impact would result with implementation of the proposed project due to the conversion of important farmland designated as Agricultural the County General Plan. **Table 20, County of Ventura Farmland Conversion Threshold Criteria**, summarizes these results. The conversion of 152 acres of Prime Farmland and 200 acres of Unique Farmland to urban uses would represent a significant impact under the County's criteria.

Table 20
County of Ventura Farmland Conversion Threshold Criteria

County General Plan Land Use Designation	Farmland Classification	Threshold Criteria	Impacts of the Proposed Project	Is Impact Significant?
Agricultural/Agricultural – Urban Reserve	Prime/Statewide	5 acres lost	152	**Yes**
	Unique	10 acres lost	200	**Yes**
	Local	15 acres lost	0	No
Total Acreage Impacted			352	

Source: Impact Sciences. 2007.

The Ventura County Initial Study Assessment Guidelines further state that any project that would result in the direct and/or indirect loss of agricultural soils is considered as having a contribution to a significant cumulative impact. However, the cumulative loss of agricultural soils was discussed in the Final EIR for the Comprehensive Amendment to the County General Plan (1988). The conclusions of that EIR were that there will be a significant loss of agricultural soils and, although the General Plan contains policies and programs that serve to partially mitigate the cumulative impact, the impact can't be reduced to a less than significant level. The Ventura County Initial Study Assessment Guidelines further state that any project that entails a General Plan amendment and would result in the loss of agricultural soils equal to or greater that that indicated above is considered as having a substantial contribution to a significant cumulative impact, and would require an EIR.

Because the East Area 1 property was considered as part of existing agricultural land inventory in the 1998 Final EIR, the loss of these lands under the County criteria would be considered both individually and cumulatively significant.

7.4.2 *Agricultural Resources - Water*

The Ventura County Initial Study Assessment Guidelines provide criteria and methodology used for determining whether a proposed project may have a significant adverse impact on water quality and quantity available for agriculture.[46] The Ventura County Initial Study Assessment Guidelines define the issue as "Water for agricultural resources means the water that is necessary and available for agricultural production. This issue includes surface, ground and imported water as well as water quantity and quality."

7.4.2.1 Water Quality

The Ventura County Initial Study Assessment Guidelines establish thresholds for both surface and ground water quality that in either case, a decrease the quality of surface or ground water available for agriculture to a level greater than 1200 mg/1 Total Dissolved Solids (TDS) is considered to have a significant project and cumulative impact.[47]

Most of the East Area 1 project site is currently in agricultural use, and therefore there are few or no water quality control devices. The existing land is in a pervious state, so what little water quality enhancement offered by the site is due to infiltration and passing pollutants through the vadose zone.

The amount and type of water contamination generated in urban areas differ from those generated in farmlands. Urbanization usually results in increased surface water concentrations of fecal coliform, oil, grease, and heavy metals. Most farmers systematically apply a variety of pesticides and fertilizers to their crops. Some of these chemicals reach the soil and eventually leach into the groundwater. Soil and groundwater contamination also occur where chemicals are mixed or stored, where wells are constructed or abandoned, and through rainwater infiltration. Agricultural application of pesticides accounts for approximately 92 percent of all pesticide use in California (including chlorine).

Conversion of farmlands to urban use decreases the area treated with pesticides and herbicides from agricultural use. However, the potential exists for these to be introduced back into the environment by other new users (residential and others for landscaping purposes).

Increase in contamination from residential and commercial activities will be controlled to avoid impacts to agricultural users for surface and groundwater downstream. Future improvements in wastewater treatment and other Best Management Practices for managing stormwater runoff will reduce impacts. Several detention basins will serve flood control and water quality purposes. The detention basins will be sized to treat water emanating from the storm drain system as required by the Ventura County Stormwater Quality Urban Impact Mitigation Plan. The detention basins will be developed in such a manner that the sides will be tiered, allowing for differing plant species to develop on the various tiers.

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46 Ventura County, Initial Study Assessment Guidelines, February 2006, p. 39.

47 Ibid.

As stormwater flows increase, successive tiers will be inundated with stormwater, slowing the flow through the basin and allowing contact time with the species. By reducing the outlet structure size and "choking" the outflows, contact time within the detention basin will be maximized allowing for sediment and pollutants to drop out.

The proposed project will not decrease surface or ground water quality to a level greater than 1,200 mg/l for TDS. The project includes features as described above to prevent contaminants from entering the groundwater system or leaving the site in surface water runoff. Impacts to groundwater from surface water runoff would be less than significant.

The project will provide ground water to the City via on-site production wells. This water will become part of the City's overall supply. As the project will transfer ground water to the City, it will become part of the City's overall system and treated for domestic use at the existing City treatment plant. Wastewater generated by the project n also will be treated at the City's existing wastewater treatment plant prior to release. Therefore, there will be no impacts to ground water quality.

7.4.2.2 Water Supply

As provided in the Ventura County Initial Study Assessment Guidelines, a use that will cause a net decrease in the availability of water for agriculture is considered to have a significant project and cumulative impact. This includes uses that may increase the net utilization of ground water in an overdrafted basis or in a basin in hydrologic continuity with a basin in overdraft. The Ventura County Initial Study Assessment Guidelines further state that a use that will cause a net decrease in the availability of imported water supplies currently used by agriculture is considered to have a significant project and cumulative impact.

Water on the project site has been historically supplied from on-site wells that extract groundwater from the Santa Paula Groundwater Basin. The withdrawal of groundwater from the Santa Paula Basin has been adjudicated and is managed in accordance with this adjudication to ensure a safe groundwater yield. Limoneira Company has an allocation under the adjudication that sets forth an agreement between the City of Buenaventura and the Santa Paula Basin Pumpers Association (SPBPA). Currently, the members of the SPBPA have a cumulative allocation to pump on average 27,500 acre-feet per year (AFY); of which Limoneira Company has an allocation of 3,173 AFY. Approximately 1,145 AFY of the total 3,173 AFY is earned by production of the wells on the project site. In addition, the Newsom Family Trust has an allocation of 138 AFY bringing the total available water for the site to 1,283 AFY.

Currently, the site has approximately 405 acres of land under agricultural production within the 501-acre project site. Over the last five years, the water required to meet production needs has averaged 816.3

AFY; this has resulted in an annual average water demand of 0.4 AFY per acre. The balance of the Specific Plan area consists of upland areas that are not irrigated.

The water demand for the Specific Plan provides an estimated 39.4 AFY for continued irrigation of the orchards within the agricultural preserve.[48] This demand is based on existing uses for irrigation of the site orchards on the site. As the project proposes adequate water for existing agricultural use, there will be no impacts to water supply. The project as proposed, therefore, will not result in any impacts to the availability of groundwater in the Santa Paula Basin needed to support agriculture.

Because the site will not cause a net decrease in water available for agriculture, and because the site does not utilize imported water, impacts to the quantity of water available for agricultural uses would be less than significant.

7.4.3 Agricultural Resources – Air Quality/Micro Climate

As provided in the Ventura County Initial Study Assessment Guidelines, a proposed project may have a significant adverse impact on air quality/microclimate affecting agriculture.[49] The Ventura County Initial Study Assessment Guidelines define this issue as "Air Quality/Microclimate for agricultural resources means the meteorological conditions on an agricultural area that fosters the growing of crops. Factors that may adversely affect air quality/microclimate include such items as dust, reduced solar access, elimination of windbreaks, etc." Any project located within 0.5 mile of agricultural areas should be considered as having an impact.

The Ventura County Initial Study Assessment Guidelines establish thresholds for dust, solar access, tree row and other considerations as follows:

> **Dust** - All projects will cause some increase in dust. Any use that will cause a 10 percent or greater increase in dust on agricultural parcels is considered to have a significant impact.
>
> **Solar Access** – Any use that will cause a 10percent or greater decrease in solar energy for an agricultural parcel is considered to have a significant impact.
>
> **Tree Row** – Any use that will cause the removal of any tree row is considered to have a potentially significant impact, necessitating more detailed review on a case-by-case basis.
>
> **Other** – Any use that will cause a substantial adverse change in an agricultural area's air quality and/or microclimate. Other than dust, decreased solar access or tree row removal is considered to have a significant impact.

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48 Water Supply Assessment & Verification for the East Area 1 Specific Plan, November 2007.

49 Ventura County, Initial Study Assessment Guidelines, February 2006, p. 40.

The proposed project is within 0.25 mile of other existing agricultural operation. As shown on **Figure 7**, are located adjacent to the site. These lands would be potentially impacted from dust generated during construction activities on the project site. However, these activities would short-term in duration. Additionally, construction activities would be required to comply with the requirements of the Ventura County Air Pollution District as they relate to dust suppression. These impacts would be less than significant.

The propose project would not decrease solar access to existing agricultural areas. The areas of the agricultural preserve to remain on-site are upslope for the development areas and would not be impacted. Off-site areas would not be impacted from development as buffer areas would be established as previously discussed to the agricultural lands to the east. There would be no impact.

The are existing tree rows located on the project site. The project is proposing maintain the tree rows on the eastern portion of the site and incorporate them as part of the mindscape plan. The existing Cottonwoods trees that located in the upper portion of the site along existing drainages may be retained. However, these tree rows, should they be removed, would not be adjacent to any agricultural areas, therefore, their removal would be less than significant.

Recent studies have identified potential generation of "heat islands" resulting from the development of land.[50] The U.S. EPA has developed information on the potential for "urban heat islands" to occur as a result of urban development. The EPA describes "heat islands" as occurring when; an umbrella of air occurs over city and built-up areas, which is warmer than the air surrounding it. According to the EPA, studies have shown that depending upon the area; "heat islands" can increase air temperatures up to 8 to 10 degrees.[51] It should be noted that the extreme increase occur in inner city urban areas. Studies show the following range of temperature increases depending upon type of development:[52]

Development Type	Heat Increase
Rural	0 degrees
Suburban Residential	0 to 3 degrees
Commercial	3 to 4 degrees
Downtown Urban	4 to 7 degrees
Urban Residential	3 to 4 degrees
Parks	1 to 2 degrees

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50 U.S. Environmental Protection Agency, *Smart Growth and Urban Heat Island,* Smart Growth Fact Sheet Series, EPR 430-F-03-001.

51 U.S. Environmental Protection Agency, *Cooling Our Communities - A Guidebook on Tree Planting and Light-Colored Surfacing,* EPA 22P-2--1, January 1992.

52 U.S. Environmental Protection Agency, *Smart Growth and Urban Heat Island,* Smart Growth Fact Sheet Series, EPR 430-F-03-001.

The proposed project site is located in a rural area adjacent to the City. Based on the above development types, it would correspond more to a Suburban Residential designation than the others. As such, it could create some increase in temperatures in the microclimate. As such, impacts to the microclimate and the generation of "heat islands" would be less than significant.

There would be no significant adverse change in local climate conditions as a result of the proposed East Area 1 project. The air quality in the local area will change as a result of increased mobile emissions from project traffic. As the Specific Plan area is located near the existing City of Santa Paula and State Route 126, it currently experiences some localized degradation in air quality. The increases in air pollutant emissions associated with the proposed project will not have a substantial impact on surrounding agricultural operations, as all traffic would utilize SR 126 through the Santa Clara River Valley or local streets in the City of Santa Paula. As a result, there will not be localized concentrations of pollutants such as concentrations of carbon monoxide. Impacts will be less than significant impact on remaining or adjacent agricultural operations.

7.4.4 *Agricultural Resources – Pests/Diseases*

The Ventura County Initial Study Assessment Guidelines present criteria for determining whether a proposed use may have a significant adverse impact on agriculture by the introduction of or increased potential for agricultural pests and/or diseases.[53] The Ventura County Initial Study Assessment Guidelines define this issue as: "Pests/diseases means the direct or indirect introduction of biological organisms that may be harmful to agricultural production. Indirect introduction can occur when a use will cause a decrease in beneficial organisms or natural or man made protection against harmful biological organisms." Any proposed non-agricultural land use/development located on or within 0.25 mile of property currently in, or suitable for, agricultural production may have an impact.

The Ventura County Initial Study Assessment Guidelines use the following definitions:

> **Disease** – An abnormal condition of an organism or part, especially as a consequence of infection, weakness, or environmental stress, that impairs normal physiological functioning.
>
> **Biological Organism** – A living entity, a plant, animal, bacterium, virus, or other entity that lives and is capable of reproduction.
>
> **Pest** – Any plant, animal or living organism that is harmful to agricultural production.

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53 Ventura County, Initial Study Assessment Guidelines, February 2006, p. 42.

The proposed project is within 0.5 mile of other existing agricultural operation. As shown on **Figure 7**, are located adjacent to the site.

The County Agriculture Commissioner monitors all aspects of the agricultural production in the County and has the duty to exercise the powers and duties of that office to protect the environment, as it relates to agricultural activities, from adverse effects of biological organisms released into the environment and to protect beneficial biological organisms in the County. The Agricultural Commissioner is authorized to import, collect, release, destroy, and propagate of beneficial organisms when such action is deemed to be in the best interest of agricultural activities in the County and its environment.

The Agricultural Commissioner's Office indicates their primary concern regarding the possible transport of pest and disease into agricultural operations adjacent to urban development is through physical transport by vehicular traffic, not through incident trespass by from pedestrians or animals of residential development.[54] As the proposed project has no direct street access or vehicle route from the developed areas to ongoing agricultural operation, the Agricultural Commissioner's Office indicates that the risk of introduction of pests and/or disease would be low.

The Commissioner is authorized to implement or cooperate in management or mitigation programs to be conducted against such plant, environmental, or nuisance pests as can be controlled in an economically, ecologically, and biologically sound manner to protect agriculture.

As proposed, the East Area 1 Specific Plan would permit agricultural production to continue in the northern portion of the site. Agricultural practices, such as the restriction of the use agricultural chemicals and practices that would generate high levels of dust, noise, and odors, in areas adjacent to residential uses permitted by the Specific Plan would be conducted to ensure compatibility between the agricultural and new residential uses. Specifically, recordation of a covenant is proposed that would restrict this preserve to utilize modified farming cultural practices via a legally enforceable covenant that will adequately mitigate impacts between the farmland and adjacent non-farming land uses. In addition, buffer areas will be implemented along those areas of the project that will be adjacent to existing agricultural lands to the east, across Haun Creek from the Specific Plan area. With the implementation of these measures, the potential for direct or indirect introduction of biological organisms is low because the ability for animals, other vectors, insects, and pests to carry bio-organism would be controlled. Impacts would be less than significant.

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54 Personal Communication with Ms. Rita Graham, Agricultural Planner, Ventura County Agricultural Commissioner's Office, Oct. 23, 2007.

7.4.5 *Agricultural Resources - Land Use Compatibility*

The County 's Initial Study Assessment Guidelines provides thresholds to ensure consistent and complete assessment of development/project related impacts on surrounding agricultural land use.[55] The Ventura County Initial Study Assessment Guidelines define this issue as "Land uses that, due to their nature, design, or operation, may be incompatible with nearby agricultural production due to impacts on agriculture (e.g., vandalism, pilferage) or being impacted by agriculture (e.g., chemical spraying). Agricultural production includes both growing of agricultural crops for food, fiber, fuel and ornament, and animal husbandry."

The Ventura County Initial Study Assessment Guidelines establish specific criteria for determining impacts. Any proposed non-agricultural land use/development located within 0.25 mile of property currently in, or suitable for, agricultural production may have a potential impact. Properties suitable for agricultural production include lands designated Prime, Statewide Importance, Unique, and Local Importance by the Important Farmlands Inventory (IFI).

Any non-agricultural land use/development that, by its nature, design, or operation may pose substantial land use incompatibilities with nearby property currently in, or suitable for, agricultural production will have a significant impact. Although this determination must be made on a case-by-case basis, dwellings, schools, hospitals, care facilities, detention facilities, churches, libraries, and outdoor recreational uses are considered potentially significant in the following situations:

1. Within 300 feet of irrigated agriculture
2. Within 200 feet of dry farming
3. Within 100 feet of grazing lands
4. Does not provide perimeter fencing sufficient to keep human and livestock/pets from crossing property lines

Cumulative development exceeding the above criteria will normally be considered as having a substantial effect on agricultural production and cultural practices in the project area (e.g., movement of farm equipment, spraying of farm chemicals).

The proposed project will be located within 0.25 mile of existing agricultural lands, and portions of the project will be within 300 feet of irrigated agriculture as noted in **Figure 7**.

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55 Ventura County, Initial Study Assessment Guidelines, February 2006, p. 43.

As previously discussed in **Section 7.3.3**, the project will include an agricultural preserve on the northern portion. This area will be adjacent to new development consisting of single-family residential housing. The project includes an buffer via a restricted covenant on 300 feet of the agricultural preserve to provide for ongoing farming activities. Along the eastern side of the property, proximate to the Haun Creek drainage, the East Area 1 Specific Plan proposes dedicated open space that would be utilized as greenways and passive recreation (see **Figure 3**). These areas would range from a minimum of 150 feet to over 300 feet in width between existing agriculture and lot lines of the proposed residences.

While conflicts between the residential and farming uses may exist, diminishing the edge relationships and exposures between the two, as well as adopting policies and regulations to mitigate their mutual impacts can minimize them. State and federal law restricts pesticide use in certain areas, and "right-to-farm" ordinances alone would not diminish the impact of the restrictions on pesticide use on farming operations. The project site will be adjacent to agricultural uses along its northeastern boundary. The proposed project would be separated from adjacent properties by Haun Creek and by planned open space areas, which would contribute to minimize land use conflicts and would provide a buffer between agriculture and specific plan uses.

With the implementation of the proposed buffers, impacts would be less than significant.

7.5 Conflicts with Williamson Act Contracts

None of the parcels in the East Area 1 Specific Plan area is under either Williamson Act or Farmland Security Act contracts. There would be no impact.

8.0 SUMMARY OF IMPACTS

Implementation of the East Area 1 Specific Plan would result in the conversion of agricultural land to non-agricultural uses.

This conversion of agricultural land was evaluated in terms of converting State Important Farmland; removal of lands from agricultural cultivation, modification of the existing greenbelt agreement, and compatibility with existing agricultural uses around the site.

As discussed in **Section 7.2**, the following impacts would result:

- The State Important Farmland Map for Ventura County identifies a total of approximately 154 acres of Prime Farmland and 282 acres of Unique Farmland on the site (total of approximately 436 acres). Implementation of the proposed project would result in the conversion to non-agricultural uses of approximately 352 acres of Prime Farmland (approximately 152 acres) and Unique Farmland (approximately 200 acres). This impact would be significant.

- Currently, approximately 405 acres of the 501-acre site are under cultivation and production on the East Area Specific Plan 1 site. Approximately 350 acres of the 405 acres under production would be taken out of production as a result of the proposed project. The remaining 55 acres currently in production along the northern portion of the site would remain in production under the proposed Specific Plan, which designates this portion of the Specific Plan area as Open Space-Agricultural Preserve. This impact would be significant.

- The proposed East Area 1 Specific Plan property is located in the Fillmore-Santa Paula Greenbelt. The greenbelt was adopted by resolution by the participating cities and county. Because the greenbelt was adopted by resolution, it can be terminated by any party. The City of Santa Paula General Plan notes that "The City intends to amend the agreement to remove 567 acres that are part of expansions areas East Area 1 and East Area 2."[56] This impact would be less than significant.

9.0 MITIGATION MEASURES

The City of Santa Paula General Plan includes a policy requiring that applicants for development of land in agricultural production located within an existing greenbelt to provide easements or other agricultural land to compensate for the loss of agricultural land or provide funds to the Ventura County Agricultural Land Trust for the purchase of agricultural lands and/or easements within the Santa Paula Area of Interest.[57] The State Department of Conservation Division of Land Resource Protection also recommends the consideration of the purchase of agricultural conservation easements on land of equal quality or size to compensate for the direct impact of the loss of agricultural land.

Consistent with the City's General Plan policy and the recommendation of the State Department of Conservation, the following program has been developed to mitigate for the direct impacts of the project on agricultural resources. As supported by the analysis in this study, the project will not result in any significant indirect impacts to other agricultural lands near the site or to the economic integrity of the agricultural industry in Ventura County.

The following measures are proposed to mitigate the significant direct impact of the loss of 352 acres of Prime and Unique Farmland by the project on agricultural resources to a less than significant level.

- A conservation covenant will be recorded by the applicant on the 55 acres of land currently in avocado production in the proposed agricultural preserve located along the northern portion of the East Area 1 site that restricts activities to agricultural operations. This will represent mitigation for 55 acres of agricultural land to be converted on the East Area 1 Specific Plan project site. This covenant will also require use of modified farming cultural practices, such as the restriction of the use agricultural chemicals and practices that would generate high levels of dust, noise and odors, to ensure the compatibility of this agricultural use with the residential uses the Specific Plan would permit immediately south of this area.

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56 City of Santa Paula, *General Plan*, Land Use Element, Section III.C. Greenbelt Agreements, p. LU-25.

57 Ibid, Section IV. Goals, Objectives, and Policies, Agriculture and Soils, Policy 3.c.c, p. CO-45.

- To mitigate the impact on the remaining 297 acres of active agricultural land to be converted on the East Area 1 Specific Plan site, the applicant will record an agricultural conservation covenant on 34 acres of other agricultural land owned by the applicant and currently under agricultural production within the City of Santa Paula's Area of Interest. This area is located within the Santa Paula-San Buenaventura greenbelt. The 34-acre mitigation site is located within a group of parcels south of Hwy. 126 and southwest of the City. Details of the potential mitigation parcels are provided in Appendix C. These parcels consist of agricultural land with higher agricultural productivity than the 297 acres impacted by the project. This 34-acre mitigation site produces agricultural products equal in economic value to those produced on the 297 acres to be converted to non-agricultural use. The net annual production revenue for the mitigation site is more than $9,000 per acre and the total net production revenue was more than $306,000 for the period from 2003 to 2007. The 297 acres of the site to be converted to non-agricultural use has averaged net revenue over the past five years of approximately $305,910 (at a net return of $1,030 per acre). Recordation of an agricultural conservation covenant on the mitigation site will, therefore, result in the preservation of agricultural land in the City's Area of Interest of equal quality and economic value.

With the implementation of these mitigation measures, the direct impact of the project on agricultural resources will be mitigated to less than significant.

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Ventura Local Agency Formation Commission, Meeting Minutes, February 21, 2207.

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11.0 REPORT PREPARATION

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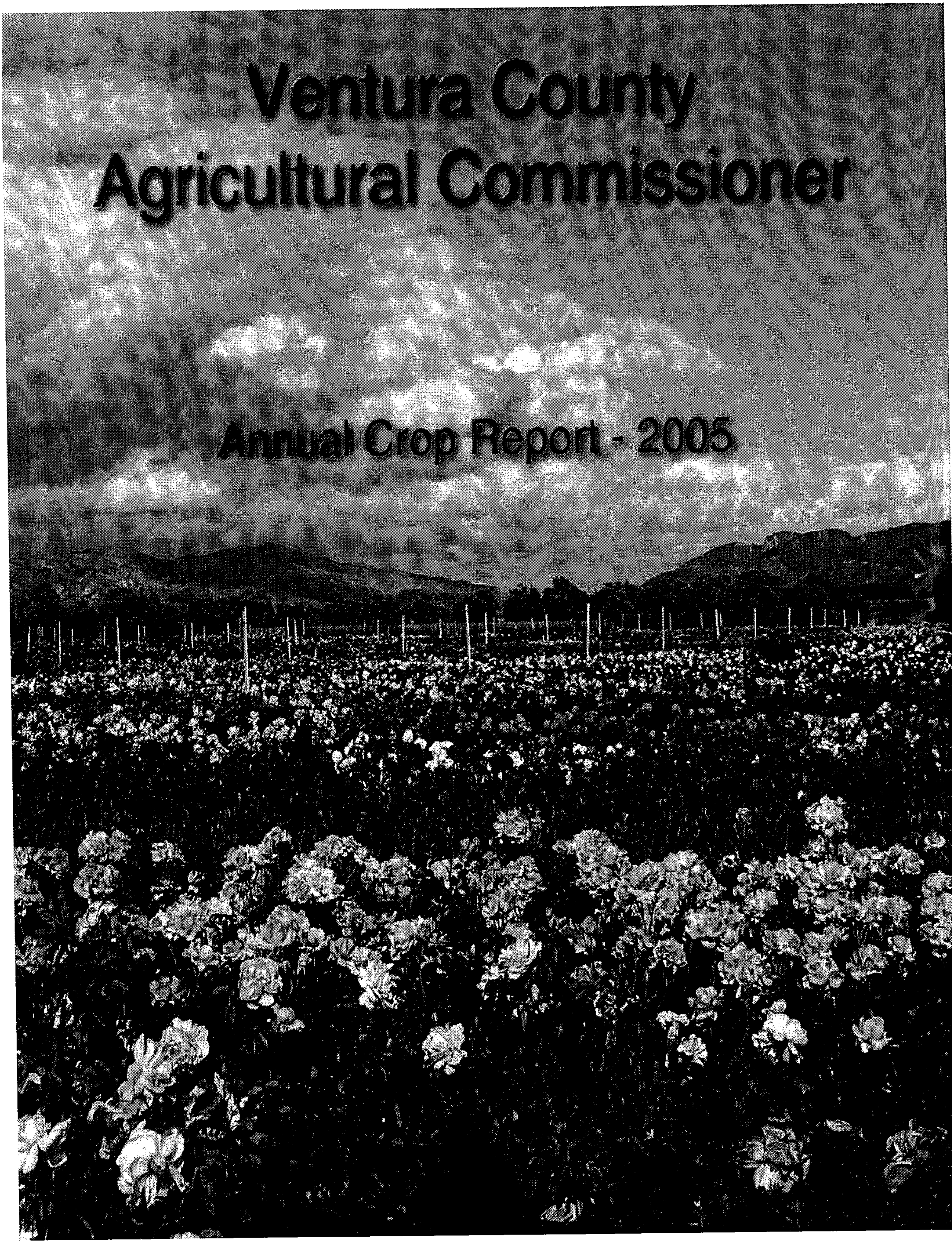
APPENDIX A

Ventura County Agricultural Commissioner Annual Crop Report, 2005

Ventura County Agricultural Commissioner

Annual Crop Report - 2005



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Agricultural Commissioner
W. Earl McPhail

Chief Deputy
David B. Buettner

July 5, 2006

TO: THE HONORABLE BOARD OF SUPERVISORS OF VENTURA COUNTY

LINDA PARKS, Chair	District 2
STEVE BENNETT	District 1
KATHY LONG	District 3
JUDY MIKELS	District 4
JOHN K. FLYNN	District 5

and
A. G. KAWAMURA, SECRETARY,
California State Department of Food and Agriculture

Pursuant to Section 2279 of the California Food and Agricultural Code, I hereby submit the Ventura County Annual Crop and Livestock Report for 2005.

