the primary yield-reducing "pests", and large herds are often supported by remote alfalfa fields when naturally-occurring vegetation is limiting and herd numbers are high.

Enhancing wildlife. Although this summary and other evidence shows that alfalfa is a significant habitat for many species of wildlife, there is more that growers can do to produce alfalfa in a way that is beneficial to both wildlife and the environment. Pest management can be practiced in a fashion that protects and utilizes the beneficial insects in alfalfa, which benefit other crops as well as wildlife (Integrated Pest Management). Several growers have taken steps to provide nesting sites for owls and bats to encourage their rodent and insect-eating habits (see paper this Symposium). Other growers have installed perch poles in an otherwise horizontal landscape to encourage raptor activity. A grower in the Sacramento Valley each year retrieves waterfowl eggs from fields prior to first cutting, and incubates them and releases a significant quantity of ducks each year. Other growers have tried to develop devices to be mounted on swathers to help protect nesting birds in alfalfa fields. These, and many other steps would enable an enhancement of the benefits to wildlife of the alfalfa production system.

We believe that most growers have a deep and abiding appreciation for the wildlife on their ranches. In fact, that is probably one of the primary incentives for many who pursue this profession: the love of the outdoors, and of nature. However, the alfalfa industry in California needs to be more articulate about the importance of this crop to wildlife. In the 1990s, we are not in the position of simply producing an economic product. Agriculture must increasingly convince a skeptical public that it provides other benefits as well, including the nurturing of many wildlife species which enhance the aesthetic value of the landscape.



CONCLUSIONS

Often, in arguments between "environmental interests" and "agricultural interests"over water allocations, the complexities of cropland landscape ecological interactions are lost. A too narrow view of agricultural water-use, which only ascribes benefits to agriculture, confuses the public about the value of a productive agriculture to the overall societal well-being, including protection of the soil, biological diversity, and wildlife. In this paper, we have shown that alfalfa makes many important contributions to broader societal goals relating to a sustainable agriculture and the environment. Removal or severe reduction in alfalfa acreage would not only have large economic consequences, but also reduce these benefits. While there is considerable room for further enhancement of the benefits of alfalfa to cropping systems and wildlife, it should be recognized that perennial legumes, particularly alfalfa, are vitally important to the future sustainability of California agro-ecosystems.

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