The Potential Economic Effects of Red Imported Fire Ants in California

By

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Abstract

This study estimates the costs to households, agriculture, and wildlife from the spread of the red imported fire ant, a newly introduced pest into California, throughout the state. The results show that almost all agricultural activities would be affected; however, the majority of costs would be incurred by households. Total estimated costs are between $398 million and $989 million per year.

Introduction

The discovery of the Red Imported Fire Ant (RIFA), *Solenopsis invicta*, in almond orchards in the San Joaquin Valley and, more recently, in many parts of Orange, Riverside and Los Angeles Counties has raised concerns about the effects of its recent introduction and potential spread throughout California. This pest is of particular importance because it threatens urban, agricultural, and wilderness areas.

Due to its large populations and omnivorous diet, RIFA can have a tremendous effect on the environment. Several hundred thousand workers live in large, mounded nests that can damage mowing and harvesting equipment. Cultivation of row crops destroys the mounds, but they may still form along field edges and in perennial crops such as tree fruits, nuts and vineyards. When the nests are disrupted by humans or animals, aggressive ants swarm out and sting, causing a burning sensation and formation of pustules.

RIFAs are also known to cause extensive damage to irrigation lines. They are attracted to electrical fields, which can result in short circuits or interference with switches and mechanical equipment such as water pumps, computers, and air conditioners. Even more serious problems can arise when they infest traffic signals and airport landing lights.

Background

The RIFA is native to lowland areas of Argentina and Brazil, and was most likely introduced into the U.S. around 1940. At that time several native fire ant species thrived in the southeast and the presence of another species created little concern. However, by the 1950's the rapid spread (sometimes over 100 miles per year), dense local infestations, aggressive nature, and markedly more serious sting of imported fire ants, alerted scientists and the public to the special threat posed by this exotic pest. The current geographic distribution of RIFA includes all

of the southern states from Florida to Texas, and as far north as southern Virginia, Tennessee, and Oklahoma.

Even though the USDA and State of California have maintained quarantines against regions inhabited by RIFA, over the last 15 years it has been intercepted on numerous occasions at California border stations and periodic outbreaks have occurred in several counties. These outbreaks have been associated with commerce, as the ants have arrived on trucks, trains or other vehicles. In 1997 RIFA was identified on bee shipments from Texas destined for almond orchards in the San Joaquin Valley. The resulting infestations are undergoing eradication efforts by the California Department of Food and Agriculture (CDFA).

Numerous colonies of RIFA were detected in Orange and Riverside counties in October 1998. This was the first time the ant had been found on residential as well as commercial property. As a consequence, state and federal quarantines were imposed on all of Orange County, parts of Riverside County near Indio and Moreno Valley, and a small section of Los Angeles County. From the size and distribution of these infestations it appears that RIFA had been established and spreading in Southern California for several years.

There is no way of predicting how far and fast RIFA will spread in California, but if its history of expansion in the South is any indication, its future distribution in the state could be extensive. Two limiting factors, temperature and moisture, are critical for RIFA's survival. For example, scarce water makes the desert regions of California inhospitable to the ant but, due to irrigation, RIFAs are thriving on golf courses, nurseries, horse facilities and a turf farm in Southern California. As soil conditions become dryer RIFA will move its nests to wetter areas such as homes, irrigated farmland, watering holes on rangelands, lakes, ponds, and streams. It is unlikely, however, that RIFA could survive in the cooler climates of the Sierra Nevada and

northern California.

Potential Costs and Benefits to Different Groups

Households, agriculture and wildlife are all affected by RIFA. However, the costs and benefits of RIFA spreading throughout California would not be evenly distributed. Some households, farms or ranches may suffer from large infestations and resulting costs, while nearby homes and agricultural operations may have little or no damage. Costs may also deviate from the wetter, southeastern U.S. because of California's drier climate.

The costs and benefits estimated in this study are based on average costs from studies of damage by RIFA in the southeastern United States. These costs are applied to the susceptible regions in California as determined by climatic factors and adjusted, where applicable, to account for low and high-risk areas. Lower risk areas are along California's central coast while higher risk areas are located in California's central valley and in Southern California.

Costs to Urban Households

RIFA's presence in the urban environment has many potential effects. The more serious include medical problems associated with skin abrasions and possible allergic reactions to stings, reduced use of recreational facilities, interference with damage to communications and electrical equipment, and the expense and indirect costs associated with increased use of pesticides (Dukes, et al. 1999).