The estimated gross value for Ventura County agriculture for Calendar year 2005 is $1,225,109,000. This is an overall decrease of $164,343,000 from 2004. This report reflects gross values only and does not represent the net return to growers.

Highlights of the 2005 Crop Report are as follows:

- Strawberries are, once again, the leading commodity in 2005 with a value of $325,567,000.
- Vegetables crop value decreased by $24,245,000.
- Fruits and nuts crop value decreased by $88,262,000.

I wish to thank all the individuals, producers, processors, and government agencies whose co-operation and assistance contributed to preparing this report. My sincerest thanks and appreciation must be especially extended to my Deputy Agricultural Commissioner Kerry DuFrain, as well as all department staff for their efforts in compiling and finalizing this report.

Respectfully submitted,

W. Earl McPhail

W. Earl McPhail
Agricultural Commissioner
County of Ventura

WEM/lh
:My Documents/Crop Reports/VC Crop Report 2005

Office of the
AGRICULTURAL COMMISSIONER

W. Earl McPhail – AGRICULTURAL COMMISSIONER

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Front cover photo: Spring rose bloom at Otto and Sons Nursery, courtesy of Cindy Klittich

AGRICULTURAL CROP REPORT
Recapitulation and Index
2004 – 2005

CROP GROUPING	YEAR	$ VALUE[1]
1. FRUIT AND NUT CROPS	2005	$652,777,000
Page #4	2004	740,039,000
2. VEGETABLE CROPS	2005	330,269,000
Page #5-6	2004	354,514,000
3. NURSERY STOCK[2]	2005	213,661,000
Page #7	2004	222,214,000
4. CUT FLOWERS	2005	51,751,000
Page #8	2004	65,663,000
5. FIELD CROPS	2005	1,931,000
Page #8	2004	2,270,000
6. LIVESTOCK AND POULTRY	2005	2,150,000
Page #9	2004	1,942,000
7. APIARY PRODUCTS	2005	509,000
Page #9	2004	362,000
8. TIMBER	2005	62,000
Page #9	2004	71,000
9. SUSTAINABLE AGRICULTURE	2005	1,999,000
Page #10	2004	2,377,000
GRAND TOTAL	2005	$1,225,109,000
	2004	$1,389,452,000

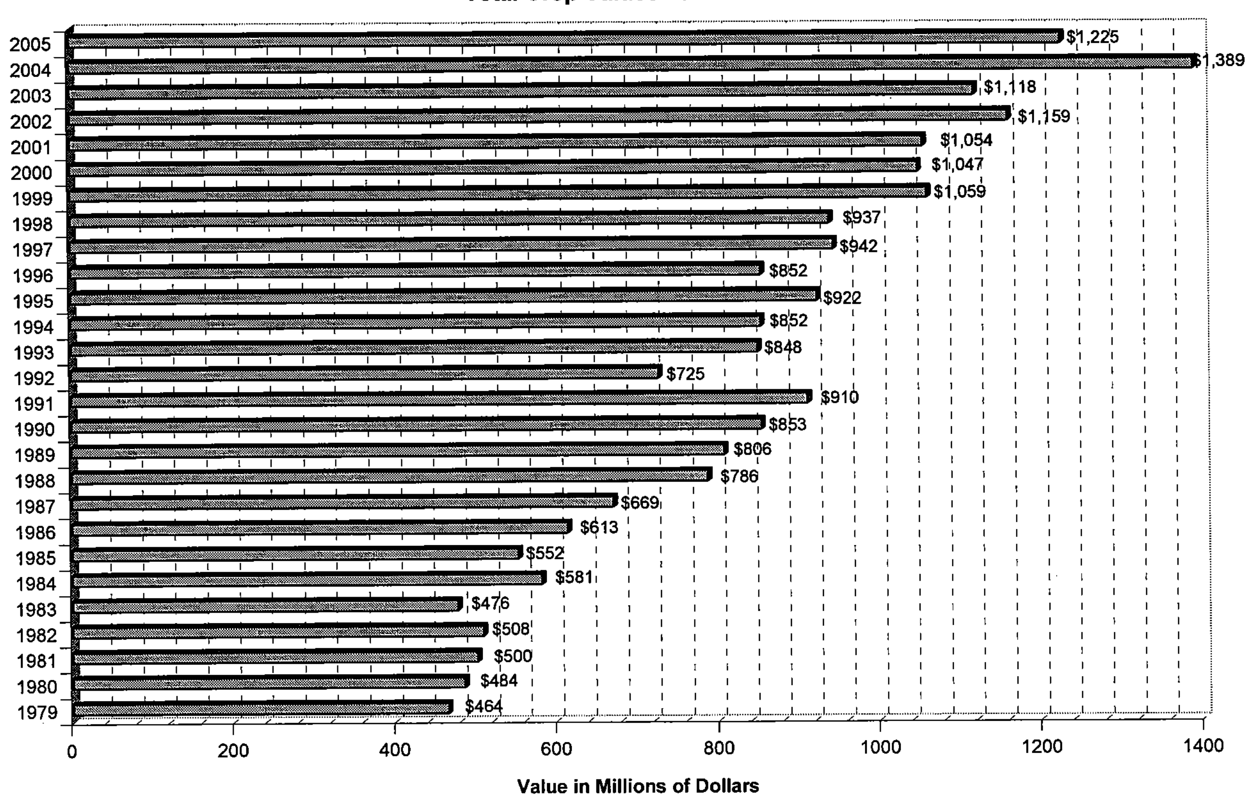
[1] Figures are rounded off to nearest $1000
[2] Includes Cut Christmas Trees

Five Year Comparison Of

Ventura County Crop Values

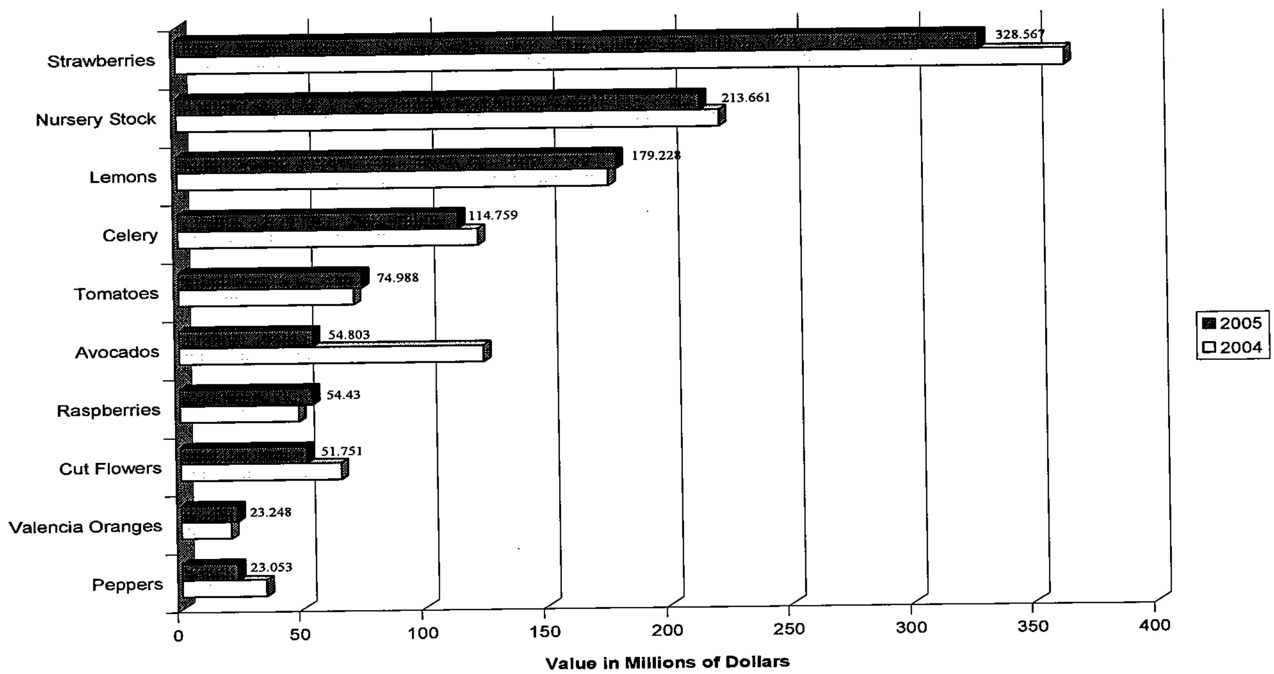
	2001	2002	2003	2004	2005
Fruit and Nut Crops	511,167,000	631,018,000	591,667,000	740,039,000	652,777,000
Vegetable Crops	309,423,000	304,020,000	298,743,000	354,514,000	330,269,000
Livestock and Poultry Products	2,827,000	2,423,000	2,126,000	1,942,000	2,150,000
Apiary Products	591,000	863,000	1,339,000	362,000	509,000
Nursery Stock	171,651,000	173,896,000	173,262,000	222,214,000	213,661,000
Cut Flowers	51,717,000	40,349,000	44,515,000	65,663,000	51,751,000
Field Crops	3,176,000	3,628,000	3,108,000	2,270,000	1,931,000
Timber	78,000	69,000	61,000	71,000	62,000
Biological Control	3,084,000	3,039,000	2,807,000	2,377,000	1,999,000
GRAND TOTAL	$1,053,714,000	$1,159,305,000	$1,117,628,000	1,389,452,000	1,225,109,000

Total Crop Values 1979-2005



TEN LEADING CROPS
FOR 2005

RANK	CROP	VALUE
1st	Strawberries	$328,567,000
2nd	Nursery Stock	213,661,000
3rd	Lemons	179,228,000
4th	Celery	114,759,000
5th	Tomatoes	74,988,000
6th	Avocados	54,803,000
7th	Raspberries	54,430,000
8th	Cut Flowers	51,751,000
9th	Valencia Oranges	23,248,000
10th	Peppers	23,053,000



OTHER MILLION DOLLAR CROPS

Greens	15,102,000	Beans (all)	3,799,000
Cabbage	11,451,000	Oriental Vegetables	2,718,000
Lettuce	9,410,000	*Orchids	2,498,000
*Veg. Transplants	8,159,000	Radishes	2,488,000
Spinach	7,867,000	Livestock	2,150,000
Broccoli	6,089,000	*Poinsettia	1,565,000
Navel Oranges	5,938,000	Cucumber	1,224,000
Cilantro	5,220,000	Sweet Corn	1,123,000
Onions (all)	4,232,000	Kale	1,042,000
Parsley	3,917,000		

* Included in Nursery Stock total above

FRUIT AND NUT CROPS
ACREAGE, PRODUCTION AND VALUES 2004-05

CROP	YEAR	PRODUCTION HARVESTED ACREAGE	PER ACRE	TOTAL	UNIT	$ VALUE PER UNIT	TOTAL
AVOCADOS	2005	19,206	1.54	29,592	Tons	$1,851.95	$54,803,000
	2004	19,234	3.28	63,095	"	1,975.78	124,662,000
GRAPEFRUIT							
Total	2005	108	14.75	1,593	"	364.72	581,000
	2004	75	17.73	1,330	"	378.20	503,000
LEMONS							
Total	2005	20,875	19.02	396,939	"	451.53	179,228,000
	2004	22,520	15.39	346,601	"	508.83	176,361,000
ORANGES (Navel)							
Total	2005	617	13.81	8,519	"	697.03	5,938,000
	2004	501	7.97	3,991	"	558.51	2,229,000
ORANGES (Valencia)							
Total	2005	5,075	11.18	56,715	"	409.91	23,248,000
	2004	5,426	10.12	54,935	"	373.62	20,525,000
RASPBERRIES	2005	1,251	10.94	13,684	"	3,977.20	54,430,000
	2004	1,477	11.53	17,034	"	2,852.30	48,586,000
STRAWBERRIES							
Total	2005	11,333	25.28	286,498	"	1,146.84	328,567,000
	2004	10,349	26.41	273,312	"	1,330.49	363,646,000
Fresh	2005			199,461	"	1,427.00	284,631,000
	2004			170,705	"	1,833.71	313,023,000
Processed	2005			87,021	"	504.89	43,936,000
	2004			102,612	"	493.34	50,623,000
TANGERINES & TANGELOS	2005	159	6.07	965	"	1,886.01	1,820,000
	2004	148	3.2	474	"	1,734.18	822,000
MISC. FRUITS AND NUTS[3]	2005	492			"		4,162,000
	2004	460			"		2,705,000
TOTAL	2005	59,116					$652,777,000
	2004	60,190					$740,039,000

[3] MISC. FRUITS AND NUTS include Apples, Apricots, Asian Pears, Bushberries, Cherimoya, Grapes, Guavas, Kiwi, Limes, Persimmons, Macadamias, Tangelos, Tangerines, Walnuts; and miscellaneous citrus, deciduous, and subtropicals

VEGETABLE CROPS
ACREAGE, PRODUCTION AND VALUES 2004-05

CROP	YEAR	HARVESTED ACREAGE	PRODUCTION PER ACRE	PRODUCTION TOTAL	UNIT	$ VALUE PER UNIT	$ VALUE TOTAL
BEANS							
Green and Dry Limas,	2005	2,255	2.32	5,221	Tons	727.64	$3,799,000
Green Snap	2004	3,064	2.31	7,080	"	846.19	5,991,000
BEETS	2005	210	9.53	2,001	"	931.53	1,864,000
BROCCOLI							
Fresh and	2005	1,329	6.82	9,070	"	671.33	6,089,000
Processed	2004	1,348	7.64	10,301	"	650.81	6,704,000
CABBAGE	2005	2,260	24.78	56,003	"	204.87	11,451,000
	2004	2,213	20.81	46,063	"	230.73	10,628,000
CELERY	2005	10,778	35.33	380,825	"	301.34	114,759,000
	2004	11,249	39.55	444,867	"	276.11	122,832,000
CILANTRO	2005	763	8.11	6,190	"	843.30	5,220,000
	2004	1,614	8.92	14,397	"	551.92	7,946,000
CUCUMBERS	2005	71	11.65	827	"	1,480.05	1,224,000
	2004	127	8.86	1,125	"	824.89	928,000
GREENS[4]	2005	1,731	-	2,414,688	Ctns	6.25	15,102,000
	2004	1,603	-	1,623,197	"	8.86	14,376,000
KALE	2005	153	9.07	1,388	Tons	750.72	1,042,000
	2004	322	9.61	3,093	"	900.74	2,786,000
LETTUCE	2005	1,576	11.96	18,848	"	499.29	9,410,000
Total	2004	2,306	12.52	28,881	"	413.66	11,947,000
Head	2005	119	18.04	2,147	"	305.08	655,000
	2004	311	18.49	5,749	"	266.48	1,532,000
Romaine	2005	955	12.10	11,558	"	445.58	5,150,000
	2004	1,155	13.42	15,499	"	394.09	6,108,000
Leaf	2005	502	10.25	5,143	"	700.95	3,605,000
	2004	840	9.09	7,633	"	564.26	4,307,000

[4] Includes: chard, collard, mustard, turnip and watercress.

VEGETABLE CROPS
ACREAGE, PRODUCTION AND VALUES 2004-05

CROP	YEAR	HARVESTED ACREAGE	PRODUCTION PER ACRE	PRODUCTION TOTAL	UNIT	$ VALUE PER UNIT	$ VALUE TOTAL
ORIENTAL VEG.	2005	670	9.02	6,045	Tons	449.63	$2,718,000
	2004	627	6.88	4,311	"	593.37	2,558,000
ONIONS	2005	720	20.77	14,955	"	282.98	4,232,000
Green & Dry	2004	999	14.10	14,087	"	404.56	5,699,000
PARSLEY	2005	361	13.19	4,762	"	822.55	3,917,000
	2004	579	7.96	4,609	"	856.80	3,949,000
PEPPERS							
Bell and	2005	2,041	21.17	43,201	"	533.62	23,053,000
Chili	2004	3,155	22.88	72,195	"	479.65	34,628,000
PUMPKIN	2005	127	18.05	2,292	"	217.28	498,000
	2004	84	16.26	1,366	"	187.41	256,000
RADISHES	2005	347	10.66	3,699	"	672.61	2,488,000
	2004	1,031	6.11	6,295	"	1,121.37	7,059,000
SPINACH	2005	1,054	4.53	4,772	"	1,648.58	7,867,000
	2004	901	7.39	6,659	"	1,432.35	9,538,000
SWEET CORN	2005	510	5.05	2,577	"	435.78	1,123,000
	2004	374	7.06	2,640	"	500.38	1,321,000
TOMATOES[5]							
	2005	1,586	53.46	84,793	"	884.37	74,988,000
	2004	966	51.66	49,907	"	1,437.37	71,735,000
VEGETABLES, MISC.[6]							
Field,							
Indoor, and	2005	2,069			"		39,425,000
Processed	2004	1,776			"		31,551,000
TOTAL	2005	30,611					$330,269,000
	2004	34,474					$354,514,000

[5] Includes hydroponics

[6] Includes: artichokes, arugula, asparagus, baby vegetables, carrot, cauliflower, eggplant, endive, garlic, gourds, herbs, kohlrabi, leeks, melons, mushrooms, peas, radicchio, sprouts, squash, tomatillos, and turnips.

NURSERY STOCK
PRODUCTION AND VALUES 2004-05

ITEM	YEAR	PRODUCTION		PRODUCTION AREA Greenhouse Square Feet	Field Acres	Per Unit	TOTAL
NURSERY STOCK							
	2005	--------	--------	5,667,265	4,181		$213,661,000
	2004	--------	--------	7,801,452	3,861		221,999,000
Fruit and Nut	2005	933,648	Trees		142	14.28	13,335,000
Trees	2004	914,696	Trees		97	14.30	13,082,000
Potted Plants	2005	3,764,599	Pots	2,102,162	42	3.25	12,250,000
	2004	4,271,607	Pots	3,808,587	34	3.58	15,300,000
Propagative Mat	2005	56,360,767	Cuttings	496,370	14	.12	7,031,000
	2004	60,078,014	Cuttings	424,030	16	.16	9,772,000
Herb. Perennials	2005	3,782,162	Containers	671,229	79	3.13	11,844,000
	2004	4,741,509	Containers	682,932	110	2.50	11,850,000
Woody Orn.	2005	10,239,759	Tree/Shrubs	885,042	1,817	8.98	91,917,000
	2004	12,281,426	Tree/Shrubs	1,138,180	1,362	7.61	93,515,000
Bed. Plants	2005	61,161,757	Flats	485,432	2,083	1.13	69,125,000
Gr. Cover & Turf	2004	73,437,894	Flats	411,860	2,223	1.00	73,153,000
Veg. Transplants	2005	2,494,434	Flats	1,027,030	4	3.27	8,159,000
	2004	2,628,520	Flats	1,335,863	19	2.03	5,327,000
CHRISTMAS*	2005						
TREES (CUT)	2004	8,344	Trees		23	25.77	215,,000
TOTAL	2005						$213,661,000
	2004						$222,214,000

*Included in Woody Ornamentals for 2005

CUT FLOWERS
PRODUCTION AND VALUES 2004-05

ITEM	YEAR	ACRES	PRODUCTION	UNIT	TOTAL $ VALUE
FLOWER BLOOMS &	2005	26	9,501,406	Blooms	$2,770,000
STEMS	2004	23	7,969,547	"	2,099,000
CUT GREENS & DRIED	2005	140	429,141	Bunches	622,000
FLOWERS	2004	150	483,585	"	577,000
FLOWER BUNCHES	2005	787	19,047,702	Bunches	48,359,000
Total	2004	905	29,442,642	"	62,987,000
Statice, Lace, Aster	2005	156	2,686,071	"	5,710,000
And Gypsophila	2004	116	2,597,881	"	4,776,000
Chrysanthemums and	2005	52	3,882,208	"	5,381,000
Sunflowers	2004	72	4,408,250	"	5,402,000
Lilies & Irises	2005	61	2,940,109	"	13,598,000
	2004	59	2,770,048	"	12,313,000
Lisianthus	2005	28	620,273	"	2,459,000
	2004	32	1,286,437	"	5,543,000
Stock, Larkspur,	2005	251	4,029,353	"	9,036,000
Delphinium & Snapdragons	2004	225	7,530,542	"	11,501,000
Miscellaneous	2005	239	4,889,688	"	12,175,000
	2004	401	10,849,484	"	23,452,000
TOTAL	2005	953			$51,751,000
	2004	1,078			$65,663,000

FIELD CROPS
ACREAGE, PRODUCTION AND VALUE 2004-05

CROP	YEAR	HARVESTED ACREAGE	TOTAL $ VALUE
ALFALFA AND PASTURE	2005	100,294	$1,032,000
Irrigated and Non-Irrigated	2004	100,360	1,061,000
GRAIN[7], HAY, FLOWER	2005	1,134	899,000
& VEGETABLE SEED	2004	1,330	1,209,000
TOTAL	2005		$1,931,000
	2004		$2,270,000

[7] Includes green barley

LIVESTOCK AND POULTRY PRODUCTION AND VALUES 2004-05

ITEM	YEAR	PRODUCTION	UNIT	$ VALUE PER UNIT	$ VALUE TOTAL
LIVESTOCK					
Cattle, Hogs	2005	16,240	cwt.	120.69	$1,960,000
Sheep	2004	16,219	cwt.	109.75	$1,780,000
POULTRY					
Eggs, Ducks	2005				94,000
	2004				92,000
OTHER LIVESTOCK[8]	2005				96,000
	2004				70,000
TOTAL	2005				$2,150,000
	2004				$1,942,000

APIARY PRODUCTS PRODUCTION AND VALUES 2004-05

CROP	YEAR	PRODUCTION	UNIT	$ VALUE PER UNIT	$ VALUE TOTAL
HONEY	2005	523,072	lbs.	$.85	$446,000
	2004	155,830	lbs.	.96	150,000
BEESWAX	2005	12,687		1.50	19,000
	2004	3,165		1.58	5,000
POLLINATION USE	2005				44,000
	2004				207,000
TOTAL	2005				$509,000
	2004				$362,000

TIMBER PRODUCTION AND VALUES 2004-05

CROP	YEAR	$VALUE
TIMBER[9]	2005	$62,000
	2004	$71,000

[8] Deer, squab and alpaca
[9] Timber harvested for lumber.

SUSTAINABLE AGRICULTURE

ITEM	PEST	AGENT	SCOPE OF PROGRAM
BIOLOGICAL CONTROL Commercial Insectaries	Red and black scale, Mealybug, snails, various aphids mites and flies	Aphytus melinus, Cryptolemus, Decollate snails, various predators, parasitic wasps and nematodes	Estimate 768,163,715 beneficials, released on 330 ranches. Valued at $1,999,000
COLONIZATION OF BENEFICIAL ORGANISMS	Yellow Star Thistle	Puccinia jacaea	2 sites/1 release each 100 mg spores/sq. meter
PEST ERADICATION	Dalmation Toadflax	Mechanical/ Digging	1 Site
	Scotch Thistle	Mechanical/ Digging	1 Site
	Spotted Knapweed	Mechanical/ Digging	1 Site
PEST EXCLUSION		Incoming Shipments	
	Various	Postal/UPS/Fed Express (Parcels)	9,246
		Truck/Air Freight	4,200
	Gypsy Moth	Household Goods (Inspections)	168
		Total	13,614

ORGANIC FARMING				
Number of registered growers	47	Vegetables	Acreage	1,676
		Fruits and Nuts	Acreage	2,667
		Field Crops	Acreage	359
		Flowers	Acreage	10

APPENDIX B

California Agricultural Land Evaluation and Site Assessment (LESA) Model Work Sheet

California Agricultural Land Evaluation and Site Assessment (LESA) Model Worksheet 1 for East Area 1

							Storie Index			Project Size Score				
Soil Map Unit Symbol	Soil Map Unit Name	Acres	Proportion	Capability Grouping LCC	LCC Rating	LCC Score	Index Rating	Index Score	Soil Grade	LCC Class I-II	LCC Class III	LCC Class IV-VIII	Meets Gov Code 56064 Prime Ag Land Definition	Prime Farmland on State Important Farmland Map
CrC	Cortina stony sandy loam, 2 to 9 percent slopes	146.6	0.412	IVs-7	40	16.5	27	11.1	4			146.6		
GaC	Garretson loam, 2 to 9 percent slopes	17.5	.049	IIe-1	90	4.4	90	4.4	1	17.5			Yes – Class II Soil & Storie Index Rating of 90	Yes
GbC	Garretson gravelly loam, 2 to 9 percent slopes	44.3	0.124	IIe-1	90	11.2	63	7.8	2	44.3			Yes – Class II Soil	Yes
MkG	Millsholm very rocky loam, 30 to 75 percent slopes	0.5	.001	VIIs-8	10	0.01	4	0.004	6			0.5		
PcA	Pico sandy loam, 0 to 2 percent slopes	50.0	0.140	IIs-4	80	11.2	86	12.0	1	50.0			Yes – Class II Soil	Yes
PcC	Pico sandy loam, 2 to 9 percent slope	12.7	0.036	IIe-1	90	3.2	77	2.8	2	12.7			Yes – Class II Soil	Yes
Rw	Riverwash	4.7	0.013	VIIIw-4	0	0.0	<5	0.07	6			4.7		
SsE2	Soper loam, 15 to 30 percent slopes, eroded	36.0	0.101	VIe-1	20	2.0	36	3.6	4			36.0		
SvF2	Soper gravelly loam, 30 to 50 percent slopes, eroded	14.3	0.04	VIIe-1	10	0.4	13	0.5	5			14.3		
SwA	Sorrento loam, 0 to 2 percent slopes	29.4	.083	I-1	100	8.3	100	8.3	1	29.4			Yes – Class I Soil & Storie Index Rating of 100	Yes
	Total	**356.0**	**1.000**			**57.2**		**50.6**		153.9	0	202.1		
	Total meeting Gov Code Prime Ag Definition	**153.9**							**Scores**	**100**	**0**	**60**		

East Area 1 Site Assessment Worksheet 2 - Water Resources Availability

Project Portion	Water Source	Proportion of Project Area	Water Availability Score	Weighted Availability Score
1	On-Site Wells	1.00	100	100
	Threshold Percentage of Project's Zone of Influence in Agricultural Use	Actual	Surrounding Agricultural Land Score	
	50 to 54	53	60	
	Threshold Percentage of Project's Zone of Influence Defined as Protected	Actual	Surrounding Protected Resource Land Score	
	20-29	20	10	

APPENDIX C

Analysis of Proposed Mitigation Parcel

Analysis of Proposed Mitigation Parcel

C.1 *Description of the Proposed Mitigation Parcel*

The proposed mitigation parcel is located approximately 7 miles southwest of the East Area 1 Specific Plan project, in the City of Santa Paula's Area of Interest. The parcel is bounded by the Santa Clara River to the south, Todd Road to the east, Highway 126 to the north, and Ellsworth Barranca to the west. **Figure C-1, Location of Proposed Mitigation Parcels,** and **Figure C-2, Mitigation Parcel Location Map,** show the location of the mitigation parcel in reference to the City of Santa Paula and the East Area 1 Project Site. This parcel is within the City's Area of Interest consistent with the General Plan's implementation measure (IV.19) requiring applicants for development of land in agricultural production that is within an existing greenbelt to provide acquisition of lands and/or easements within the Santa Paula Area of Interest.

