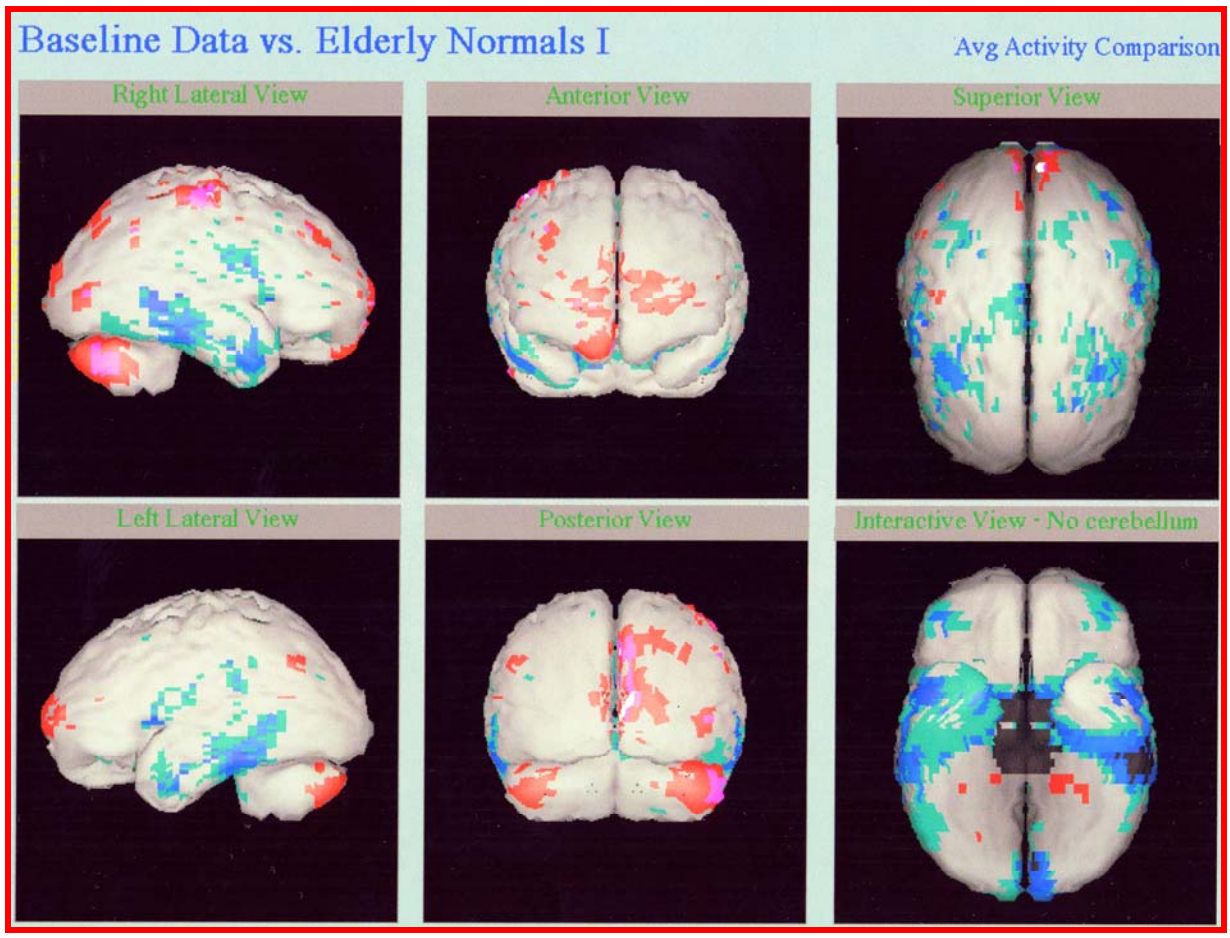
2005 Annual Report
City of Fort Collins
Mosquito Control Program



October 2005

Colorado Mosquito Control, Inc.

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ON THE COVER:

THIS IS YOUR BRAIN WITH WEST NILE VIRUS.....

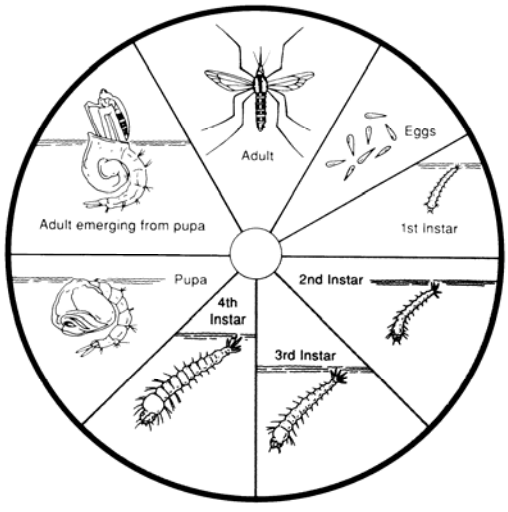
BRAIN SCAN FALSE COLOR IMAGE OF INCREASED (RED) AND REDUCED (BLUE/GREEN) BRAIN ACTIVITY AND BLOOD FLOW IN A PERSON 2 YEARS AFTER INFECTION WITH WEST NILE VIRUS.

BITTEN BY AN INFECTED MOSQUITO IN JULY OF 2003 ON THE COLORADO FRONT RANGE, THIS PERSON WENT FROM A NORMAL, HEALTHY AND ACTIVE ADULT TO BEING UNABLE TO UNDERSTAND AND COMMUNICATE WITH FRIENDS AND FAMILY AND SUFFERED NUMEROUS OTHER SEVERE PHYSICAL AND MENTAL SYMPTOMS. AND NOW TWO YEARS LATER, STILL SUFFERS FROM SIGNIFICANT MEMORY PROBLEMS, SEVERELY REDUCED COGNITIVE STAMINA, FATIGUE, DIFFICULTY IN CONCENTRATING, AND HEADACHES.

DURING THE SUMMER OF 2003, THE STATE OF COLORADO EXPERIENCED THE WORST EPIDEMIC OF HUMAN MOSQUITO-BORNE DISEASE ON RECORD IN THE WESTERN UNITED STATES WITH NEARLY 3,000 CASES AND 63 DEATHS. IN 2004 NEARLY 300 CASES AND 3 DEATHS WERE RECORDED.

AS OF OCTOBER 12, 2005 THE RISK OF WNV INFECTION IN COLORADO CONTINUES. 83 HUMAN CASES OF WEST NILE VIRUS HAVE BEEN REPORTED IN COLORADO WITH ONE DEATH, IN MORGAN COUNTY.

THE MOSQUITO LIFE CYCLE



City of Fort Collins
Mosquito Control Program
2005 Annual Report

1. Introduction

A. Background

The City of Fort Collins Mosquito Management Program has completed its 2nd year of cost effective bio-rational integrated mosquito control, and its 3rd year of mosquito surveillance. By contracting with Colorado Mosquito Control, Inc. (CMC) the City has 1) reduced the number of disease-vectoring mosquitoes, most before they can arise from the water to spread disease; 2) provided all residents with effective mosquito control using trained technicians who are able to concentrate on constantly changing mosquito populations; 3) freed up municipal personnel to perform their regular duties; and 4) provided a cost savings to the City.

B. Program Goals

Integrated Pest Management:

> *"A process consisting of the balanced use of cultural, biological, and least-toxic chemical procedures that are environmentally compatible and economically feasible to reduce human disease to a minimal level."*

The goal of Colorado Mosquito Control, Inc. (CMC) is to provide all residents of the City of Fort Collins with the best in safe, effective, modern integrated mosquito management. This environmentally friendly program always uses cultural and biological control choices first, such as naturally occurring bacteria. These efforts are all designed to reduce target mosquito populations to below established disease thresholds.

The Mosquito Control Area now contains approximately 112.8 square miles, 61.7 square miles of which are outside City limits (See Figure 1 for a map of the City's Program). Although many of the mosquito production sites are outside the City limits, all are well within the flight range of most mosquitoes. Larval control work outside the City will continue to remain a critical part of the overall operation of CMC.