Urban households incur costs to treat mounds, repair damage to electrical equipment, and for medical and veterinary expenses. In a survey of South Carolina households, the average total cost per household due to RIFA was $80. However, in lower risk areas it was only $33, compared to $104 in higher risk areas.

Given the wide range in costs and climatic conditions in California, three methods were

used to estimate the economic effects of RIFA infestations on urban households. The first was to multiply the number of households in counties susceptible to RIFA infestations by the average cost per household for all households. The second method was to multiply the number of households in the low risk counties by the average low-risk cost, and the number of households in the high-risk counties by the average high-risk cost, and then add the two together. The third method was to multiply the number of households in susceptible counties by the average costs per low risk household.

In 1999, the total number of households in susceptible counties was 10,363,432 (DOF 2000). In the low-risk counties there were 2,711,036 households and in the high-risk 7,652,396. Total estimated cost of RIFA to urban households is $829 million when average costs for all households are used to calculate the total; $885 million when cost is calculated by region; and $342 million when the average low risk cost is used for all susceptible households. This is a significant cost due to the large number of households in California.

Costs to Agriculture

Tree Crops and Vineyards

Tree crops and vineyards use hand labor throughout the year for such tasks as pruning, raking and harvesting. In fields infested with RIFA, crews may not be able to enter because of the ant's aggressive nature and painful stings, or they may request a higher fee to compensate for the additional risks. Alternatively, producers could treat fields with insecticides and control RIFA before crews enter. In our analysis, we assume that producers would treat twice a year to control RIFA with the growth regulator Extinguish, which is registered for use on all tree crops and vineyards in California. Total application costs for both treatments are $55 per acre.

The extent to which RIFA would establish in groves, orchards and vineyards may vary

depending on previous treatments and agro-climatic conditions. Therefore, a range of acreage is used to estimate the additional costs to tree fruit, nut and vine industries in California. A low impact level of 10% of total acreage affected, a medium one of 25% and a high level of 40% is used based on interviews of scientists familiar with RIFA problems in Florida and Arkansas.

Total increases in costs for all crops would range from $12 million at low infestation levels to $30 at medium levels to $48 million at high. Absolute increases in costs would range from $81 thousand for figs at low impact levels to $16.45 million for grapes at high (Table 1).

Table 1 about here

While the dollar amount is substantial, as a percentage of total farm receipts it is less than 1%, even when 40% of acreage is affected. Costs as a percentage of farm receipts are greatest for figs, walnuts and prunes, and lowest for lemons, nectarines and peaches, pears, apples, and plums. Additional cost may also accrue to activities such as bee keeping because quarantine restrictions would have to be met before hives are moved from one field or orchard to another.

Additional Effects on Citrus

The RIFA may also damage young citrus when they build nests near the base of trees 1-4 years old. The ants feed on the bark and cambium to obtain sap, often girdling and killing the young trees. They also chew off new growth at the tips of branches and feed on flowers of developing fruit. Dead trees must be removed and replanted, raising the costs to establish an orchard. Based on field experiments in Florida, nursery stock mortality in untreated groves increased three to five fold per hectare and total loss of newly planted groves due to RIFA feeding has occurred (Banks, Adams and Lofgren 1991).

To decrease tree mortality, growers may choose to treat groves with insecticides for two to three years until young trees develop woody bark that RIFA cannot chew through. RIFA

control undertaken during grove establishment would increase investment costs, and must be depreciated over the life of the grove. When groves are treated with two applications of Extinguish at an annual cost of $55 per acre establishment costs increase by $110 per acre if the grove is treated the first two years and by $165 per acre for three years. Depreciation of the additional investment costs to establish the grove would increase annual cash costs by $9 per acre when treatments last two years, and by $13 per acre for three years. This increase is less than 0.5% of the total annual cash costs based on University of California Cooperative Extensive farm budgets for citrus.

Vegetables and Melons

Because frequent discing disrupts the interior, the RIFA builds nests around the edges of fields planted in vegetable crops. From there they have been observed entering fields and damaging crops primarily by consuming developing fruit, seeds, roots or tubers. Documented losses from RIFA include a yield loss of 50% on eggplants and a sunflower plant loss of 2.4% to 4.0% (Adams 1983; Steward and Vinson 1991). In the sunflower field no further damage was observed after a treatment with insecticides.