The Limoneira Company currently owns the parcel and is leasing it to a strawberry farming company. **Figure C-3, Location of Proposed Mitigation Agriculture Blocks,** shows the specific agriculture production blocks on this parcel of land. The mitigation parcel consists of three agriculture production blocks (designated as numbers LF1, LF2, and LF3). The following is a description of each of these blocks:

- Block LF1 is located just east of block L90 and consists of approximately 16 acres. All of the 16 acres of land in segment LF1 are designated as Prime Farmland on the State Important Farmland Map.
- Block LF2 is located just east of block LF1 and consists of approximately 17 acres. All of the 17 acres of land in segment LF1 are designated Prime Farmland on the State Important Farmland Map.
- Block LF3 consists of approximately 47 acres. Of the 47.acres, 46 acres are designated as Prime Farmland and one acre is designated as Farmland of Statewide Importance on the State Important Farmland Map.

The mitigation parcel has been in agricultural production for at least the last 10 years and has historically been farmed for strawberry production. Strawberries are one of the largest crops and historically have been one of the largest revenue crops in Ventura County. **Table C-1** provides information on Countywide production for strawberries from 2001 to 2005, and estimates the net revenue per acre. As shown, the average per acre net revenue for strawberries in the County is approximately $20,042 per acre.

Using the five-year average net revenue for strawberries in Ventura County, the mitigation parcel has yielded a total net revenue of approximately $696,338 as shown in **Table C-2.**

Table C-1
Ventura County Strawberry Production 2001-2005

Year	Harvested Acreage(1)	Total Value(1)	Per Acre			
			Gross Revenue	Land Cost(2)	Production Cost(3)	Net Revenue
2001	7,777	$230,697,000	$29,664	$2,500	$19,000	$8,164
2002	8,582	$297,924,000	$34,715	$2,500	$19,950	$12,265
2003	8,794	$300,746,000	$34,199	$2,500	$20,948	$10,752
2004	10,349	$363,646,000	$35,138	$2,500	$21,995	$10,643
2005	11,333	$328,567,000	$28,992	$2,500	$23,095	$3,397
Five Year Average						$9,044

Notes: *(1) Data from Ventura County Agricultural Commissioner's Annual Reports for Years 2002 to 2005.*
(2) Provided by Limoneira Company, property owner.
(3) Estimate to account for plant costs, fertilizers and pesticides, fuel and machinery, labor, and irrigation costs.

Table C-2
Estimated Per Acre Strawberry Net Revenue for the Mitigation Parcel

Block	Acres	Net Revenue per Acre
L90	44	$397,936
LF1	16	$144,704
LF2	17	$153,748
Totals	77	$696,338

The Proposed Mitigation Parcel is made up of Prime and Unique Farmland as shown in **Figure C-4, State Important Farmland Map Designations.**

The types of soils must also be taken into account on the Proposed Mitigation Parcel. There are eight different types of soils that are located within the proposed project site, including; Metz loamy fine sand (McA), Metz loamy sand (MeA), Mocho loam (MoA), Mocho clay loam 0 -2 percent slopes (MsA), Mocho clay loam 25 percent slopes (MsB), Pico sandy loam (PcA), Pico loam sandy substratum (PsA) and Sandy alluvial land (Sd). The percentage of each soil within the Mitigation Parcel is described in the attached Land Evaluation and Site Assessment (LESA) score sheets. Each type of soil and its location within the segments of the parcel are shown in **Figure C-5, Mitigation Parcel Soil Designations.**

C.2 California Agricultural Land Evaluation and Assessment Model

The LESA model rates the relative quality of land resources, based on specific measurable features. The LESA model is comprised of six weighted factors:

- Two Land Evaluation (LE) factors are based on measures of soil resource quality and
- Four Site Assessment (SA) factors based on the amount of agricultural land, water availability, surrounding agricultural lands, and the presence of surrounding protected-resource lands.

C.2.1 Land Evaluation Factors

Each of the LE factors is rated on a 100-point scale and weighted relative to one another to generate a single numeric potential-significance threshold score, with 100 points as the maximum attainable score.

The Soil Survey, Ventura Area, California was used to determine soil mapping units for the property, as well as the:

- United States Department of Agriculture (USDA) Land Capability Classification (LCC), which rates soil limitations and risk of agricultural damage to soils from outside factors such as change in soil chemistry from the use of herbicides. Class I provides the lowest risk and Class VIII the highest risk for agricultural production and
- Storie index which rates the relative degree of soil suitability for intensive agriculture.

Multiplying the proportion of each of the soils on the site by the LESA point rating scale generates a single project site score for each LE factor.

C.2.2 Site Assessment Factors

The Project Size Rating segregates acreage figures for groupings of LCC classes and points are assigned for each of the groupings on a 100-point scale. The model requires use of the highest value from amongst the groupings; since either of the two represented groupings attained the highest or 100 points, the score of 100 was entered into the proposed mitigation parcel's total area LESA Score model.

The Water Resources Availability Rating is based on drought and non-drought restrictions on water supply for the site. Since the site uses only on-site water as its sole source, it received a value of 100, which was proposed mitigation parcel's total area LESA Score model.

A Zone of Influence (ZOI) was identified and used to determine the final two SA factors: Surrounding Agricultural Land Rating and Surrounding Protected Resource Land Rating. The ZOI includes all parcels within 0.5 mile of the property. The Agricultural Land Rating score is based on the percentage of the ZOI currently producing agricultural crops (55 percent), and the Surrounding Protected Resource Land Rating is based on the percentage of the ZOI lands with long-term restrictions compatible with or supportive of agricultural land uses, including Williamson Act lands (approximately 0 percent). Each of these values is assigned points based on area and the points appear in the spreadsheets. The Zone of Influence for the proposed mitigation parcel's total area is shown in **Figure C-6, Zone of Influence of the Mitigation Parcel.**

C.2.3 Mitigation Area LESA Scoring

A single LESA score is generated for a given site after all the individual LE and SA factors have been scored and weighted. The California Agricultural LESA Model is weighted so that 50 percent of the total LESA score of a given project is derived from the LE factors and 50 percent from the SA factors. Individual factor weights are listed below, with the sum of the factor weights required to equal 100 percent.

The results of the LESA model for the proposed mitigation parcel's total area is shown in **Table C-3, Proposed Mitigation Parcel Total Area LESA Score**. The Proposed Mitigation Parcel Score Sheet is attached. Also provided in **Tables C-4 to C-7** are the results of the LESA model on each segment of land that is being considered in the project. Each mitigation score sheet for each of the four different segments is also attached.

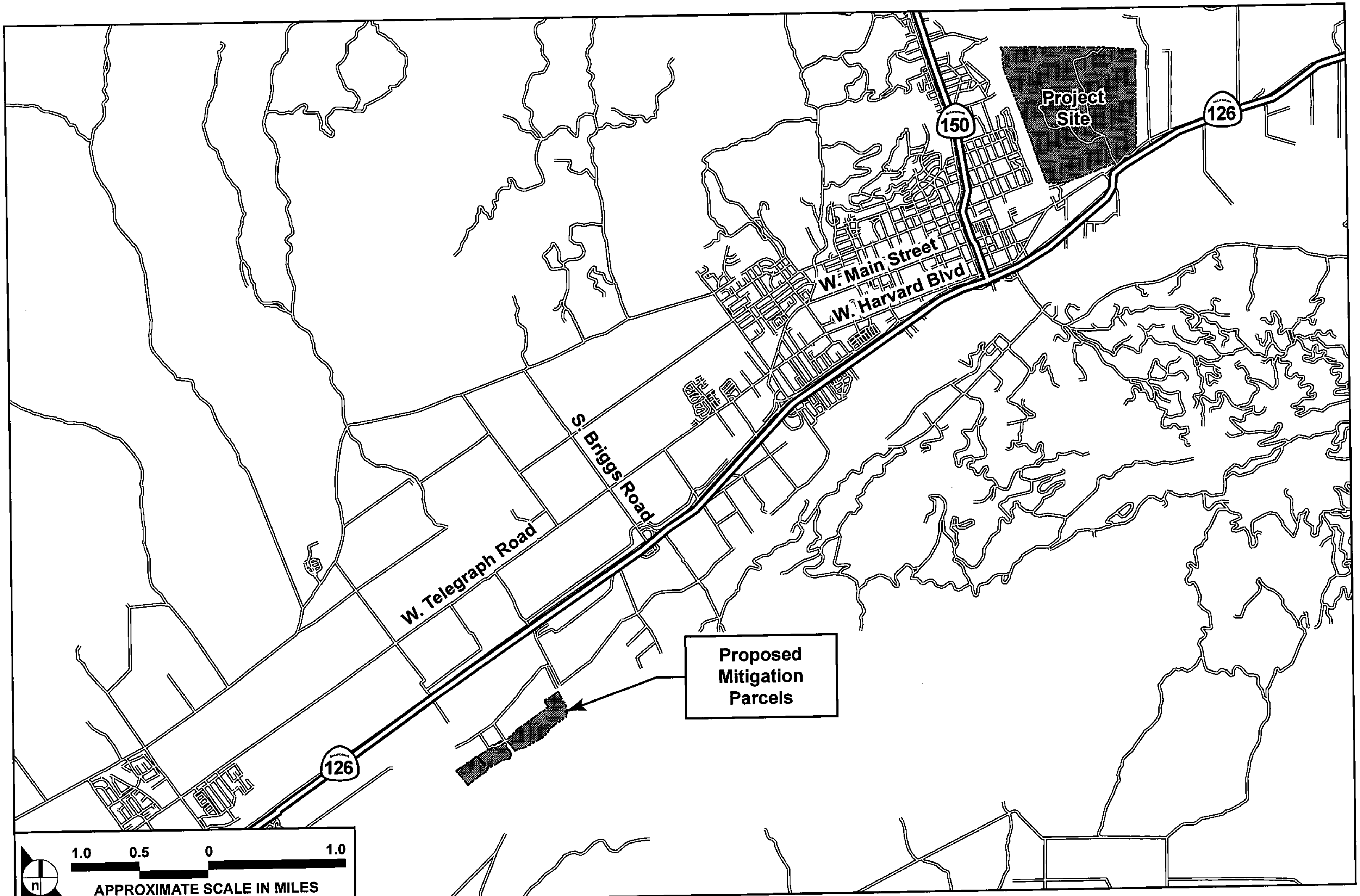
Total Mitigation Area - With a final LESA Score of 79 as shown in **Table C-3, Proposed Mitigation Parcel Total Area LESA Score**, and given that each of the LE and SA subscores are greater than 20 points, this parcel's LESA score exceeds the land being converted on the East Area 1 site, the LESA score for which is 67.

Block LF1 - With a final LESA Score of 70 as shown in **Table C-4, Block LF1 Mitigation LESA Score**, and given that each of the LE and SA sub-scores are greater than 20 points, this parcel's LESA score exceeds the land being converted on the East Area 1 site, the LESA score for which is 67.

Block LF2 - With a final LESA Score of 67 as shown in **Table C-5, Block LF2 Mitigation LESA Score**, and given that each of the LE and SA sub-scores are greater than 20 points, this parcel's LESA score is the same as the land being converted on the East Area 1, the LESA score for which is of 67.

Block LF3 - With a final LESA Score of 75 as shown in **Table C-6, Block LF3 Mitigation LESA Score**, and given that each of the LE and SA subscores are greater than 20 points, this parcel's LESA score exceeds the land being converted on the East Area 1 site, the LESA score for which is 67.

The LESA model worksheets for the proposed mitigation parcel and each of the individual blocks are shown in **Tables C-7** through **C-10**.

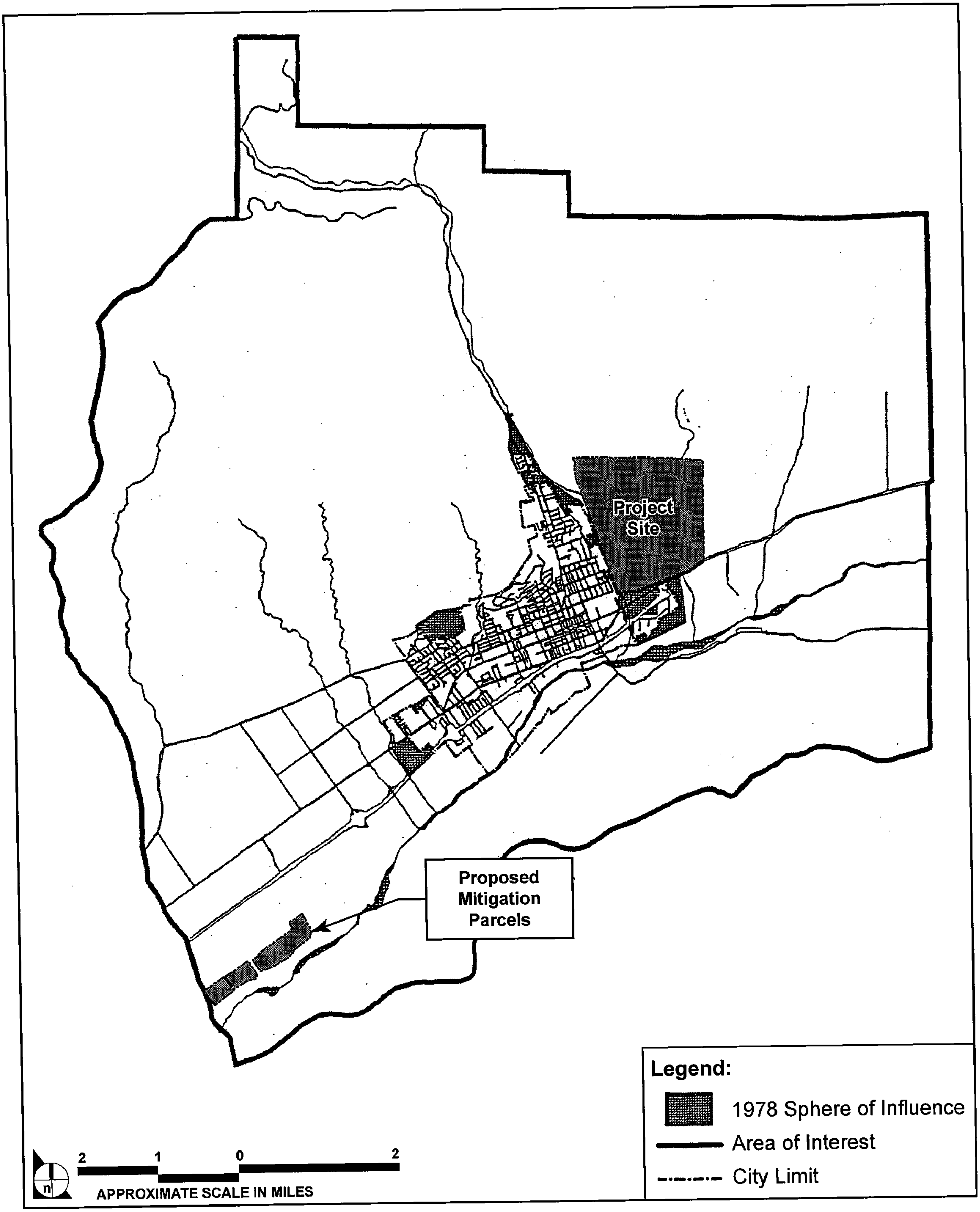


SOURCE: Impact Sciences, Inc. – April 2007

FIGURE C-1

Location of Proposed Mitigation Parcels

831-001•05/07

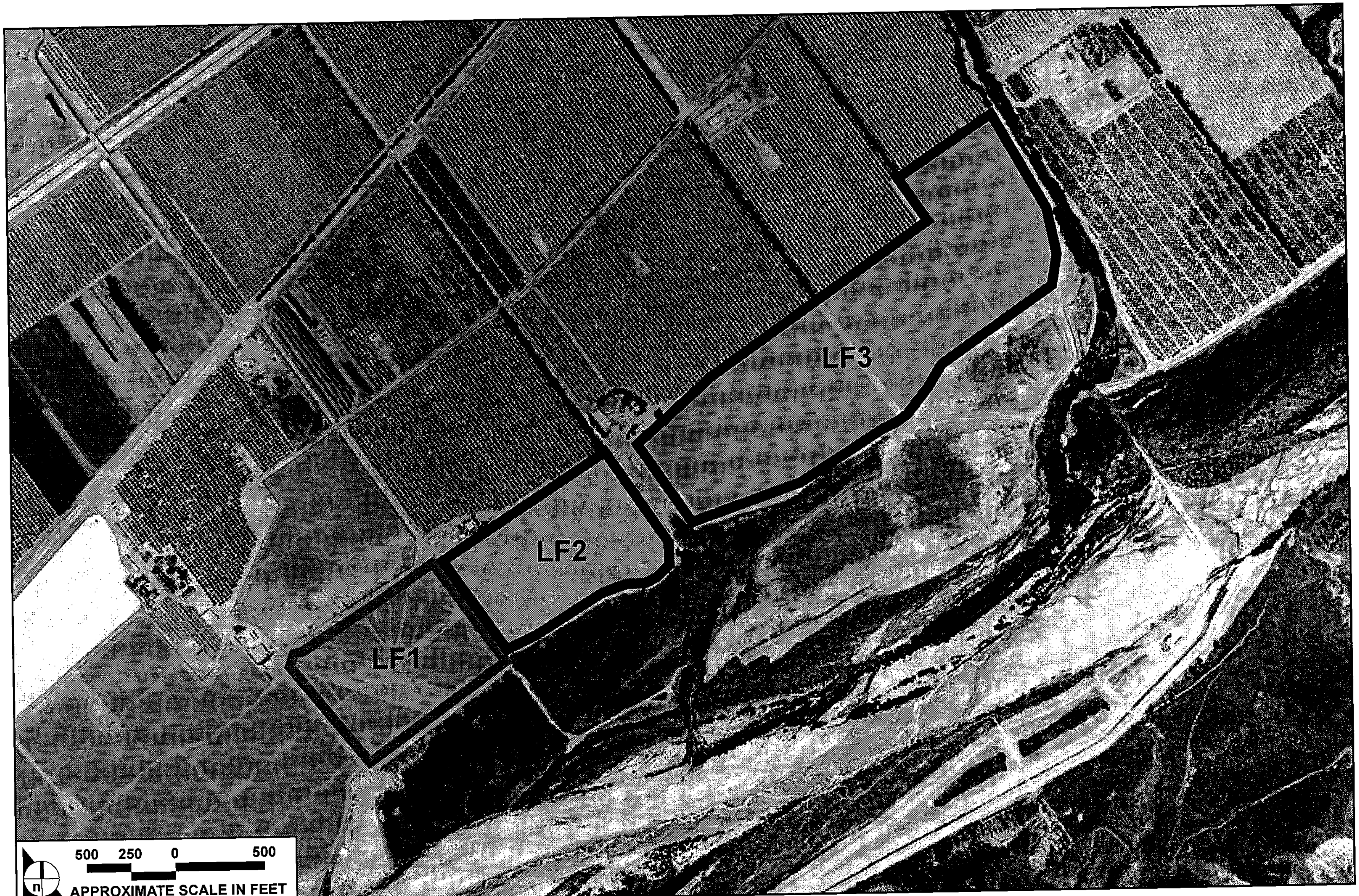


SOURCE: Impact Sciences, Inc. – April 2007

FIGURE C-2

Mitigation Parcel Location Map

831-001•05/07

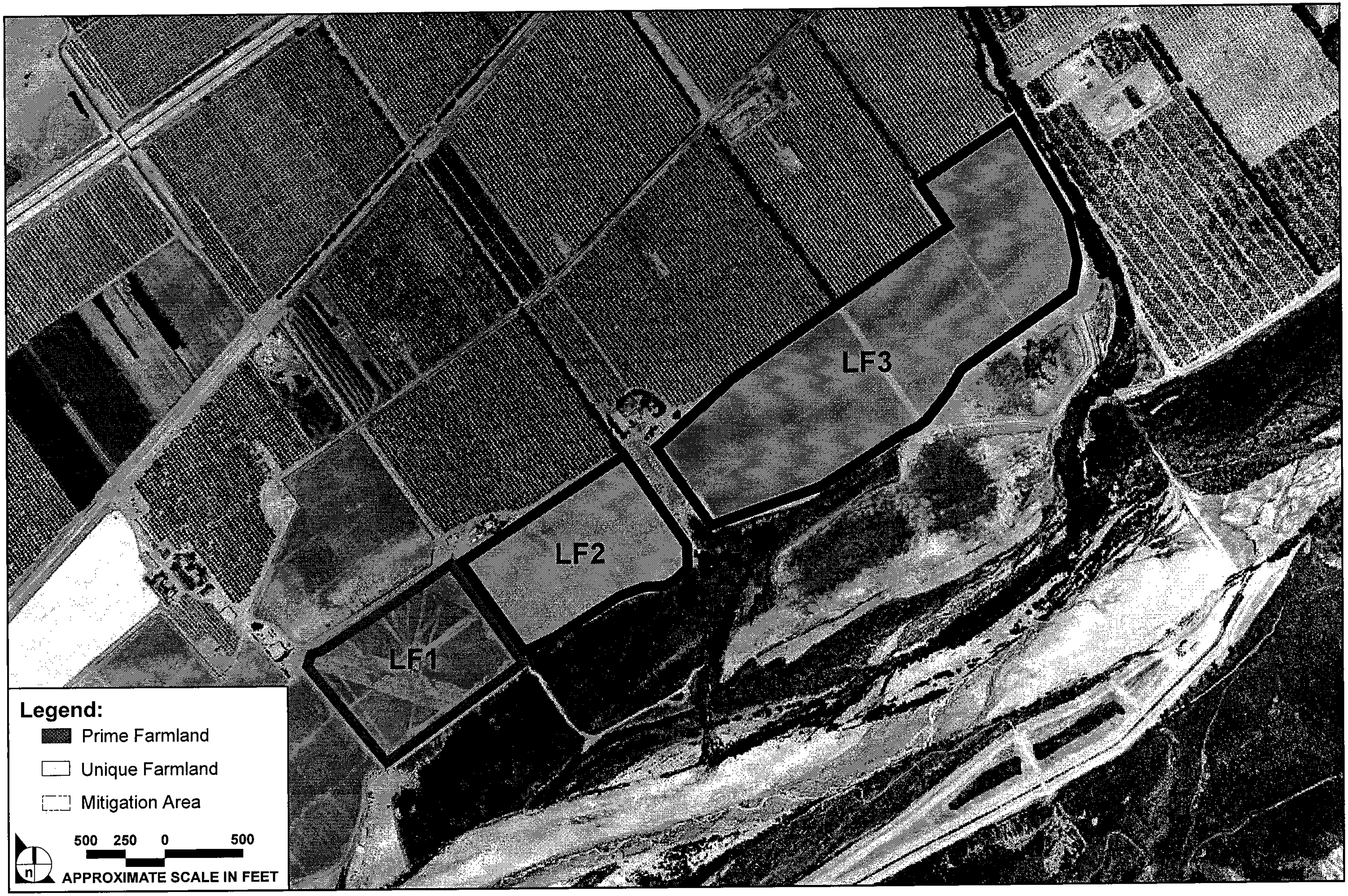


SOURCE: Impact Sciences, Inc. – April 2007

FIGURE C-3

Location of Proposed Mitigation Agriculture Blocks

831-001•05/07



SOURCE: Impact Sciences, Inc. – April 2007

FIGURE **C-4**

State Important Farmland Map Designations

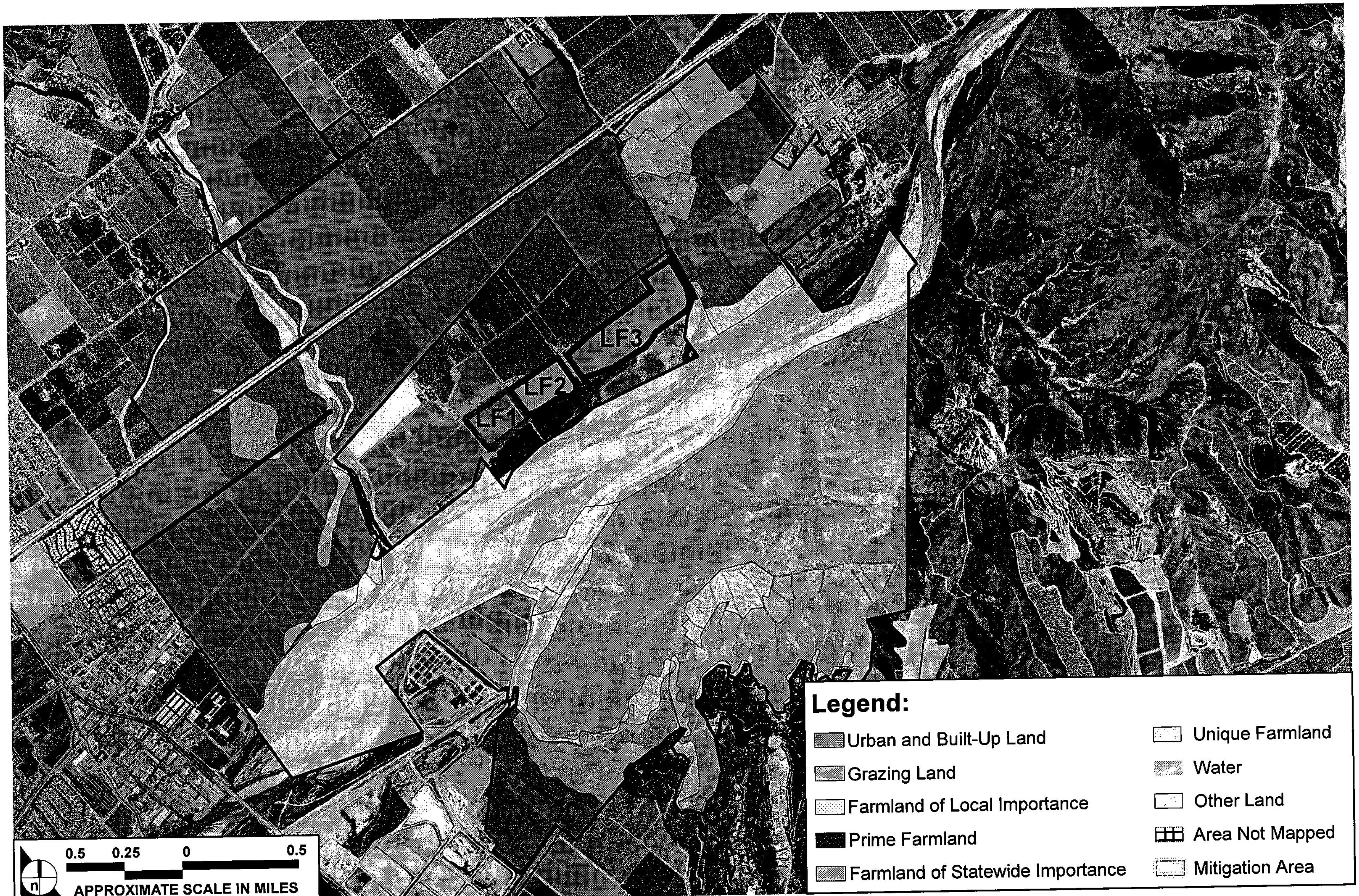
831-001•05/07

SOURCE: Impact Sciences, Inc. – April 2007

FIGURE C-5

Mitigation Parcel Soil Designations

831-001•05/07



SOURCE: Impact Sciences, Inc. – April 2007

FIGURE **C-6**

Zone of Influence of the Mitigation Parcel

831-001•05/07

Table C-3
Proposed Mitigation Parcel Total Area LESA Score

	Factor Scores	Factor Weight	Weighted Factor Scores
LE Factors			
Land Capability Classification	85	0.25	21
Storie Index	87	0.25	22
LE Subtotal		0.5	43
SA Factors			
Project Size	100	0.15	15
Water Resource Availability	100	0.15	15
Surrounding Agricultural Land	40	0.15	6
Protected Resource Land	0	0.05	0
SA Subtotal		0.5	36
Final LESA Score			79

