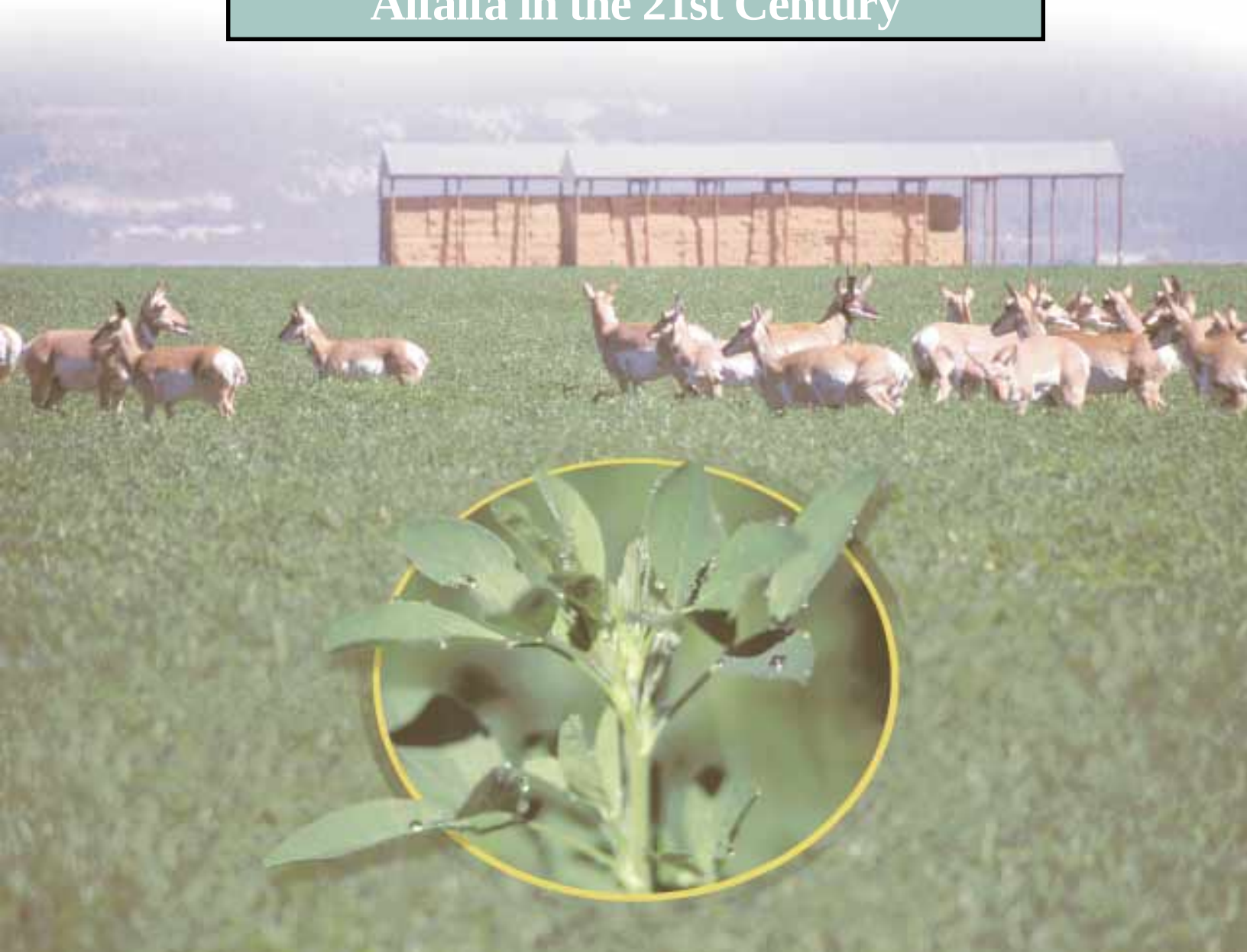
Alfalfa, Wildlife and the Environment

The Importance and Benefits of Alfalfa in the 21st Century



Executive Summary

Will an advanced industrial society value humble crop plants being grown adjacent to multi-million dollar office complexes or homes? Does the public know how important agriculture is to their daily lives, providing not only food but a wide variety of other benefits as well? Or, when push comes to shove, will society simply dispense with agriculture, allocating land and water to other uses, without consideration of the long-term consequences?

These are important concerns of growers as agriculture enters the 21st Century. Farmers have become an increasingly smaller component of the population, and it is safe to say that very few in the general public have an in-depth appreciation of agriculture.

A public disconnected with agriculture is particularly a problem for alfalfa, which is two steps removed from the dinner plate, but nevertheless important for human nutrition.

There are about 23 million acres of alfalfa in the US. Alfalfa plus other hay is the third crop in value in the US, behind only corn and soybeans. However, mention the word "alfalfa", and most people would associate the word with the sprouts used on their salad (a minor use) or with the Little Rascals. Very few would recognize the important role alfalfa plays in their lives in the form of milk, cheese pizza, ice cream, honey, leather, or wool sweaters. Fewer still would recognize the non-economic roles that alfalfa plays in maintaining a healthy environment.

This effort to document the importance of alfalfa to food production systems and environmental goals originated with a small group of alfalfa growers in California. While California is the nation's leading producer of alfalfa hay, the crop has come under increased criticism in that state due to its use of water and pesticides. During the 1990s, these growers met with a number of critics of alfalfa to discuss these issues and try to understand their points of view. It was apparent that many of the attributes of alfalfa were poorly understood. Furthermore, there were few publications that attempted to document the benefits of agriculture to the environment.

In this publication, we present a series of topics related to alfalfa's role in agriculture and the environment. The goal of this publication is to allow readers to become more familiar with alfalfa's importance as a crop, and its contributions to broader social goals.

There are several key points:

Alfalfa Has Broad Economic Value. While alfalfa is often characterized as being of 'low value', its true economic impact is much greater than just its gross receipts. Alfalfa is the beginning of a complex food chain, and affects many industries from dairying to wool and beef production and horseracing. The many end-uses, such as cheese making and pizza marketing are worth billions of dollars more than the value of the crop itself; but they begin with alfalfa.

Protecting the Soil. The deep-rooted characteristics of alfalfa and vigorous year-round canopy help protect the soil from becoming airborne and causing dusty conditions, or being washed into rivers as sediment.

Rotation/Nitrogen Benefits. The biological N_2 fixation by bacteria growing on alfalfa roots helps save energy – no N fertilizers are needed! In addition, alfalfa leaves behind nitrogen and improves soil structure for the crop that follows so farmers can apply less chemical fertilizer.

Providing Significant Wildlife Habitat. Alfalfa is the beginning of a food chain, and contributes valuable habitat for hundreds of species of herbivores and animals of prey. It hosts several endangered species, plus many familiar ones. Those who love nature should appreciate alfalfa's support of many wildlife species.

Alfalfa as an Insectary. Alfalfa is a source of incredible insect diversity, which includes many valuable 'beneficial' insects. These, in turn help control many other types of insect and mite pests in alfalfa and other crops.

Efficiency in Water Use. While it is true that alfalfa uses a significant amount of water per year, alfalfa is a relatively efficient user of irrigation water; it produces high tonnage of dry matter for the water applied. This is due to its year-long growth habit, its high yield, and the fact that all the above-ground portion of the plant is harvested. Alfalfa's deep-roots assure that a large proportion of the water applied is used by the crop, not wasted. While there is room for improvement in water use efficiency, alfalfa should not be considered to be a water waster.

Mitigating Contamination Problems. Alfalfa has been used to mitigate several environmental problems that are a consequence of our industrial society, including absorbing nitrates from groundwater, recycling dairy or municipal wastes, and mitigating industrial compounds that could contaminate groundwater.

Aesthetic Value and Open Space. While it is difficult to put a value on aesthetics, the open space and beauty that alfalfa provides a community are significant in their own right – and besides, nothing can beat the fragrance of a newly-mown alfalfa field.

Often, in arguments between 'environmental interests' and 'agricultural interests', the complexities and benefits of a crop landscape are lost. Alfalfa makes many important contributions to broader societal goals related to the environment, and should be considered an important component of sustainable agro-ecosystems for the future.

Authors:
Dan Putnam (dhputnam@ucdavis.edu)
Forage Specialist
University of California, Davis, CA

Michael Russelle
Soil Scientist
USDA-ARS, St. Paul MN

Steve Orloff
UC Farm Advisor
Yreka, CA

Jim Kuhn
Alfalfa Grower and Photographer
El Centro, CA

Lee Fitzhugh
Wildlife Biologist
University of California, Davis, CA

Larry Godfrey
Entomologist
University of California, Davis, CA

Aaron Kiess
Executive Director
CAFA, Novato, CA

Rachael Long
UC Farm Advisor
Woodland, CA

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California Alfalfa and Forage Association
36 Grande Vista, Novato, CA 94947.
Phone: 415/892-0167
For futher information about alfalfa,
see: http://alfalfa.ucdavis.edu and
http://www.mother.com/~cafa/

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Tom Ellis, President, CAFA, Joe Rominger, Grower, Winters, CA, Larry Teuber, Professor, UC Davis, Bill Rains, Professor, UC Davis; Jess Dancer, Grower, Macdoel, CA; Ford Denison, Professor, UC Davis, Bill Williams, Professor Emeritus, UC Davis; Eric Natwick, UC Farm Advisor, El Centro, CA; Juan Guerrero, UC Farm Advisor, El Centro, CA; Gerald Holmes, NC State; Lara Hartley, Journalist, Hinkley, CA; Mel Coehlo, San Joaquin Valley Haygrowers Association; Herman S. Meister, UC Farm Advisor, El Centro; Mike San Miguel, Ornithologist, Los Angeles; Andrew Engilis, Jr. Wildlife Biologist UC Davis

Cover photo: Pronghorn antelope in intermountain alfalfa in Butte Valley in Northern California (Steve Orloff, photos).
Opposite page photo: Egret in alfalfa
This page: High desert alfalfa production near Willow Springs, California (Steve Orloff, photo).
Back cover: Sheep graze in an alfalfa field in Imperial Valley, California, with Signal Mountain, Mexico in background (Gerald Holmes, photo).

CAFA
CALIFORNIA ALFALFA & FORAGE ASSOCIATION

A Long, Rich History

Hay Schooner circa 1890's
San Joaquin River Delta, California

Alfalfa is one of the earliest crops domesticated by man and has a long and rich history.

Remains of alfalfa more than 6,000 years old have been found in Iran, and the oldest writen reference for alfalfa is from Turkey in 1300 BC! Alfalfa has a long association with many ancient civilizations, and continues to contribute to agriculture through present times.

Alfalfa was likely domesticated near present-day Turkmenistan, Iran, Turkey, the Caucasus regions, and other countries in Asia Minor. It was important to the early Babylonian cultures, and to the Persians, Greeks, and Romans. Both Aristotle and Aristophanes wrote about it. Alfalfa was reportedly brought into Greece about 500 BC by invading Median armies to feed their chariot warhorses. The Romans later acquired alfalfa and became known for their forage culture throughout the Mediterranean basin in the ancient world – for alfalfa was tied to military might.