2. 2005 Season Summary

All aspects of the mosquito program attempt to minimize the number of WNV human cases in Fort Collins. Most importantly, all Fort Collins field staff were immediately trained to recognize the larvae of *Culex* mosquitoes, the type responsible for transmitting WNV. Second, these *Culex* production sites were always given first priority.

The season in summary:

● There were 10 human cases of West Nile Virus (WNV), 2 of which were serious, in Fort Collins in 2005. There were also 10 WNV-positive mosquito samples, 12 WNV-positive birds, and 1 WNV-positive squirrel. Compare this to 2004 with 10 human cases, 2 positive mosquito samples, and no positive birds. The data over the last 4 years strongly indicates that WNV is likely to be present in varying amounts for years to come. (See Figure 1 for the locations of WNV-positive mosquitoes in Fort Collins).

● The larval control area was roughly the same size as in 2004 (112 sq. miles), with some reductions in size because the Town of Timnath took over a small section, and because the outer areas were eliminated at the end of July due to workforce issues. (See Figure 1).

● The summer in 2005 had nearly the same amount as rain as the epidemic 2003 year, but was slightly cooler. This resulted in WNV starting its peak later, with fewer human cases. (See Figure 2).

● Because the City did not adulticide in 2005, the total number of calls plummeted. Most of the remaining calls were to report standing water. (See Figure 3).

● 88% of the treatments were made with environmentally friendly bacterial products, showing a decrease in both larviciding oil and insect growth regulators (See Figure 4).

● Field staff found a record number of mosquito sites in 2005 – an increase of 497 sites to 1,364 sites by the end of 2005**.** (See Figure 5)

● Improved Quality Control methods revealed that over 70% of larval inspections were done accurately, and resulted in immediate retraining efforts for the remaining 30% of inspections that needed improvement.

● The number of adult mosquitoes increase slightly compared to last year, but the data strongly suggest that the larval program has been highly effective in reducing the number of *Culex* mosquitoes – the type that carries WNV. (See Figures 6, 7, 8, 9, 10, and 11).

● CMC started 3 innovative methods of larval control in 2005 – staging a one day "Fish Giveaway" for local residents to stock their backyard ponds with mosquito-eating fish, stocking agricultural ponds throughout the summer with the same type of fish, and treating Culex-producing trash cans at all City parks and schools.

Many have asked what the future of WNV will be like here in Fort Collins. After 4 consecutive years with virus activity, it is highly probable that WNV is here to stay. John Pape, an epidemiologist at the Colorado Department of Health and Environment, was quoted at the end of last year, "2003 was likely as bad as it gets, 2004 is likely as good as it gets, every year from now on will be somewhere in between." His words have rung true.

3. Mosquito Control Staff

The 2005 Fort Collins mosquito staff consisted of 17 Full-time Equivalent employees (FTE). Specifically, we had 1 Manager, 1 Field Supervisor, 9.25 Field Technicians, 0.25 Fish Program Manager, 1.5 Urban Programs Technicians (i.e., for Backyard Program, Storm Drain Program, and Public Education Program), 0.5 Surveillance Supervisor, 1 Surveillance Technician, 0.5 Maintenance Technician, 0.5 Quality Control Supervisor, and 1.5 Office Staff. In 2004 we had 17.5 FTEs.

4. Customer Calls

There was no fogging sponsored by the City of Fort Collins in 2005, which likely caused the 85% drop in calls to the mosquito office. Most of the 2005 calls were to citizen reports of standing water.

The number of total customer calls to the mosquito office in 2005 was 151. Of these, 65 were to report potential mosquito breeding sites, 39 were to request WNV or other information, 20 were biting mosquito complaint calls, 13 were miscellaneous calls, 4 were to request inclusion on the fogging notification or shutoff lists, 2 were to report dead birds for WNV testing, 2 were to request mosquitofish, 3 were to request special event spraying, 1 was a complaint about allergies, and 1 was a complaint about bees. Compare this to 2004 (998) and 2003 (423). (See Figure 3).

The complaint calls discussed above are used as a secondary indicator of where populations of adult mosquitoes are high. The primary indicator is our series of adult mosquito light traps located in all sections of the City. We use traps as the primary indicator because tolerance to mosquitoes, and desire to report high numbers, varies greatly from person to person. Setting adult mosquito traps allows us to quickly identify a problem area before residents have had several days to build up concerns about a spike in mosquito populations.

5. Larval Mosquito Control

Weather conditions were nearly ideal for mosquito production in 2005, but CMC staff kept total populations, and especially *Culex* mosquitoes, very low. This was done through increasing the number of sites by 36% and by targeting high production sites using a "site priority" system. (See Figure 5).

Because of WNV, emphasis was always put on finding and treating sites that contained *Culex* mosquito larvae. (*Culex* mosquitoes are the primary transmitters of WNV in Colorado). When time was short, this sometimes meant allowing nuisance mosquitoes to escape while time and manpower was spent treating potential disease producing larvae. Fortunately, since all field staff were trained to identify *Culex* mosquitoes by eye while sampling, it was quite simple to determine which sites contained *Culex* mosquitoes.

"Larviciding" is the process of inspecting, and if necessary, treating, any standing water for mosquitoes while they are growing under water. Currently, CMC checks every potential larval development site (e.g., ponds, wetlands, agricultural fields, residential backyards) in the Fort Collins area (now 1,472 sites) based on its production history. Therefore, the highest producing sites were checked more than once per week, and the lowest producing sites checked once or twice once per month. Some sites were checked when an irrigation event was expected and/or a large rainstorm had just occurred.

The sites were reached on foot or by using an All Terrain Vehicle (ATV). Use of the ATV is critical in the large and/or hard to reach areas. The ATV allowed the field staff to cover large sites quickly and efficiently. The staff checked for larvae at each site by taking water samples with a plastic dipper. If larvae were present, the site was treated with one of the products described below.

The product most commonly used in 2005 was a virtually non-toxic substance derived from a bacterium called *Bacillus thuringiensis* sub. *israelensis* (Bti). The active ingredient is used in a form marketed as "Vectobac". Byproducts from Bti kill mosquito larvae within approximately 24 hours of application, and require additional treatments every 4-7 days as long as larvae are present

A second bacterium, *Bacillus sphaericus* (H-5a5b), referred to as "Bs," is a classical biological control organism. Bs was used throughout the season in a form marketed as "Vectolex". Bs kills mosquito larvae within approximately 48 hours, and

has a longer period of effectiveness (approximately 21 days). It is effective longer because the Bs bacteria have the ability to reproduce in the cadavers of dead larvae.

In some cases an extremely thin larviciding oil must be used. The larviciding oil used in 2005 is marketed as "Bonide Larviciding Oil." It consists of mineral oil with a small percentage of spreading agents. It is normally used only where mosquitoes developed to the late larval or pupal stage, or if larval populations were so high that Bti would not be effective. The oil was used quite a bit less in the 2005 season because the staff were able to visit the sites more quickly, thus catching most mosquitoes in the larval stage.

We also use a mosquito growth inhibitor called Methoprene in select locations. It is marketed in several forms under the trade name of "Altosid." Altosid products work by preventing larval mosquitoes from developing into adults. Altosid has no noticeable effect on most other animals, and allows the larval mosquitoes to grow normally until the pupal stage. This allows them to play their normal role in the ecosystem -- as a food source for fish and other aquatic organisms. It has several limitations, so can only be used in a few areas.

In 2005, 842.8 acres were treated with the bacteria Bti, 136.8 acres with the bacteria Bs, 97.4 acres with larviciding oils, and 32.8 acres with the mosquito growth regulator Methoprene. See Figure 4 to compares the use of these products over the past few years. Note that in 2003, all 500 acres were treated over 2 days by helicopter. In 2004 and 2005, several thousand treatments were done on foot or on ATV.

The following is a summary of larviciding efforts in 2005:

1) **WNV Targeting** - CMC field staff were again trained to identify *Culex* larvae, enabling them to concentrate on sites that often produce these mosquitoes. In total, they killed approximately **2.4 Billion** *Culex* larvae (the species that transmit WNV), and **5.3 billion** larvae overall.