It is often the case that crop damage will not be significant enough to economically justify treatment. However, many vegetable and melon crops are hand-harvested so growers may need to treat fields for worker protection. To control RIFA in vegetable and melon fields two applications of Extinguish would be applied per year at a total cost of $55 per acre. Because ant pressures will vary from year to year industry costs were calculated for infestation levels of 10%, 25% and 40%.

Total potential costs to the vegetable and melon industries would range from $3.7 million when only 10% of acreage is infested to $9.2 million when the infestation level is 25%, and to

$14.8 million when the level is 40% (Table 2). While the dollar figures would be large, as a percentage of farm receipts they would be less than 1% in all cases, and under 0.5% in most, even when up to 40% of acreage is affected.

Table 2 about here

As percentage of farm receipts, costs are greatest for asparagus and honeydew melons and lowest for celery and cucumbers.

Field crops

Non-yield damages to field crops such as wheat, rice and cotton include down-time to repair combines, electrical problems with pumps and machinery, other equipment damage, building damage, and medical expenses. The large nest mounds of RIFA interfere with cultivation and mowing. In mowing weeds or cutting alfalfa, farm operators must either raise the cutting bar to prevent damage, switch from sickle bar to disc type cutters, repair equipment damaged by the mounds, or use insecticides to destroy colonies. Not included in our analysis are the costs to repair and replace irrigation equipment. Because RIFA has previously established in areas with rainfed agriculture, costs involving damage and repair to irrigation equipment are not available.

In a survey of Arkansas field crop producers, non-yield costs of RIFA per farm were $1,478 per year (Jones, Thompson and Davis 1997). Over half of these costs were due to combine damage and down time for cutter blade repair. The next highest cost was for repair of electrical equipment. On a per acre basis, the cost for all yield and non-yield damage was $1.00 for rice, $0.25 for wheat and $1.35 for hay. In general, it was not cost effective to treat for RIFA in field crops.

RIFAs are predators of many agricultural pests. Among cotton pests in California, the

tobacco budworm, and the pink and cotton bollworms would all be preyed upon by RIFA. Field experiments in Texas show that the presence of RIFA can significantly decrease bollworms in cotton fields and increase yields (Brinkley, Ervin and Sterling 1991). However, because RIFA also damages electrical machinery and clogs sprinklers and irrigation equipment, the net result on profits is ambiguous. Therefore, no losses or benefits are estimated for cotton.

The total number of susceptible field crop farms in California, based on the 1997 Census of Agriculture, is 5,526. This includes grain, oilseeds and hay enterprises. The cost per farm is set at the average level incurred per farm by Arkansas growers. Costs are again calculated assuming 10%, 25% and 40% of acreage would be affected. Total annual estimated costs for the state are $817 thousand when 10% is infested, $2 million at 25% and $3.3 million at 40%.

Hay growers may have additional costs due to quarantine regulations since hay stored on the ground may not be moved out of a quarantined area. How this affects growers would depend on the amount of production that would leave the area and the cost of alternative storage methods. Even if hay is not transported out of the region, growers would need to take precautionary measures against RIFA as horses, cattle and other livestock will not eat RIFA infested hay. Quarantine regulations would also require that farm machinery and soil be treated before leaving the area.

Nursery Industry

All nurseries within a quarantine area would need to meet quarantine regulations in order to ship plants outside of the region. Open land on which nursery stock is grown would need to be treated once every three months with fenoxycarb or hydramethylnon, alternating between the two insecticides. In addition, growers would need to treat the individual containers in which the plants are grown. Acceptable treatments include either a drench with chlorpyrifos thirty days

before shipping, or incorporating a granular insecticide, bifenthrin, into the soil every six months. Because of environmental regulations concerning pesticide run-off and the need to treat frequently with chlorpyrifos, bifenthrin is more commonly used.

Annual costs to treat nurseries for RIFA would be about $650 per acre. The applications of fenoxycarb and hydramethylnon are $60 per acre with the use of bifenthrin accounting for the remaining costs. According to the American Nursery and Landscape Association, the treatment cost per plant per container is about two cents. Only open nursery acreage that produces container plants would be affected by the quarantine regulations. Based on the 1997 Census of Agriculture, 28,000 acres were devoted to open field nursery production of bedding and flower plants, foliage, potted flowers and other nursery stock. Because nurseries within the quarantined regions must treat in order to ship outside of the quarantine, even if the nursery does not have RIFA, almost all nurseries would be affected by the regulations. Total costs to the nursery industry are thus calculated on all open field acreage and are equal to $18.2 million. In addition, nurseries would need to be inspected for RIFA by placing bait out quarterly. Additional costs for inspection and certification are about $1.40 per acre.