In 126 BC, the Emperor of China dispatched an expedition to the Near East to collect specimens of the highly prized Persian horses, at which time alfalfa was brought to China. It contributed greatly to Chinese agriculture and is still widely grown there today.

The Romans introduced alfalfa into Europe as early as the First Century AD. The Arab empires of the Middle Ages spread alfalfa throughout many regions of Europe and North Africa, and especially Spain. In many of these cultures, alfalfa was associated with the horse; the name 'alfalfa' comes from Arabic, Persian, and Kashmiri words meaning 'best horse fodder' and 'horse power'. The Spanish and Portuguese later spread alfalfa to the New World during the conquest of Mexico, Peru, and Chile.

Although there is ample evidence that eastern US colonists, including Thomas Jefferson and George Washington, grew alfalfa on a few acres, it was not widely adopted in the US until its introduction into western states in the early 1850s. 'Chilean clover' (alfalfa brought from Chile), was introduced during the gold rush of 1849-1850 and was instantly adapted to the warm sun

Petaluma Hay Press. Petaluma, California, circa 1870's.

The Most Important Invention in 2000 Years?

Hay... yes, hay! At least according to one scholar. In a recent review of the most important inventions of the past 2,000 years, physicist and nobelist Freeman Dyson, Professor at the Institute for Advanced Study at Princeton University chose hay as the most important invention of the past 2000 years. Why? All civilizations have historically depended upon animals. In ancient times, animal husbandry depended exclusively upon grazing. Civilization could exist only in warm climates where horses and cattle could stay alive through the winter by grazing. At some point in history, according to Dyson, some unknown genius invented hay, which was reaped and stored. Thus civilization moved north over the Alps. The assurance of a year-long feed supply enabled a reliable horse and animal culture. So, according to Dyson, hay gave birth to Vienna and Paris, to London and Berlin, and later to Moscow and New York. Hay, the most important invention in 2000 years!

and rich soils of California. Horses, beef and milk cows were valuable, and everything was animal powered! From California, alfalfa spread eastward to Nevada, Utah, Kansas, Nebraska and other states where it rapidly took hold. Within a few years, alfalfa was a key crop in the expanding West of the 19th Century. The names Alfalfa County, OK, Lucerne, CA, and Alfalfa, WA, are testaments to its importance in those regions. In 1900, 98% of the alfalfa in the US was grown west of the Mississippi River. Cold-tolerant introductions from Germany ('Grimm' alfalfa) and plant breeding later allowed alfalfa to be adapted to the cold and wet conditions of the East. This enabled US acreage to expand 15-fold to 30 million acres by 1950, mostly in the upper Midwest and Eastern states.

From its humble origins as a deep-rooted, drought resistant perennial legume growing wild on the Steppes of Asia, alfalfa has spread throughout Asia, Europe, Australia, Northern Africa, North and South America. Many farmers and cultures value its high productivity, wide adaptation, and life-sustaining nutritional characteristics.

"...it dungs the land"

– Lucius Junius Moderatus Columella, Roman Writer, 56 A.D.

"Gold could not always be found with pick and shovel, it could without fail be found by alfalfa roots."

– Coburn, 1908 describing the history of alfalfa during the California Gold Rush in the 1850's.

Importance of Alfalfa

Alfalfa is considered the 'Queen of Forages' all over the world!

Growers admire alfalfa for its high yield, wide adaptation, disease resistance, and excellent feeding quality. Alfalfa makes a tremendous contribution to world food production, a contribution that often goes unrecognized.

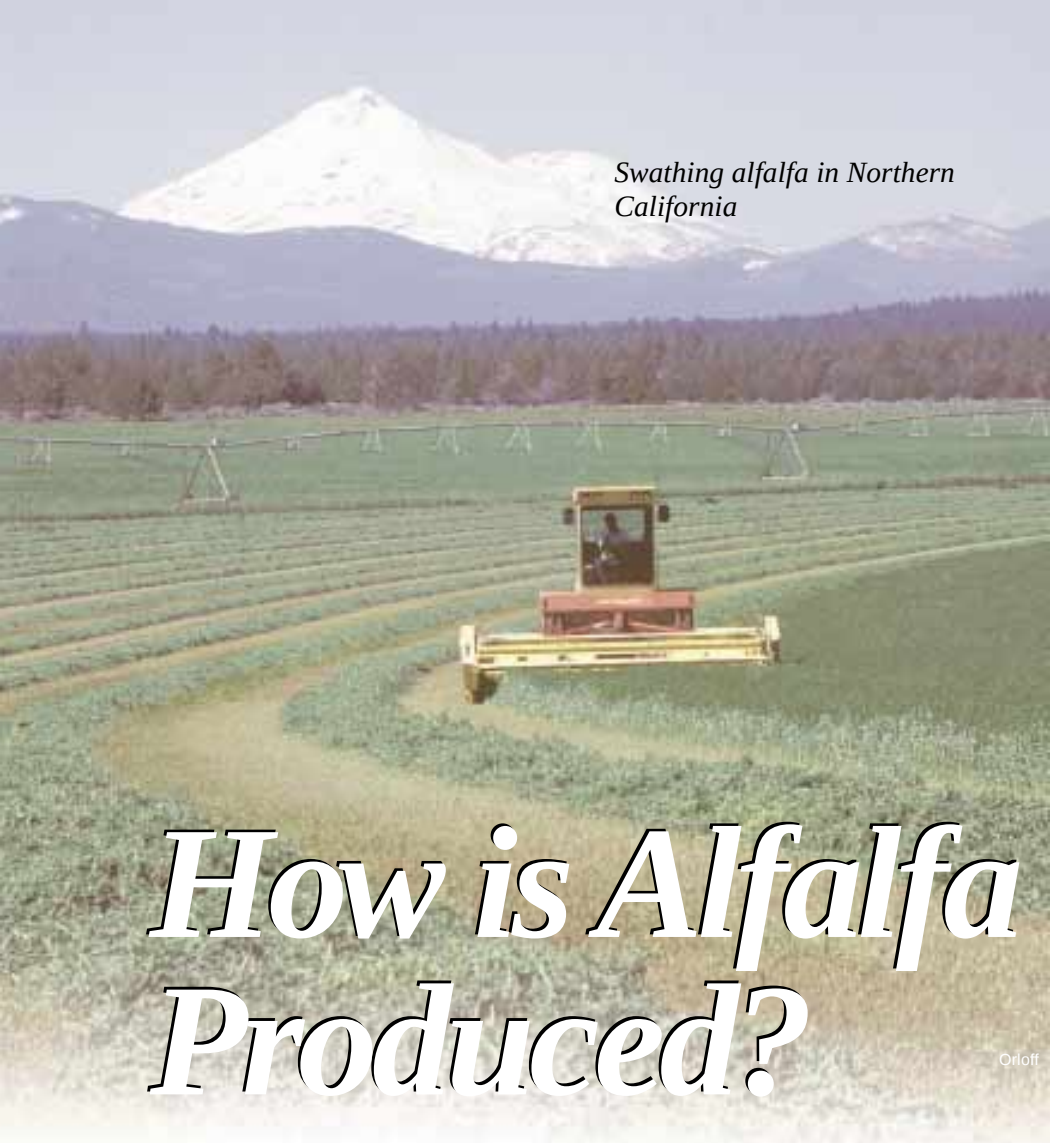
The United States grows about 23 million acres of alfalfa each year. Alfalfa is third in value behind only corn and soybeans. It is worth more than $8 billion annually not including the value of dairy products. The top alfalfa-producing states are in the West and Midwest: California, South Dakota, Wisconsin, Minnesota, Idaho, Nebraska, Iowa, Montana, Kansas, and Colorado. About 40% of the nation's alfalfa crop is grown in the 11 western states from Colorado west. Alfalfa is not commonly grown as much in the southern US, but can be grown there as well on well-drained soils.

Early growers marveled at the vigor of alfalfa. Photo from Imperial Valley, California, 1903.

Alfalfa is usually closely associated with dairy production, which is the primary use of alfalfa. However, alfalfa is also used extensively as a horse feed, and for sheep, beef and other animals. Without alfalfa, many farms and ranches would fail.

Alfalfa is one of the world's most versatile crops. It is grown in environments ranging from burning hot deserts to cool high mountain valleys, from the frozen continental climate of Minnesota, to the Mediterranean valleys of California. Alfalfa can grow on soils ranging from beach sands to heavy clays. It is grown as an intensive cash crop under irrigation, or as a lower-intensity rainfed pasture crop in forage mixes. Alfalfa can be grazed, fed fresh as green chop, baled, cubed, pelleted, or ensiled. Alfalfa is the key forage crop for dairy producers in the US and the world; it is no accident that the two top dairy states, California and Wisconsin, are also leading states in alfalfa production.

But alfalfa is not as easily recognized on the dinner table as are major grain crops such as corn or wheat. This 'Rodney Dangerfield' of crops has been a mainstay of US farms and ranches for more than a century, but its continued importance is often not recognized by the general public.



Swathing alfalfa in Northern California

How is Alfalfa Produced?

Alfalfa is produced in a wide variety of ways. Here are some common methods of alfalfa production.

Stand Establishment. Alfalfa is a perennial – it is planted in the spring or fall and then harvested for many years. The seedbed is usually prepared finely to cover the seed, but some growers seed alfalfa without tillage, directly into stubble. Alfalfa seed must be planted close to the soil surface since it is very small (1-2 mm). About 15-25 lbs of seed per acre is planted using a grain drill, broadcast seeder, or airplane. Alfalfa is a relatively weak seedling and must be protected from weeds. However, after developing a 'crown' (top of the root), alfalfa is very vigorous, and can re-grow many times after cutting.

Varieties. There are many varieties of alfalfa. Some tolerate freezing – these are grown in northern US states and Canada. Other varieties continue growing during winter months – these are grown in the southwestern states of California and Arizona where growers harvest up to 12 months of the year! Alfalfa breeders have developed many varieties of alfalfa that are highly resistant to diseases and insect pests, thereby reducing the need for pesticides.

Raking alfalfa.

Cutting Schedules. Alfalfa is harvested 3-4 times/year in most of the US, but up to 10-11 times/year in the southwestern US. In many areas, growers harvest every 25-35 days, depending upon the weather. Most alfalfa stands last 3-6 years before planting another crop, but some alfalfa stands have lasted more than 25 years!

Crop Protection. Alfalfa has tremendous genetic resistance to many pests, a result of traditional plant breeding. Consequently, alfalfa does not need a large amount of pesticides each year compared with other crops. However, there is a large benefit from controlling insect and weed pests of alfalfa in new and established alfalfa stands using Integrated Pest Management techniques. Key insect pests include alfalfa weevil, leafhoppers, alfalfa caterpillar, armyworms, and many types of aphids. Weeds can be a major problem, especially during stand establishment. Weeds can severely reduce the nutritional quality of alfalfa, but a vigorous alfalfa stand is highly resistant to weed infestation.