2) **Products Used** – In 2005, approximately 76% of the acreage was treated with Vectobac products, 12% with Vectolex products, 9% with larviciding oil, and 3% with Altosid products. See Figure 4 for a comparison with the last few years.

3) **Site Inspections** - The staff made 8,211 visits to mosquito larvae sites, compared to 9,680 in 2004 and 0 in 2003. This was 15% lower than last year because we were able to use 2004 data to increase visits to sites that produce heavily, and reduce visits to sites that do not.

3) **Size of Control Area** -The larval surveillance area in 2005 was 112.8 square miles through July, and cut to approximately 15 square miles for the remainder of the season. This reduction was due to a decrease in field staff.

4**) Number of Larval Sites** -The total number of larval sites has been increasing dramatically since the start of the program – **from 70 sites in 2003 (a one time treatment attempting to stem rampant WNV transmission) to 867 in 2004 to 1,364 by the end of 2005.** There would be more sites, but we inactivated 52 sites due to lack of production and deleted 56 sites because they were either destroyed or the water source was removed (e.g., irrigated farm land sold for development). (See Figure 5)

5) **Number of Treated Acres** -The number of acres treated in 2005 was 1,110.7. In 2004 the treated acreage was 1,256.9. This was less than last year, likely because less rain in 2005 resulted in smaller acreage per site. *Note that the total number of larvae killed was higher in 2005, despite lower total acreage treated.*

6) **Inspection Efficiency** – It is impossible to know if a given mosquito site will or will not be producing larvae on a given day unless it is physically inspected by a technician. However, using historical data, CMC can prioritize which sites should be checked semi-weekly, weekly, or less often. This year, approximately 83% of sites were wet when inspected, and 34% were producing larvae when inspected. In 2004, these numbers were 78% and 21%, respectively. **This huge increase in efficiency was due to CMC's unique site priority system.**

7) **Helicopter Usage** – Helicopters were not used this year because CMC employed an additional one and a half "attack team" field technicians who assisted with the chronically large mosquito sites. However, a helicopter may become necessary in the future if mosquito populations temporarily expand beyond our "on the ground" employee capabilities.

8) **Storm Drain Program** - The storm drain program is now in its 2nd year, and we now have enough data to streamline it for following years.

CMC staff monitored 3,353 individual storm drains (often called catch basins) throughout the City. There were 4,924 visits to these drains. During 458 of these visits, the technician manually sampled the drain for mosquito larvae (the remainder were only visually inspected, and treated if there was water collecting in the drain at the time of the visit). The 4,924 visits resulted in 698 treatments – 636 with Altosid 30 day briquettes, 21 with Altosid 30 day pellets, and 41 with larviciding oil.

The primary species found in storm drains was *Culex pipiens*, a known vector of WNV. *Culex tarsalis*, also a WNV vector, was also found in a few drains.

9) **Residentia**l **Backyard Program** –*Culex pipiens* is a known vector of WNV, and it usually is found primarily in residential settings. In 2004 we standardized an inspection system to keep on top of residential properties which produce *Culex* mosquitoes. In 2005, this program expanded from 41 yards to 121, resulting in significant reductions in *Culex pipiens*, and numerous opportunities to educate homeowners. These contacts with homeowners resulted in 9 backyard sites being cleaned up by the owner, therefore eliminating any "breeding" potential.

10) **Fish Program** - In the summer of 2005, Colorado Mosquito Control implemented a new fish program that will aid in the biological control of mosquitoes. The species of choice was the "fathead minnow" (*Pimephales promelas*). This species was chosen because of several qualities this small fish possesses: 1) They are endemic to Colorado, specifically to the Platte, Republican, Arkansas, and Rio Grande basins; 2) They are excellent consumers of mosquito larvae: and 3) They are very tolerant in harsh conditions. These minnows have a life span of approximately three years and are prolific spawners with the ability to establish viable populations throughout the state. Colorado Division of Wildlife approves and recommends the use of Fathead minnow for our purposes. Species such as the "mosquitofish" (*Gambusia affinis*) are not recommended because they are not native and can easily displace native species in Colorado.

Both agricultural and residential ponds were targeted. For residential ponds, CMC sponsored a "Fish Giveaway" on a Saturday in mid-summer at the Downtown Ace Hardware. More than **1,700 fish** were given to residents to stock approximately **50 ornamental ponds** in the Fort Collins area. From both mosquito control and public awareness perspectives, it was a huge success.

For agricultural mosquitoes, 15 ponds in the Fort Collins area were evaluated by CMC for stocking. Of these, 7 ponds were stocked with fathead minnows at the rate of 400-600 fish per acre surface area, using approximately 1,520 fish total. When CMC evaluated each stocked pond at the end of the season, 1 pond definitely still had a viable fish population, 4 still had good conditions for fish survival (although no fish were seen during the brief visit), and 2 ponds had dried up. In summary, 1 stocking was definitely successful (and will likely not need restocking next year), 4 were likely successful (and may not need to be restocked next year), and 2 will likely need to be restocked next year.

11) **Quality Control Program** – In 2005 the quality control program was formalized. It had two parts – a half-time Quality Control Supervisor who randomly chose sites to inspect, and quizzes several times a week throughout the season. The random inspections resulted in huge improvements in identification of training needs, product usage, acreage estimation, and various other larval control issues. The quizzes, which were often based on training deficiencies discovered in the field, reinforced appropriate treatment strategies for the experienced employees, and retrained the new employees.

The Quality Control Supervisor found that approximately 70% of the 8,211 site visits were completed accurately and efficiently. Improvements were needed on 30% of the visits, such as the technician using too little or too much larvicide per acre, missing part of a site, returning too late, under or overestimating acreage, taking too much or not enough time, etc. Most of these deficiencies resulted in immediate retraining of the technician by the Field Supervisor and/or the Quality Control Supervisor. Most issues, once identified, were quickly rectified.

12) **Park and School Cans** – Because of an unexplained increase in *Culex pipiens* late in the summer, CMC decided to investigate if trash cans in parks and schools could be a potential source of this species. On August 31 and September 1, CMC staff inspected all cans at 23 schools, 1 park, the Colorado State University Campus, and the Archery Range. Please note that these inspections were done just after schools came back into session. Therefore, it was less likely to find larvae at this time because many schools began regularly emptying cans in the last weeks of August.

In total, 223 cans were inspected by CMC for *Culex pipiens* larvae. (i.e., 5 cans from Westfield Park, 30 from the CSU campus, 5 from the Archery Range, and 183 from various schools. At the schools, 21 cans (11%) were producing. At CSU, 4 cans (13%) were producing. At the Archery Range, 2 cans (40%) were producing. Of all producing cans, there was an average of 32 larvae per dip. This equals approximately 1,760 larvae per can. In other words, approximately 40,480 *Culex* mosquitoes were killed by CMC in this one round of inspections. **At this point it appears that trash cans pose a higher WNV risk than storm drains. Therefore, CMC recommends that periodic trash can inspections get higher priority than storm drain inspections in future larviciding programs in Fort Collins.**

6. Adult Mosquito Control

A. Monitoring of Adult Mosquitoes

Surveillance of adult mosquitoes in Fort Collins centered on locating from where *Culex* mosquitoes arise. Nuisance mosquitoes were noted and attempts were also made to locate the water sources from which they were arising, but most efforts went towards *Culex* mosquitoes.

In 2005, mosquito populations in the City were monitored at 45 adult light trap locations (approximately 1 per square mile). This is an increase of 1 trap location compared to 2004. Battery-operated "light traps" were set weekly in each location, and gravid traps were set every 3 to 4 weeks in each location. A few traps a week were also placed in the yards of residents who complained of excessive mosquitoes.

Results of the monitoring efforts are shown in Figures 6 through 11. Note in Figures 7 through 10 that mosquito populations were a mere shadow of what they were in 2003 (Figure 11 shows nuisance floodwater mosquitoes, which were intentionally not treated at various times throughout the season).