Table C-4
Block LF1 Mitigation LESA Score

	Factor Scores	Factor Weight	Weighted Factor Scores
LE Factors			
Land Capability Classification	90	0.25	22
Storie Index	89	0.25	22
LE Subtotal		0.5	44
SA Factors			
Project Size	30	0.15	5
Water Resource Availability	100	0.15	15
Surrounding Agricultural Land	40	0.15	6
Protected Resource Land	0	0.05	0
SA Subtotal		0.5	26
Final LESA Score			70

Table C-5
Block LF2 Mitigation LESA Score

	Factor Scores	Factor Weight	Weighted Factor Scores
LE Factors			
Land Capability Classification	81	0.25	20
Storie Index	82	0.25	20
LE Subtotal		0.5	40
SA Factors			
Project Size	30	0.15	5
Water Resource Availability	100	0.15	15
Surrounding Agricultural Land	40	0.15	6
Protected Resource Land	0	0.05	0
SA Subtotal		0.5	26
Final LESA Score			66

Table C-6
Block LF3 Mitigation LESA Score

	Factor Scores	Factor Weight	Weighted Factor Scores
LE Factors			
Land Capability Classification	82	0.25	21
Storie Index	85	0.25	21
LE Subtotal		0.5	42
SA Factors			
Project Size	80	0.15	12
Water Resource Availability	100	0.15	15
Surrounding Agricultural Land	40	0.15	6
Protected Resource Land	0	0.05	0
SA Subtotal		0.5	33
Final LESA Score			75

Table C- 7
California Agricultural Land Evaluation and Site Assessment (LESA) Model Work Sheet
Total Proposed Mitigation Parcel

Soil Map Unit Symbol	Soil Map Unit Name	Acres	Proportion	Capability Grouping LCC	LCC Rating	LCC Score	Storie Index			Project Size Score			Meets Gov Code 56064 Prime Ag Land Definition
							Index Rating	Index Score	Soil Grade	LCC Class I-II	LCC Class III	LCC Class IV-VIII	
McA	Metz loamy fine sand	6.63	0.053	IIs-4	80	4.24	72	3.816		6.63			Yes- Class II soil
MeA	Metz loamy sand	0.70	0.006	IIIs-4	60	0.36	64	0.384			0.70		
MoA	Mocho loam	29.73	0.238	I-1	100	23.8	100	23.80		29.73			Storie Index rating of 100
MsA	Mocho clay loan 0-2 percent slopes	6.95	0.056	I-1	100	5.6	85	4.76		6.95			Storie Index rating of 100
MsB	Mocho clay loam 25 percent slopes	4.36	0.035	IIe-1	90	3.15	81	2.835		4.36			Yes- Class II soil
PcA	Pico sandy loam	72.87	0.584	IIs-4	80	46.72	86	50.224		72.87			Yes- Class II soil
PsA	Pico sandy loam substratum	1.29	0.010	IIIs-0	60	0.60	76	0.76			1.29		
Sd	Sandy alluvial land	2.28	0.018	IVw-4	40	0.72	10	0.18				2.28	
	Total	**124.81**	**1.000**			**85.19**		**86.759**		**120.54**	**1.99**	**2.28**	
	Total meeting Gov Code Prime Ag Definition	**120.54**							**Project Size Scores**	**100**	**0**	**0**	

Table C-8
California Agricultural Land Evaluation and Site Assessment (LESA) Model Work Sheet
LF1 Mitigation Block

Soil Map Unit Symbol	Soil Map Unit Name	Acres	Proportion	Capability Grouping LCC	LCC Rating	LCC Score	Storie Index			Project Size Score			Meets Gov Code 56064 Prime Ag Land Definition
							Index Rating	Index Score	Soil Grade	LCC Class I-II	LCC Class III	LCC Class IV-VIII	
McA	Metz loamy fine sand	2.06161	0.132	IIs-4	80	10.57	72	9.516		2.06			Yes- Class II soil
MoA	Mocho loam	6.474532	0.415	I-1	100	41.5	100	41.51		6.47			Storie Index rating of 100
MsB	Mocho clay loam 25 percent slopes	2.228935	0.143	IIe-1	90	12.86	81	11.575		2.23			Yes- Class II soil
PcA	Pico sandy loam	4.832726	0.310	IIs-4	80	24.79	86	26.646		4.83			Yes- Class II soil
	Total	**15.60**	**1.000**			**89.73**		**89.246**		15.60	0.00	0.00	
	Total meeting Gov Code Prime Ag Definition	**15.60**							**Project Size Scores**	**30**	**0**	**0**	

Table C-9
California Agricultural Land Evaluation and Site Assessment (LESA) Model Work Sheet
LF2 Mitigation Block

Soil Map Unit Symbol	Soil Map Unit Name	Acres	Proportion	Capability Grouping LCC	LCC Rating	LCC Score	Storie Index			Project Size Score			Meets Gov Code 56064 Prime Ag Land Definition
							Index Rating	Index Score	Soil Grade	LCC Class I-II	LCC Class III	LCC Class IV-VIII	
McA	Mocho loam	4.566731	0.271	IIs-4	80	21.66	72	19.490		4.566731			Yes- Class II soil
MsB	Mocho clay loam 25 percent slopes	2.060948	0.122	IIe-1	90	10.99	81	9.895		2.060948			Yes- Class II soil
PcA	Pico sandy loam	10.2406	0.607	IIs-4	80	48.56	86	52.205		10.2406			Yes- Class II soil
	Total	**16.87**	**1.000**			**81.21**		**81.591**		16.87	0.00	0.00	
	Total meeting Gov Code Prime Ag Definition	**16.87**							**Project Size Scores**	**30**	**0**	**0**	

Table C- 10
California Agricultural Land Evaluation and Site Assessment (LESA) Model Work Sheet
LF3 Mitigation Block

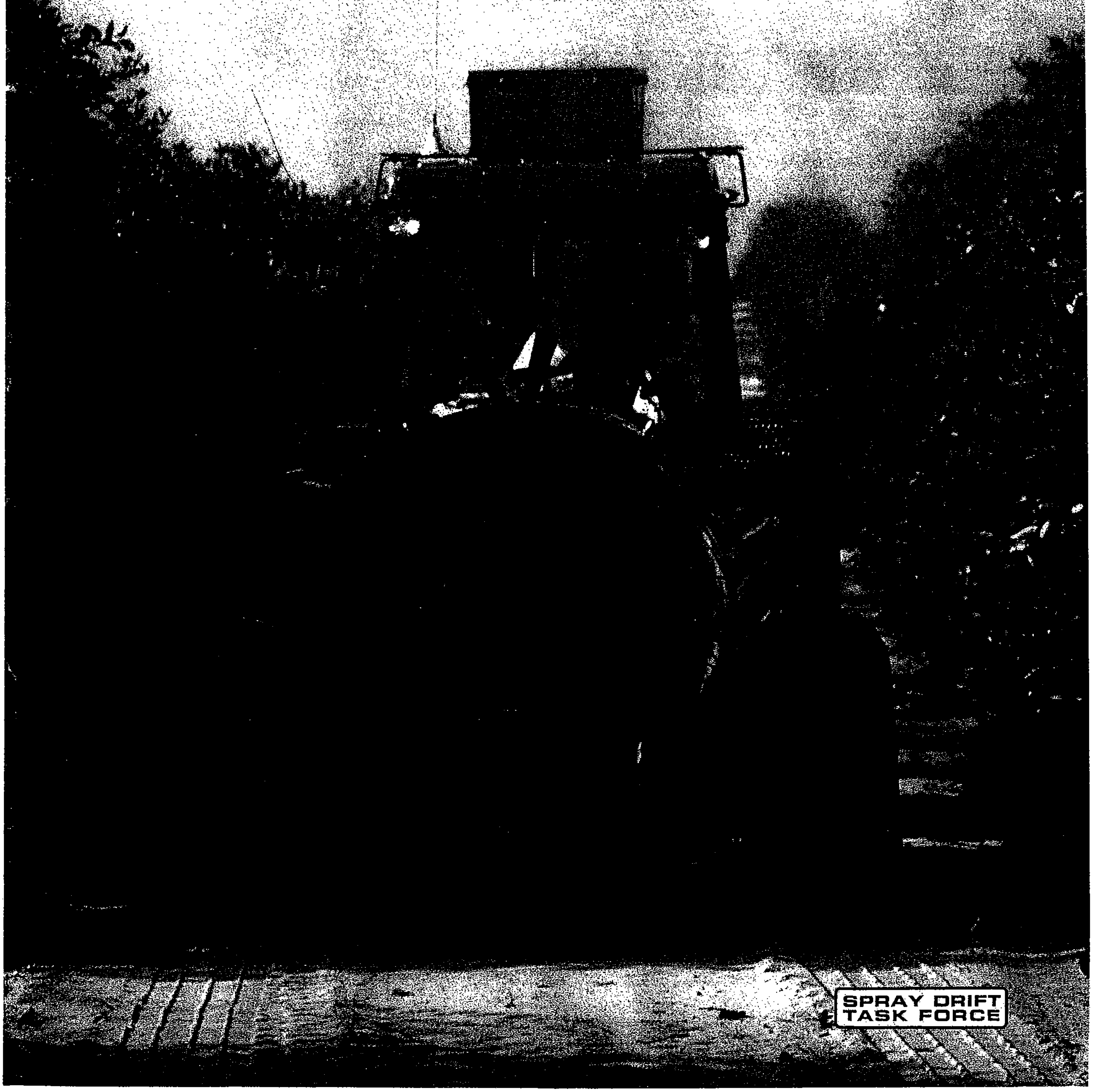
Soil Map Unit Symbol	Soil Map Unit Name	Acres	Proportion	Capability Grouping LCC	LCC Rating	LCC Score	Storie Index			Project Size Score			Meets Gov Code 56064 Prime Ag Land Definition
							Index Rating	Index Score	Soil Grade	LCC Class I-II	LCC Class III	LCC Class IV-VIII	
MeA	Metz loamy sand	0.699225	0.015	IIIs-4	60	0.88	64	0.935			0.699225		
MsA	Mocho clay loan 0-2 percent slopes	6.948304	0.145	I-1	100	14.5	85	12.34		6.948304			Storie Index rating of 100
PcA	Pico sandy loam	38.94286	0.813	IIs-4	80	65.07	86	69.947		38.94286			Yes- Class II soil
PsA	Pico sandy loam substratum	1.289008	0.027	IIIs-0	60	1.62	76	2.05			1.29		
	Total	**47.88**	**1.000**			**82.07**		**85.263**		45.89	1.99	0.00	
	Total meeting Gov Code Prime Ag Definition	**45.89**							**Project Size Scores**	**80**	**0**	**0**	

APPENDIX D

Spray Drift Task Force report Summaries

A SUMMARY OF

Airblast Application Studies



SPRAY DRIFT TASK FORCE

Introduction

The incidence and impact of spray drift can be minimized by proper equipment selection and setup, and good application technique. Although the Spray Drift Task Force (SDTF) studies were conducted to support product registration, they provide substantial information that can be used to minimize the incidence and impact of spray drift. The purpose of this report is to describe the SDTF orchard airblast application studies and to raise the level of understanding about the factors that affect spray drift.

The SDTF is a consortium of 38 agricultural chemical companies established in 1990 in response to Environmental Protection Agency (EPA) spray drift data requirements. Data were generated to support the reregistration of approximately 2,000 existing products and the registration of future products from SDTF member companies. The studies were designed and conducted in consultation with scientists at universities, research institutions, and the EPA.

The purpose of the SDTF studies was to quantify primary spray drift from aerial, ground hydraulic, airblast and chemigation applications. Using a common experimental design, more than 300 applications were made in 10 field studies covering a range of application practices for each type of application.

The data generated in the field studies were used to establish quantitative databases which, when accepted by EPA, will be used to conduct environmental risk assessments. These databases are also being used to validate computer models that the EPA can use in lieu of directly accessing the databases. The models will provide a much faster way to estimate drift, and will cover a wider range of application scenarios than tested in the field studies. The models are being jointly developed by the EPA, SDTF and United States Department of Agriculture (USDA).

Overall, the SDTF studies confirm conventional knowledge on the relative role of the factors that affect spray drift. Droplet size was confirmed to be the most important factor. The studies also confirmed that the active ingredient does not significantly affect spray drift. The physical properties of the spray mixture generally have a small effect relative to the combined effects of equipment parameters, application technique, crop canopy and the weather. This confirmed that spray drift is primarily a generic phenomenon, and justified use of a common set of databases and models for all products. The SDTF developed an extensive database and model quantifying how the liquid physical properties of the spray mixture affect droplet size.

The SDTF measured primary spray drift, the off-site movement of spray droplets before deposition. It did not cover vapor drift, or any other form of secondary drift (after deposition), because secondary drift is predominantly specific to the active ingredient.

Prior to initiating the studies, the SDTF consulted with technical experts from research institutions around the world and compiled a list of 2,500 drift-related studies from the scientific literature. Because of differing techniques, it was difficult to compare results across the studies. However, the information from these references was useful in developing test protocols that were consistently followed throughout the field studies.

The objective of the orchard airblast studies was to quantify drift from a range of orchard types, environmental conditions, and sprayer types. Because the spray plume from airblast sprayers is often very visible, a perception existed that there was a high level of drift from most orchard airblast applications. However, the amount of drift measured from most orchard types was relatively low. Although these results were consistent with other orchard drift studies in the published literature, the SDTF conducted additional studies to better understand how factors such as canopy characteristics and sprayer type affect the amount of drift.

The information being presented is not an in-depth presentation of all data generated by the SDTF. Use of pesticide products is strictly governed by label instructions. Always read and follow the label directions.

Procedures

Test site location and layout

Applications were made to grapes, apples (foliated and dormant), almonds, and oranges located in the southwest corner of the San Joaquin Valley of California. A pecan study was conducted in southwest Georgia and grapefruit (full-sized and young trees) studies were conducted on the central east coast of Florida.

The test application area consisted of the outside six rows (12 rows for grapes) of commercial orchards (figure 1). Within each six row area, applications were made separately to the three inner and outer rows. The inner rows always contributed less drift than the outer rows. Therefore, in this report the drift from the inner and outer rows was combined to give the total for all six rows.

Aerial View of Test Site

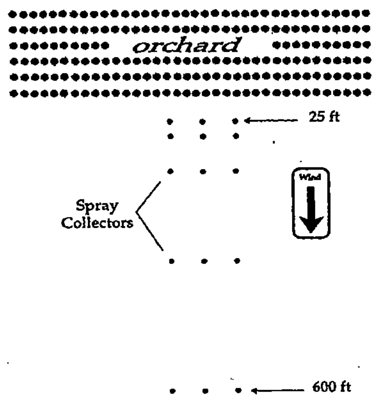


figure 1

Three lines of horizontal alpha-cellulose (absorbent material similar to thick blotting paper) were placed on the ground at selected intervals from 25 feet to 600 feet downwind from the edge of the orchards. These collectors simulated the potential exposure of terrestrial and aquatic habitats to drift.

Ground deposition measurements began 25 feet downwind because this was a typical distance from the edge of the trees to the true edge of the orchard. In the initial studies (California), ground deposition measurements were made to 1800 feet downwind. However, because there were normally no measurable levels of ground deposition beyond 600 feet, sampling stopped at this distance in the later studies.

Findings

Typical drift levels from orchard airblast application

The goal of orchard airblast applicators is to protect crops from diseases and insects, while keeping drift as close to zero as possible. The SDTF studies show that drift can be kept very low by using good application procedures.

Based on data generated by the SDTF, in a typical orchard airblast application to a 1200 feet wide grove of oranges, over 99% of the applied active ingredient stays on the crop and less than 0.5% drifts (figure 2).

Typical Orchard Airblast Application

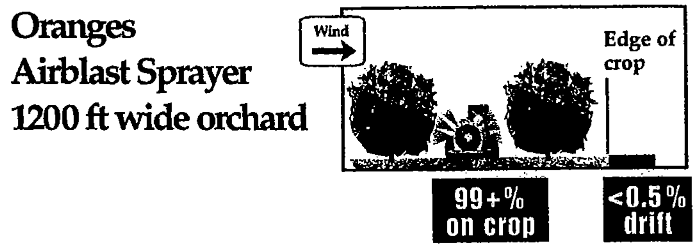


figure 2

Although airblast applications are commonly made in orchards at least 1,200 feet wide, using an application area of this size was not practical. Instead, six row sections of orchards (12 rows in grapes) were used in the SDTF studies. This design generated data representative of larger orchards because most drift originates from the outer rows.

Because the application area was smaller than for a typical orchard, and because most drift comes from the outer downwind rows, the percentage of active ingredient deposited on the ground downwind of the grove in the SDTF studies was approximately 4% (figure 3), rather than 0.5%. This percentage of drift is artificially high due to the relative size and location of the application areas.

SDTF Application to Oranges

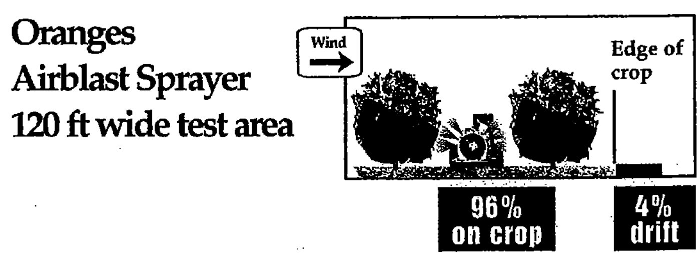
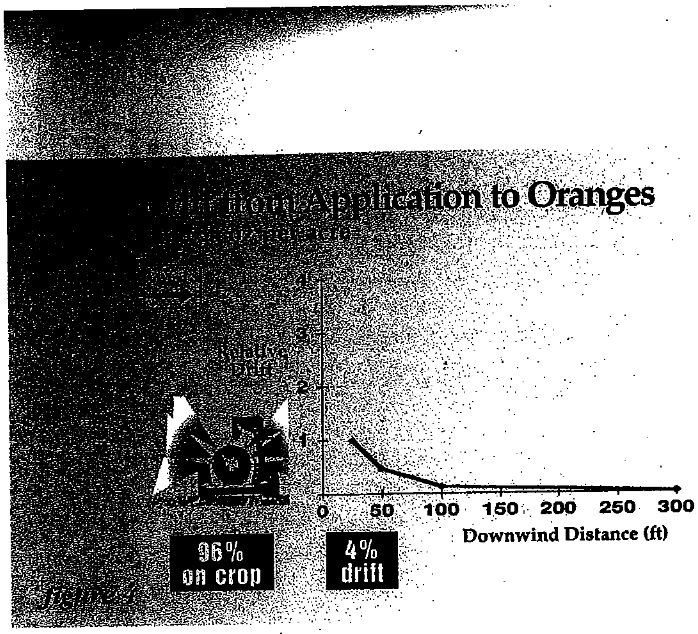


figure 3

Figure 4 shows how the 4% of drift from the outer six rows of the California orange grove deposited downwind. The amount of material deposited on the ground decreased rapidly with distance and approached zero at 100 feet downwind.



A scale of relative drift is used in this and subsequent graphs to facilitate comparisons among treatments. The deposition from California oranges will be used as a standard of comparison, and was set to 1.0 at 25 feet. For an application of one pound of active ingredient per acre, this represents 0.55 ounces per acre deposited on the ground at 25 feet. A Relative Drift value of 0.5 indicates that one-half as much was deposited. A value of 2 indicates that twice as much was deposited.

In figures 5, 10, 16, 18, 20 and 23 the deposition profile for California oranges was chosen as the standard for comparison because it represented an intermediate drift level relative to the other orchard scenarios that were tested. The deposition profile for oranges is always shown in red. In this report, ground deposition measurements are only shown to 300 feet downwind in order to better illustrate the differences among treatments.

How orchard type affects ground deposition

Figure 5 shows the ground deposition data from the alpha cellulose cards for each orchard type tested. The highest levels of ground deposition occurred from dormant apples where there was no foliage to intercept the spray droplets, and from a young grapefruit grove where there were relatively large gaps between trees. Ground deposition was approximately 22 times greater at 25 feet from dormant compared to foliated apples, and three times greater from young grapefruit trees compared to mature grapefruit trees.

The highest drift from a mature, fully foliated crop came from pecans due to their great height. The next highest drift came from grapefruit and oranges, whose dense foliage forced spray droplets over the tops of the trees. Almonds, the second tallest crop, was next. Almonds had less dense foliage than citrus which acted as an effective filter. The lowest drift came from apples and grapes, the shortest crops evaluated. The ground deposition from apples was approximately five times less than from the California oranges at 25 feet downwind.

How orchard type affects ground deposition

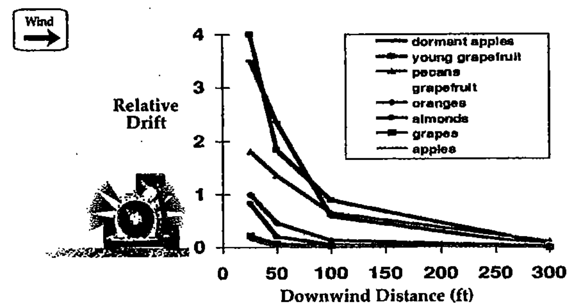


figure 5

Vertical deposition profile

A special series of applications was used to better understand how canopy characteristics influence the movement of spray droplets within, and subsequently outside, different orchard types. In these applications, the sprayer made a single pass between two rows (figure 6). Three vertical string collectors were suspended from 40-foot (12 meters) towers that were placed after the first five downwind rows to measure the vertical deposition profile. The string collectors were cut and analyzed in one-meter increments. Data in this report are presented as the average amount of active ingredient collected on each one-meter section of the three string collectors. On all vertical profile graphs (figures 7, 8, 9, 11, 12, 14, 15, 17, 19, 21, 22) the horizontal axis indicates the percentage of applied active ingredient. Because the scale changes radically among the graphs, the 1% level is always highlighted in red in order to facilitate comparisons.

Single Row Application (Orchard)

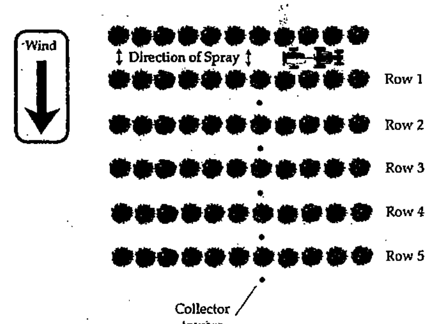


figure 6

Although the interaction of many canopy-related factors effect the amount of drift from orchards, results from the SDTF attempted to separate effects due to 1) height and shape, 2) foliage density, and 3) space between trees.

How canopy height and shape affect drift

Grapes

The grape vines formed continuous rows of foliage approximately 6 feet tall. Since the vines were substantially shorter than the trees, the string collectors only extended to 20 feet (6 meters). The row spacing in grapes was narrower than the tree crops tested, so string collectors were placed every two rows to keep the distance between the collectors relatively constant.

Most of the spray moving past the first two rows was above the top of the vines (figure 7). However, at no height did it exceed 0.75 % of the total applied active ingredient. As with all the crops tested, the amount of spray moving through the vineyard decreased rapidly, and never exceeded 0.06% of the applied active ingredient at any height after the tenth row. This was due to a combination of droplet settling, and the filtering effect of the foliage.

Vertical Deposition Profile 2, 4 and 10 Rows Beyond Sprayer
(Grapes, Airblast Sprayer)

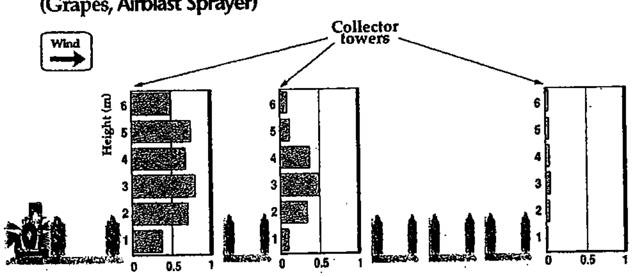


figure 7

Apples

The apple trees used in the SDTF studies were approximately 14 feet (4 meters) tall with open areas at the bottom, no distinct gaps between trees, and a moderately dense canopy. For apples, and the rest of the orchards tested, the string data were collected between each row to a height of 12 meters.