Method of Harvest. Alfalfa is typically harvested with a 'swather', which cuts the crop and places it in windrow strips 3-5 feet wide. These are allowed to dry, using natural solar energy. Windrows are sometimes raked or 'tedded' (fluffed) to speed drying. Then, balers are used to gather the forage into a hay bale, which can range from small (50 lb) to very large (1 ton). Alfalfa also can be made into silage or haylage by harvesting the forage when it is moist and placing it into a silo where it ferments for preservation. It can also be grazed by sheep or cattle or made into cubes or pellets.

Irrigation. Irrigation is not widely used in humid Midwestern or Eastern growing regions. In western states, irrigation is usually a prerequisite for alfalfa production, and alfalfa yields are highly responsive to irrigation. Alfalfa is usually irrigated 1-3 times between cuttings, depending upon time of year, location, and soil type. Alfalfa water use varies greatly between regions, ranging from 2 acre feet per year to 6-7 acre feet per year.

Rotation. After alfalfa stands decline, growers generally plow up

Baling hay using large baler

alfalfa to plant corn, wheat, or other crops, such as tomatoes. Alfalfa does not leave residues that require burning. Alfalfa benefits a subsequent crop by providing residual nitrogen (from biological N fixation) and by providing better 'tilth' or crumbliness of the soil.

Quality. There is a wide range of alfalfa quality, from supreme to very poor. Hay growers all over the world want to "make hay while the sun shines," since hay quality decreases when hay is rained on. Pure alfalfa is usually higher quality than weedy alfalfa. Alfalfa harvested before bloom produces the highest quality hay which low in fiber and high in protein. If alfalfa is cut late (while in bloom), its feeding quality is lower. Hay quality is important economically – it is estimated that more than $300 million of California's $1 billion alfalfa crop value is determined by quality factors.

Uses. After harvest, alfalfa may be fed on-farm to livestock, or sold on the market. In western states, a large percentage of the alfalfa is sold on the market, whereas in other regions, most is used on-farm. Pure alfalfa of high quality is in high demand by the dairy industry, but all types of hay are used by dairies, horses, beef, and sheep operations. Other uses have been explored, including export, manufacturing of feeds, extraction of compounds, and use of alfalfa as an energy crop. As one of the top three crops in the US, many farms and ranches would fail without alfalfa.

"Harrow-beds" are used to pick up and stack small bales in western states.

Fourth Generation Farmer Carries on the Family Tradition

America's family farms are often rich in history. Many of today's growers are descendants of early pioneers and ranchers who were among the first to experiment with alfalfa in America. Brad Harlan of Fresno County, CA is a fourth-generation farmer who grows alfalfa on land his family first purchased in 1874.

Harlan's great grandfather George Harlan was a wagon master who left Michigan in 1845 and met up with the Donner Party at Fort Bridger, a territory that would later become Wyoming. The Donner Party is a well-chronicled part of California history; their fate was sealed by a fierce winter storm that buried them deep in snow in the Sierras. Fortunately for Brad, George Harlan crossed the Sierras before the Donner Party's ill-fated trek, and their family eventually settled in "less crowded territory" – California's Great Central Valley.

Today, Brad and his wife, Blair, continue the tradition established by pioneer George Harlan. Mechanization and other advances have dramatically changed agriculture. While Harlan's grandfather harvested and stacked hay by hand, today harvesting is completely mechanized. From seed to baled hay, it is not touched by human hands. But, one thing that hasn't changed are long hours and hard work. Harlan and his family grow about 200 acres of alfalfa annually – without hired help. During the growing season, a typical workday starts before sunup and extends well into the night.

Brad and Blair Harlan on their ranch

Harlan is conscious of the need to grow high quality alfalfa for California dairies – a task that requires top management. He averages seven to eight cuttings per season and cuts a small amount of hay at a time, usually in the afternoon. He bales at night or early in the morning "to hit the dew just right." Like many western alfalfa growers, he waits for 'the wiley dew,' to soften the high protein leaves and prevent their loss during the baling process.

Harlan is keenly aware of the important role high-quality alfalfa plays in milk production and maintaining herd health. An animal science major at Cal Poly San Luis Obispo, he later earned an MS in ruminant nutrition at Kansas State before returning to the family farm in 1981. He calls the farm his "first love and a great place to raise children." Their daughters, Tricia and Breanne, are active in 4-H.

Like all alfalfa growers, Harlan is at the mercy of weather, pests, and market forces that are beyond his control. But despite the long hours and challenges, he's happy to carry on a family tradition that dates back to the 19th century.

Alfalfa planted in orchards for soil conservation, soil fertility, and extra income near Orland, CA.

Sustaining the Soil for Future Generations

Alfalfa is highly beneficial to soil health and cropping systems.

This simple statement of truth has been known by agriculturalists for thousands of years. Ancient Roman, Greek, and Persian agriculturalists understood the value of alfalfa in benefiting soil tilth and soil fertility. However, many in today's public are unaware of this major contribution of alfalfa to our environment.

Our soil is worth protecting: this thin, fragile layer sustains all terrestrial life! Millions of tons are lost permanently each year due to wind and water erosion, overgrazing, poor agricultural practices, and to urbanization. Alfalfa can aid in protecting the soil from loss, and actually improves the soil's ability to sustain food production.

There are a number of key attributes that enable alfalfa to improve and protect the soil. These are primarily related to its deep and vigorous perennial root system, protective canopy of leaves, and its capability to 'fix' atmospheric nitrogen.

Alfalfa Prevents Erosion. Although much of the current concern about the environmental effects of agriculture is focused on pesticides, soil erosion has always been a significant environmental hazard of agriculture. Soil erosion is a permanent loss of productive potential, since the most fertile soil layers erode, only to pollute streams and lakes with sediment. Alfalfa protects the soil from erosion in several key ways: by reducing the amount of cultivation, by holding the soil in place through extensive rooting, by providing a vigorous above-ground canopy, and by improving 'tilth' and water penetration.

Reduced Cultivation. While many crops must be cultivated several times per year to remove weeds, little soil disturbance occurs in alfalfa fields after the crop is established. Most alfalfa fields are never tilled for 3-6 years after planting! This greatly reduces the chances of wind and water erosion, and lessens the negative effects of dust on human health.

Very Deep Roots. Alfalfa's roots go much deeper than do most crops. This deep rooting pattern is highly beneficial to soils. Alfalfa roots are commonly 9 - 16 feet (3 - 5 meters) and may extend much deeper. The deep, vigorous alfalfa root system holds the soil in place and creates many channels in the soil that encourage water infiltration, biological activity in the root zone, and improved nutrient cycling. Water use efficiency may be improved in subsequent crops.

Vigorous Canopy. A canopy of alfalfa quickly covers the soil, protecting the soil from wind or water erosion. Unlike row crops, alfalfa covers most parts of the soil, slowing water droplets before they have a chance to loosen and erode the soil.

Reduced Runoff. The amount of soil or water that runs off alfalfa fields is a small fraction of the runoff from bare soil or from many other types of cropland. This helps prevent pesticide and sediment movement to natural waterways.

Weed Suppression. Alfalfa fullfills a very important role in crop rotations by suppressing weeds that are common in annual crops. The dense vigorous alfalfa canopy shades these weeds and frequent cutting prevents weed seed production. This could reduce pesticide use in subsequent crops.

Low Pesticide Use. Alfalfa sometimes requires herbicides and insecticides for optimum crop production, but the intensity of pesticide use in alfalfa is typically far lower than many other crops, particularly the 'higher value' crops. There are millions of acres of alfalfa in the US that receive no pesticides at all. This lowers the overall risk of crop production to the environment.

Alfalfa 'Rhizosphere'. Alfalfa roots produce an excellent environment for growth of microorganisms immediately

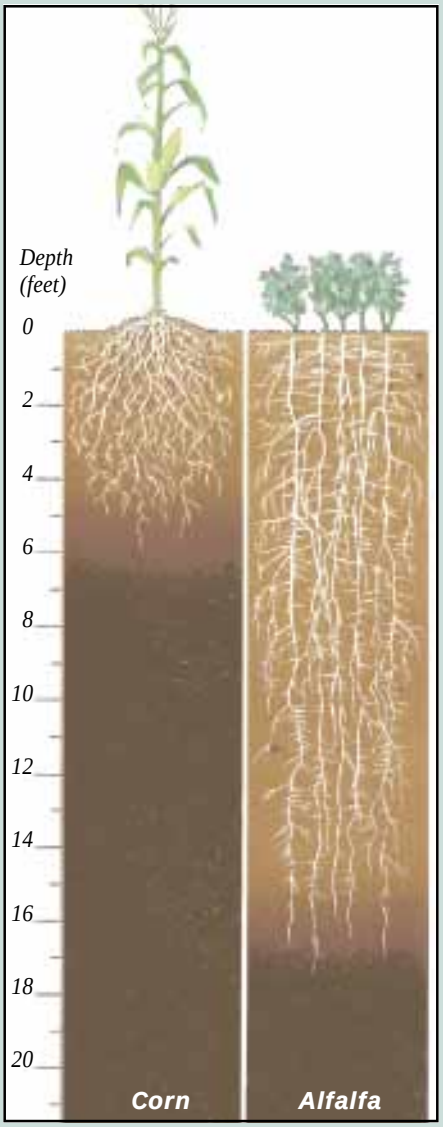
surrounding the root (the rhizosphere). This flurry of biological activity is due to natural chemical exudates from roots, but also to the nitrogen and carbon in dead and dying roots and root nodules. Microorganism populations are usually 10 to 100 times higher next to the root than in the bulk soil. The alfalfa 'rhizosphere' is very important environmentally and is beneficial to the soil.

Improved Soil Tilth. Organic acids produced in the rhizosphere improve the structure of the soil surrounding alfalfa roots. Soil particles aggregate, creating pore space for air and water movement. The soil becomes 'crumbly' leaving many 'channels' – ideal for plant growth and water infiltration. Farmers the world over recognize the beneficial effect of alfalfa on the soil and the following crop. As Roman writer Columella wrote in 56 AD of alfalfa, "it dungs the land." This refers to not only the residual N from alfalfa, but also to soil tilth.

Nitrogen Fixation. One of the key values of alfalfa is its ability to 'fix' nitrogen gas (N_2) from the air so that N is available for plant growth. Available N is very limited in the Earth's crust and is frequently deficient in plants. Nitrogen is a basic building block for plant proteins, and for human protein nutrition. While cereal crops require millions of tons of N fertilizers per year, alfalfa requires essentially no N fertilizers for optimum growth. Estimates for N_2 fixation in alfalfa range from 120 to 540 lbs of N per acre per year!