The data in Figure 9 strongly suggest that the notable reduction in *Culex* mosquitoes is due to the presence of a larval control program in Fort Collins. Specifically, *Culex tarsalis* populations were much higher in 2003 when Loveland had a mosquito program and Fort Collins did not. In the following 2 years, the *Culex tarsalis* populations have been nearly identical. The only significant difference between the two Cities was the presence or absence of a mosquito program. A similar trend is seen is *Culex pipiens*, not shown.

Figure 6 displays the general trend in mosquito populations over the last 3 years. Figure 7 displays weekly changes in mosquito populations *within* each year.

Some species of mosquitoes can transmit West Nile Virus, Western Equine Encephalitis and St. Louis Encephalitis and others cannot. Therefore, it is critical to know what species are present in Fort Collins, where they are, and when they are there. Figure 8 shows the relative abundance of these and other species in the Fort Collins/Ft. Collins area. The samples were taken within, or immediately adjacent to, City limits.

Figure 8 represents two important items: 1) the changing overall populations from year to year, and 2) the changing proportions of one species over another. First, note the population of "floodwater" (i.e., nuisance) mosquitoes, as indicated by blue tones. Second, note the *Culex* mosquitoes, as indicated by the red tones. These *Culex* mosquitoes have been noticeably suppressed.

B. Adult Mosquito Control

The primary emphasis of the Fort Collins program is to control mosquitoes in the larval stage, using safe biological control products. However, CMC was prepared to adulticide if disease conditions made it absolutely necessary. Fortunately, WNV was not present over a large area, so no adulticiding was requested by City officials.

It is important to note that CMC did adulticide on numerous occasions within the City of Fort Collins in 2005 at the request of several private homeowners' associations. It is also likely that adulticiding was done by other mosquito control contractors within City limits.

C. Resident Notification

Although no adulticiding was planned by the City of Fort Collins, at least four residents requested to be placed on a "no spray" list. Their information was taken by CMC office staff for future reference.

7. Virus Surveillance Program

West Nile Virus has not behaved like other mosquito-borne diseases in Colorado. Unlike Western Equine Encephalitis and St. Louis Encephalitis, which appear at low levels every 7 to 10 years, WNV looks like it will be present every year at widely varying levels.

The purpose of a surveillance program is to be an early warning system. In other words, the system is intended to alert mosquito personnel of an impending health crisis. The key is that the system gives enough advance warning that mosquito control personnel can take effective steps to minimize the number of human cases.

As in 2004, all *Culex* mosquitoes were sent to either the Centers for Disease Control (CDC) or the State Health Department for WNV testing. **Sending this exceptionally large numbers of *Culex* mosquitoes for testing is highly unusual in Colorado.** Most parts of the state have only 2 traps per county. There are over 80 traps within Fort Collins and Loveland alone. We are fortunate because the CDC has been conducting a multi-year WNV study within the two Cities. **CDC's study depends on consistent collections in both cities for the next several years.**

There were 10 mosquito samples found positive for WNV in Fort Collins 2005. See Figure 1 for details about the locations and dates of the positive mosquitoes. In 2004 there were 2, and in 2003 there were over 50.

There were 10 humans found positive for WNV for people with Fort Collins addresses in 2005. Compare this to 10 in 2004 and 302 in 2003.

8. Public Education

CMC normally does a great deal of public education through hundreds of personal contacts in the field and through hundreds of calls to our office. However, in 2005 we hired a part-time employee to both take some of the residential workload off of the field technicians and to attend public functions.

To this end, the "Backyard Technician" attended 7 city-sponsored public events, such as concerts, farmer's markets, etc. to give out information about the City's mosquito control program, WNV, and mosquito control. In addition, she helped organize the first annual "Fish Giveaway" where over 50 City residents received information, and of course, fish. (See item #10 in the Larval Mosquito Control section above for details).

An additional part of this job was investigating calls from the public regarding potential mosquito sites. This resulted in her locating 80 new backyard ornamental ponds that were producing mosquitoes, not to mention dozens of productive conversations with homeowners.

9. Mosquito Research

CMC seeks to assist in mosquito research that will improve the quality and efficiency of our mosquito control programs.

In 2005, we were involved with the following research programs:

1) Centers for Disease Control West Nile Virus Study: Throughout the Cities of Loveland and Fort Collins, CMC collected and identified adult mosquitoes weekly from mid-May to mid-September using CO2-baited light traps. These mosquitoes were identified to species , then sent to the Centers for Disease Control in Fort Collins for testing for West Nile Virus. CMC, the Larimer County Health Department, and the Colorado Department of Public Health and Environment used this information for immediate operational decisions. This information will also be used by the Centers of Disease Control to make mosquito control recommendations to communities across the country.

2) Permethrin Resistance Study: Mike Doyle of CMC is serving on the committee of Adam Strong, a Naval Medical Entomologist presently earning his M.S. degree at Colorado State University. In summary, Petty Officer Strong is trying to determine if: 1) adult mosquitoes are becoming resistant to permethrin, a botanically based chemical commonly used in residential, agricultural, and mosquito control pesticides. (Currently, permethrin is the primary ingredient in CMC's mosquito adulticides), and 2) If the source of resistance is more closely tied to agricultural, residential, or mosquito control sources of permethrin.

Specifically, Petty Officer Strong is working on a research project to determine the level of resistance the major West Nile virus-transmitting mosquito, *Culex tarsalis*, has to permethrin. During the first stage of the project, he reared a lab strain of *Culex tarsalis* and conducted standard CDC bottle and bioassays using a permethrin containing insecticide called "Aqua-Reslin RTU". Aqua-Reslin RTU is the primary adulticide used by CMC. These experiments determined baseline levels of resistance and enzyme levels to which the field strain are compared. Over the summer of 2005, he worked with CMC Inc. and collected *Culex tarsalis* as larvae from several CMC Inc. treatment sites in northern Colorado. These larvae were reared to adulthood and then tested for resistance to permethrin using bottle and bioassays by comparing the results to the baseline lab data. After analyzing the preliminary data, it appears that the field *Culex tarsalis* strain exhibits some resistance to permethrin. The summer of 2005 resulted in an identification of reliable *Culex tarsalis* collection sites, fine-tuning of rearing methods, and determining a discriminating insecticide dose to use in the bottle assays. During the summer of 2006, many more collections and experiments will be run and analyzed. Using SAS statistical analysis, data will be compared to determine if there are any significant differences in resistance between the lab and field strains, different treatment sites, and the same treatment sites over time. Possible mechanisms behind that resistance will be analyzed and tied to the different strains of mosquitoes, location of larval sites, and times of larvae

collections. For example, is the resistance related to residential, agricultural, mosquito control, or other sources of permethrin in the environment? Is the resistance due to exposure to permethrin or to some other closely related chemical compounds? This study will help CMC Inc. in managing mosquito populations in northern Colorado by applying local resistance data to adulticide-related decisions.

3) USDA National Wildlife Research Center WNV Study – CMC is providing adult mosquito surveillance data to researchers with the Wildlife Disease Program at the USDA National Wildlife Research Center. They are trying to use the swallows as a predictor of when and where WNV will affect the human population. If they can detect an emerging problem in a localized area, perhaps a city/county can begin a more intensive mosquito control effort in that area. The questions they want to answer are:
1) Is there a difference in WNV activity in swallows between areas where mosquito control was performed and not performed? and 2) Can WNV activity in mosquitoes and WNV activity in swallows be matched in a particular area? This study is planned for the next 3 years, so relies on the City of Fort Collins continuing their mosquito surveillance program.

10. APPENDIX (Maps & Figures)

Please see following pages.