Greenhouses that use containers placed on benches are exempt from the quarantine regulations. However, greenhouse operations would still need to treat around the perimeter of buildings if infested with RIFA for worker safety, and to protect electrical equipment. These expenses would increase the costs to the nursery industry.

Sod growers are also affected by quarantine regulations. Insecticide treatment for sod would be an application of chlorpyrifos. Materials and application costs are $330 per acre. Based on the 1997 Census of Agriculture, a total of 13,665 acres would be affected. Total costs are $4.5 million.

Animal Industries

The RIFA attacks cattle and other livestock. The ants are attracted to mucous membranes in the animal's eyes and nostrils, and the stings cause blindness and swelling, which may cause suffocation. Immobilized animals, such as penned or newborn livestock, are at the greatest risk. In a survey of Texas veterinarians, the most common problem was skin inflammations from RIFA stings (49.6 % of all cases) (Barr and Drees 1994). The next most common problem was blindness (20.1 %) followed by secondary infections (14.4 %), and injury to convalescent animals (12.3 %).

Although more than half of the cases seen by the Texas veterinarians were pets and small animals, mortality associated with RIFA was greatest for cattle. With cattle, however, it was often difficult to determine if RIFA caused death or if it the ants were observed on livestock after death. Of all cases seen by veterinarians, cases involving RIFA accounted for less than 1%.

RIFA also infests hay and other feed sources. In avoiding ants, livestock may become malnourished or dehydrated when the ants invade their food and water. Cattle will not consume hay, nor will poultry eat feed, infested with RIFA. The agitation caused by RIFA invading poultry houses has been observed to decrease egg production. Extra expenses would be incurred to purchase RIFA free hay, or to treat around buildings to prevent RIFA invasions of calving pens, dairy and hog barns, and poultry houses.

RIFA may provide a benefit to the cattle industry by preying immature ticks and horn flies. Because these pests are vectors, RIFA may potentially decrease the incidence of certain animal diseases.

Rangeland Effects

Costs to ranchers from RIFA include damage to electrical and hay harvesting equipment

as well as cattle injury and loss. In the survey of Texas ranchers, 71% reported some type of economic loss (Teal et al. 1998). Average losses were reported by county with the largest damage levels estimated at $28.06 per acre; however, many counties in the dryer, western regions had damages of less than $2 per acre. Even though damages were averaged on a per acre basis, about 95% of the total costs occur on about 5% of the land. Most costs would be from damages around buildings, electrical equipment and water sources.

Because overall climate patterns in California differ markedly from Texas, costs in California are more likely to resemble those incurred by ranchers located in Texas' western counties. Furthermore, a significant proportion of rangeland in California is in counties too cold or dry to support RIFA. Excluding rangelands in counties not susceptible to RIFA results in a potential 15,759 acres at risk. This includes private rangelands, Bureau of Land Management land, and national forest grazing land.

RIFA will not be a problem on all susceptible acreage. As in the case of agricultural crops, we use different impact levels to indicate the potential range in costs. However, because a higher proportion of ranchers reported economic losses from RIFA than growers, a higher range of acreage is used. Thus, infestation levels of 25%, 40% and 65% of all susceptible acres are used to determine the range in costs. At per acre costs of $1.50, total annual potential costs to cattle ranchers are $5.9 million when 25% of rangeland is affected, $9.5 million for 40% and $15.4 million for 65%.

Costs to Wilderness

Substantial evidence exists that RIFAs affect wildlife and reduce biodiversity of native plants and animals (Allen, Demarais and Lutz 1994). Due to their enormous population size and foraging efficiency, when imported fire ants move into an area they become formidable

competitors and predators, often displacing native ants and other invertebrates as well as inflicting damage on native reptiles, mammals and ground-nesting birds. Thus, biodiversity in many coastal and low altitude wilderness areas of California may be at risk.

RIFA appears to affect bird and reptilian populations primarily by destroying the eggs and the young. One study in Texas found that RIFA predation caused a 92 % reduction in the number of waterbird offspring when natural habitats were not treated for ant infestations. Of special significance to California are studies that have documented fire ant predation on tortoise and reptile hatchlings. They may also prey on quail. In addition many chemical control measures for fire ants adversely effect wildlife.