N_2 fixation is accomplished by symbiotic association with the bacteria *Sinorhizobium meliloti*, which lives in nodules in alfalfa roots. The US alfalfa crop fixes an estimated 2 – 2.5 million tons of N each year, which is used for protein production and plant growth. Dinitrogen fixation by alfalfa has several important environmental benefits, which are not broadly recognized:

Reduced energy needs for food production. First, alfalfa produces high quantities of protein with no added N fertilizers. This has an environmental benefit in resource conservation and energy use. For example, in 2000, California produced 7.1 million tons of alfalfa or approximately 1.4 million tons of protein from alfalfa on 1 million acres. To produce the same amount of protein per acre would require 4.6 million acres of corn (assuming average US corn yields and 8% protein in the grain). Using a very conservative average figure of 100 lbs N/acre as the fertilizer requirement for corn, this protein would require 230,000 tons of N (or about 280,000 tons of anhydrous ammonia) as fertilizer. Nitrogen fertilizer manufacturing is heavily dependent upon fossil fuel, especially natural gas. About 33.5 million BTUs from natural gas are required to produce 1 ton of anhydrous ammonia. Therefore, over 9 trillion BTUs of energy would be required to produce the protein from California's alfalfa crop each year. This does not consider the application and transportation, energy costs, and inefficiency in plant uptake of fertilizer.



Alfalfa exhibits substantial belowground growth and biological activity. Measurements of alfalfa roots to 15 feet or deeper are common. The N_2 fixation and rhizosphere activity of alfalfa is of great benefit, conserving soil fertility and energy resources. (Illust. U. of MN Coop. Ext.)

Alfalfa provides N to subsequent crops. In addition to lessening the environmental costs of protein production from the crop itself, alfalfa contributes significant N to subsequent crops (e.g. wheat, corn). In most farm states the "N credit" for alfalfa ranges from 40-190 lbs N per acre. This is essentially free 'fertilizer' that can be utilized by the following crop. The exact amount available will depend upon alfalfa stand, soil type, and how much top growth is plowed down.

In the US, assuming that about 20%, or 4.8 million acres of alfalfa are rotated to another crop each year (a conservative estimate), and using a conservative N credit of 50 lbs/acre to the subsequent crop, this amounts to 120,000 tons of N, or 146,000 tons of anhydrous ammonia equivalent potentially saved each year. This is worth over 4 trillion BTUs of fossil fuel energy from natural gas, in addition to the amounts directly from alfalfa detailed above. The N_2 fixation of alfalfa is of tremendous environmental benefit to the United States each year!

Alfalfa – Part of Sustainable Cropping Systems. Alfalfa performs a humble, unsung, yet vitally important role in cropping systems due to these characteristics. Some growers would continue to grow alfalfa solely for its rotational value and benefits to subsequent crops, even if the economic returns were marginal. Alfalfa's N_2 fixation, deep roots, protection and enhancement of the soil, relatively low pesticide load, and contributions to subsequent crops make it a highly valued component of sustainable agricultural systems.

What do you make of this hay?

Alfalfa – Ice Cream in the Making!

Alfalfa ice cream??! Isn't that something that cows eat?

Exactly. While we don't consume alfalfa directly (other than alfalfa sprouts), alfalfa contributes to a wide range of nutritious foods that we enjoy every day. Would a person eating a taco, pizza, or cheeseburger, or pouring milk on their cereal recognize that the cheese, sour cream, milk, or meat originated with alfalfa? Probably not. But these foods begin with alfalfa.

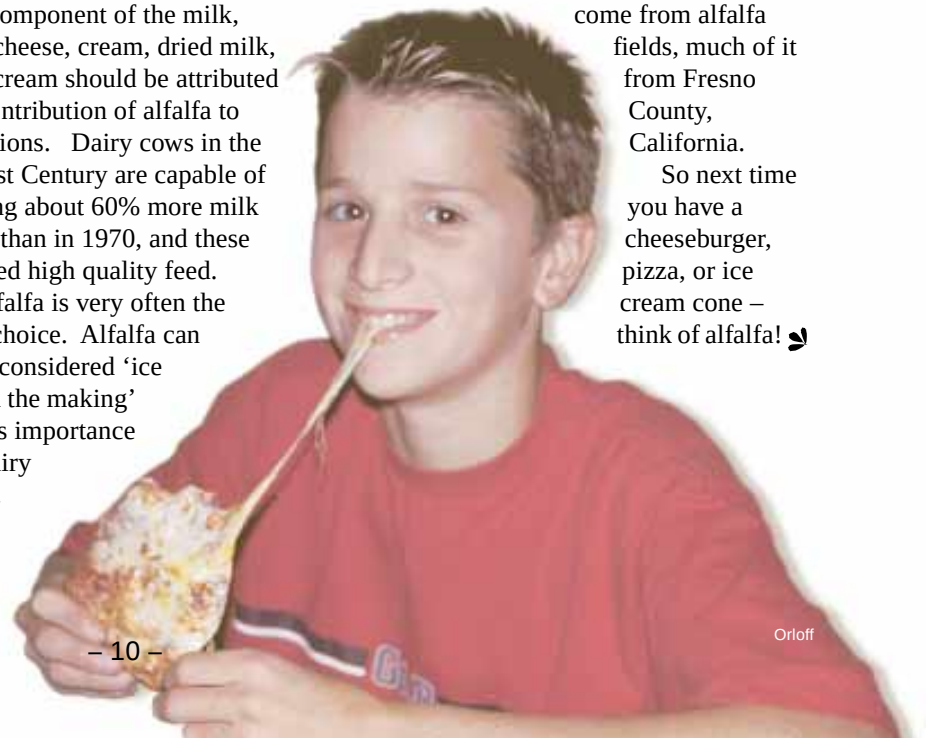
The most important use of alfalfa is the dairy industry. Alfalfa is considered the premier forage for dairy cows. Thus a large component of the milk, yogurt, cheese, cream, dried milk, and ice cream should be attributed to the contribution of alfalfa to dairy rations. Dairy cows in the early 21st Century are capable of producing about 60% more milk per cow than in 1970, and these cows need high quality feed. Thus, alfalfa is very often the feed of choice. Alfalfa can truly be considered 'ice cream in the making' due to its importance to the dairy industry.

Milk Advisory Board

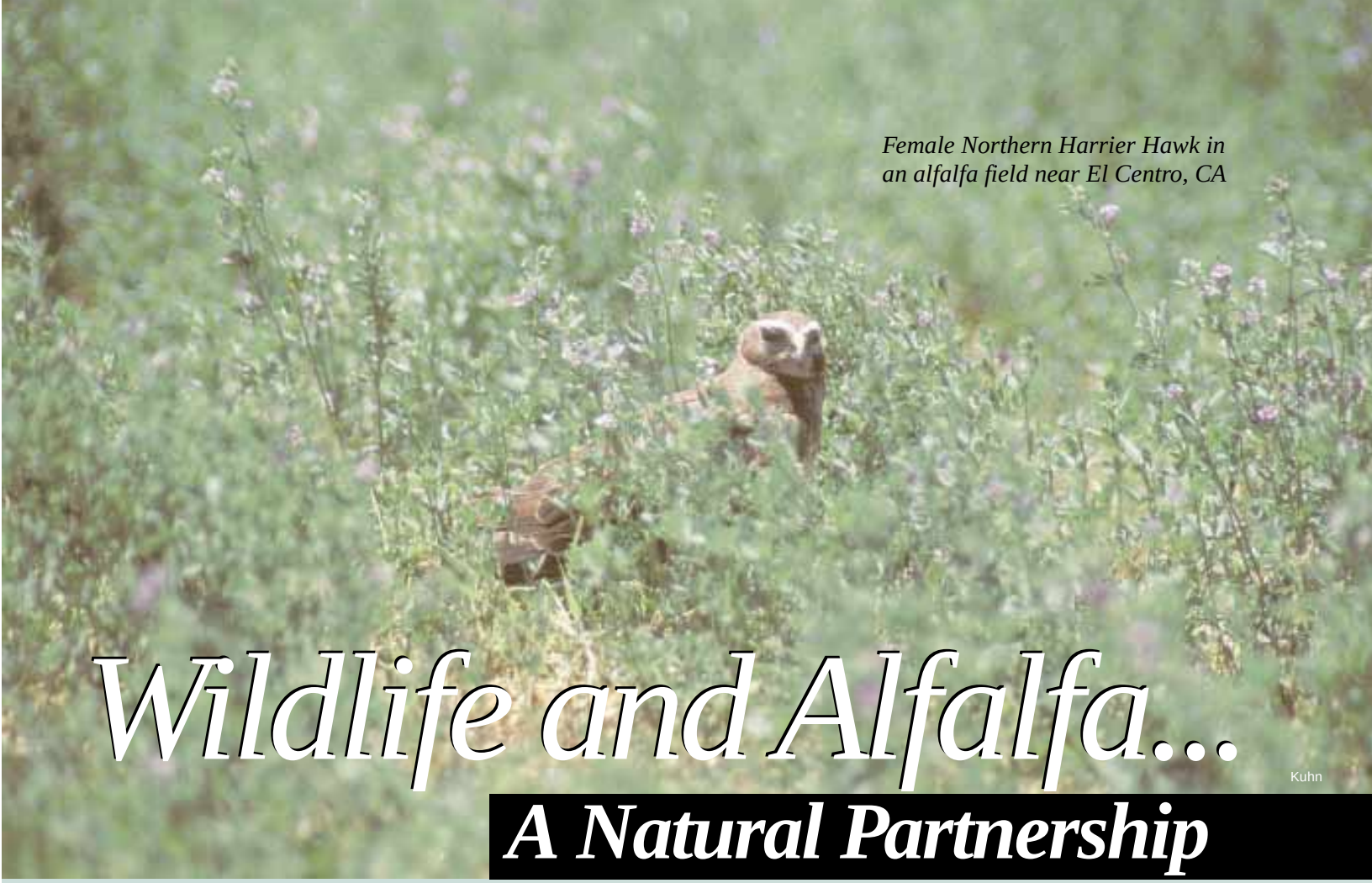
Yet alfalfa's contribution to human health and well-being doesn't stop there. Alfalfa contributes significantly to beef and sheep production, and recreational horses. That wool sweater hanging in your closet may have received a contribution from alfalfa somewhere down the line. The use of recreational horses has grown sharply over the past 20 years – we likely have more horses now than at any time in America's past! Unusual animals, such as elephants in zoos, also thrive on alfalfa.

Honey is an important product of alfalfa. Since alfalfa seed growers need cross-pollination for good seed production, bees are a common sight in seed fields. The nectar makes highly prized, clear honey. Approximately one-third of the honey in the US is estimated to come from alfalfa fields, much of it from Fresno County, California.

So next time you have a cheeseburger, pizza, or ice cream cone – think of alfalfa!



Orloff



Female Northern Harrier Hawk in an alfalfa field near El Centro, CA

Kuhn

Wildlife and Alfalfa...

A Natural Partnership

While it is true that crop production represents a significant change from naturally-occurring landscapes, it's not true that wildlife are the automatic losers in this exchange.

In fact, many species of wildlife thrive within and alongside agriculture. Wildlife benefits from crops like rice and wheat, which provide grain for food. However, wildlife particularly benefits from alfalfa. Alfalfa provides significant habitat due to its nesting cover, abundant insects, perennial growth pattern, and feeding opportunities. In fact, there are hundreds of species that prefer alfalfa to other, even natural, landscapes.

What are the characteristics that make alfalfa such a good habitat for so many species?

Perenniality. Alfalfa fields represent a stable, relatively undisturbed area where plant growth continues throughout the year, unlike other sites that are either disturbed, or exhibit only seasonal growth.