Most of the spray passing the first row moved through the open space under the trees. The highest amount measured was less than 2.5%, compared to 0.75% in grapes (figure 8). However, because these higher levels were measured relatively close to the ground, the majority of the droplets deposited before passing the second row. Therefore, the vertical profile beyond the second row was very similar to that from grapes. This explains why the downwind ground deposition was very low for both apples and grapes.

Vertical Deposition Profile 1, 2 and 5 Rows Beyond Sprayer
(Apples, Airblast Sprayer)

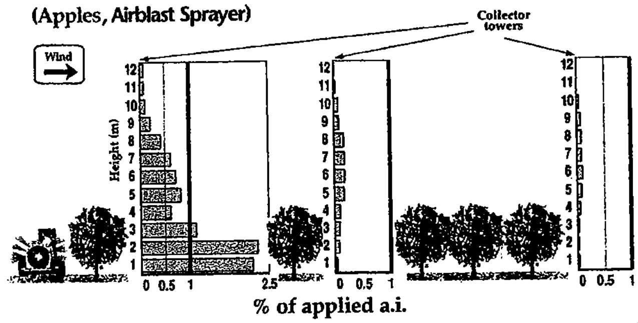


figure 8

Almonds

The almond trees used in the field studies were approximately 26 feet (8 meters) tall, with a relatively diffuse canopy, and large open areas beneath the trees.

As with apples, most of the spray moved past the first row under the trees, and deposited on the ground before passing the second row (figure 9). Due to the greater amount of open area under the canopy, the highest amount measured was close to 4%, as compared to approximately 2.5% in apples. The amount of spray passing over the top of the trees was similar to that measured for apples, but was at a greater height above the ground. This helps explain why the downwind ground deposition was greater than from the apples and grapes. As with the other crops, the vertical profile of the spray reflects the size and shape of the canopy.

Vertical Deposition Profile 1, 2 and 5 Rows Beyond Sprayer
(Almonds, Airblast Sprayer)

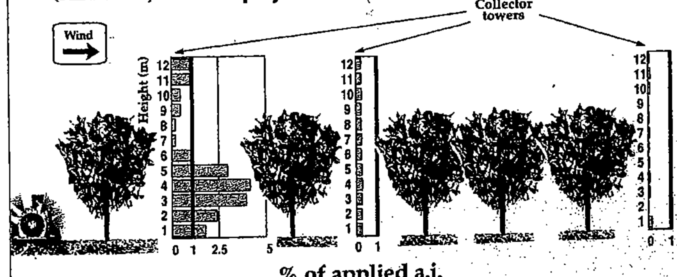


figure 9

Pecans

Pecans are the tallest orchard (nut) crop grown in the U.S. The average height of the trees in the SDTF studies was 68 feet (21 meters), which made the use of vertical string collectors impractical. However, the ground deposition levels outside the orchard were substantially higher than for almonds. Logically, this was due to the droplets being propelled to a greater height above the ground.

Summary

Although drift from orchards is due to the interaction of many canopy-related factors, downwind ground deposition tended to increase with increasing tree height (figure 10).

How canopy height and shape affect ground deposition

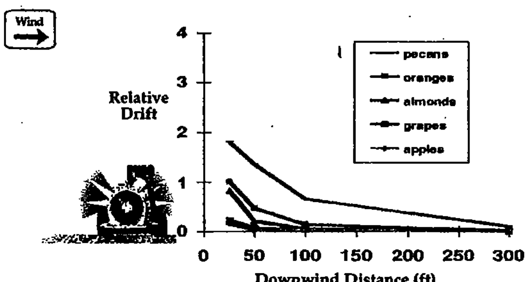


figure 10

How foliage density affects drift

Oranges

A dominant factor influencing drift from oranges and grapefruit is foliage density. Orange trees in the SDTF studies averaged 17 feet (5 meters) in height, with a very dense canopy extending close to the ground, and small gaps between the trees.

Compared to apples and almonds, less spray moved under and through the canopy, but up to three times more moved over the tops of the trees (figure 11). The relatively dense, continuous canopy appears to deflect more of the airflow from the sprayer over the top of the trees. This airflow carries droplets that would not normally have the momentum to rise above the trees. Therefore, the amount of ground deposition outside the orange groves tends to be higher than might be expected from trees of this height.

Vertical Deposition Profile 1, 2 and 5 Rows Beyond Sprayer
(Oranges, Airblast Sprayer)

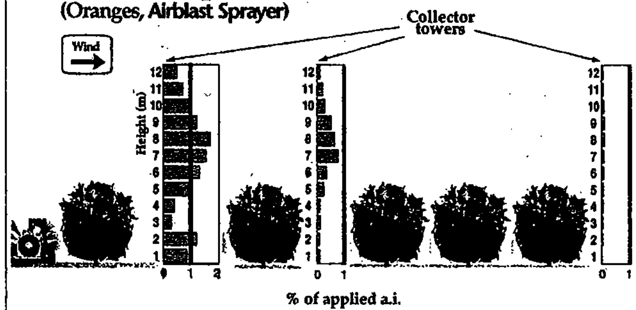


figure 11

Grapefruit

Canopy density in the Florida grapefruit was similar to the California oranges. However, the dense foliage formed a more solid wall because there were virtually no gaps between the trees.

The vertical profile measured in the grapefruit was similar to the oranges, but approximately twice as much spray moved over the tops of the trees (figure 12). This increase may have been due in part to the lack of gaps between trees. However, there is another factor that probably had a much greater influence on the amount of drift from the grapefruit versus the oranges.

The Florida grapefruit trees were grown on raised beds to facilitate irrigation and drainage (figure 13). This resulted in a 2 foot to 3 foot difference in the height of the sprayer as it passed between alternate rows. Since the sprayer was adjusted to reach the top of the trees from the lower position, a portion of the spray was directed above the trees when in the higher position. In comparison, the California orange grove was on flat ground.

Vertical Deposition Profile 1, 2 and 5 Rows Beyond Sprayer
(Grapefruit, Airblast Sprayer)

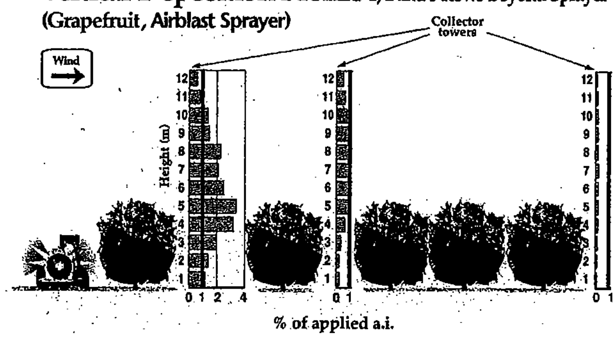


figure 12

Florida Grapefruit Grove

(Typical airblast application)

igure 13

Dormant Apples

Compared to citrus, dormant apples are at the opposite extreme of foliage density. The same apple orchard that was tested with full foliage was also tested when dormant (no foliage). Because of the lack of foliage, dormant apples were the only crop tested in which wind speed had a substantial effect on the vertical and ground deposition profiles. This was because it was also the only situation where a change in the wind speed outside the orchard was reflected by a change in wind speed inside the orchard.

In a 4.4 mph wind, approximately five times more spray passed the first row in dormant compared to foliated apples (figures 14 and 15). However, because most of the spray was moving close to the ground, it deposited rapidly before moving very far downwind. At five rows downwind, the amount of spray measured from both dormant and foliated apples was very low. In a 12 mph wind, more of the spray moved above the dormant trees (figure 15) and approximately ten times more spray was measured after the fifth row than in a 4.4 mph wind.

Vertical Deposition Profile 1, 2 and 5 Rows Beyond Sprayer

(Dormant Apples, Airblast Sprayer)

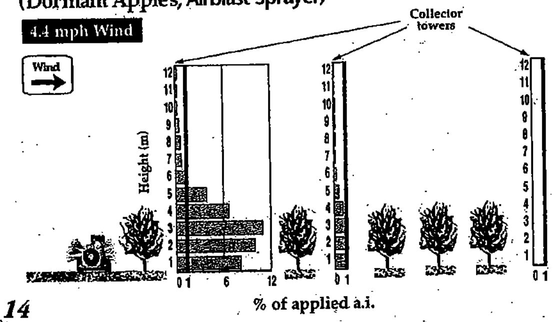


figure 14

Vertical Deposition Profile 1, 2 and 5 Rows Beyond Sprayer

(Dormant Apples, Airblast Sprayer)

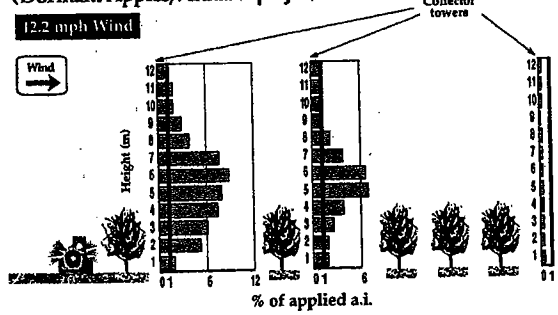


figure 15

Summary

Although the amount of drift from orchards results from the interaction of many canopy-related factors, figure 16 shows the differences in ground deposition that were due primarily to differences in foliage density. The greatest amount of downwind ground deposition was from dormant apples, where only trunks and branches intercepted droplets and modified the effects of the wind. Wind speed in the dormant apple ground deposition studies was intermediate between the 4.4 mph and 12 mph wind speeds measured in the vertical deposition studies.
In comparison, ground deposition from the same apple orchard with full foliage was close to the lowest level measured by the SDTF.

For oranges and grapefruit, the opposite was observed. The high foliage density, which might be expected to reduce drift, actually caused these crops to have a relatively high level of downwind ground deposition because the dense foliage deflected air from the sprayer over the tops of the trees. For grapefruit, the raised bed system also contributed to the higher level of ground deposition.

How foliage density affects ground deposition

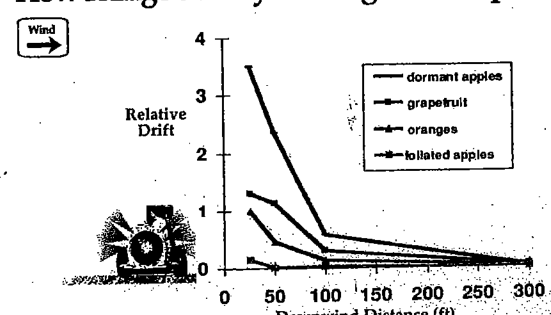


figure 16

How open spaces between trees affect drift

Young Grapefruit

The third canopy characteristic that affected drift was the amount of open spaces between trees. The most extreme example tested by the SDTF was a grove of young grapefruit trees. Average tree height was 7 feet, approximately one half the height of the mature trees. However, unlike the mature grapefruit trees that formed essentially a solid wall of foliage, there was a 5-foot open space (approximate) between each young tree. These are believed to be the smallest citrus trees sprayed with a standard airblast sprayer.

The vertical profile measured in the young grapefruit trees depended on whether the string collectors were located directly behind the trees, or in the gaps. Figure 17 shows that when the strings were directly behind trees, as indicated on the two graphs at the right, the vertical profile was similar to the mature trees. However, as would be expected, the vertical profile was very different when the string collectors were located between the trees. Most of the spray moving between the young grapefruit trees was relatively close to the ground, where it should have settled out relatively quickly. However, the combined amount of spray moving above and between the young trees resulted in approximately four times more ground deposition at 25 feet, than from the mature trees (figure 18). This difference had disappeared by 300 feet downwind.

Vertical Deposition Profile 1 Row Beyond Sprayer

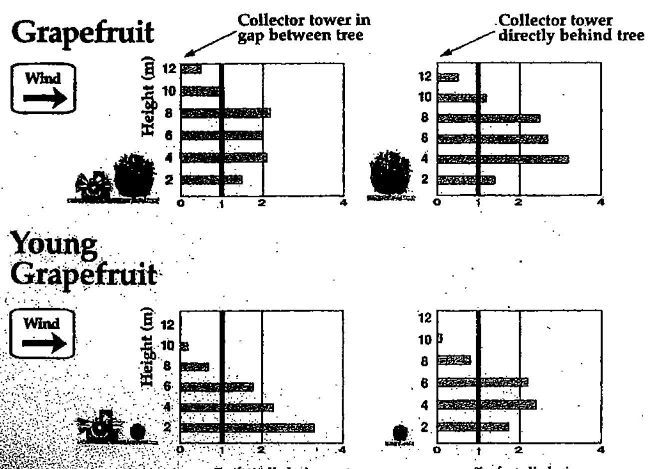


figure 17

How open spaces between trees affect ground deposition

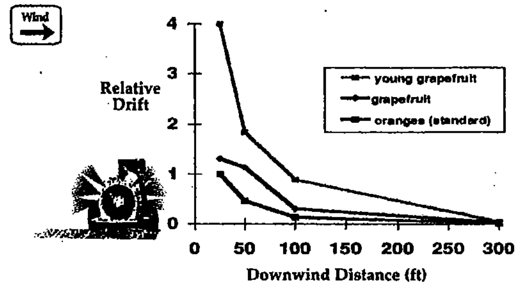


figure 18

How sprayer type affects drift

At the time of the SDTF studies, most orchard and vineyard sprays in the U.S. were applied with radial type airblast sprayers. However, the SDTF also included two other sprayer types, a "wrap-around" hydraulic sprayer used in vineyards, and a low volume "mist blower" used in orchards.

Wrap-Around Sprayer

The wrap-around sprayer has booms positioned horizontally over the tops of the rows and vertically along the sides. It uses hydraulic nozzles, sometimes at very high spray pressures. Unlike the airblast sprayer, there is no fan to increase air flow.

Figure 19 shows the vertical deposition profile two rows downwind from the airblast and wrap-around sprayers in grapes. Although the drift is very low for both sprayers, much less spray was collected from the wrap-around sprayer, particularly above the vines. The low amount of spray intercepted by the string was also reflected in the ground deposition outside the vineyard (figure 20). Ground deposition from the wrap-around sprayer was four times less than from the airblast sprayer at 25 feet downwind. If the major concern is minimizing drift, the wrap-around sprayer is clearly an effective alternative to the airblast sprayer.

Vertical Deposition Profile 2 Rows Beyond Sprayer
(Grapes)

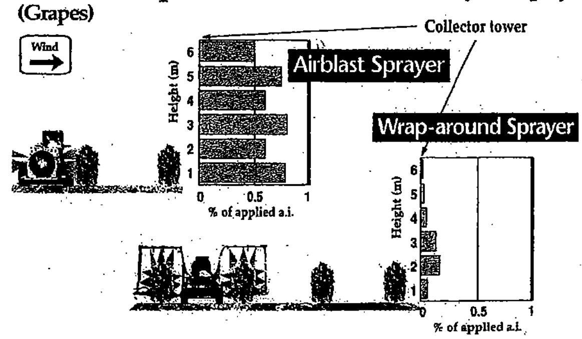


figure 19

How sprayer type affects ground deposition in grapes

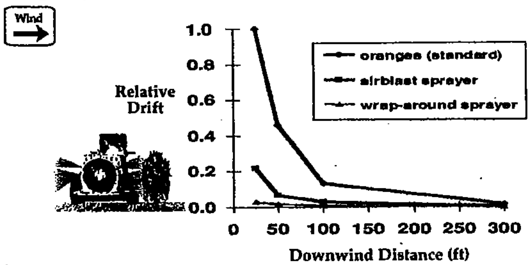


figure 20

Mist Blower

An Ag Tech Crop Sprayer was used to represent the "mist blower" class of sprayers. They typically produce a finer droplet size spectrum than airblast sprayers, and are used to apply lower volumes of 25 to 50 gallons per acre versus 60 to more than 800 gallons per acre.

Since different nozzle sizes are typically used around the arc on radial airblast sprayers and mist blowers, the SDTF measured the droplet size spectrum produced by each of the nozzles on both sprayers. The Volume Median Diameter (VMD) ranged from 138 microns to 210 microns for the airblast sprayer, and 73 microns to 110 microns for the mist blower. VMD is the droplet diameter at which half of the spray volume is composed of larger droplets and half is composed of smaller droplets. Therefore, VMD is essentially an average droplet size based on spray volume.

The percentage of the spray volume in droplets less than 141 microns in diameter (% volume <141 microns) ranged from 26% to 52% for the airblast sprayer, and 65% to 90% for the mist blower. The % volume <141 microns was selected because of the characteristics of the particle-measuring instrument, and because it is close to 150 microns, which is commonly considered a point below which droplets are more prone to drift.

Both the VMD and percent volume <141 microns confirm that the mist blower produced a finer droplet size spectrum, and a higher volume of very small drift-prone droplets. This helps explain the difference in vertical and ground deposition profiles observed for the two sprayers.

Summary

In the mature grapefruit grove the vertical deposition profiles were very different for the two sprayers at one row downwind from the sprayer (figure 21a). Overall, four times more spray was collected from the airblast sprayer. However, for the airblast sprayer, the amount of spray moving past the first row above the tops of the trees decreased with increasing height. For the mist blower, the amount of spray collected increased slightly with height.

At two rows downwind, more spray was still collected from the airblast sprayer, but the vertical profiles showed that a higher proportion of spray from the mist blower was moving at a greater height (figure 21b). At five rows downwind, the total amount collected from the two sprayers was similar, but the mist blower continued to show a higher proportion of the spray at a greater height (figure 21c).

Vertical Deposition Profile (Grapefruit)
1 Row Beyond Sprayer

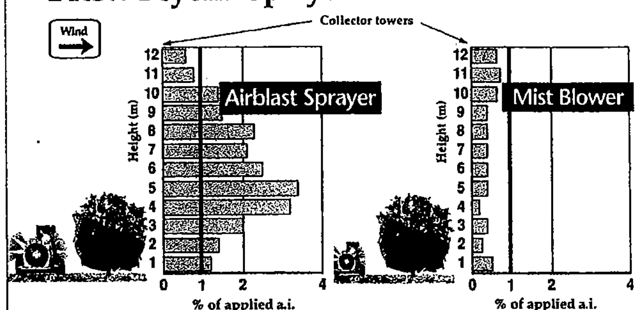


figure 21a

2 Rows Beyond Sprayer

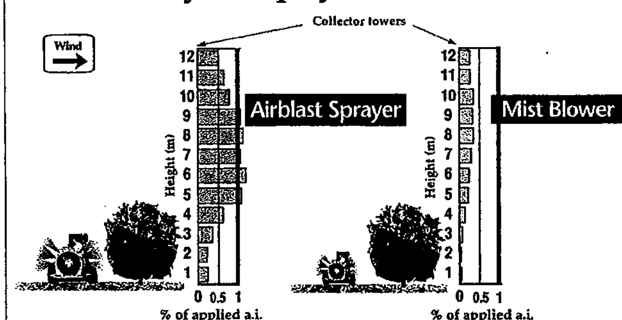


figure 21b

5 Rows Beyond Sprayer

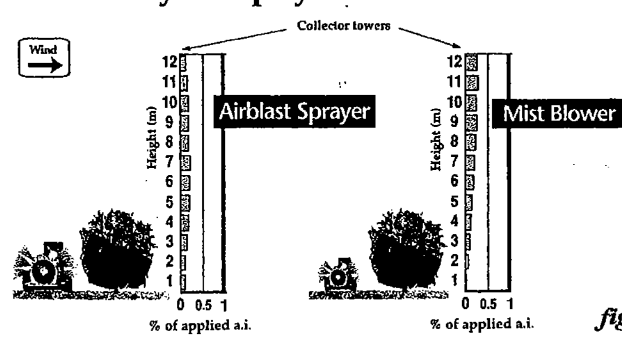


figure 21c

In the young grapefruit, the vertical deposition profile one row downwind was very similar for the two sprayers (figure 22a). However, at two rows downwind, more spray was collected at greater heights from the mist blower (figure 22b). This was the same pattern observed in the mature grapefruit, but the total amount collected was higher. At five rows downwind, considerably more spray was collected from the mist blower, particularly at the greater heights (figure 22c).

Vertical Deposition Profile (Young Grapefruit)
1 Row Beyond Sprayer

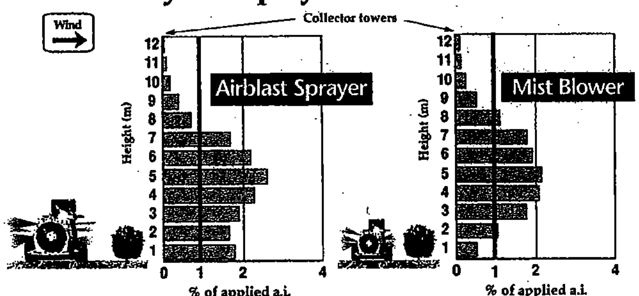


figure 22a

2 Rows Beyond Sprayer

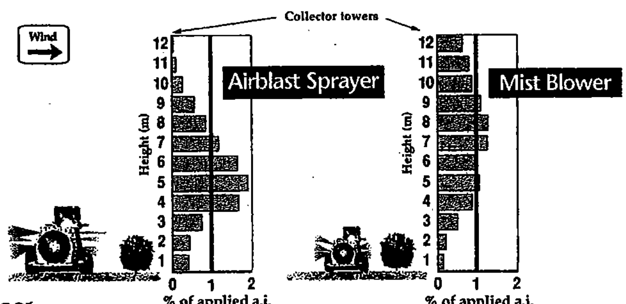


figure 22b

5 Rows Beyond Sprayer

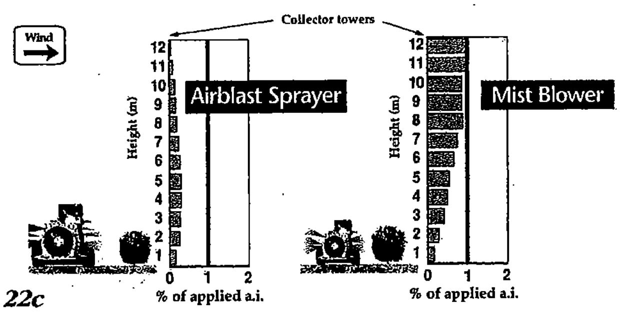


figure 22c

Figure 23 shows the ground deposition data for both sprayer types in young and mature grapefruit. Ground deposition was higher close to the edge of the grove from the airblast sprayer in both mature and young grapefruit. However, at distances beyond 300 feet downwind (data not shown) this relationship reversed and the amount of ground deposition was higher from the mist blower. This was most likely due to the higher volume of small droplets which remained suspended in the air over a longer distance. This conclusion is consistent with the vertical deposition profiles observed in mature and young grapefruit.

How tree size and sprayer affect ground deposition

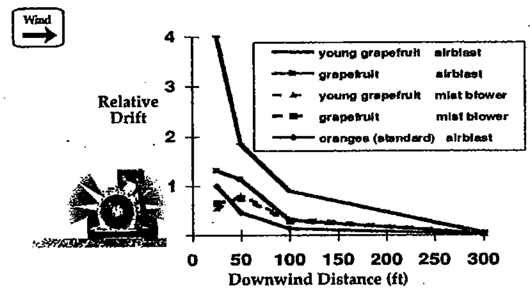


figure 23

Conclusions

Looking broadly at all types of application, droplet size is the most important factor affecting spray drift. However, for orchard airblast, the characteristics of the crop canopy tend to be of at least equal importance since, unlike most other types of application, the spray is always released from within, rather than above the canopy.

The potential for drift is due primarily to the interaction between droplet size and the canopy characteristics: height and shape, foliage density, and the amount of open space between trees. Wind speed tends to increase in importance as the amount of foliage decreases.

The amount of drift from orchard airblast applications was found to be much lower than is often perceived. There are several reasons for this apparent discrepancy.

a. The relatively high application volumes result in very visible spray plumes, which are comprised primarily of larger droplets that settle out before drifting from the site.

b. The high spray volumes also result in relatively low concentrations, so that drifting droplets do not contain much active ingredient.

c. Most of the very small droplets that are capable of drifting long distances are either intercepted by the canopy, or do not have enough momentum to leave the site.

d. Most of the spray volume leaving a site is comprised of relatively large droplets that do not drift long distances.

e. The orchard canopies tend to reduce the effects of wind.