Figure 1
City of Fort Collins Mosquito Program
2005

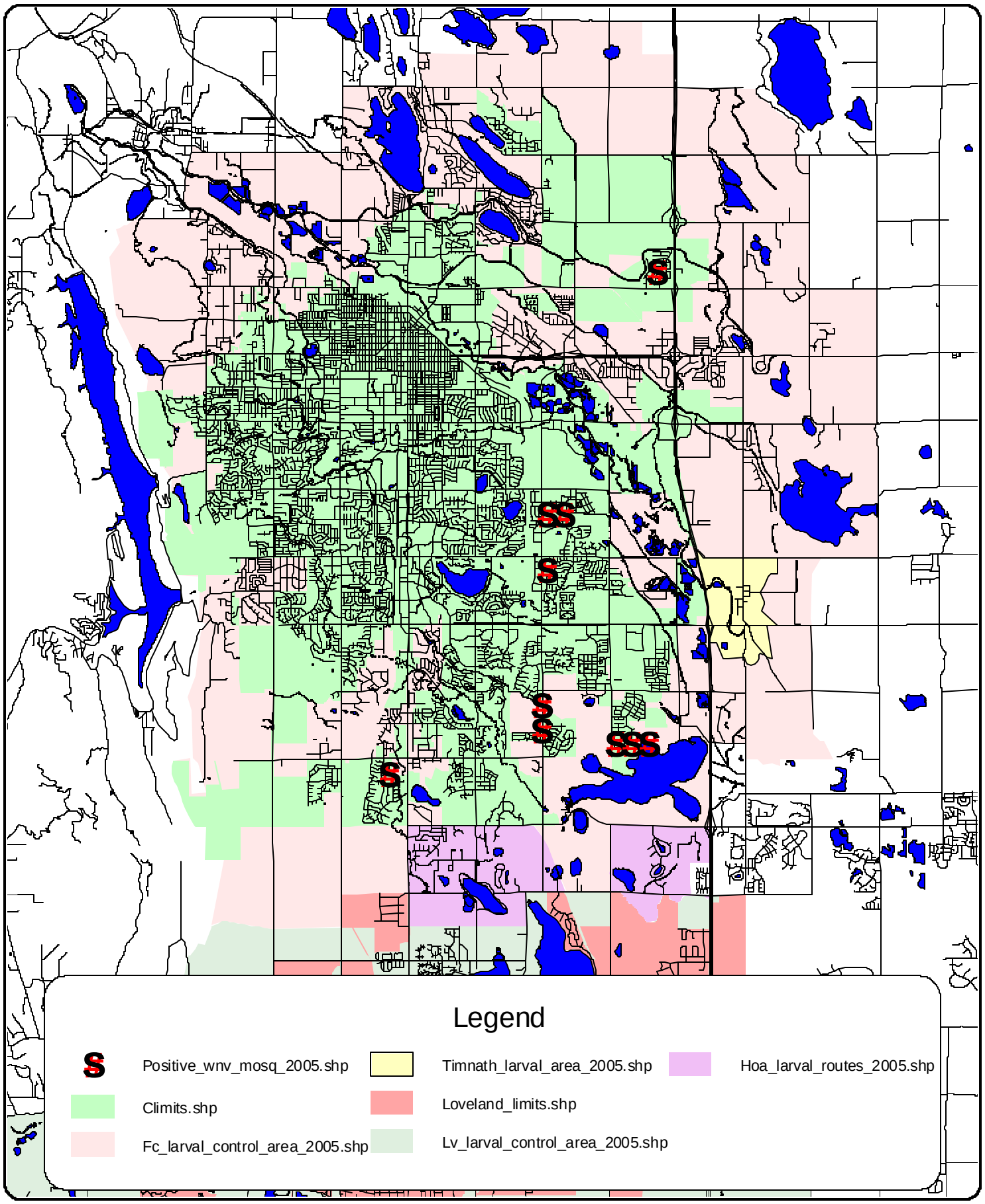
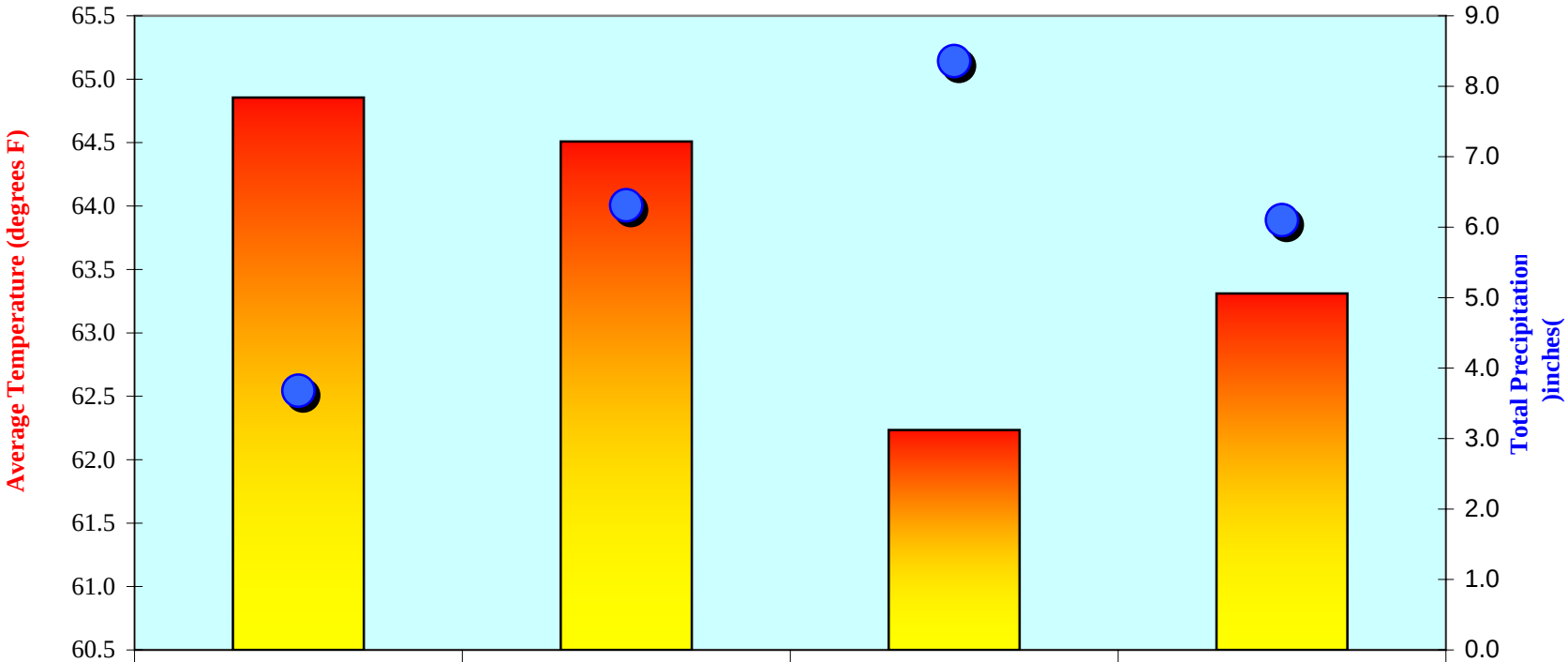