High Feeding Value. The high palatability of alfalfa, which makes it such a good dairy feed, also makes it desirable to many herbivores, including many species of insects, rodents and grazing animals.

Cover. Alfalfa canopies provide an

Alfalfa – The Beginning of a Food Chain!

While most people see an alfalfa field as simply a uniform horizontal green mass, of benefit only to the farmer, an alfalfa field is teeming with many forms of life that enrich us all. To many species of wildlife, alfalfa fields provide an oasis of green in landscapes of tilled fields or dry brush. Alfalfa is a 'primary producer' that supports many types of insects and vertebrate herbivores, such as gophers that inhabit the root zone. In turn, songbirds, migratory birds, birds of prey, hunting mammals, snakes, and lizards feed upon the herbivores. Deer, antelope, and elk commonly feed in alfalfa fields, especially in times of drought. Foxes can be seen hunting rabbits and gophers, which feed on alfalfa fields. Many raptor species, including Swainson's Hawk and bald eagles, can be found hunting in alfalfa fields. Alfalfa is the beginning of a food chain that supports not only millions of farm animals and human beings, but many forms of wildlife that are important to the Earth's ecosystems.

Alfalfa Enriches Wildlife Habitat...

effective cover for many species for feeding, sleeping, nesting, or escaping predators.

Below-Ground Diversity. There is considerable below-ground biological activity in alfalfa fields, including earth worms, insects, and other organisms. Gophers and other rodents frequently make their homes under alfalfa fields.

Insect Diversity. There is a wide range of insects, both herbivores and predators, that are present in large populations in alfalfa fields.

Frequent Irrigations. The presence of irrigation water in alfalfa fields during hot periods is important to wildlife species as well as to the crop. In some environments, alfalfa irrigations are a welcome respite for thirsty animals. Irrigation also flushes insects and rodents to the surface, which are food sources for birds, snakes, and raptors, such as eagles and hawks. Irrigation and a closed canopy creates a humid microclimate desirable for insects and bird eggs.

Open Spaces for Hunting. Raptors are frequently found soaring above alfalfa fields, or awaiting prey from nearby posts. Some growers have planted trees, provided raptor poles, or built owl boxes to encourage raptor habitat in an otherwise horizontal landscape. Around the field margins animals can easily find trees, shrubs and weeds in which to nest, coupled with access to a plentiful supply of water nearby.

Of all the animals that use alfalfa (not including insects or reptiles), 10% use it extensively for breeding and reproduction, 24% find it highly suitable for cover, and 57% use it for feeding.

Alfalfa – the Beginning of a Food Chain. The alfalfa wildlife food chain begins with alfalfa itself – a high quality, palatable crop to foragers. Next there


Burrowing Owl in alfalfa
Kuhn


Great Blue Heron in alfalfa
Kuhn


Deer using alfalfa for forage
Orloff

HOW WILDLIFE SPECIES USE ALFALFA

This listing of many forms of wildlife found in alfalfa fields was obtained by considering the 675 regularly-occurring resident and migratory terrestrial wildlife (amphibians, birds, mammals and reptiles) that live in California. Of these, 182 species, or 27% were considered to be frequent, moderate, or occasional users of alfalfa, either in the crop itself, along the margins of the fields, or in the plowed or seeded fields during cultivation and stand establishment, or during harvest or irrigation events. The suitability of alfalfa for a species for Reproduction (R), Cover (C), or Feeding (F) is designated, along with the degree of suitability (•••= High, ••= Moderate, or •= Low). A certain species may use alfalfa only at certain stages of field management, crop growth, or stage of the wildlife. These designations were developed by L. Fitzhugh (Wildlife Biologist, UC Davis), based upon the California Wildlife Habitat Relationships model, version 7.0, and modified through literature review and consultation with other experienced wildlife biologists and ornithologists.

BIRDS

Species	Use of Alfalfa		
Great Blue Heron		C•••	F•••
Green Heron			F•••
Black-crowned Night heron		C••	F•••
Snowy Egret		C••	F••
Great Egret		C•••	F•••
Cattle Egret		C•••	F•••
White-Faced Ibis		C•	F•••
Fulvous whistling duck		C••	F•••
Tundra Swan		C•••	F•••
Greater White Fronted Goose		C•••	F•••
Ross' Goose		C•••	F•••
Snow Goose		C•••	F•••
Canada Goose	R•	C•••	F•••
Mallard	R•••	C•••	F•••
Northern Pintail	R•••	C•••	F•••
Cinnamon Teal	R••	C••	F••
Blue-winged Teal		C•	F••
Green-winged Teal		C•	F••
Gadwall	R••	C••	F•
Northern Shoveler	R•	C•	
American Widgeon	R•	C•	F••
Turkey Vulture			F••
White Tailed Kite			F•••
Northern Harrier	R•••	C•••	F•••
Red-Shouldered Hawk			F•••
Swainson's Hawk			F•••
Red-tailed Hawk	R•	C•	F••
Ferruginous Hawk			F•••
Rough-Legged Hawk			F••
Golden Eagle			F•••
American Kestrel		C•••	F••
Merlin		C••	F•••
Peregrine Falcon		C•	F••
Prairie Falcon		C•	F•••
Ring-Necked Pheasant	R•••	C•••	F•••
Wild Turkey			F••

...and Wildlife
Enriches Us All!

are the smallest, and most abundant creatures – the insects, of which there are hundreds of species. Each successive re-growth of alfalfa creates an environment that teems with insect life! Depending on these insects for feed are a large number of species, including songbirds, swallows, bats, and many types of waterfowl and migratory birds. Feeding directly on the alfalfa are mammals such as gophers, mice, and rabbits. Larger herbivorous mammals, such as deer, antelope, and elk, frequent alfalfa fields, especially during dry or cold seasons. Hawks, eagles, migratory birds, coyotes, and mountain lions feed on the birds and rodents that feed on the alfalfa. Finally scavengers such as coyotes and vultures feed on the carrion to complete the food chain.

Although alfalfa makes an excellent habitat for many species, its main disadvantage is frequent mowing. Farmers have been active in aiding efforts to design bird-flushing mechanisms for swathers to reduce the impact of mowing on nesting birds, and in collecting and incubating eggs. Others have chosen to leave strips for habitat at certain times of the year.

Statistics support the importance of alfalfa to wildlife habitat. In a survey of the 675 wild animals and birds that occur regularly in California, 27 percent use alfalfa, according to wildlife biologists.

Although alfalfa farming is an economic enterprise, many farmers truly appreciate the wildlife on their farms and ranches. Most farmers are conscious of the need to preserve the land to maintain the viability of the soil and field environment. Several farmers and farming organizations are actively pursuing ways to invite more wildlife onto their land, ultimately resulting in a more wildlife-friendly method of farming.

White Faced Ibis feeding during irrigation in alfalfa Kuhn

BIRDS

California Quail	R••	C••	F•••
American Coot			F•••
Sandhill Crane	R•••	C•••	F•••
Black-bellied Plover		C•••	F•••
Mountain Plover		C•••	F•••
Killdeer	R•••	C•••	F•••
Black-necked Stilt		C•	F••
American Avocet	R•	C••	F•••
Willet		C••	F•
Whimbrel		C•••	F•••
Long-billed Curlew	R•••	C•••	F•••
Marbled Godwit		C••	F••
Western Sandpiper		C•••	F•••
Spotted Sandpiper			F••
Least Sandpiper		C•••	F•••
Dunlin	R•	C•	
Long-billed Dowicher		C•••	F•••
Common Snipe		C••	F••
Wilson's Phalarope	R•	C•••	F•••
Ring-billed Gull		C•••	F•••
California Gull		C•••	F•••
Herring Gull		C••	F••
Yellow-Footed Gull		C•	F••
Greater Yellowlegs		C•	F••
Lesser Yellowlegs		C•	F••
Gull-billed Tern			F•••
Black Tern		C•	F•••
Rock Dove			F••
Wite-winged Dove			F••
Mourning Dove			F••
Inca Dove	R•	C••	F••
Common Ground Dove		C••	F••
Greater Roadrunner		C•••	F••
Barn Owl		C•••	F•••
Western Screech Owl			F•••
Great Horned Owl			F•••
Northern Pygmy Owl			F•••
Burrowing Owl	R•••	C•••	F•••
Long Eared Owl			F•••
Short Eared Owl	R•	C•••	F•••
Lesser Nighthawk			F•••
Common Nighthawk			F•••
Northern Flicker			F•••
Western Wood Pewee			F••
Black Phoebe		C••	F••
Say's Phoebe		C••	F••
Vermillion Flycatcher		C•	F•••
Ash-throated Flycatcher			F••
Western Kingbird			F•••
Horned Lark		C••	F•••
Purple Martin			F•••
Tree Swallow			F•••
Violet-green Swallow			F•••
Northern Rough-winged Swallow			F•••
Bank Swallow			F•••
Cliff Swallow	R••	C••	F•••
Barn Swallow	R••	C••	F•••
Scrub Jay			F••
Black-billed Magpie			F•••
Yellow-billed Magpie			F•••
American Crow			F•••
Common Raven			F•••
Western Bluebird			F••
Mountain Bluebird		C•••	F•••
American Robin			F••
Northern Mockingbird			F••
American Pipit		C•••	F•••
Northern Shrike		C••	F•••
Loggerhead Shrike		C••	F••
European Starling			F•••
Marsh Wren		C••	F••
Ruby-Crowned Kinglet			F•••
Wilson's Warbler			F••
Yellow Warbler			F••
Yellow-rumped Warbler			F••
Blue Grosbeak		C••	F•••
Vesper Sparrow	R•	C••	F••
Lark Sparrow	R••	C••	F••
Lincoln's Sparrow		C••	F••
Savannah Sparrow	R••	C••	F••