Many endangered species are among the wildlife threatened (Table 3). Either directly as a source of food for the ants or indirectly from ant predation on a food source, 58 out of California's 79 endangered animal species are susceptible to RIFA. Insects, young rodents, reptiles, amphibians and ground-nesting birds are directly susceptible through RIFA feeding.

Table 3 about here

In addition several endangered birds, such as the northern spotted owl and bald eagle, may be at risk through reductions in their food sources. While no exact value is available for the increased risk of extinction, most people value the preservation of endangered species and this potential increase in risk represents an additional cost of RIFA establishment.

Discussion of Results and Policy Considerations

The spread of RIFA throughout California would result in the establishment of a major nuisance pest. Total annual losses are estimated to be between $387 million at the low impact level and $989 million at the high (Table 4).

Table 4 about here

Because of the large number of households in California, their costs account for about 90% of the total. However, costs to agriculture are still significant and range from $45.1 million, to $73.5 million, to $104.2 million. The greatest costs will be from the repair of electrical and irrigation equipment, insecticide treatments, and treatments to meet quarantine regulations.

Other significant costs would accrue from the disruption of ecosystems, which in turn would threaten California's native plant and animal biodiversity. It is also possible that dozens of endangered species in California would face a greater risk of extinction.

Eradication efforts are underway to rid California of RIFA. A rapid response to this exotic pest outbreak is imperative because the longer the delay between detection and treatment the more time the pest has to spread. In the South eradication efforts have always failed because fire ants recolonized from the surrounding infested areas. Fortunately the situation in California is different because outbreaks are isolated and eradication may be possible if executed quickly. A rapid response is also efficient since survey and treatment costs increase exponentially with the elapsed time between detection and treatment.

Because eradication of imported fire ants serves the public welfare central planning and coordination of urban, agricultural and wilderness group efforts is essential. For example, eradication in one municipality will be a waste of time and money if neighboring municipalities do not participate because fire ants will simply recolonize from the surrounding untreated area.

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Table 1. RIFA Effects on Selected Tree and Vine Crops

Crop	Acres	Farm Receipts	Additional Costs to Industry* Acreage Affected 10%	25%	40%	% of Farm Receipts Acreage Affected 10%	25%	40%
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Almonds	456	1,165,150	2,509	6,273	10,037	0.22	0.54	0.86
Apples	39	207,151	216	541	865	0.10	0.26	0.42
Apricots	21	57,309	114	286	457	0.20	0.50	0.80
Avocados	58	272,406	321	802	1,283	0.12	0.29	0.47
Cherries	18	79,103	96	241	386	0.12	0.30	0.49
Figs	15	18,149	81	203	325	0.45	1.12	1.79
Grapefruit	17	73,794	93	232	371	0.13	0.31	0.50
Grapes	747	3,178,940	4,111	10,277	16,444	0.13	0.32	0.52
Lemons	49	347,329	271	677	1,083	0.08	0.19	0.31
Nectarines & Peaches	110	556,535	604	1,511	2,417	0.11	0.27	0.43
Olives	34	73,677	185	463	741	0.25	0.63	1.01
Oranges	205	906,317	1,125	2,813	4,500	0.12	0.31	0.50
Pears	19	90,479	105	264	422	0.12	0.29	0.47
Pistachios	65	181,678	358	895	1,431	0.20	0.49	0.79
Plums	43	199,801	238	595	952	0.12	0.30	0.48
Prunes	86	151,822	471	1,176	1,882	0.31	0.77	1.24
Walnuts	202	344,848	1,109	2,774	4,438	0.32	0.80	1.29
Total	2,183	7,904,486	12,009	30,022	48,035	0.15	0.38	0.61