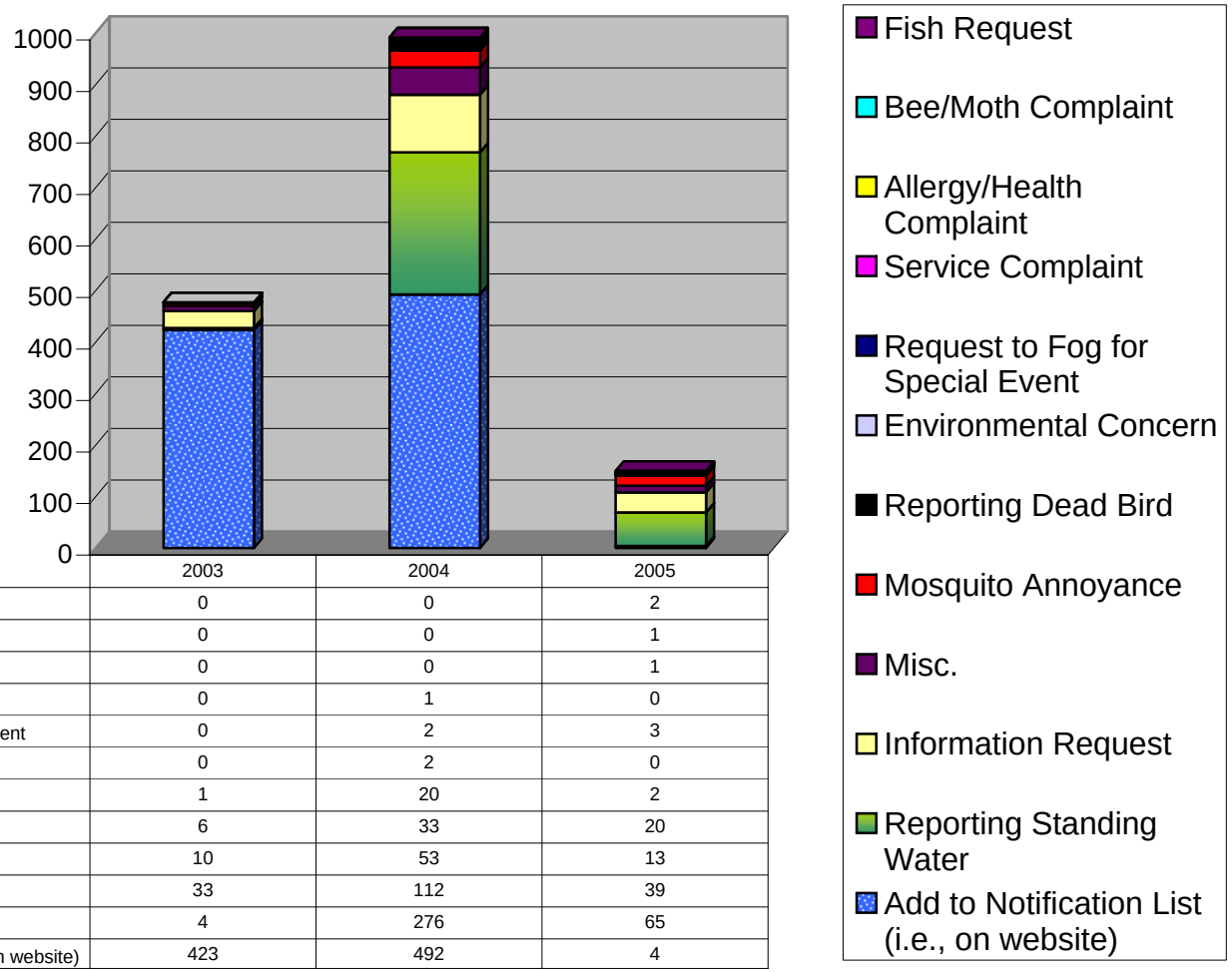
Figure 2
Fort Collins Area Weather
(May through August Only)



	2002	2003	2004	2005
Average Temp. (F)	64.9	64.5	62.2	63.3
Total Precip. (In.)	3.7	6.3	8.4	6.1

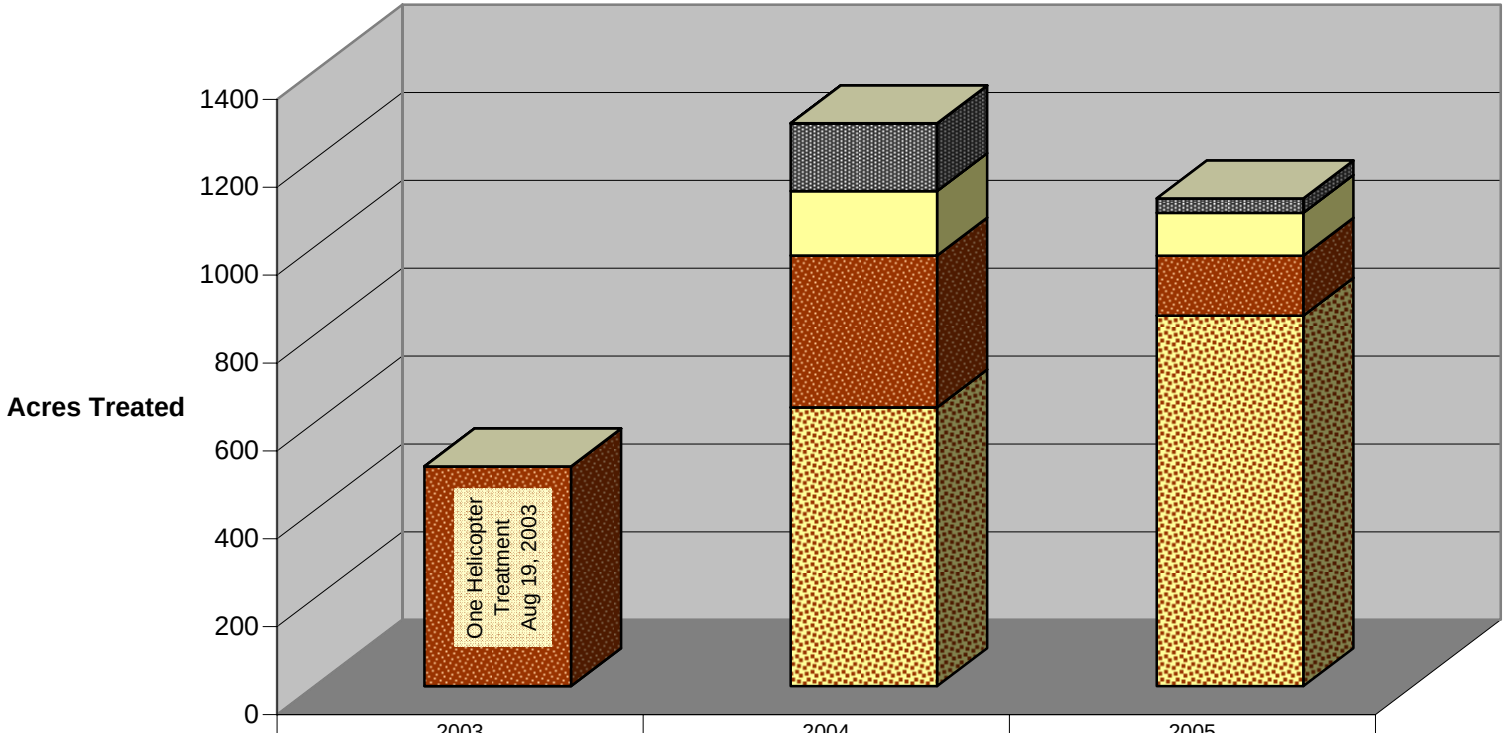
Year

Figure 3
Calls to CMC Office
City of Fort Collins Mosquito Program



	2003	2004	2005
Fish Request	0	0	2
Bee/Moth Complaint	0	0	1
Allergy/Health Complaint	0	0	1
Service Complaint	0	1	0
Request to Fog for Special Event	0	2	3
Environmental Concern	0	2	0
Reporting Dead Bird	1	20	2
Mosquito Annoyance	6	33	20
Misc.	10	53	13
Information Request	33	112	39
Reporting Standing Water	4	276	65
Add to Notification List (i.e., on website)	423	492	4

Figure 4
Larvicide Products
Fort Collins Mosquito Program



	2003	2004	2005
Temephos (conventional insecticide)	0	0.05	0
Methoprene (mosquito growth inhibitor)	0	154.2	32.8
Larviciding Oil	0	146.6	97.4
Bs (bacteria)	500	345.6	136.8
Bti (bacteria)	0	634.3	842.8