Continued from previous page

BIRDS	*Harris' Sparrow*		C••	F••
	White-Crowned Sparrow		C•	F••
	Golden-Crowned Sparrow		C••	F••
	White Throated Sparrow		C••	F••
	Brewer's Sparrow		C••	F••
	Dark-eyed Junco		C••	F••
	Red-winged Blackbird			F•••
	Tricolored Blackbird			F•••
	Western Meadowlark	R•••	C•••	F•••
	Yellow-headed Blackbird			F••
	Brewer's Blackbird	R•	C••	F•••
	Great-tailed Grackle			F••
	Bronzed Cowbird			F•••
	Brown-headed Cowbird			F•••
	House Finch		C••	F•••
	Pine Siskin			F••
	Lesser Goldfinch		C••	F••
	Lawrence's Goldfinch			F••
	American Goldfinch			F••
	House Sparrow		C•••	F•••
MAMMALS	*Virginia Opossum*	R•	C•	F••
	Broad-footed Mole	R••	C••	F••
	Townsend's Mole	R••	C••	F••
	California Myotis			F••
	Big Brown Bat			F••
	Yuma Myotis Bat			F••
	Silver-haired Bat			F••
	Western Mostitt Bat			F•••
	Pallid Bat			F•••
	Mexican Freetailed Bat			F•••
	Western Red Bat			F••
	Desert Cottontail	R••	C••	F•••
	Brush Rabbit	R••	C••	F•••
	White-tailed Jackrabbit		C•	F•••
	Black-tailed Jackrabbit	R••	C••	F•••
	Townsend's Ground Squirrel	R•	C••	F•••
	Belding's Ground Squirrel	R•	C••	F•••
	California Ground Squirrel	R•	C••	F•••
	Botta's Pocket Gopher	R•••	C•••	F•••
	Northern Pocket Gopher	R•••	C•••	F•••
	Western Pocket Gopher	R•••	C•••	F•••
	Mountain Pocket Gopher	R•••	C•••	F•••
	Western Harvest Mouse	R••	C•••	F•••
	Deer Mouse	R•	C••	F••
	Hispid Cotton Rat	R•••	C•••	F•••
	Arizona Cotton Rat	R•••	C•••	F•••
	Montane Vole	R••	C••	F••
	Creeping Vole	R•	C••	F•••
	Townsend's Vole	R•	C••	F•••
	California Vole	R••	C••	F•••
	Long-Tailed Vole	R••	C••	F•••
	Black Rat	R••	C••	F••
	Norway Rat	R••	C••	F••
	House Mouse	R•	C•	F••
	Coyote	R•	C•	F•••
	Feral Dog	R•	C••	F•••
	Red Fox	R•	C••	F•••
	Kit Fox		C••	F•••
	Gray Fox		C•	F•••
	Ringtail		C•	F••
	Racoon		C•	F••
	Long-tailed Weasel	R•	C•	F••
	American Badger	R•	C•	F••
	Striped Skunk		C•	F•••
	Bobcat			F••
	Feral Cat	R•	C••	F••
	Elk			F•••
	Mule Deer		C•	F•••
	Feral Pig		C•	F•••
	Pronghorn	R•	C•••	F•••
	Feral Horse		C•	F•••
	Feral Ass		C•	F•••
OTHER	*Western Toad*	R•••	C••	F••
	Western Fence Lizard	R••	C••	F••
	Racer Snake	R•	C•	F•
	Gopher Snake	R•••	C•••	F•••
	Common Kingsnake	R••	C••	F••
	Common Garter Snake	R••	C••	F••
	Checkered Garter Snake	R•••	C•••	F•••

Farm Families Help Nurture Wildlife

While alfalfa provides a great habitat for wildlife 'as is', some farm families are taking extra steps to help it along. Jeff and Sharon Mancebo of Dos Palos, California, and their son Dustin are doing just that, taking a leading role in helping to ensure the diversity of wild birds on their ranch.

Young Dustin started taking an interest in raising wild birds at the age of fourteen. Dustin's grandfather instructed him in the value of abundant bird populations, which historically thrived in rice fields and alfalfa fields in their county. Dustin decided to lend a helping hand and began rearing birds that are released around the family farm. Three years later, he was rearing and releasing more than 300 birds each year.

Jeff Mancebo and his son Dustin.

Dustin started with day-old chicks bought from a hatchery in Fresno, but then began collecting and incubating eggs from the field. He has since invested a good deal of time and about $4,000 of his own money to hatch and raise birds, mainly pheasants, quail, chukar, and some wild turkeys that are later released. When birds abandon nests or fall victim to predators, the Mancebos recover the eggs and Dustin puts them in an incubator.

"It's a seven-day a week job" says Dustin. Luckily, he gets lots of support from his father, Jeff. The corners of alfalfa fields are maintained without harvesting to provide cover, food, and habitat for birds. While alfalfa is the preferred habitat, Jeff notes that sugarbeets also attract the birds. He has planted safflower or sorghum in the corner of sugarbeet fields to provide additional food for birds.

Many of their Dos Palos neighbors have reported greater sightings of pheasants and other birds after Dustin started his project. In 2001, Dustin won honors from FFA for his wildlife work. He is looking for other bird species to raise and hopes to someday start a full-fledged hatchery business.

Like the Mancebos, many farm families are at the forefront of environmental stewardship. The opportunity for a close relationship to wildlife is an important reason for remaining on the farm.

Ring-necked Pheasant near an alfalfa field.

Alfalfa – an Incredible Insectary

A fieldside view of an alfalfa field may show little apparent activity – simply a mass of green. But look a little closer – alfalfa teems with insect life! The diversity of insects in alfalfa fields have been described as 'incredible' by researchers – it is a great resource for insect diversity.

Researchers from California have identified over 1,000 arthropod species (insects, spiders, mites, and other relatives) that inhabit alfalfa fields. A small percentage (less than 1%) of these arthropods inflict damage to alfalfa and cause concern to alfalfa growers. Several of these insects function as predators and parasites. From a crop production standpoint, these are considered beneficial organisms.

However, most of the arthropods in the alfalfa system are neither beneficial nor detrimental; their populations simply reside in alfalfa fields. Though not highly visible, they add to overall biodiversity of the landscape.

Why is alfalfa such a desirable habitat for many insect species? Alfalfa has unique attributes. The dense foliage of alfalfa during much of the year, retention of moisture, and high availability of food resources meet the major requirements of these organisms.

Annual cropping systems are too short-term to function well for insect biodiversity. Other perennial crops such as orchards and vineyards fulfill the stability requirement, but they often have barren soil. Barren soil is needed for orchard production during portions of the year but does not favor insect survival. In addition, natural areas such as the foothill vegetation may not adequately maintain moisture for some organisms.

Properly managed alfalfa fields can aid in the management of crop pests in other cropping systems. This was recognized some 40 years ago and is becoming an increasingly important tool in Integrated Pest Management (IPM) systems. These types of natural control measures may reduce the reliance on insecticides and benefit birds, mamals and reptiles.

Alfalfa fields are known as insectaries because of the high number of beneficial insects residing within them. California farmers utilize alfalfa as a pest management tool in several ways including:

1) planting strips of alfalfa within

Continued on next page


UCIPM

A Honey of a Crop!

Alfalfa is the primary honey crop in the US, accounting for about one-third of the annual production. Honey is produced during the seed production process. Bees are required for cross pollination.

BENEFICIAL INSECTS

Alfalfa is host to a wide diversity of arthropods including many beneficial ones that keep damaging insect pests in check and prevent damage to crops and neighboring vegetation. Pictured top to bottom: Parasitic wasp stinging an aphid; Ladybird beetle; Big-Eyed Bug; immature Lacewing larva consuming an aphid.

Photos UCIPM

Continued from previous page

other crops, such as cotton, to aid in managing cotton pests such as plant bugs and spider mites,

2) managing alfalfa cutting cycles to maintain growth and habitat for insect predators and parasites,

3) leaving a few strips of unharvested alfalfa within fields at the time of cutting to allow for insect survival.

Conserving these populations of helpful insects and allowing them to move into fields of vegetables, cotton, and other crops saves growers money and helps to protect the environment. Further research is underway to better understand and define the role of alfalfa in insect pest management.

Some of the beneficial insects found in alfalfa – pictured top to bottom: Minute Pirate Bug; Parasitic Wasp parasitizing larva of an insect pest; Flower Fly.

Photos UCIPM

Going Batty in Alfalfa

Bats are one of the most under-appreciated wild species that use alfalfa. Some bat species use alfalfa fields extensively for feeding, but bats also may play a role in controlling insect pests. Their preferred objects of prey are moths, including important yield-reducing pests such as cutworms or armyworms (moths in larval form). Bats also "chase" insects away with their echolocation calls – this effect can be seen up to 130 feet away. A colony of several hundred bats can consume millions of insect pests each growing season. A number of growers have installed bat houses on their farms to attract bats to aid in insect pest control.

BCI

Pallid bat captures a grasshopper in an alfalfa field

BCI

Barn Owls and Alfalfa

Barn owls feed almost exclusively on rodents. They use alfalfa significantly for feeding when their nests are located near alfalfa fields. Growers like to see barn owls on their farms since rodents can significantly harm alfalfa fields if populations go unchecked. During the spring and summer, barn owls eat mostly gophers, then switch to voles and mice during winter. A pair of nesting barn owls will eat an average of almost one gopher per day. Barn owls are limited by the availability of nesting cavities and readily use artificial nest boxes, so some growers have built nesting boxes on their ranches. Barn owls exhibit a low degree of territoriality, so several houses may be concentrated in a small area, such as around a barn.

Gill

Aesthetic Value

The Value of Open Space

Weeds, Field Crops, or Strip Malls... Which Provides the Most Aesthetic Value?

A Northern Harrier sails over a newly-cut alfalfa field, searching for an unlucky gopher or mouse. Swallows bank and dive after an insect breakfast. The tips of a jackrabbit's ears are just visible, as the guest hopes to steal a small portion of the ranchers' harvest. Sheep graze, giving the appearance of widely-spaced cotton balls set amongst the deep green carpet of forage. A flock of migratory Sandhill Cranes lands in an alfalfa field for a rest and to browse for a meal. A few bees buzz above the alfalfa plants searching for the purple flowers and the nectar they contain. The fragrance of newly-mowed hay lingers over the field as the morning dew dissipates. The day begins on an alfalfa ranch.

This somewhat flowery description illustrates some of the 'non-economic' values of alfalfa in our ever-urbanizing world. While it is true that aesthetic value is highly subjective, many farmers and rural residents can attest to the pleasures of neighboring alfalfa fields. The fields are pleasant landscapes that provide open spaces. They can create an oasis-like atmosphere – a lush green color and rich aroma that is home for many accompanying wildlife residents and guests. Although there are sometimes conflicts at the rural-urban interface, the aesthetic values of agriculture, particularly alfalfa, should be considered as a part of the 'value' of a cropland to our society. Lush green alfalfa fields or concrete office buildings, parking lots, weedy lots, strip malls, crowded highways – which landscapes enrich our lives through their aesthetic value? You be the judge.

Gulls feeding in alfalfa

Kuhn

Swainson's Hawk is a migratory species threatened in California, that travels from South to North America and frequently uses alfalfa. Wildlife biologists have observed that Swainson's Hawk highly prefers alfalfa fields to many other types of landscapes.

Kuhn

Alfalfa –

Helping to Solve Environmental Problems

- *Nitrate Contamination*
- *Chemical Spills*
- *Organic Contaminants in Soil*
- *Water Contaminants*
- *Particulates in Air (PM_{10})*
- *Recycling Wastes*

It is not widely known that alfalfa plays an important role in preventing or alleviating several important environmental problems facing the United States. Alfalfa has a very important role to play in the 'phytoremediation' of environmental problems, due to its deep roots and its effective absorption of water and chemical compounds from depth. The following are some examples:

Preventing Nitrate Leaching. Alfalfa, more than most other crop species, has the ability to intercept nitrates from the soil. Nitrates are considered by EPA to be a major water contamination problem in the US. Sources of nitrate may be fertilizers, manures, industrial spills, or natural sources. Nitrate (NO_3) is highly soluble, and moves with rainwater or irrigation water, and can contaminate groundwater, wells, streams, or estuaries. Nitrates can cause health problems in humans and animals, and adversely affect ecosystems. These problems may be prevented or alleviated using alfalfa.