*Treatment costs are $55 per acre

Table 2. RIFA Effects on Selected Vegetable and Melon Crops

Crop	Acres	Farm Receipts	Additional Costs to Industry* Acreage Affected 10%	25%	40%	% of Farm Receipts Acreage Affected 10%	25%	40%
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Artichokes	10	68,405	55	138	220	0.08	0.20	0.32
Asparagus	31	109,624	171	428	685	0.16	0.39	0.63
Beans, Fresh	5	25,758	25	63	101	0.10	0.25	0.39
Broccoli	120	467,088	660	1,650	2,640	0.14	0.35	0.57
Brussels Sprouts	3	21,715	18	44	70	0.08	0.20	0.32
Cabbage	14	74,401	76	191	306	0.10	0.26	0.41
Cantaloupe	63	240,525	345	861	1,378	0.14	0.36	0.57
Cauliflower	39	189,263	213	533	853	0.11	0.28	0.45
Celery	24	227,443	133	333	534	0.06	0.15	0.23
Cucumbers	6	52,676	35	87	139	0.07	0.16	0.26
Garlic	34	220,199	184	461	737	0.08	0.21	0.33
Honeydew	21	71,720	113	282	451	0.16	0.39	0.63
Lettuce, Head	142	868,571	778	1,946	3,113	0.09	0.22	0.36
Lettuce, Leaf	42	261,755	231	578	924	0.09	0.22	0.35
Lettuce, Romaine	27	156,520	149	371	594	0.09	0.24	0.38
Onions	39	169,254	214	534	855	0.13	0.32	0.50
Peppers, Bell	22	162,707	118	296	473	0.07	0.18	0.29
Spinach, Fresh	15	84,816	83	208	332	0.10	0.24	0.39
Watermelon	17	84,216	93	233	373	0.11	0.28	0.44
Total	672	3,556,651	3,694	9,236	14,777	0.10	0.26	0.42

*Treatment costs are $55 per acre

Table 3. Endangered Species Susceptible to a Red Imported Fire Ant Invasion

Endangered Species	Reason	Endangered Species	Reason
Beetle, delta green ground	insect	Fairy shrimp, vernal pool	eggs in soil of dried pools
Butterfly, bay checkerspot	insect	Tadpole shrimp, vernal pool	eggs in soil of dried pools
Butterfly, El Segundo blue	insect	Lizard, blunt-nosed leopard	reptile
Butterfly, Lange's metalmark	insect	Lizard, Coachella Valley fringe-toed	reptile
Butterfly, lotis blue	insect	Lizard, Island night	reptile
Butterfly, mission blue	insect	Snake, giant garter	reptile
Butterfly, Myrtle's silverspot	insect	Snake, San Francisco garter	reptile
Butterfly, Oregon silverspot	insect	Tortoise, desert	reptile
Butterfly, Palos Verdes blue	insect	Turtle, green sea	reptile
Butterfly, San Bruno elfin	insect	Turtle, leatherback sea	reptile
Butterfly, Smith's blue	insect	Turtle, loggerhead sea	reptile
Fly, Delhi Sands flower-loving	insect	Turtle, olive (=Pacific) ridley sea	reptile
Flycatcher, Southwestern willow	insect	Snail, Morro shoulderband	mollusk
Gnatcatcher, coastal California	insect	Kangaroo rat, Fresno	rodent young
Moth, Kern primrose sphinx	insect	Kangaroo rat, giant	rodent young
Beetle, valley elderberry longhorn	insect	Kangaroo rat, Morro Bay	rodent young
Goose, Aleutian Canada	ground nesting bird	Kangaroo rat, Stephens'	rodent young
Plover, western snowy	ground nesting bird	Kangaroo rat, Tipton	rodent young
Rail, California clapper	ground nesting bird	Mouse, Pacific pocket	rodent young
Rail, light-footed clapper	ground nesting bird	Mouse, salt marsh harvest	rodent young
Rail, Yuma clapper	ground nesting bird	Vole, Amargosa	rodent young
Shrike, San Clemente loggerhead	ground nesting bird	Mountain beaver, Point Arena	habitat disruption
Tern, California least	ground nesting bird	Condor, California *	reduction in food source
Towhee, Inyo California	ground nesting bird	Eagle, bald*	reduction in food source
Pelican, brown	ground nesting bird	Falcon, American peregrine*	reduction in food source
Frog , California red-legged	soft shelled eggs	Owl, northern spotted *	reduction in food source
Salamander, desert slender	soft shelled eggs	Sparrow, San Clemente sage*	reduction in food source
Salamander, Santa Cruz long-toed	soft shelled eggs	Murrelet, marbled*	reduction in food source
Toad, arroyo southwestern	soft shelled eggs	Vireo, least Bell's *	low tree nesting bird

*Possible indirect effect

Table 4. Total Annual Costs of RIFA Establishing in California

Category	Impact		
	Low	Medium	High
	($ million)		
Tree and Vine Crops	12.0	30.0	48.0
Vegetable Crops	3.7	9.2	14.8
Field Crops	0.8	2.0	3.3
Nursery	18.2	18.2	18.2
Sod	4.5	4.5	4.5
Rangelands	5.9	9.5	15.4
Total Agricultural	45.1	73.5	104.2
Total Household	342.0	829.0	885.0
Total	387.1	902.5	989.2