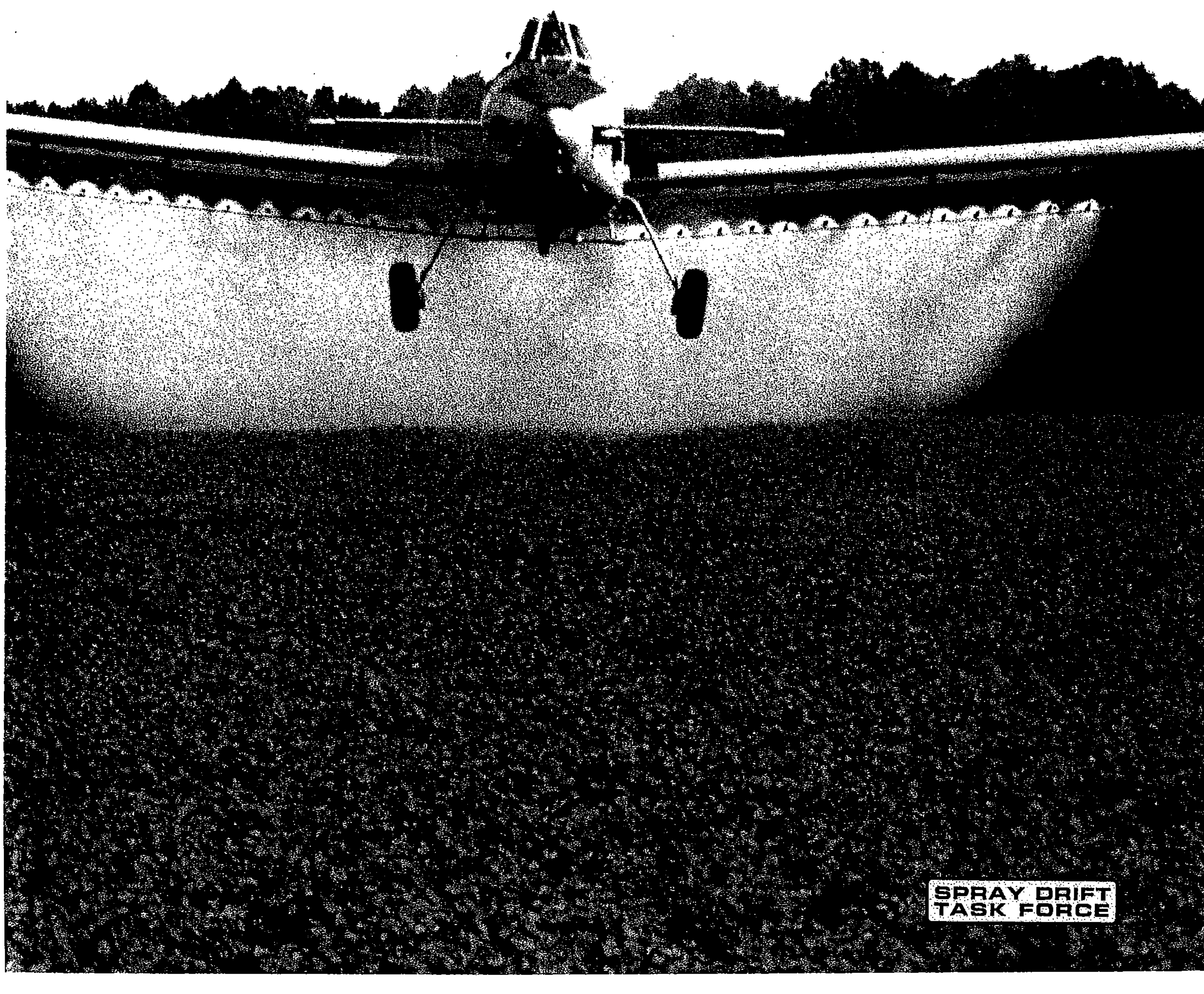
When accepted by EPA, the SDTF model and databases will be used by the crop protection industry and EPA in environmental risk assessments. Even though active ingredients do not differ in drift potential, they can differ in their potential to cause adverse environmental effects. Since drift cannot be completely eliminated with current technology, the SDTF database and models will be used to determine if the drift from individual crop protection products is low enough to avoid harmful environmental effects. When drift cannot be reduced to low enough levels by altering spray equipment set-up and application techniques, buffer zones can be imposed to protect sensitive areas downwind of applications.

Mention of a trademark, vendor, technique, or proprietary product does not constitute an endorsement, guarantee, or warranty of the product by the authors, their companies, or the Spray Drift Task Force, and does not imply its approval to the exclusion of other products or techniques that may also be suitable.

For more information contact David Johnson at Stewart Agricultural Research Services, Inc., P.O. Box 509, Macon, Missouri 63552. (660) 762-4240 or fax (660) 762-4295.

A SUMMARY OF

Aerial Application Studies



Introduction

The incidence and impact of spray drift can be minimized by proper equipment selection and setup, and good application technique. Although the Spray Drift Task Force (SDTF) studies were conducted to support product registration, they provide substantial information that can be used to minimize the incidence and impact of spray drift. The purpose of this report is to describe the SDTF aerial application studies and to raise the level of understanding about the factors that affect spray drift.

The SDTF is a consortium of 38 agricultural chemical companies established in 1990 in response to Environmental Protection Agency (EPA) spray drift data requirements. Data were generated to support the reregistration of approximately 2,000 existing products and the registration of future products from SDTF member companies. The studies were designed and conducted in consultation with scientists at universities, research institutions, and the EPA.

The purpose of the SDTF studies was to quantify primary spray drift from aerial, ground hydraulic, air blast and chemigation applications. Using a common experimental design, more than 300 applications were made in 10 field studies covering a range of application practices for each type of application.

The data generated in the field studies were used to establish quantitative databases which, when accepted by EPA, will be used to conduct environmental risk assessments. These databases are also being used to validate computer models that the EPA can use in lieu of directly accessing the databases. The models will provide a much faster way to estimate drift, and will cover a wider range of application scenarios than tested in the field studies. The models are being jointly developed by the EPA, SDTF and United States Department of Agriculture (USDA).

Overall, the SDTF studies confirm conventional knowledge on the relative role of the factors that affect spray drift. Droplet size was confirmed to be the most important factor. The studies also confirmed that the active ingredient does not significantly affect spray drift. The physical properties of the spray mixture generally have a small effect relative to the combined effects of equipment parameters, application technique, and the weather. This confirmed that spray drift is primarily a generic phenomenon, and justified use of a common set of databases and models for all products. The SDTF developed an extensive database and model quantifying how the liquid physical properties of the spray mixture affect droplet size.

The SDTF measured primary spray drift, the off-site movement of spray droplets before deposition. It did not cover vapor drift, or any other form of secondary drift (after deposition), because secondary drift is predominantly specific to the active ingredient.

Prior to initiating the studies, the SDTF consulted with technical experts from research institutions around the world and compiled a list of 2,500 drift-related studies from the scientific literature. Because of differing techniques, it was difficult to compare results across the studies. However, the information from these references was useful in developing test protocols that were consistently followed throughout the field studies.

The objective of the aerial field studies was to quantify drift from the range of application practices common in the early 1990s. Since some practices may have changed since then, it is important to recognize that the aerial model will use inputs based on current practices.

The information being presented is not an in-depth presentation of all data generated by the SDTF. Use of pesticide products is strictly governed by label instructions. Always read and follow the label directions.

Procedures

Test site location and layout

Two sites were chosen in Texas because they provided open expanses, up to one-half mile downwind from the application areas, and a wide range of weather conditions. Wind speeds varied from 2 mph to 17 mph, with an average of 10 mph across all applications. Air temperatures varied from 32°F to 95°F and relative humidity varied from 7% to 94%.

Aerial View of Test Site

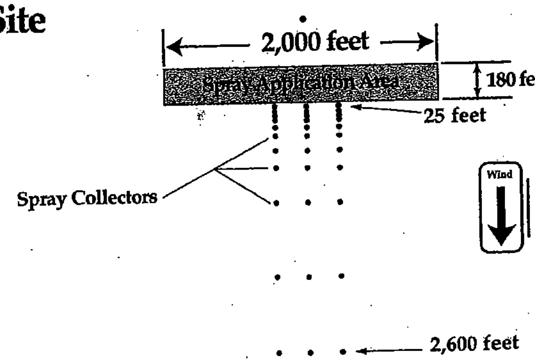


figure 1

The test application area measured 2,000 feet in length and 180 feet in width (figure 1). Four, 45-foot wide parallel swaths were sprayed going from left-to-right and right-to-left. Three lines of horizontal alpha-cellulose cards (absorbent material similar to thick blotting paper) were placed on the ground at 12 selected intervals from 25 feet to 2,600 feet downwind from the edge of the application area. These collectors simulated the potential exposure of terrestrial and aquatic habitats to drift. A collector was also positioned upwind from the application area to verify that drift only occurs in a downwind direction.

Relating droplet size spectra to drift

All agricultural nozzles produce a range of droplet sizes known as the droplet size spectrum. In order to measure the droplet size spectrum that was applied in each field study treatment (and that represent those produced from commercial applications), the critical application parameters (nozzle type, orifice size, pressure, angle, and air speed) were duplicated in an extensive series of atomization tests conducted in a wind tunnel. The controlled conditions of the wind tunnel allowed the droplet size spectrum to be accurately measured using a laser particle measuring instrument.

The volume median diameter (VMD) is commonly used to characterize droplet size spectra. It is the droplet size at which half the spray volume is composed of larger droplets and half is composed of smaller droplets. Although VMD is useful for characterizing the entire droplet spectrum, it is not the best indicator of drift potential.

A more useful measure for evaluating drift potential is the percentage of spray volume consisting of droplets less than 141 microns in diameter. This value was selected because of the characteristics of the particle-measuring instrument, and because it is close to 150 microns, which is commonly considered a point below which droplets are more prone to drift.

The cut-off point of 141 microns or 150 microns has been established as a guide to indicate which droplet sizes are most prone to drift. However, it is important to recognize that drift doesn't start and stop at 141 microns. Drift potential continually increases as droplets get smaller than 141 microns, and continually decreases as droplets get bigger.

The wind tunnel atomization tests verified that a broad range of droplet size spectra was applied in the field study treatments. These measurements were critical to understanding the differences in spray drift that were measured for each field study treatment.

Other factors affecting drift

Other variables that were tested include: nozzle heights from 6 feet to 31 feet above the ground; boom lengths of 69% and 84% of the wingspan; oil as a carrier for the ultra low volume (ULV) applications; the effects of liquid physical properties of the pesticide spray mixture; and the effects of crop canopy.

Weather-related factors including wind speed and direction, and air temperature were recorded during the field trials at four separate heights between 1 and 30 feet. Relative humidity, solar radiation, barometric pressure, and atmospheric stability were also recorded.

Experimental design

The varying weather conditions encountered during multiple-application field studies presented a good opportunity to evaluate their effects on drift. However, these variations complicated efforts to measure the effects of equipment-related factors. For example, if a treatment using 8002 nozzles (producing a fine droplet spectrum) was run during low wind speeds, and then a treatment using D8 nozzles (producing a coarse droplet spectrum) was run during high wind speeds, the amount of drift would have been affected both by the change in droplet size and the wind speed.

To factor out the meteorological effects, the SDTF used a covariate experimental design, which is a commonly accepted statistical technique for this type of study. The design entailed a control treatment that was always applied immediately after an experimental treatment. The control treatment was a medium droplet size spectrum produced with D6-46 nozzles at a 45° angle on a fixed-wing airplane traveling at 110 mph. It was always applied in exactly the same manner. The experimental treatment differed from application to application in nozzle type, nozzle orifice size, aircraft speed, etc.

The primary test airplane, a Cessna Ag Husky®, was equipped with a dual application system (tank, pump and boom) that permitted successive applications of the control and experimental treatments without landing. The two booms were never used simultaneously in order to avoid any potential interference between the sprays.

Four swaths of the experimental treatment were applied first, beginning at the downwind side. The control treatment was then immediately applied over the same area. The total elapsed time for both applications was 12 minutes. Continuous weather monitoring showed no appreciable changes in atmospheric

Typical Aerial Application

Air Tractor 401®
1200 ft wide field
Medium spray
10 mph crosswind
60 ft swath adjustment
8 ft nozzle height

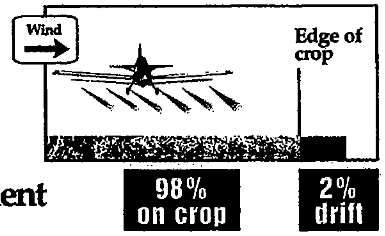


figure 2

conditions during the 12 minute periods. The downwind collectors were analyzed for both diazinon (the tracer used with the control treatment) and malathion (the tracer used with the experimental treatment).

Using this experimental design, differences between replications of the control treatments are due only to atmospheric conditions, since the application procedures were always the same. Differences between experimental treatments are due to changes in the atmospheric conditions and application procedures. Consequently, differences between experimental and control treatments are due to application procedures. This allowed direct comparisons to be made among all the experimental treatments by factoring out the effects of weather (as measured by the control applications).

A total of 90 experimental (45 treatments, 2 replicates each) and a corresponding 90 control applications were made. Besides providing a means of adjusting for atmospheric conditions, the 90 applications of the control treatment also provided an extensive database for evaluating the effects of meteorological parameters on drift.

Aerial drift model

Due to the complexity of evaluating all possible interactions of the numerous application variables, a computer model is the most practical way to conduct spray drift risk assessments. For aerial application, a highly sophisticated simulation model had been developed previously by the USDA Forest Service for forestry applications. The SDTF, EPA and USDA worked together to adapt and validate this model for agricultural applications using the data generated in the SDTF field and atomization studies. After final review and acceptance by the EPA, this model will allow evaluation of a much wider range of applications than those tested in the field studies. Its use will help ensure that SDTF assessments reflect current application practices.

Because so many interacting factors affect aerial spray drift, this report only offers examples of how the major variables affect drift.

Findings

Typical drift levels from aerial application

The goal of aerial applicators is to protect crops from diseases, insects and weeds while keeping drift as close to zero as possible. The SDTF studies show that drift can be kept very low by using good application procedures.

Based on data generated by the SDTF, in a typical full field aerial application, 98% of the total applied active ingredient stays on the field and only 2% drifts (figure 2). A typical application was defined as a 1200-foot wide, 20-swath field (suggested by EPA) using an Air Tractor 401® set-up to produce a medium droplet spectrum, in a 10 mph crosswind (typically the maximum allowable wind speed), a 60-foot swath adjustment, and 8-foot nozzle height (application height).

Average SDTF Control Application
(90 replicates)

Cessna Ag Husky®
180 ft wide field
Medium spray
10 mph crosswind
50 ft swath adjustment
8 ft nozzle height

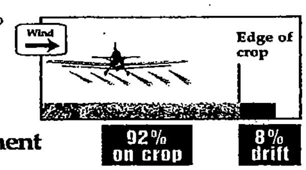


figure 3

Although aerial applications typically consist of twenty or more swaths, using fields of this size was not practical. Instead, a four-swath (180 feet wide) application area was used in the field studies. This design generated data that represented drift from a 20-swath field since most drift originates from the farthest downwind swaths.

Because the application area was smaller than is typical for commercial applications, and because most drift comes from the outer swaths of the field, the percentage of the active ingredient leaving the field in the SDTF studies was 8% rather than 2% (figure 3). This percentage of drift is artificially high due to the relative size of the application areas. The 8% drift is the average of the 90 applications of the control treatment. The SDTF control application differed from the typical application only in the aircraft used, swath width, and the size of the application area.

Figure 4 shows how the 8% of the control treatment that left the field deposited downwind. The amount of material that deposits on the ground decreases rapidly with distance and is already approaching zero at 250 feet downwind. Ground deposition was measured out to one-half mile downwind, but the amount of material was normally too low beyond 250 feet to illustrate any differences between treatments..

Drift from the SDTF Control Application
1.0 = 1.2 oz per acre

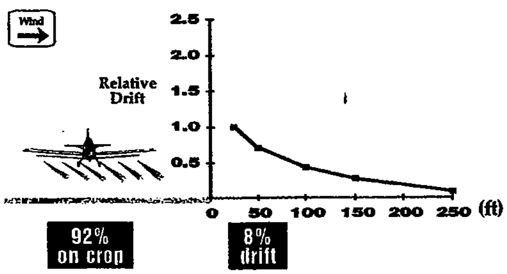


figure 4

Ground deposition measurements began 25 feet downwind, which represents a reasonable distance from the edge of a crop to the effective edge of a field where drift would begin to be of concern.

A scale of Relative Drift is used in this and all subsequent graphs to facilitate comparisons among treatments. Since the control treatment will be used as a standard of comparison, it was set to 1.0 at 25 feet. For an application of one pound of active ingredient per acre, this represents 1.2 ounces per acre deposited on the ground at 25 feet. A Relative Drift value of 0.5 indicates that one-half as much was deposited. A value of 2 would indicate twice as much was deposited. In subsequent graphs the deposition profile for the control treatment is shown in red in order to facilitate comparisons.

How swath adjustment reduces drift

When the wind is low, virtually all of the spray is deposited directly under the aircraft allowing the pilot to fly close to the edge of the field (figure 5a). With a crosswind, the spray swath is displaced downwind (figure 5b). Pilots typically compensate for this swath displacement by adjusting the position of the aircraft upwind (figure 5c). The amount of swath adjustment can vary from one half, to more than two swath widths, depending upon wind speeds and proximity to sensitive areas.

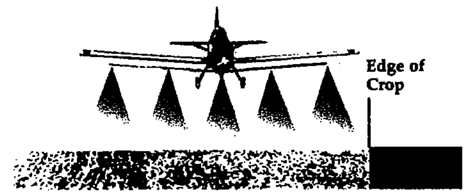


figure 5a

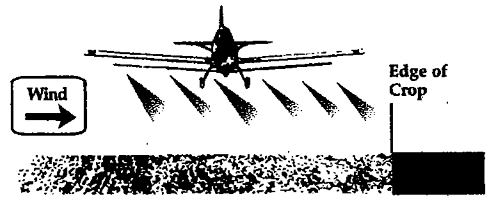


figure 5b

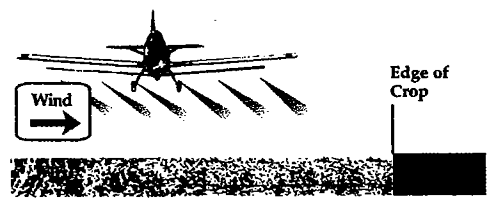


figure 5c

In order to maintain consistency across all applications in the SDTF field studies, the pilot made no swath adjustment. However, in this report a swath adjustment was applied by mathematically shifting the deposition curve upwind by 50 feet. This would be a typical swath adjustment in a 10-mph crosswind, the average wind speed in the field studies.

The effects of swath adjustment are illustrated in figure 6 for no adjustment, a half swath adjustment, and a full swath adjustment as applied for the control treatment. With no swath adjustment, the amount of spray material depositing at 25 feet downwind is approximately three and a half times that from a full swath adjustment. Swath adjustment substantially reduces drift, especially in the first 100 feet. These results are for a medium droplet size spectra from the control

How swath adjustment affects drift
Control Application

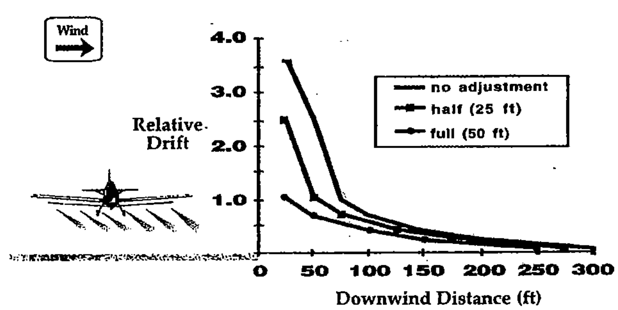


figure 6

treatment. The effects would be even more dramatic with a finer droplet spectrum.

How nozzle and droplet size affect drift

The effect of droplet size on downwind ground deposition is illustrated in figure 7. It shows that drift decreases dramatically as the percent of volume in droplets smaller than 141 microns decreases due to the use of different nozzles, nozzle angles, and/or air speeds.

The control treatment had 15% of the spray volume in small droplets (less than 141 microns). The smaller D4-45 nozzle at the same angle produced twice the volume of small droplets and twice the amount of drift at 25 feet. The solid stream nozzle (D8) at a 0° angle produced a much lower volume of small droplets and substantially less drift than the control.

How nozzle and droplet size affect drift

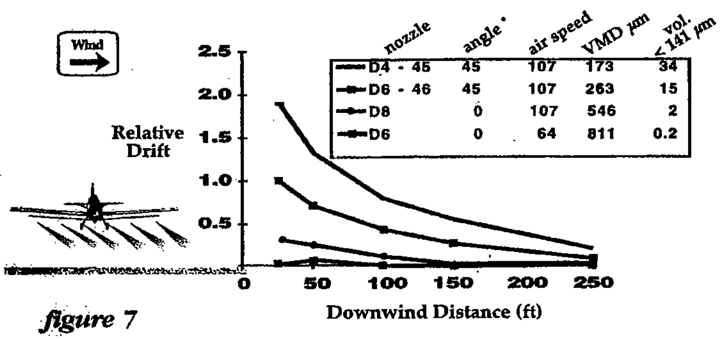


figure 7

Although droplet size was the primary factor affecting drift, the data for the D6 at 64 mph are not directly comparable because they were obtained with a helicopter instead of a fixed wing airplane. The helicopter data are included to illustrate that it is possible to reduce the percentage of small droplets to very low levels with a corresponding decrease in drift. The results show that pilots can minimize drift by managing the factors affecting droplet size.

How air shear affects droplet size and drift

Air shear across the nozzle tip, which is a function of both nozzle angle and aircraft speed, significantly affects droplet size. When nozzles are pointed toward the back of the plane, air shear is less than when the nozzles are pointed downward (figure 8). Air shear across the nozzle tip also increases with faster aircraft speeds, resulting in smaller droplets. The effect of air shear on droplet formation and drift was studied by

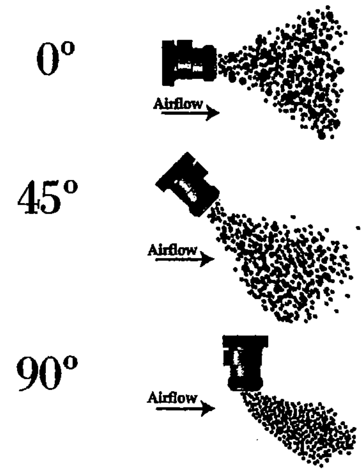


figure 8

setting up identical nozzles and nozzle angles on three aircraft: a helicopter, which flew at 64 mph; a piston-powered, fixed-wing airplane at 107 mph; and a turbine-powered, fixed-wing airplane at 156 mph. The nozzle height was 8 feet.

When the same nozzles (D6-46) were positioned at a 45° angle on all three aircraft, there were differences in drift due to air shear (figure 9). At 156 mph, 39% of the droplet volume was less than 141 microns. As speed and subsequent air shear decreased, the volume percent less than 141 microns decreased to 6% with a corresponding decrease in drift.

It must be emphasized that figure 9 illustrates the effect of air shear on droplet size and drift. It does not indicate that these are typical droplet spectra for each aircraft. Normally the sizes and/or angles of the nozzles are changed to compensate for the air shear at higher speeds.

How air shear affects drift

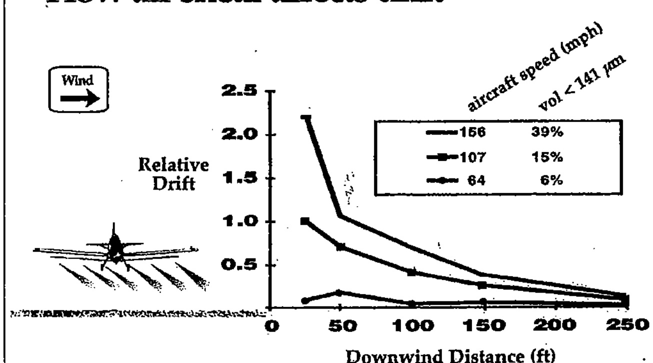


figure 9

How nozzle height affects drift

In aerial applications over agricultural crop areas, spray is typically released when the nozzles are about 8 feet above the ground or crop, compared with forestry and rangeland applications which are sometimes made at 20 feet or higher. Figure 10 compares drift from the control treatment when the nozzle height is changed from 8 feet to 22 feet. It shows that the higher nozzle height results in approximately 2.5 times more drift at 25 feet downwind.

How nozzle height affects drift
Control Application

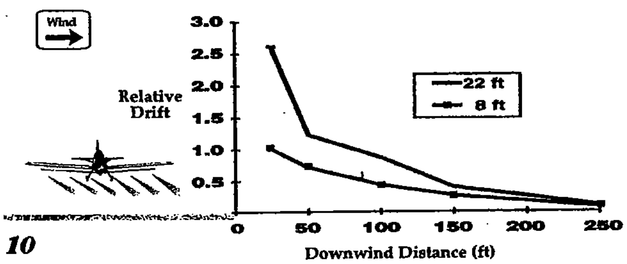


figure 10

With a finer droplet spectrum, this difference would have been greater; with a coarser droplet spectrum, the differences would have been less.

How boom length affects drift

Turbulent air, referred to as vortices, is created by the wings. Wing or rotor tip vortices exist on all aircraft. When the length of the boom is too long, spray droplets are caught in these vortices. The smaller droplets follow the air movement up and over the wing or rotor which effectively increases the application height and increases the potential for drift. When boom lengths are shortened, fewer droplets enter the vortices and drift is reduced.

How boom length affects drift
Model-generated data for Control Application

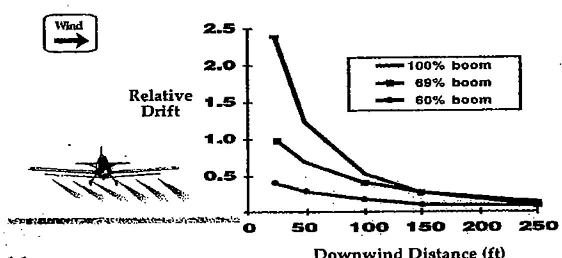


figure 11

Although the SDTF did not extensively test the effects of boom length on drift, the computer drift model affirms that the common practice of maintaining boom length at 70% or less of the wingspan minimizes drift (figure 11). The effect of boom length is more important when spraying a fine versus coarse droplet size spectrum.

How dynamic surface tension affects drift

Physical properties of the tank mixture can influence the formation of droplets by agricultural nozzles, although this effect is most important at higher levels of air shear.

The SDTF examined dynamic surface tension, shear viscosity, and extensional viscosity. Of these three physical properties, dynamic surface tension usually has the greatest influence on droplet size. Figure 12 represents the maximum range of drift attributable to dynamic surface tension for the SDTF control treatment. The 72 dynes/cm represents water, 32 dynes/cm represents the most extreme case, and 45 dynes/cm represents a large percentage of commercial pesticide tank mixtures.

These curves were generated by the computer drift model. Field study data confirmed that for the control treatment, physical properties had a very small effect on drift compared to equipment and application procedures.

How dynamic surface tension affects drift
Model-generated data

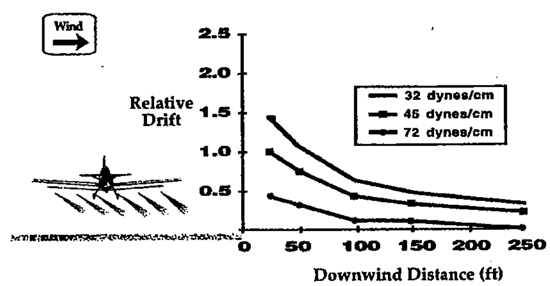


figure 12

How wind speed affects drift

The 90 replicates of the control applications clearly established that wind speed was the most important atmospheric factor affecting drift (figure 13). Although it is commonly accepted that hot, dry conditions accelerate droplet evaporation, which results in smaller droplets, this was not found to be as important as wind speed.