Year

Figure 5
Total Larval Sites per Year
City of Fort Collins

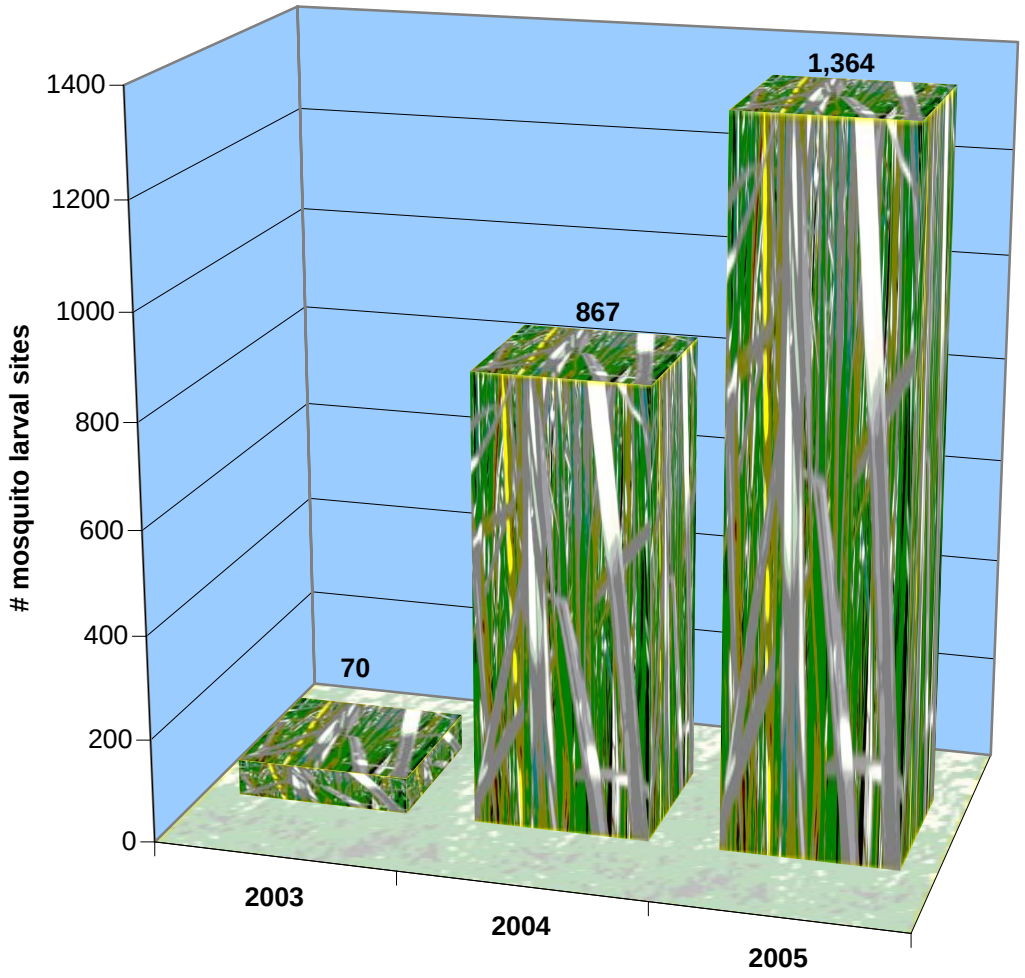


Figure 6
Adult Mosquito Population Trends
Fort Collins, CO

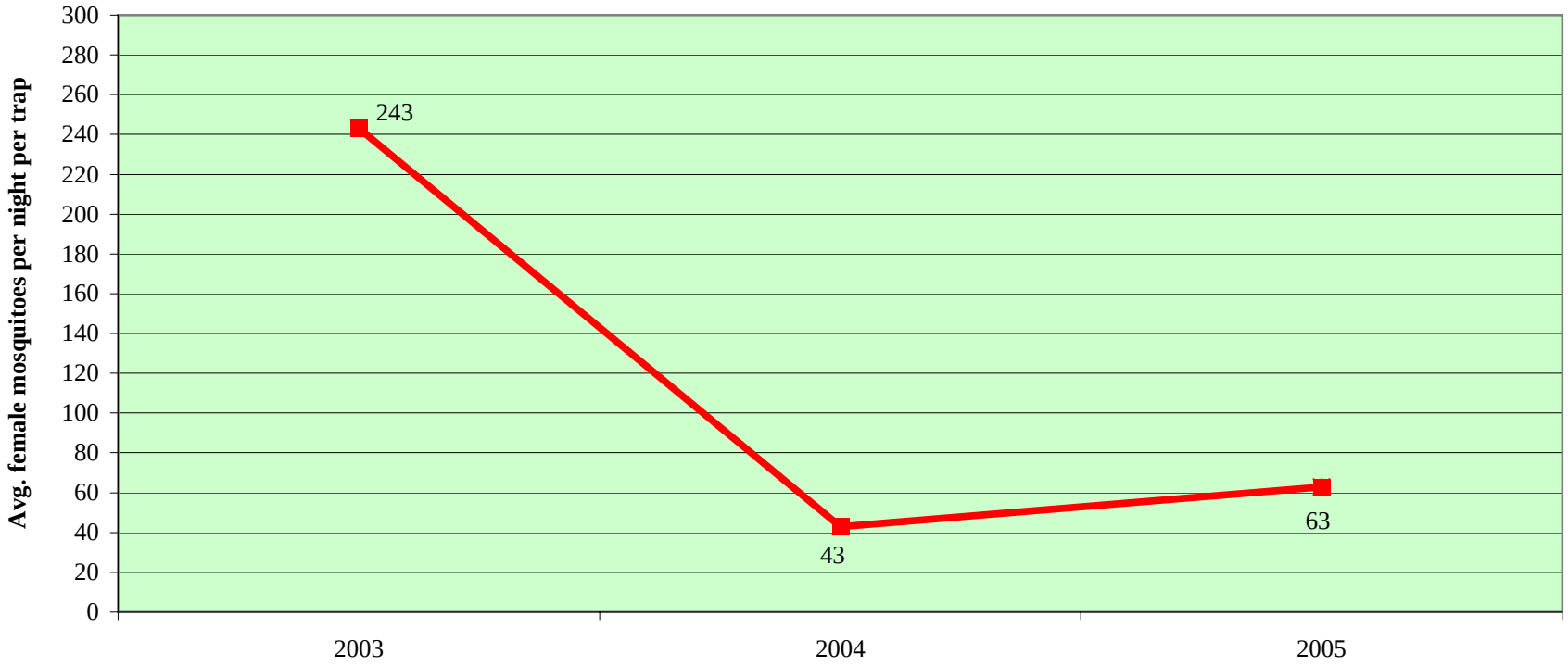


Figure 7
City of Fort Collins