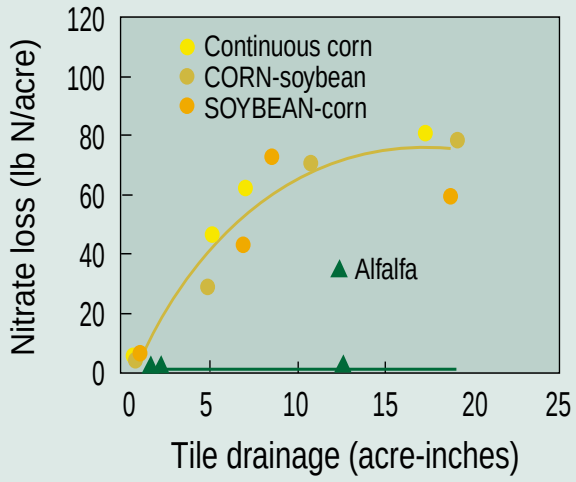
Alfalfa's ability to 'scrounge' nitrate is partially due to its ability to extract water. Alfalfa recovers most of the water in the root zone, and since most of the nitrate is dissolved in the soil water, the plant intercepts it. Secondly, alfalfa has an outstanding ability to absorb nitrate from the soil solution. Recent field research on a sandy soil in Minnesota showed that alfalfa reduced the nitrate concentration of water flowing through the root zone from 25 to less than 1 part per million (ppm) nitrate-nitrogen, and from 50 to less than 5 ppm. If concentrations in the soil are kept low by alfalfa, even large losses of water from the root zone will not contaminate groundwater aquifers.

Deep Roots. A third key aspect of alfalfa's value in preventing contamination problems is deep-rootedness. In 1917, researchers reported that alfalfa roots were plentiful in the upper 6 feet of soil and penetrated to the water table at 15 feet on a sandy loam soil in the Imperial Valley of California. More recent soil coring and isotope labeling experiments confirm the activity of alfalfa roots deep in the soil. This deep vigorous root system prevents nitrates or other compounds from leaching. Most annual plants, like corn, are active in only a shallow portion of the root zone (see page 9), and their root systems require several months to reestablish each year.

Protecting Estuaries & Surface Water. Reducing losses of nitrate in tile drainage water is extremely important for protection of surface water quality and the health of estuaries. In tile-drained fields in Minnesota, both alfalfa and a grass/alfalfa mixture kept annual nitrate-N losses in tile drainage to less than 5 lb/acre, while losses under continuous corn or corn/soybean rotations averaged over 40 lb/acre (see figure).

Mitigating Accidental Chemical Spills. Because of alfalfa's high protein yield per acre, it is a valuable crop for cleaning up sites with too much available N. Alfalfa was used at derailment sites in both North Dakota and California to remove excess spilled nitrate from the soil and groundwater. At the ND spill site, total N removal in alfalfa over 3 years was 870 lb/acre, whereas corn and wheat removed only 330 lb/acre.

Managing Water Tables. Alfalfa's high water absorption and deep roots also make it a valuable crop to manage water tables. In Australia, the federal



Nitrate loss through tile drains from alfalfa acreage is typically a small fraction of that lost from a corn or soybean cropping system. This is a function of both water uptake and efficient nitrate absorption, as well as lack of any N fertilizer applications on alfalfa compared with corn-based systems (MN data-Randall et al., 1997).

research agency recommends using alfalfa in rotations with annual crops to help reduce water table levels. Alfalfa is also commonly used in the Delta region and Imperial Valley of California, as well as in locations in the US Northern Great Plains to draw down high water tables and to limit saline seeps. The specific hydrologic and chemical conditions at each site will determine whether alfalfa can be used for this purpose.

Removing Carcinogens from the Soil. The 'rhizosphere' of soil and organic compounds surrounding the root is very important environmentally. There is good evidence that the organisms around alfalfa roots can efficiently degrade petroleum products and carcinogenic polynuclear aromatic hydrocarbons (PAHs). At one site, a standard alfalfa cultivar reduced PAH concentration by over 70%. Genetic engineering may improve this capability.

Uptake of Contaminants. If heavy metals are a problem in soils, alfalfa may be able to absorb them, and – depending upon the concentration in the forage – the harvested forage can then be fed or incinerated. Alfalfa has been used to mitigate the 'Chromium 6' water contamination problem of 'Erin Brockovitch' movie fame (see box). Alfalfa has been used to mitigate perchlorate contamination in water, a result of the manufacture of rocket fuel.

Researchers have also begun to develop alfalfa that can absorb and breakdown atrazine, a widely used herbicide sometimes found contaminating well water. A team of researchers have found a Pseudomonas bacterium that decomposes atrazine to harmless byproducts. After moving the bacteria's naturally occurring gene into alfalfa, they developed a plant that takes up 3 times as much atrazine as normal alfalfa. They hope this alfalfa can play a role in preventing and cleaning up water contamination.

Recycling Organic Wastes. A wide range of organic waste products can be recycled using alfalfa. Many of these 'waste' products are, in fact, fertilizers, if used properly. Alfalfa is commonly used in many locations to recycle dairy manures. In other areas, alfalfa is used for municipal waste recycling. Although careful monitoring of heavy metals and biological compounds may be necessary, alfalfa can be used for the effective recycling of many different types of organic wastes.

Lowering Particulates in Air. Dust is a common hazard of farming and industry. Health professionals are concerned with PM_{10} particles since they are smaller than 10 microns and can lodge in the human lung, causing health problems. The federal EPA has developed guidelines to limit PM_{10} particles in air. Alfalfa contributes greatly to limiting particulates released into the air. Alfalfa releases only a small fraction of the particulates that are released from other agricultural and non-agricultural activities. Furthermore, the vigorous canopy prevents movement of dust out of fields due to windstorms, and traps fugitive dust from other areas.

CO_2 Sequestration. As a perennial crop, alfalfa fixes significant quantities of CO_2 through photosynthesis. A portion of this carbon is retained in the thick root structure and in the rhizosphere surrounding the root. An alfalfa crop helps to temporarily retain carbon, both in the plant biomass and the soil rhizosphere, potentially lessening the effects of global warming. An alfalfa field naturally exchanges the CO_2 with oxygen, which freshens the surrounding atmosphere.

Summary. Alfalfa has a number of characteristics that make it a prime candidate for mitigation of environmental contamination problems. This includes deep rootedness, an active rhizosphere, and its ability to absorb water, nitrates, and other compounds from the soil.

What do Alfalfa and Erin Brockovich have in common?

Answer: They have both sought to address a soil water problem in San Bernardino County, California.

Many people may have seen the movie, Erin Brockovich, starring Julia Roberts. This movie documents an actual legal case in Hinkley, CA, about the presence in groundwater of Chromium-6 or hexavalent Chromium, a byproduct of a number of industrial processes. Erin Brockovich led a fight on the behalf of local residents, who claimed that their health was affected by water containing this element. Chromium is a naturally occurring element in rocks and minerals, and small amounts of Chromium-6 are produced during manufacturing processes. Chromium-6 is considered a carcinogen when inhaled.

What is currently being used to reduce the concentration of Chromium-6 in the groundwater at the 'Erin Brockovich' site in Hinkley? Alfalfa. The crop is sprinkler irrigated, which will allow the small quantites of Chromium-6 to be absorbed in the plant and safely be removed.

Wayne Soppeland, alfalfa grower in Hinkley, CA, inspects alfalfa hay. He irrigates alfalfa with water containing Chromium-6. The irrigation process alters the potential toxicity of the water, and the hay can be fed safely to farm animals.

The Water Story

Orloff

Why Alfalfa is Targeted. It is frequently claimed, particularly by those from urban environments, that irrigating alfalfa is a poor use of our limited water supplies. Some have pushed the argument further to say that alfalfa is a "water waster." At the heart of this discussion are several concepts that are more complex than it would first appear. In this section, we examine these concepts.

Some of the criticism related to water and alfalfa originates from a lack of knowledge about the multiple uses and importance of alfalfa to our daily lives. Alfalfa is a less-recognizable crop, and thus easily dismissed. However, as described in previous sections, alfalfa is a very important basic food crop, greatly affecting the viability of dairy, beef, and sheep production – and through these animals, alfalfa is transformed into many of the familiar daily food items that are so vital to our lives.

Water Use and Economic Return. The primary criticism of alfalfa focuses on its water use and economic return. That is: alfalfa is thought to produce a relatively small economic return for the amount of water used. For example, one publication claimed that: "78% of water applied produces only 40% of California crop revenue" (the key crops in question are alfalfa, cotton, pasture, and rice). They go on to recommend substitution of 'higher value' crops for these crops and water pricing policies that would encourage this shift (California Water 2020, Pacific Institute, 1995).

There is little doubt that a shift in cropping patterns is already occurring to a large degree in many irrigated regions – farmers are attracted by the potential returns of 'higher value' crops, and most believe that this trend will continue, partly driven by higher water costs. However, there are perspectives that should be carefully considered before we decide to encourage this trend. But first, let us examine the facts about alfalfa water use and water use efficiency.

Alfalfa Water Use. The fact that alfalfa is a major water user in many western agricultural regions is undeniable. In California, more water is applied to alfalfa than to any other single crop in most years. Irrigation water applications to alfalfa range from 24 to over 100 inches per year, depending primarily on the region where it is grown (DWR estimates). In California, a total of 4 to 5 million acre feet of water are applied to alfalfa each year, depending upon alfalfa acreage that year, weather patterns, and method of estimation. However, alfalfa's high water consumption does not mean that irrigating alfalfa is necessarily a poor use of water or that alfalfa is a water waster.

Acreage – a Primary Determinant of Water Use. The first reason for alfalfa's high water use in California

and other western states is simply due to acreage. There are approximately one million acres of alfalfa in California, currently the largest acreage field crop. Alfalfa ranks first, second or third in crop acreage in nearly all of the 11 western states (from Colorado west), and therefore is a major player when considering total agricultural water use.

Length of Season. A second important reason for alfalfa's large water use is the length of the growing season. Some crops grow for a much longer time period than others. Alfalfa, as an herbaceous perennial, may start growing in February or March each year and continue through October. In the Imperial Valley of California, alfalfa growth rarely stops – the crop grows from January through December! It is important to realize that most crops at full canopy use water at a fairly similar rate; it is primarily the length of the growing season that varies.

Lettuce, another important crop in California, uses far less water than alfalfa (from 18 inches in the Salinas area to up to 40 inches in the Imperial Valley). However, the crop is typically grown from 70 to 130 days, a very short time compared with alfalfa! With some crops like lettuce it may be possible to "double crop" (grow two crops in a single year) or even "triple crop" in some locations. Therefore, a more accurate comparison would be to compare alfalfa water use to total seasonal water use for the combination of crops that are grown in a single year. When considered in this light, alfalfa is not such a heavy water user, and in fact may use less water than some combinations of annual crops.