How wind speed affects drift
Control Application

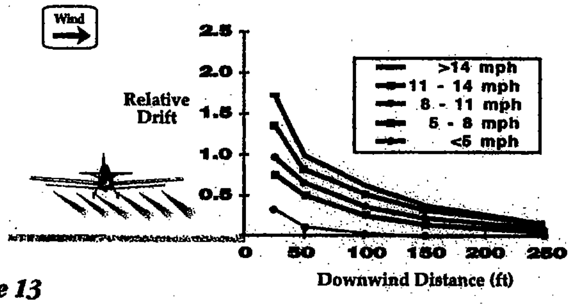


figure 13

How crop canopy affects drift

Ground cover in the application and drift collection areas consisted of short grass. A limited number of treatments were conducted over cotton to determine if there was a significant effect due to the presence of a more developed canopy. These treatments indicated a small decrease in downwind ground deposition over cotton.

Because the effect of canopy was extremely small, and because it was not practical to evaluate the infinite number of canopy shapes, heights, and densities, additional testing was not conducted. However, the treatments on cotton suggest that the SDTF field studies may slightly over-estimate drift for applications that are typically conducted over a well developed canopy.

Conclusions

The results from the SDTF studies confirm present knowledge concerning the role of factors that affect spray drift. In many cases the studies quantified what was already known qualitatively. As expected, droplet size was shown to be the most important factor affecting drift from aerial applications. Logically, the results also confirm that drift only occurs downwind. Waiting until the wind is blowing away from sensitive areas is an effective application practice. Although drift cannot be eliminated totally with current technology, there are many ways to minimize drift to levels approaching zero. The SDTF studies confirm that when good application practices are followed, all but a small percentage of the spray is deposited on target.

Drift levels can be minimized by:

a. Applying the coarsest droplet size spectrum that provides sufficient coverage and pest control.

b. Continuing the standard practice of swath adjustment.

c. Controlling the application height.

d. Using the shortest boom length that is practical.

e. Applying pesticides when wind speeds are low.

Except at high levels of air shear, the physical properties of the spray mixture have only a minimal effect on drift. The SDTF studies show that the pattern and magnitude of drift results from a complex interaction of many factors. The drift model is an effective means of predicting aerial spray drift and permits the evaluation of a much broader range of variables than those tested by the SDTF.

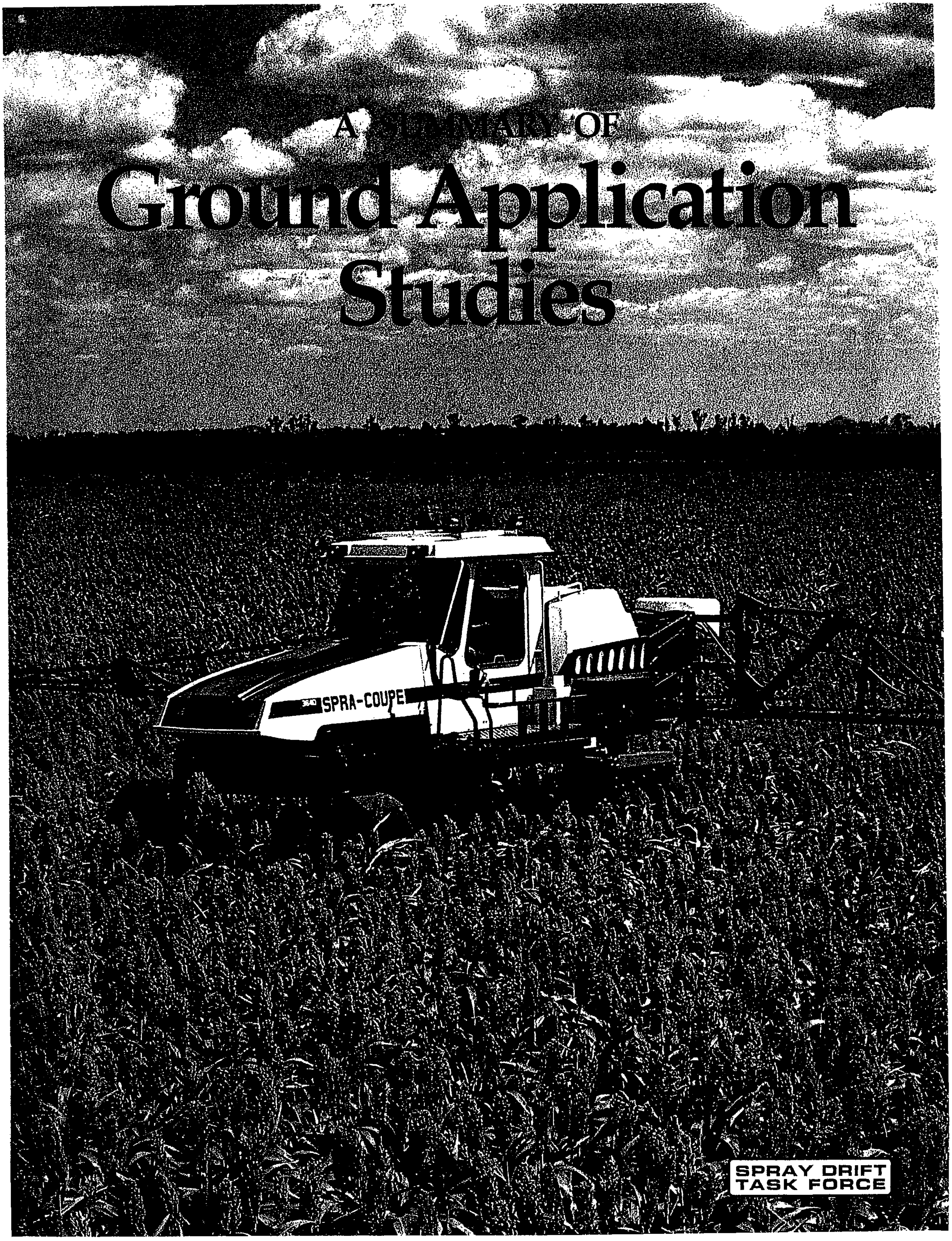
When accepted by the EPA, the SDTF model and databases will be used by the agricultural chemical industry and the EPA for environmental risk assessments. Even though active ingredients do not differ in drift potential, they can differ in the potential to cause adverse environmental effects. Since drift cannot be completely eliminated with current technology, the SDTF database and models will be used to determine if the drift from each agricultural product is low enough to avoid harmful environmental effects. When drift cannot be reduced to low enough levels through altering equipment set up and application techniques, buffer zones may be imposed to protect sensitive areas downwind of applications.

Mention of a trademark, vendor, technique, or proprietary product does not constitute an endorsement, guarantee, or warranty of the product by the authors, their companies, or the Spray Drift Task Force, and does not imply its approval to the exclusion of other products or techniques that may also be suitable.

For more information contact David Johnson at Stewart Agricultural Research Services, Inc., P.O. Box 509, Macon, Missouri 63552. (660) 762-4240 or fax (660) 762-4295.

A SUMMARY OF

Ground Application Studies



Introduction

The incidence and impact of spray drift can be minimized by proper equipment selection and setup, and good application technique. Although the Spray Drift Task Force (SDTF) studies were conducted to support product registration, they provide substantial information that can be used to minimize the incidence and impact of spray drift. The purpose of this report is to describe the SDTF ground hydraulic application studies, and to raise the level of understanding about the factors that affect spray drift.

The SDTF is a consortium of 38 agricultural chemical companies established in 1990 in response to Environmental Protection Agency (EPA) spray drift data requirements. Data were generated to support the re-registration of approximately 2,000 existing products and the registration of future products from SDTF member companies. The studies were designed and conducted in consultation with scientists at universities, research institutions, and the EPA.

The purpose of the SDTF studies was to quantify primary spray drift from aerial, ground hydraulic, airblast and chemigation applications. Using a common experimental design, more than 300 applications were made in 10 field studies covering a range of application practices for each type of application.

The data generated in the field studies were used to establish quantitative databases which, when accepted by EPA, will be used to conduct environmental risk assessments. These databases are also being used to validate computer models that the EPA can use in lieu of directly accessing the databases. The models will provide a much faster way to estimate drift, and will cover a wider range of application scenarios than tested in the field studies. The models are being jointly developed by the EPA, SDTF, and United States Department of Agriculture (USDA).

Overall, the SDTF studies confirm conventional knowledge on the relative role of the factors that affect spray drift. Droplet size was confirmed to be the most important factor. The studies also confirmed that the active ingredient does not significantly affect spray drift. The physical properties of the spray mixture generally have a small effect relative to the combined effects of equipment parameters, application technique, and the weather. This confirmed that spray drift is primarily a generic phenomenon, and justified use of a common set of databases and models for all products. The SDTF developed an extensive database and model quantifying how the liquid physical properties of the spray mixture affect droplet size.

The SDTF measured primary spray drift, the off-site movement of spray droplets before deposition. It did not cover vapor drift, or any other form of secondary drift (after deposition), because secondary drift is predominantly specific to the active ingredient.

Prior to initiating the studies, the SDTF consulted with technical experts from research institutions around the world and compiled a list of 2,500 drift-related studies from the scientific literature. Because of differing techniques, it was difficult to compare results across the studies. However, the information from these references was useful in developing test protocols that were consistently followed throughout the field studies.

The objective of the ground hydraulic studies was to develop a generic database for evaluating the effects on drift from the range of equipment combinations, atmospheric conditions and pesticide spray mixtures used by applicators.

The information being presented is not an in-depth presentation of all data generated by the SDTF. Use of pesticide products is strictly governed by label instructions. Always read and follow the label directions.

Procedures

Test site location and layout

The site chosen on the High Plains of Texas near Plainview afforded open expanses, up to one-quarter mile downwind from the application area, and a wide range of weather conditions. Wind speeds varied from 5 to 20 mph, air temperatures varied from 44° F to 91° F, and relative humidity varied from 8% to 82%. A control treatment, applied successively with each variable treatment, helped to define affects due to the weather.

Aerial View of Test Site

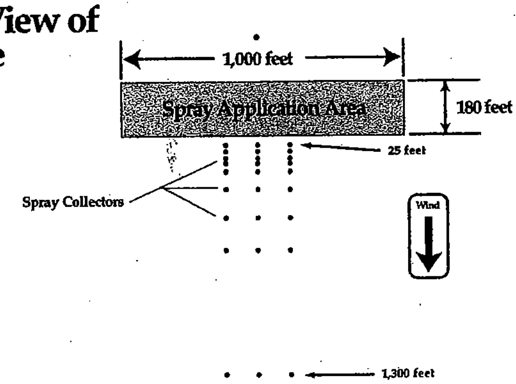


figure 1

The test application area measured 1,000 feet in length and 180 feet in width (figure 1). Four 45-foot wide parallel swaths were sprayed going from left-to-right and right-to-left using a Melroe Spra-Coupe®. Three lines of horizontal alpha-cellulose cards (absorbent material similar to thick blotting paper) were placed on the ground at 9 selected intervals from 25 feet to 1300 feet downwind from the edge of the application area. These collectors simulated the potential exposure of terrestrial and aquatic habitats to drift. A collector was also positioned upwind from the application area to verify that drift only occurs in a downwind direction.

Relating droplet size spectra to drift

All agricultural nozzles produce a range of droplet sizes known as the droplet size spectrum. In order to measure the droplet size spectrum that was applied in each field study treatment (and that represent those produced from commercial applications), the critical application parameters (nozzle type, orifice size, and pressure) were duplicated in an extensive series of atomization tests conducted in a wind tunnel. The controlled conditions of the wind tunnel allowed the droplet size spectrum to be accurately measured using a laser particle measuring instrument.

The volume median diameter (VMD) is commonly used to characterize droplet size spectra. It is the droplet size at which half the spray volume is composed of larger droplets and half is composed of smaller droplets. Although VMD is useful for characterizing the entire droplet spectrum, it is not the best indicator of drift potential.

A more useful measure for evaluating drift potential is the percentage of spray volume consisting of droplets less than 141 microns in diameter. This value was selected because of the characteristics of the particle-measuring instrument, and because it is close to 150 microns which is commonly considered a point below which droplets are more prone to drift.

The cut-off point of 141, or 150 microns, has been established as a guide to indicate which droplet sizes are most prone to drift. However, it is important to recognize that drift doesn't start and stop at 141 microns. Drift potential continually increases as droplets get smaller than 141 microns, and continually decreases as droplets get bigger.

The wind tunnel atomization tests verified that a broad range of droplet size spectra was applied in the field study treatments. This information was critical to understanding the differences in spray drift that were measured for each field study treatment.

The SDTF atomization studies also verified that the physical properties of the spray mixture have only a minimal affect on the droplet size spectrum from ground hydraulic nozzles relative to the effects of nozzle parameters. Any small differences in droplet size due to differences in physical properties would not be expected to significantly affect drift.

Test application variables

Nozzle type, orifice size and spray pressure are equipment factors that affect the droplet size spectrum for ground hydraulic sprayers. These factors were varied in the SDTF studies to provide a range of droplet size spectra similar to those used by applicators in the field (table 1).

• *8010LP* flat fan nozzle at 20 pounds per square inch (psi) pressure produced the coarsest droplet spectrum. It represented high-volume custom sprayers such as those used for turf and right-of-way applications.

• *8004LP* flat fan nozzle at 20 psi pressure produced a finer droplet spectrum than the 8010LP nozzles, but a coarser droplet spectrum than the 8004 at 40 psi. The 8004LP is a low pressure equivalent of the 8004, thus any difference in droplet size is due primarily to the lower pressure.

Nozzle	Pressure (psi)	VMD (microns)	Volume < 141 microns (%)
8010LP	20	762	1
8004LP	20	486	2
8004	40	341	7
TX6	55	175	26

table 1

Typical Ground Hydraulic Application

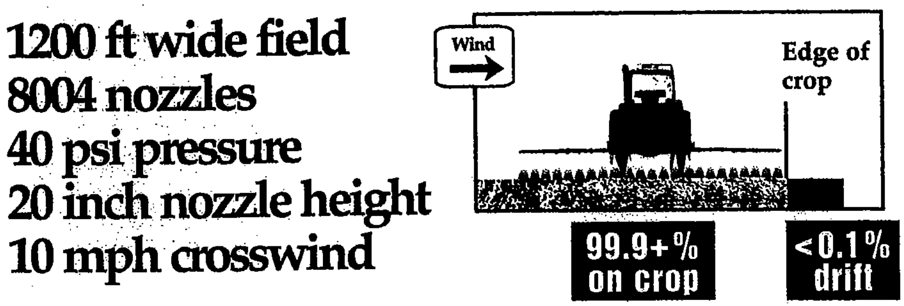


figure 2

• *8004* flat fan nozzle at 40 psi pressure produced a finer droplet spectrum than the 8004LP, but a coarser spectrum than the TX6. It is widely used for agricultural applications.

• *TX6* hollow cone nozzle at 55 psi pressure produced the finest droplet spectrum. These nozzles are commonly used to enhance penetration of insecticides and fungicides into a crop canopy. The TX6 also represents the fine droplet spectra from low volume applications.

Spray boom heights of 20 inches (typical for most agricultural applications) and 50 inches (the greatest height that could be attained with the Melroe Spra-Coupe) were evaluated for every nozzle except the 8004LP. Applications at speeds of 5 mph and 15 mph were evaluated, but are not discussed further since they were found to have no significant effect on drift.

Findings

Typical drift levels from ground hydraulic applications

The goal of ground applicators is to protect crops from diseases, insects, and weeds while keeping drift as close to zero as possible. The SDTF studies show that drift can be kept very low by using good application procedures.

Based on data generated by the SDTF, in a typical full field ground hydraulic application, more than 99.9 percent of the applied active ingredient stays on the field and less than one tenth of one percent drifts (figure 2). A typical application was defined as a 1200-foot wide, 20-swath field (suggested by the EPA), using 8004 flat fan nozzles at 40 psi, a 20-inch nozzle height, and a 10 mph crosswind.

Although ground hydraulic applications typically consist of a 1200-foot wide application area, using fields of this size was not practical. Instead, a four-swath (180 feet wide) application area was used in the field studies. This design generated data that represented drift from a 20-swath field, since most drift originates from the farthest downwind swaths.

Because the application area was smaller than is typical for commercial applications, and because most drift comes from the outer swaths of the field, the percentage of the active ingredient leaving the field in the SDTF studies was slightly higher than the typical full field application, but was still only about 0.5% (figure 3). This percentage of drift is artificially high due to the relative size of the application areas. The 0.5% drift is calculated from the average of 24 applications of the control treatment. The SDTF control application differed from the typical application only in the size of the application area.

Average SDTF Control Application
24 replicates

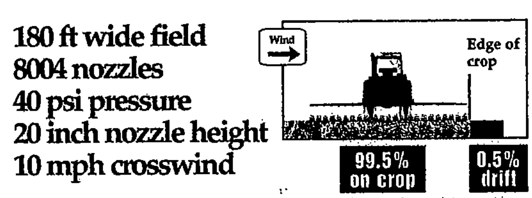


figure 3

Figure 4 shows how the 0.5% of the control treatment that left the field deposited downwind. The amount of material that deposited on the ground decreased rapidly with distance. Ground deposition was measured out to one quarter mile downwind, but data are only presented for the first 300 feet to better illustrate the differences in drift between treatments. At 300 feet, the amount of ground deposition was already extremely low. Ground deposition measurements began 25 feet downwind, which represents a reasonable distance from the edge of a crop to the effective edge of a field where drift would begin to be of concern.

A scale of Relative Drift is used in this and all subsequent graphs to facilitate comparisons among treatments. Since the control treatment will be used as a standard of comparison, it was set to 1.0 at 25 feet. For an application of one pound of active ingredient per acre, this represents only 0.08 ounce per acre deposited on the ground at 25 feet. A Relative Drift value of 0.5 indicates that one-half as much was deposited. A value of 2.0 indicates that twice as much was deposited. In subsequent graphs the deposition profile for the control treatment is shown in red in order to facilitate comparisons.

Drift from the SDTF Control Application
1.0 = 0.08 oz per acre

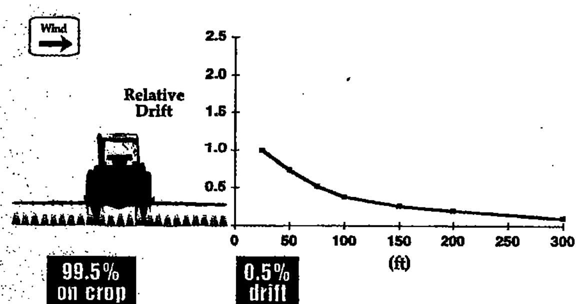


figure 4

How droplet size affects drift

The effect of droplet size on downwind ground deposition is illustrated in figure 5. Ground deposition from all four nozzles at the 20-inch boom height was

How droplet size affects drift
20 inch nozzle height

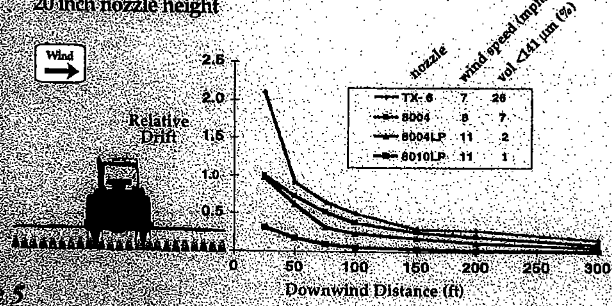


figure 5

low. As expected, there was a strong correlation between the volume less than 141 microns, and drift. In 7 mph to 8 mph winds, drift from the TX6 nozzle was greater than from the 8004 nozzle. In 11 mph winds, drift from the 8004LP nozzle was greater than from the 8010LP nozzles. Even though the wind speed was lower, drift was greater from the TX6 and 8004 than from the 8004LP and 8010LP nozzles. The largest difference in drift was between the TX6 and the other nozzles. This corresponded to the difference in the volume of droplets less than 141 microns.

How droplet size and wind speed affect drift

Wind speed significantly increased drift only for the TX6 nozzle, which produced the finest droplet spectrum (figure 6). For nozzles producing coarser droplet spectra (illustrated by the 8004LP), there was essentially no difference in drift between 8 mph and 16 mph winds.

How droplet size and wind speed affect drift
20 inch nozzle height

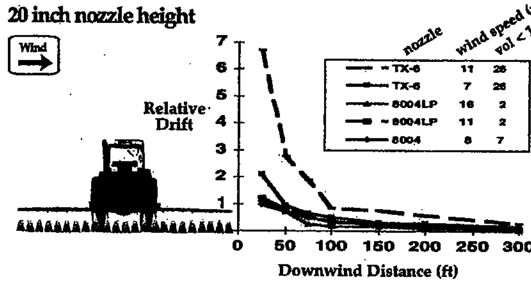


figure 6

In the scientific literature, there are correlations between wind speed and drift for ground hydraulic sprayers. However, except for the TX6 nozzle, the SDTF studies found no correlation between wind speed and drift. This apparent discrepancy is probably due to differences in the distance at which ground deposition measurements began. In the literature, correlations are usually based on drift from 0 feet to 25 feet downwind, where most of the drift occurs. In the SDTF studies, downwind deposition measurements began at 25 feet from the edge of the application area.

How nozzle height affects drift

Regardless of the droplet size spectrum, ground deposition from the 50-inch boom height was always greater than from the 20-inch height. The effect of nozzle height is illustrated for the coarsest (8010LP) and finest (TX6) droplet size spectrum in figures 7 and 8, respectively. Although drift was higher with the 50 inch boom height for both nozzles, the difference was much greater for the TX6, and was evident at greater distances downwind. This was due to the much finer droplet size spectrum compared to the 8010LP nozzle. At 25 feet downwind, the TX6 nozzle at 50 inches resulted in almost three times higher deposition than at 20 inches. This was approximately seven times higher deposition than the control treatment. These results illustrate the need to keep all nozzles, particularly those producing fine droplet spectra, at the lowest possible height that provides uniform coverage.

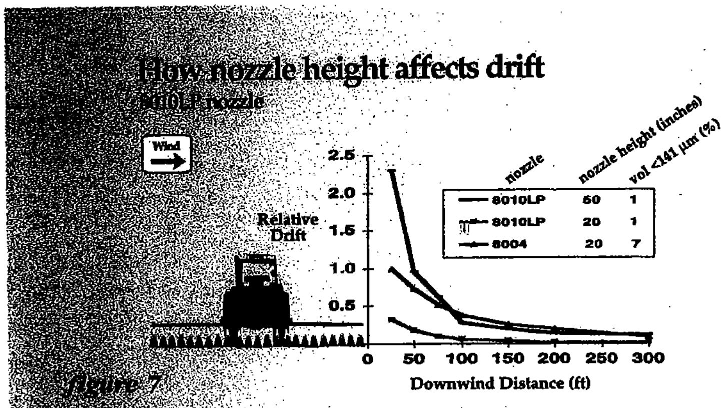


Figure 7

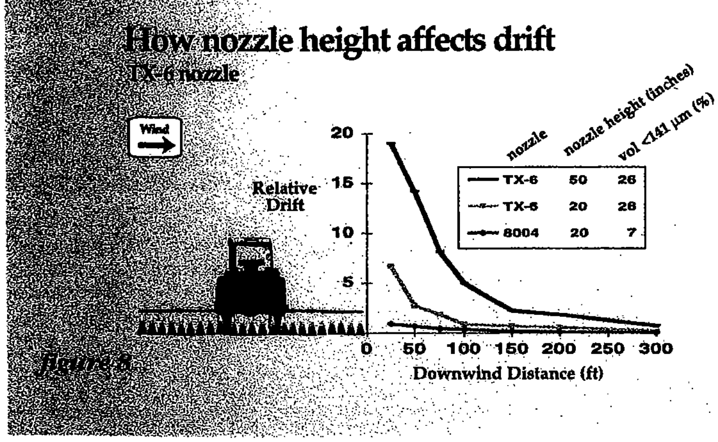


Figure 8

Conclusions

The results from the SDTF studies confirm conventional knowledge concerning the role of factors that affect spray drift. In many cases the studies quantified what was already known qualitatively. As expected, droplet size was shown to be the most important factor affecting drift from ground applications. Logically, the results also confirm that drift only occurs downwind. Waiting until the wind is blowing away from sensitive areas is an effective application practice. Although drift cannot be eliminated totally with current technology, there are many ways to minimize drift to levels approaching zero. The SDTF studies confirm that when good application practices are followed, all but a small percentage of the spray is deposited on target.

Drift levels can be minimized by:

a. Applying the coarsest droplet size spectrum that provides sufficient coverage and pest control.

b. Using the lowest nozzle height that provides uniform coverage.

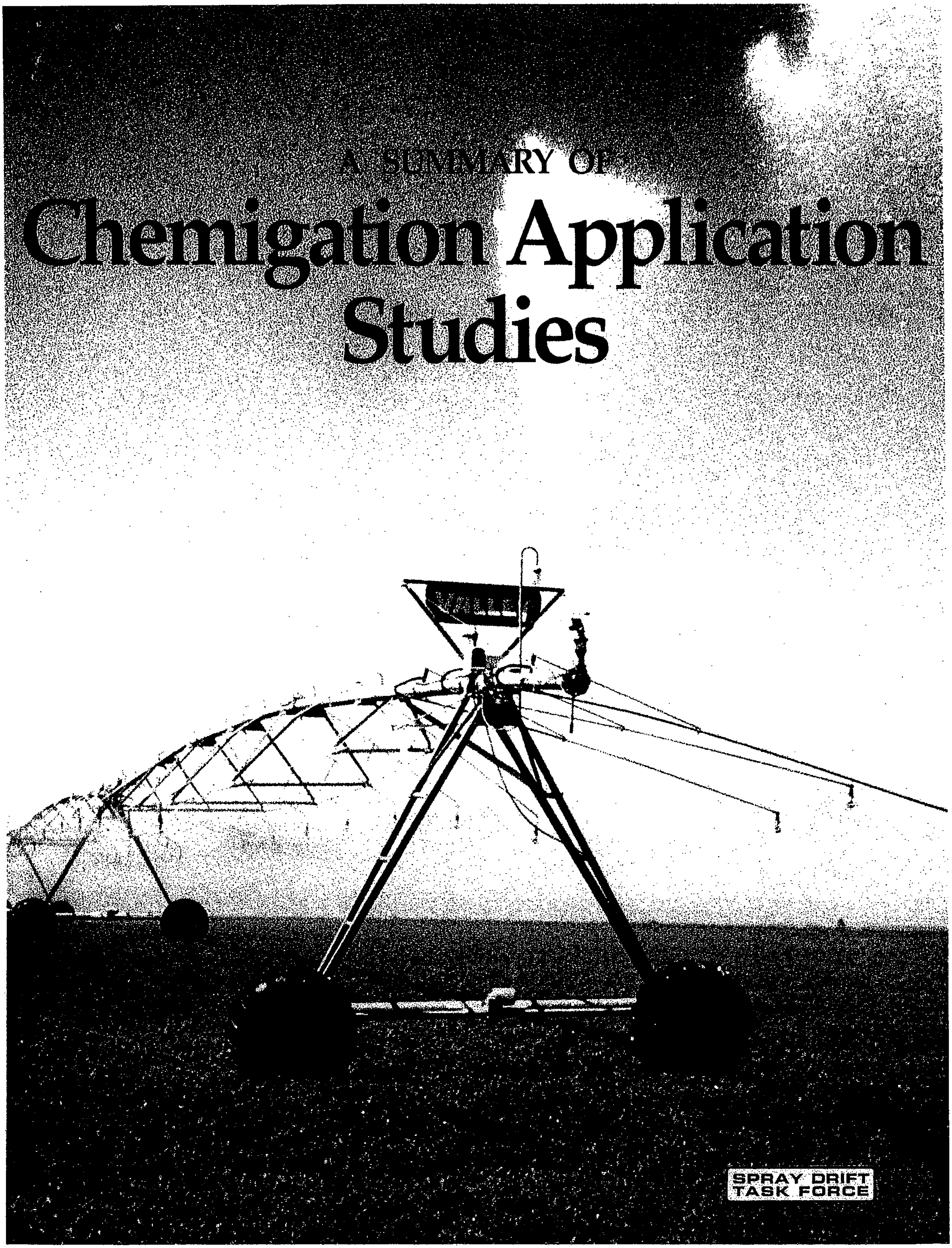
c. Applying pesticides when wind speeds are low and consistent in direction.

When accepted by the EPA, the SDTF model and databases will be used by the agricultural chemical industry and the EPA in environmental risk assessments. Even though active ingredients do not differ in drift potential, they can differ in the potential to cause adverse environmental effects. Since drift cannot be completely eliminated with current technology, the SDTF databases and models will be used to determine if the drift from each agricultural product is low enough to avoid harmful environmental effects. When drift cannot be reduced to low enough levels through altering equipment set up and application techniques, buffer zones may be imposed to protect sensitive areas downwind of applications.

For more information contact David Johnson at Stewart Agricultural Research Services, Inc., P.O. Box 509, Macon, Missouri 63552. (660) 762-4240 or fax (660) 762-4295.

A SUMMARY OF

Chemigation Application Studies



Introduction

The incidence and impact of spray drift can be minimized by proper equipment selection and setup, and good application technique. Although the Spray Drift Task Force (SDTF) studies were conducted to support product registration, they provide substantial information that can be used to minimize the incidence and impact of spray drift. The purpose of this report is to describe the SDTF chemigation application studies, and to raise the level of understanding about the factors that affect spray drift.

The SDTF is a consortium of 38 agricultural chemical companies established in 1990 in response to Environmental Protection Agency (EPA) spray drift data requirements. Data were generated to support the re-registration of approximately 2,000 existing products and the registration of future products from SDTF member companies. The studies were designed and conducted in consultation with scientists at universities, research institutions, and the EPA.

The purpose of the SDTF studies was to quantify primary spray drift from aerial, ground hydraulic, airblast and chemigation applications. Using a common experimental design, more than 300 applications were made in 10 field studies covering a range of application practices for each type of application.

The data generated in the field studies were used to establish quantitative databases which, when accepted by EPA, will be used to conduct environmental risk assessments. These databases are also being used to validate computer models that the EPA can use in lieu of directly accessing the databases. The models will provide a much faster way to estimate drift, and will cover a wider range of application scenarios than tested in the field studies. The models are being jointly developed by the EPA, SDTF, and United States Department of Agriculture (USDA).

Overall, the SDTF studies confirm conventional knowledge on the relative role of the factors that affect spray drift. The studies also confirmed that the active ingredient does not significantly affect spray drift. The physical properties of the spray mixture generally have a small effect relative to the combined effects of equipment parameters, application technique, and the weather. This confirmed that spray drift is primarily a generic phenomenon, and justified use of a common set of databases and models for all products. The SDTF developed an extensive database and model quantifying how the liquid physical properties of the spray mixture affect droplet size.

The SDTF measured primary spray drift, the off-site movement of spray droplets before deposition. It did not cover vapor drift, or any other form of secondary drift (after deposition), because secondary drift is predominantly specific to the active ingredient.

Prior to initiating the studies, the SDTF consulted with technical experts from research institutions around the world and compiled a list of 2,500 drift-related studies from the scientific literature. Because of differing techniques, it was difficult to compare results across the studies. However, the information from these references was useful in developing test protocols that were consistently followed throughout the field studies.

The objective of the chemigation studies was to develop a database for evaluating the effects on drift from low and high pressure irrigation systems, with and without end guns, over a range of atmospheric conditions.

The information being presented is not an in-depth presentation of all data generated by the SDTF. Use of pesticide products is strictly governed by label instructions. Always read and follow the label directions.

Procedures

Test site location and layout

The chemigation studies were conducted in central Washington state near Moses Lake. A center-pivot sprinkler irrigation system with a 623-foot radius covering 28 acres was used in all the field studies (figure 1).

Aerial View of Test Site

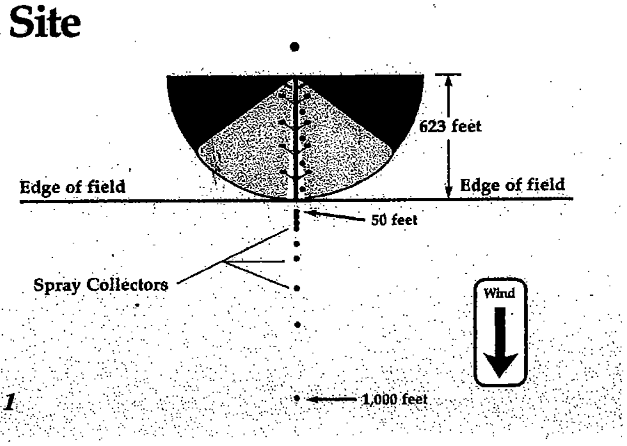


figure 1

For each treatment, the downwind quarter of the circle was irrigated during a 90-minute span, at an application rate of 0.1 acre inches of water. The quarter-circle application area was representative of the whole circle, since drift from the remainder of the circle would be negligible due to the distance from the downwind collectors.

When an end gun was operated as part of the system, the radius of the irrigated area increased to 655 feet (36 acres). The system was configured so that applications typical of high and low pressure systems could be made, with or without an end gun. A critical difference between the systems was that the spray release height for the high pressure system and the end guns was 12 feet, compared to only 5 feet in the low pressure system.

Horizontal alpha-cellulose cards (absorbent material similar to thick blotting paper) were placed on the ground at nine selected intervals from 50 feet to 1,000 feet downwind from the edge of the application area (figure 1). These collectors simulated the potential exposure of terrestrial and aquatic habitats to drift. One collector was also positioned directly upwind from the center pivot to verify that drift only occurs in a downwind direction.

Relating droplet size spectra to drift

All irrigation nozzles produce a range of droplet sizes known as the droplet size spectrum. In order to measure the droplet size spectrum applied in the field study treatments, the impact sprinkler heads and rotary spinners used in the field studies were tested in a large, specially designed facility. The controlled conditions of the facility allowed the droplet size spectra to be accurately measured using a laser particle measuring instrument. It was not possible to measure the droplet size spectrum from the end gun, but it appeared to be coarser than that measured from the impact sprinklers of the high pressure system.

The volume median diameter (VMD) is commonly used to characterize droplet size spectra. It is the droplet size at which half the spray volume is composed of larger droplets and half is composed of smaller droplets. Although VMD is useful for characterizing the entire droplet spectrum, it is not the best indicator of drift potential.

A more useful measure for evaluating drift potential is the percentage of spray volume consisting of droplets less than 141 microns in diameter. This value was selected because of the characteristics of the particle-measuring instrument, and because it is close to 150 microns, which is commonly considered a point below which droplets are more prone to drift.

The cut-off point of 141, or 150 microns, has been established as a guide to indicate which droplet sizes are most prone to drift. However, it is important to recognize that drift doesn't start and stop at 141 microns. Drift potential continually increases as droplets get smaller than 141 microns, and continually decreases as droplets get bigger.

Test application variables

The field studies consisted of four treatments: a high pressure system and a low pressure system, both with and without an end gun (table 1). The high pressure system was operated at 70 pounds per square inch (psi) with impact sprinklers located on top of the irrigation pipe, approximately 12 feet above the ground. The low pressure system was operated at 20 psi, with rotary spinners located approximately 5 feet above the ground.

Test Application Variables

	System Type*	
	High Pressure	Low Pressure
Pressure:	70 psi	20 psi
Sprinkler height:	12 feet	5 feet
Sprinkler type:	impact	rotary spinner
Volume <141 microns:	0.33%	1.3%
Volume Median Diameter: (VMD)	3,008 µm	1,690 µm

*With and without an end gun

table 1

Findings

Typical drift levels from chemigation

Based on data generated by the SDTF, in a typical chemigation application (160 acre field, high pressure system with end gun, 5 mph wind), more than 99% of the applied active ingredient stays on the field, and less than one percent drifts (figure 2).

Typical Chemigation Application

High pressure system
(with an end gun)
160 acre field
5 mph wind

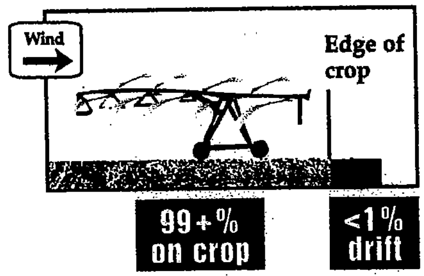


figure 2

In the SDTF studies it was not practical to apply to an entire 160 acre field due to the potential for changes in wind speed and direction during the time required for the irrigation system to travel a full circle. It was also not necessary because virtually all of the drift comes from the outside edge of the downwind portion of the circle. Therefore, applications were made only to the downwind quarter of the circle covering a 40 acre field.

Because the application area was smaller than a typical field, and because most of the drift comes from the outside edge of the downwind quarter of the irrigated circle, the percent of the active ingredient leaving the field is artificially high. Therefore, for the control treatment, the percent of the total active ingredient applied that drifted was approximately 2% rather than less than 1% for a typical application (figure 3). The only difference between the typical and control applications was the size of the application area (160 acres versus 40 acres). The high pressure system with end gun, 40 acre field, and 5 mph wind was chosen as the control because it represented an intermediate level of drift relative to the other SDTF treatments. It is used as a standard for comparison throughout this report.

SDTF Control Application

High pressure system
(with an end gun)
40 acre field
5 mph wind

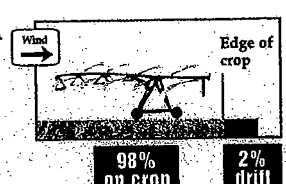


figure 3

Figure 4 shows how the 2% of the applied active ingredient that left the field in the SDTF control application deposited downwind. The amount of ground deposition decreased rapidly with distance and was already approaching zero at 150 feet downwind. Drift was measured up to 1000 feet downwind, but data are only presented for the first 300 feet to better illustrate the differences in drift between treatments. At 300 feet, the amount of ground deposition was already extremely low.

Drift from the SDTF Control Application
1.0 = 0.2 oz per acre

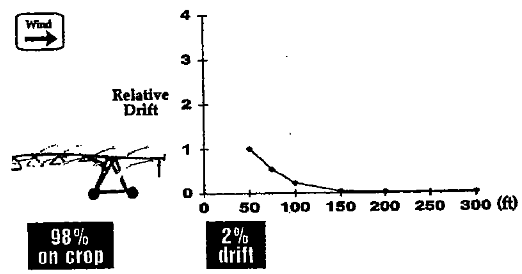


figure 4

Ground deposition measurements began 50 feet downwind from the end of the irrigation system. This distance was necessary to allow for normal variation in the size of the wetted circle inherent to impact sprinkler systems (without the effects of wind). The 50-foot distance ensured that only drift was being measured.

A scale of Relative Drift is used in this and all subsequent graphs to facilitate comparisons among treatments. Since the SDTF control treatment will be used as a standard of comparison, it was set to 1.0 at 50 feet. For an application of one pound of active ingredient per acre, this represents 0.2 ounce per acre deposited on the ground at 50 feet. A Relative Drift value of 0.5 indicates that one-half as much was deposited. A value of 2.0 indicates twice as much was deposited. In subsequent graphs, the deposition profile for the control treatment is shown in red in order to facilitate comparisons.

How droplet size affects drift

The VMD was 1690 microns for the rotary spinner nozzles on the low pressure system, and was 3008 microns for the impact sprinklers on the high pressure system (table 1). The volume of droplets less than 141 microns was 1.3% for the low pressure spinners, and 0.33% for the high pressure sprinklers. Although there was a significant difference between these droplet spectra, the volume of small, drift prone droplets was too low for either system to have a measurable affect on drift.

How sprinkler height affected drift

In 9 mph to 11 mph winds, with no end gun, drift levels were higher from the high pressure sprinklers at 12 feet than from the low pressure spinners at 5 feet (figure 5). When wind speeds were 2 mph to 3 mph, drift levels from both systems were very low, and were not significantly different.

With end guns, drift levels from the high-pressure system (sprinklers at 12 feet) were only slightly higher than from the low pressure system (rotary spinners at 5 feet) in 9 mph winds (figure 6). In 5 mph to 6 mph winds, there was virtually no difference in drift between the two systems. This is because most of the drift came from the end gun which was located at 12 feet on both systems. Higher droplet trajectories and spray velocities leaving the impact sprinklers and end guns may also have contributed to the greater drift levels.

How sprinkler height affects drift

No end gun

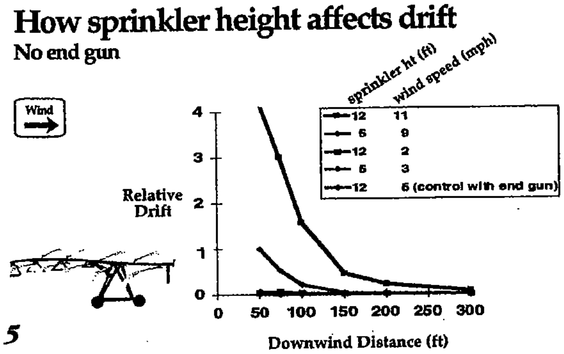


figure 5

How sprinkler height affects drift

With end gun

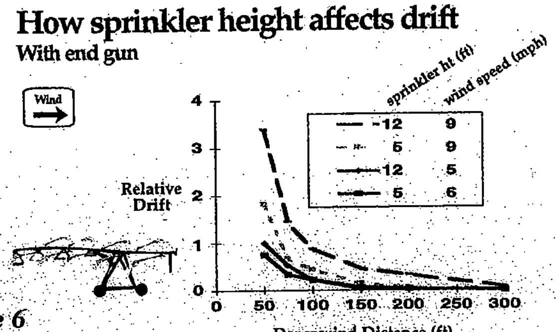


figure 6

How end guns affect drift

In the high pressure system, which produced the most drift, the addition of an end gun increased drift only slightly (figure 7). Since droplets were already released at 12 feet, the addition of the end gun had only a relatively small additive affect. The addition of an end gun had a much greater effect for the low pressure system because it increased the release height to 12 feet at the outside of the circle from where the majority of drifting droplets originated.

How end guns affect drift

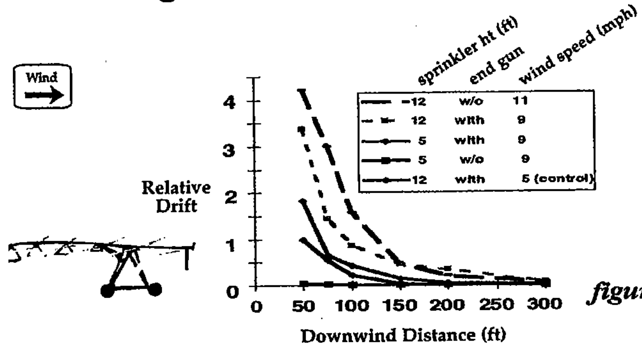


figure 7

How wind speed affects drift

In the high pressure system, with or without an end gun, there was a direct correlation between wind speed and drift. Ground deposition decreased as wind speeds dropped from 11 mph to 2 mph (figure 8).

How wind speed affects drift

12 ft sprinkler height

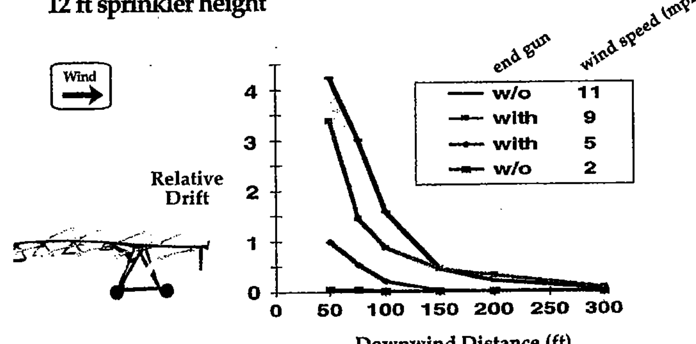
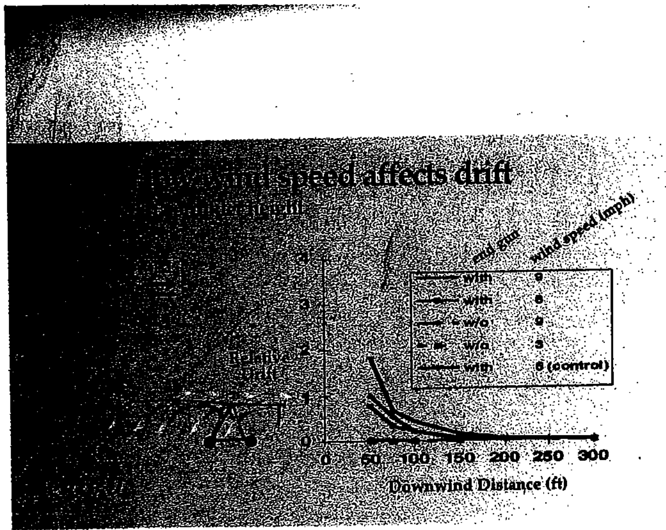


figure 8



In the low pressure system, wind speed only affected drift when there was an end gun (12-foot release height). With no end gun, all droplets were released at the 5-foot height and drift levels were very low, with no significant differences in downwind deposition between 3 mph and 9 mph winds (figure 9).

Conclusions

The level of drift from chemigation is very low because center pivot irrigation systems produce a very low level of small, drift-prone droplets (<141 microns). Drift from the high pressure system was greater than from the low pressure system primarily because of the higher release height of the droplets. The addition of an end gun to the high pressure system did not have a large additive affect on drift because droplets were already being released at 12 feet. However, addition of an end gun to the low pressure system substantially increased drift, bringing it to levels approaching the high pressure system. Wind speeds between 2 mph and 12 mph only had a significant affect on drift when droplets were released at 12 feet from the sprinklers of the high pressure system, or from an end gun. Under the range of wind speeds experienced in this study, the lowest levels of drift were measured from the low pressure system without end guns.

When accepted by the EPA, the SDTF model and databases will be used by the agricultural chemical industry and the EPA in environmental risk assessments. Even though active ingredients do not differ in drift potential, they can differ in the potential to cause adverse environmental effects. Since drift cannot be completely eliminated with current technology, the SDTF database and models will be used to determine if the drift from each agricultural product is low enough to avoid harmful environmental effects. When drift cannot be reduced to low enough levels through altering equipment set up and application techniques, buffer zones may be imposed to protect sensitive areas downwind of applications.

Mention of a trademark, vendor, technique, or proprietary product does not constitute an endorsement, guarantee, or warranty of the product by the authors, their companies, or the Spray Drift Task Force, and does not imply its approval to the exclusion of other products or techniques that may also be suitable.

For more information contact David Johnson at Stewart Agricultural Research Services, Inc., P.O. Box 509, Macon, Missouri 63552.
(660) 762-4240 or fax (660) 762-4295.

Appendix B

EPA Fact Sheet

EPA United States Environmental Protection Agency

EPA 430-F-03-001

SMART GROWTH NETWORK

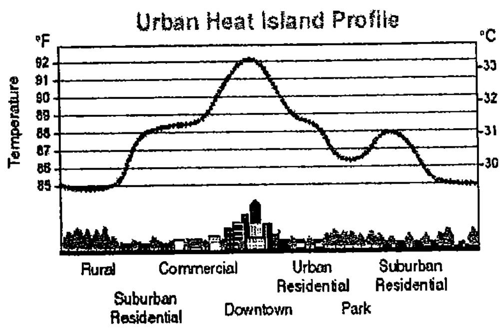
Smart Growth and Urban Heat Islands

Development patterns of the last 50 years have had both positive and negative impacts on communities across the country. One concern has been steadily increasing urban temperatures due to the effects of "urban heat islands." A heat island is an umbrella of air, often over a city or built-up area, that is warmer than the air surrounding it.

The urban heat island profile shown here demonstrates that heat islands are typically most intense over dense urban areas. The profile also shows how parks and other vegetated sections within a downtown area may help to reduce heat islands.

In general, summertime heat islands raise air conditioning demand, air pollution levels (particularly smog), and greenhouse gas emissions. They also increase the incidence of heat-related illness and mortality. In fact, in an average year, approximately 1,100 Americans die from extreme heat – the leading weather-related killer in the United States.[2]

Heat islands augment this public health threat by directly increasing temperature and indirectly raising ground-level ozone concentrations. Those at significant risk from extreme heat and ozone exposure include the elderly, children, and individuals with preexisting respiratory disease. Residents who live in homes with dark-colored roofs and no air conditioning may also be more vulnerable than the general population.



Source: EPA 1992 [1]

Because urban design plays a large role in heat island formation, smart growth development strategies provide an opportunity to reduce heat islands.

Smart growth is development that enhances both a community's economy and environment through strategies to help citizens make informed decisions about how and where they want to grow.

In addition to mitigating the heat island effect, smart growth provides a framework for increasing regional environmental protection, enhancing community character, and strengthening local economies. Here are four smart growth solutions that can achieve these goals:

- **Reducing off-street parking and using porous paving materials:** Surface parking lots replace natural vegetation with pavements that transfer heat to the surroundings. Providing on-street parking and planning compact, pedestrian-oriented development promotes transportation choices and can minimize the size and number of parking lots.
- **Planting, preserving, and maintaining trees and vegetation:** Trees and vegetation contribute to the beauty, distinctiveness, and material value of communities by incorporating the natural environment into the built environment. In addition, they cool surrounding areas by increasing evapotranspiration – a natural process that draws heat from the air to convert water in the leaf structure to water vapor. Planted adjacent to homes and buildings, trees provide shade, cool the interior, and reduce air conditioning energy demand. Trees and vegetation planted along medians and sidewalks can decrease evaporative emissions from cars and filter pollution from the air. Rooftop gardens, or green

Everyone wins. Residents get better homes, lower energy bills, and cooler neighborhoods with plenty of green space. Narrower streets and a shorter pipeline means lower installation costs, so the developer gets a subdivision that's cheaper to build. And the City ends up with less streets to maintain and a standard for future development that maintain the community's existing high quality of life.

J.D. Hightower, City Planner for Escalon, CA

Currents – An Energy Newsletter for Local Governments January/February 1999 roofs, can also mitigate urban heat islands while increasing the energy efficiency and attractiveness of commercial and residential buildings.

- **Promoting infill and higher-density development:** Development within existing communities can preserve open space and help offset heat islands and their consequences. A 2001 report found that for every acre of brownfield redevelopment, 4.5 acres of open space is preserved. Additional research found that compact development contributes less heat energy to the surrounding air than low-density dispersed growth patterns.[3]

- **Increasing public education and outreach:** Heat island mitigation strategies should reflect local variation in the built environment, as well as local preferences and attitudes. Policies should be tailored to meet these needs, based on stakeholder input, and effectively communicated to the public. Committees formed to address urban heat mitigation should include representatives from citizen groups, local government, non-governmental organizations, universities, and others concerned about how the community grows. A lead organization should be appointed [illegible] information to the community, [illegible] feedback, and [illegible] issues and concerns [illegible] into action plans. Working together, communities can address urban heat islands while enhancing the quality and character of their neighborhoods.

Case Study

Chicago is a leader in urban forestry and heat island mitigation. The city has adopted an ***open space impact fee ordinance*** that requires new residential development to contribute a proportionate amount of open space or recreational facilities, or to pay fees that ensure community residents of continued access to greenspace. Chicago also replaced a 10,080 ft^2 conventionally paved alley with a ***light-colored permeable gravel pave system***, which has eliminated chronic flooding without requiring the installation of a sewer system. In addition, between 1991 to 1998 Chicago planted ***over 500,000 trees*** and achieved a citywide tree count of 4.1 million. Chicago's Bureau of Forestry now plants a minimum of 5,000 new trees per year and plans to install -- in addition to 120 miles of existing median planters -- ***280 miles of new median planters by 2005.*** In June 2001, Chicago amended its ***energy code*** to include ***requirements for reflective or green roofs.*** See: http://www.cityofchicago.org/Environment/

Resources

For more information on heat islands, see www.epa.gov/heatisland, www.hotcities.org, and http://eetd.lbl.gov/HeatIsland.

For more information on smart growth, see www.smartgrowth.org and www.epa.gov/smartgrowth. Additional information on the relationship between the environment and the built environment can be found in "Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality." EPA 231-R-01-002.

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1 *"Cooling Our Communities – A Guidebook On Tree Planting and Light-Colored Surfacing."* U.S. Environmental Protection Agency 22P-2001, January 1992.
2 Kalkstein, LS. 1993. Health and Climate Change: Direct Impacts in Cities. *The Lancet* 342:1397-99.
3 Stone, B. and M.O. Rodgers. 2001. Urban Form and Thermal Efficiency: How the Design of Cities Influences the Urban Heat Island Effect. *Journal of the American Planning Association* 67 (2): 186-198.

[illegible] about Smart Growth and the Smart Growth [illegible] go to http://www.smartgrowth.org

Office of Air and Radiation (MC 6205J)

Office of the Administrator (MC 1808)

EPA 430-F-03-001

"EPA's mission is to protect public health and the environment. EPA works with state and local decision makers to evaluate, promote, and implement integrated, common-sense strategies that capitalize on public health and air quality improvements, while encouraging economic growth. Studies have demonstrated that mitigating heat islands provide clear environmental and financial benefits including improved local and global air quality, reduced heat-related illness and death, and increased energy savings."

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