Water Use Efficiency. The total amount of water applied to a crop tells only part of the story. The ability of the crop to use water to produce yield is more important than its total water use. *Water-use efficiency (WUE)* is a relative term that refers to the quantity of water required to produce a unit of crop yield. In the accompanying table, we compare the WUE of several crops grown in the Sacramento Valley of California.

Alfalfa is one of the highest in water-use efficiency in production of harvestable dry matter per unit of applied water among the crops commonly grown in irrigated regions. This is primarily due to several factors.

1) **High yield** – alfalfa produces high biomass yield per unit of land area compared to most other crops, therefore applications of water produce high dry matter returns.
2) **High harvest index** – the entire above-ground plant of alfalfa is harvested, whereas only the fruit, seeds, or portions of most other field or horticultural crops are harvested.
3) **Alfalfa is a perennial** – yearly stand establishment, as is required with annual crops, is avoided. Typically, substantial water is applied to germinate and establish an annual crop – more than is actually used by newly-established plants.
4) **Deep roots** – Alfalfa is able to recover most of the water applied to the soil, wasting little water drained below the root zone.

Alfalfa also is relatively efficient in the production of food products from irrigation water. In one study, Loomis and Walinga (1992) found that, when considering the efficiency of water conversion into food products (food, energy, or protein), alfalfa compared quite favorably with several other crops.

Water Use Efficiency – A complex issue. While the above discussion demonstrates alfalfa to be among our more efficient users of water in terms of economic yield and food production, this is only one dimension of efficiency. What about nutritional value and economic returns? A pound of artichokes, for example, is qualitatively (and economically) different than a pound of strawberries, lettuce, wheat, cotton, or alfalfa. Each of these crops has a unique role in supplying food or

Comparison of Water Use Efficiencies of Several Crops Grown in the Sacramento Valley of California

Crop	Duration[1] (season)	Applied Water[2] (inches)	Biomass Yield[3] lb/acre	Harvest Index[4] (%)	Crop Economic Yield[3] (lb/acre)	WUEb[6] (lbs/a inch)	WUEh[7] (lbs/a inch)
Alfalfa	Mar-Oct	42	12,833	100	12,833	306	306
Corn Grain	Apr-Aug	35	19,194	50	9,597	548	274
Wheat	Dec-Jun	19	10,055	45	4,525	529	238
Sugarbeet	Oct-Jun	43	18,529	43	8,005*	431	186
Rice	May-Oct	71	16,900	45	7,774	238	109
Dry Bean	May-Aug	28	4,382	40	1,753	156	63
Almonds	Mar-Oct	37	-	-	1,134	-	31

*1. Normal growth duration for these crops. 2. Median of a range of estimated applied water (irrigation water required to produce a crop) for Sacramento Valley, CA, values from California Water Plan Update, DWR, 1994. 3. Biomass yields are based upon economic yields and HI. Economic yields are a 5-year (1996-2000) mean from Agric. Commissioners Reports for 9 counties in the Sacramento Valley. *Sugarbeet yields are expressed as sucrose, based upon 15% sucrose in the root. 4. Harvest Index estimates are from published sources and by discussions with Cooperative Extension Specialists. Harvest Index = Percentage of plant used for economic harvest (above-ground except for sugarbeet). WUEb is the Applied Water-Use-Efficiency of biomass production (total above ground plant, except sugarbeet where roots are included). WUEh is the Applied Water-Use Efficiency of the harvested economic yield.*

Just Switch to the High-Value Crops, Right?

A common refrain, when considering a future of short water supplies, is to recommend that growers switch from lower-value crops to crops that return a higher dollar amount per unit water. Some believe that water policy should encourage this trend.

Historically, this has been a trend in California. Almonds, for example, have a relatively high return when compared with field crops. As a result, almonds and other orchard crops have expanded greatly in acreage over the past 30 years, now totaling more than 2 million acres.

No one would argue the value of such crops – which benefit the grower through improved opportunities, and benefit society through a more varied and complete diet. However, to recommend that growers shift their cropping patterns entirely to the 'higher value' specialty crops may be short-sighted. The markets for such products are usually narrow, and they are easily overproduced – this is particularly a problem with permanent crops where crop rotation is difficult. Many specialty crops also entail higher risk – both in terms of crop loss and price. Though the profits from crops such as alfalfa are rarely spectacular, its markets are dependable. It is usually at least moderately profitable and it provides a stable income throughout much of the year. Agronomic crops like alfalfa are the 'bread and butter' crops that sustain farming systems.

From a nutritional standpoint, the so called 'lower value' crops, such as wheat, rice and alfalfa are often the work-horses of food production, providing basic nutrition for millions, whereas many specialty crops occupy an important, but more peripheral role. While most people enjoy strawberries and almonds as additions to their diet, they rely on the important daily staples of rice, wheat, meat or milk products (from alfalfa). Some specialty crops may enjoy high returns, but may be less efficient in water-use in terms of yield (consider the almond example in the accompanying table, page 21). It should also be noted that higher-value specialty crops often evoke greater pesticide use and soil erosion, placing pressure on the environment. Some of the 'lower-value' crops such as alfalfa, pasture, and rice have significant wildlife habitat value, provide significant benefit to soil conservation, and provide rotational benefits for production of the 'higher value' crops.

All of these considerations indicate the complexities of this issue. While it is undoubtedly important to maximize economic returns per unit applied water for each crop, and for farming systems in general, it is not clear that encouraging growers to choose only those crops with the highest economic returns per unit water is the best strategy. Most farmers cannot depend entirely upon high-value, high-risk crops. Just as in choosing investment opportunities, a mix of higher-value, higher-risk enterprises, and lower-risk, lower-value enterprises in a biologically diverse cropping system may be better for both growers and the public alike.

Continued from previous page
fiber, and is important in their own right. Some crops provide widely-used food staples that are the basis for our everyday diet (wheat and corn), whereas others are specialty crops that enrich and balance human diets (e.g. strawberries). Some are clearly higher value crops (such as almonds) on a pound-for-pound basis, whereas other crops appear to be lower value, but have broad influence throughout the food system (e.g. alfalfa). This type of 'apples and oranges' comparison is fraught with difficulty, since there are so many qualitative differences between food products (for example, sugarbeet is many times more efficient in producing food energy – sugar – per unit water than most crops, but it produces little protein, vitamins, or other types of nutritional value).

Economic return per unit water is also a complex issue (see side bar). Economic return must be evaluated within the whole-farm system, considering risk (a characteristic of high-return crops), and broader economic impact (a characteristic of so-called 'low value' crops such as alfalfa) of the use of water. A crop choice based solely on economic return per unit applied water is often inadequate when considering the entire farm and agricultural system.

How can Water Use Efficiency be Further Improved? Alfalfa growers and the industry as a whole have done much to maximize irrigation efficiency and conserve water over the past 50 years. However, there is still room for improvement. Here are several key ideas for improving water use efficiency of alfalfa in the future:

Improved Uniformity. With more uniform water application less water can be applied while still avoiding under-irrigating large portions of the field. Advancements in surface irrigation include increased accuracy in soil leveling (computer technology and laser use), improved field design, and growing alfalfa on raised beds to improve water movement. Some growers are experimenting with buried drip systems. Sprinkler irrigation advancements include improved nozzle

design and sprinkler technology, including site-specific application technology.

Improved Monitoring and Scheduling. Better monitoring and scheduling technologies may enable growers to irrigate in a more timely fashion and more precisely match the crop's needs, avoiding over- or under-irrigation.

Summer Dry-Down. Some growers and researchers have experimented with withdrawing water during the hot summer months to save water, and then begin watering again in the fall. Although further research is needed on this technique, it has the potential of significantly improving WUE, since efficiency is higher during the cool periods of the year.

Tailwater Management-Recirculating systems. To ensure a surface-irrigated field is irrigated evenly, more water must be applied than infiltrates into the field. Hence, water runs off the lower end of the field (referred to as tailwater). Systems have been developed to better manage this tailwater and re-circulate it for re-use on the same or other fields.

Higher Yields. Although not immediately obvious, higher yields usually lead to greater efficiency of water use. Alfalfa yields in California are double those of the 1920s, and are expected to increase further through breakthroughs in plant breeding and improved crop management. With higher yields, less water is required to produce each unit of yield.

Conclusions. While alfalfa in irrigated regions uses a considerable amount of water in total, its water use is quite comparable to that of other crops when the acreage of the crop and length of the season are considered. Alfalfa is among the more efficient crop users of water in terms of yield produced per unit of applied water. Greater efficiencies in alfalfa water use may occur through improvements in irrigation management and increased yield. Although it is sometimes classified as a 'low-value' crop in irrigated systems, alfalfa produces significant value in a more complex way through linkages with animal agriculture, and produces a tremendous quantity of vital foodstuffs that are important to our daily lives.

Orloff

Alfalfa – What About the Future?

Alfalfa has a long and rich history, and is currently a key crop in many of the agricultural regions of the world. But what does the future hold for alfalfa?

There are a number of exciting areas that indicate that alfalfa has a bright future in terms of utilization. Research will change the plant itself – how it is produced and how it is utilized. Agricultural engineers and scientists continue to improve harvesting and irrigation techniques, improving efficiency of water and land use. Plant breeders are developing new alfalfa strains that are even higher yielding and more nutritious for livestock. They are developing alfalfa plants that tolerate wheel traffic and grazing pressure, plants that tolerate high salinity so that it can be grown on salt-affected soils, and plants that tolerate ammonium-N so that they can endure wastewater or manure applications. Varieties with improved root systems for extracting water and absorbing nutrients or contaminants are being developed. Research has investigated the use of alfalfa stem fibers to produce filters that remove heavy metals in urban runoff. Lactic acid can be produced from alfalfa fiber to make biodegradable plastics. Alfalfa stems have been used as a fuel for electricity generation. Scientists continue to investigate the application of alfalfa in bioremediation of contaminated sites. Further progress is possible through biotechnology, which has already been used to develop herbicide-resistance in alfalfa and improved digestibility of alfalfa fibers. The production of pharmaceuticals extracted from alfalfa leaves is being investigated. Unique traits, such as glandular-hairs, may improve alfalfa's already substantial resistance to insect pests. There are tremendous possibilities to develop innovative uses for this diverse and versatile crop.

Alfalfa is likely to remain important, or even increase in importance, in the future due to its prominence in dairy rations, and the increasing value of dairy production and other animal enterprises to the world agricultural economy. Alfalfa is an integral component of a complex food chain and therefore is likely to remain a viable crop – it is less easily imported than grain or specialty crops, which are under tremendous pressure from international markets.

Alfalfa should be considered a key component of sustainable agricultural systems for the future because of its high yield, quality and pest resistance, and it's value for soil conservation, N_2 fixation, energy savings, crop rotation, aesthetics, and wildlife habitat. Alfalfa faces tremendous challenges due to urbanization and resource limitations. However, alfalfa, the "Queen of Forages" is likely to occupy a prominent place in the future of agricultural systems.

Holmes


Great-tailed Grackle


Snow Geese


Black-necked Stilt


Sandhill Cranes


Gopher Snake


Long-billed Curlew

Inset photos: Kuhn

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A Friendly and Informative Guide to Alfalfa the "Queen of Forages"