Weekly Mosquito Population Trends

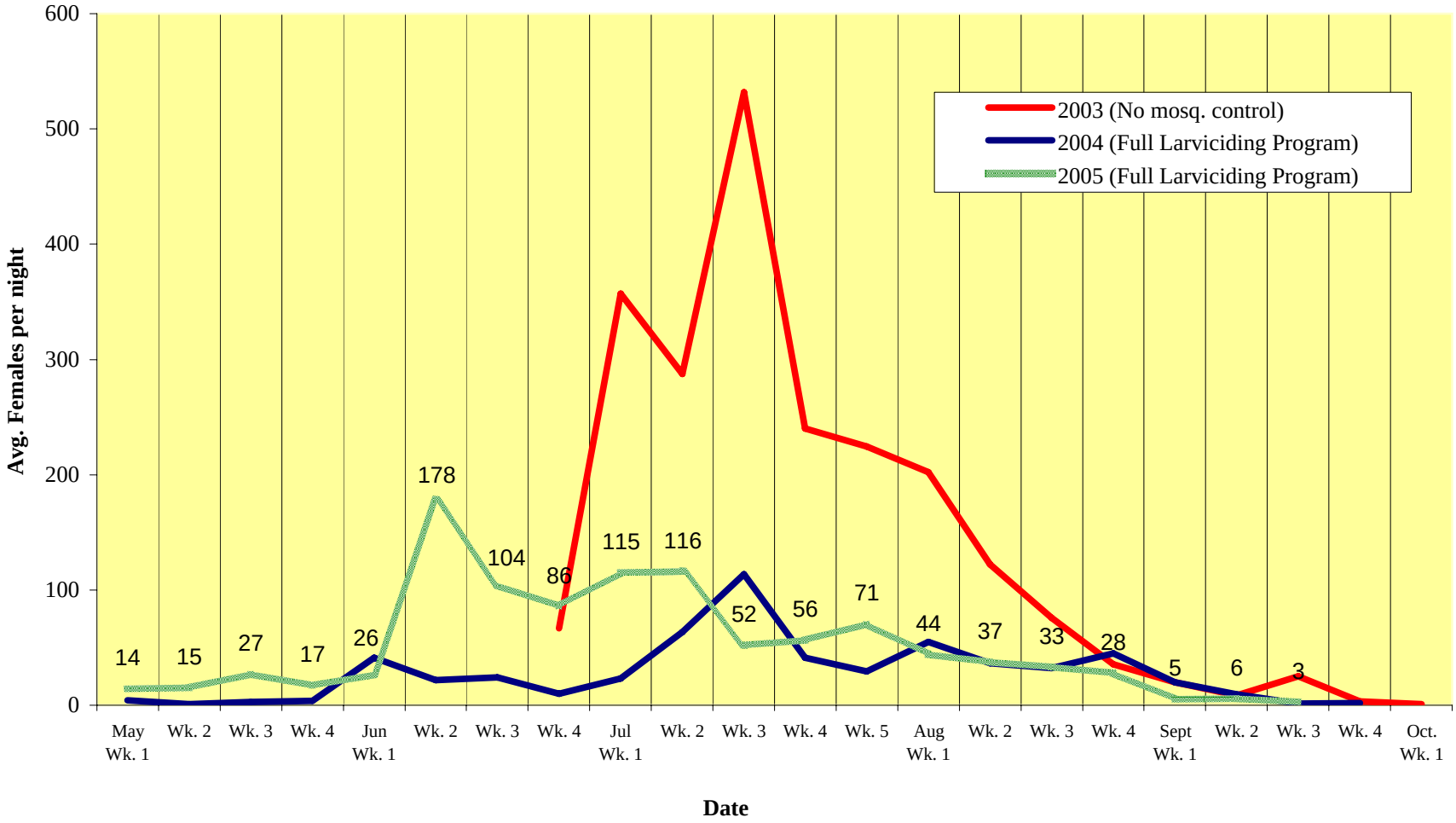


Figure 8
Species Trends
City of Fort Collins
(CDC Light/CO2 traps)

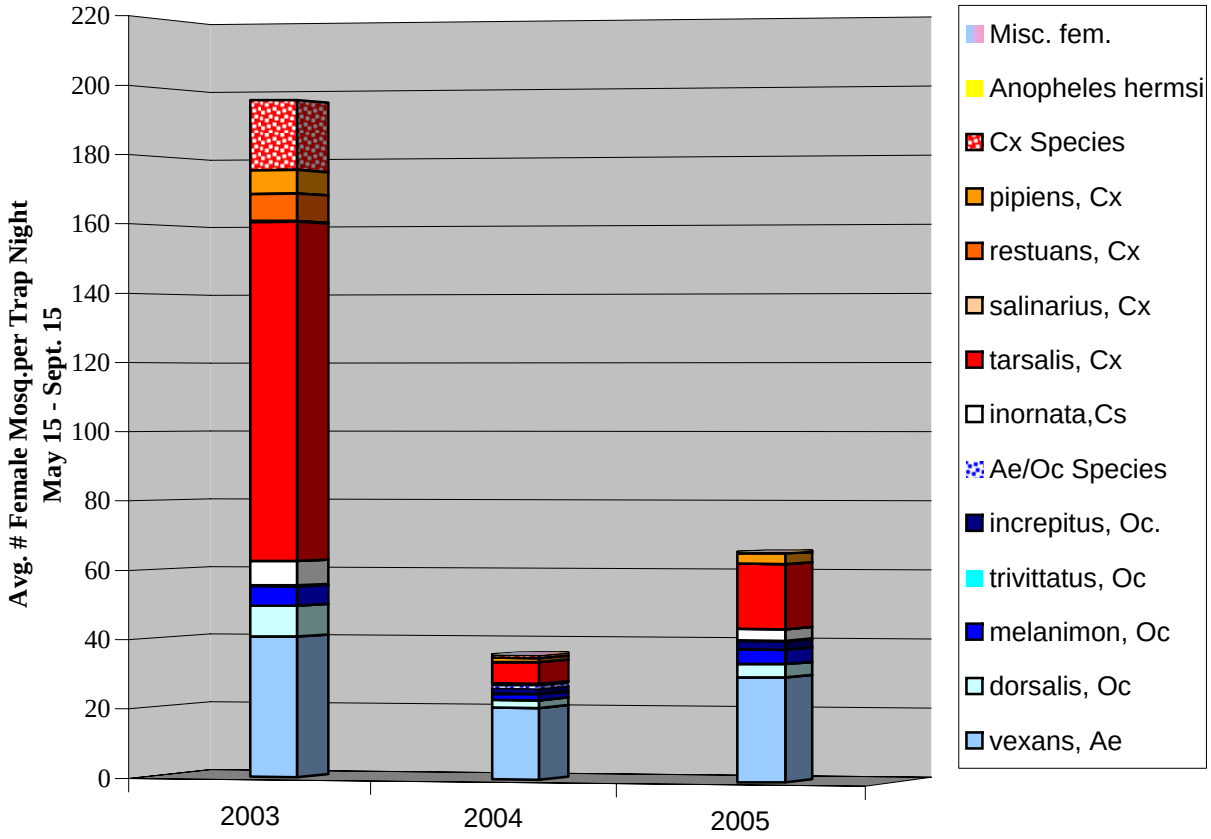
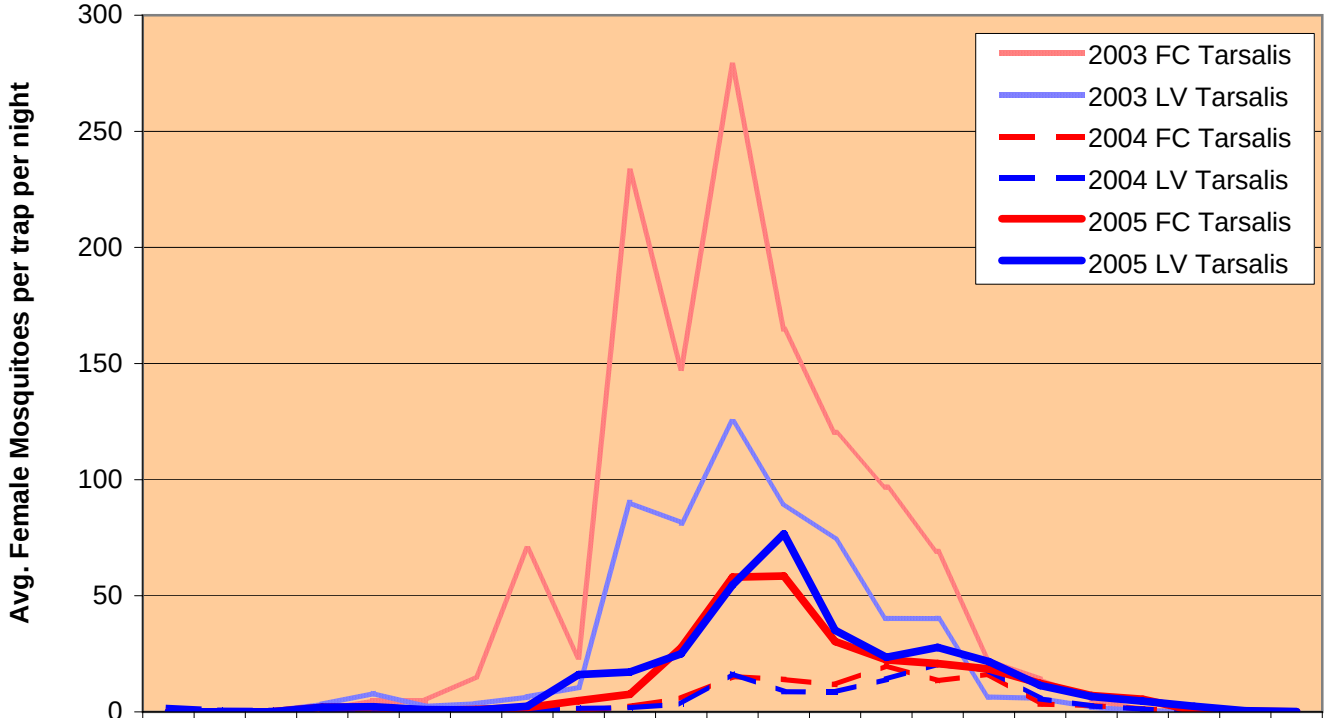


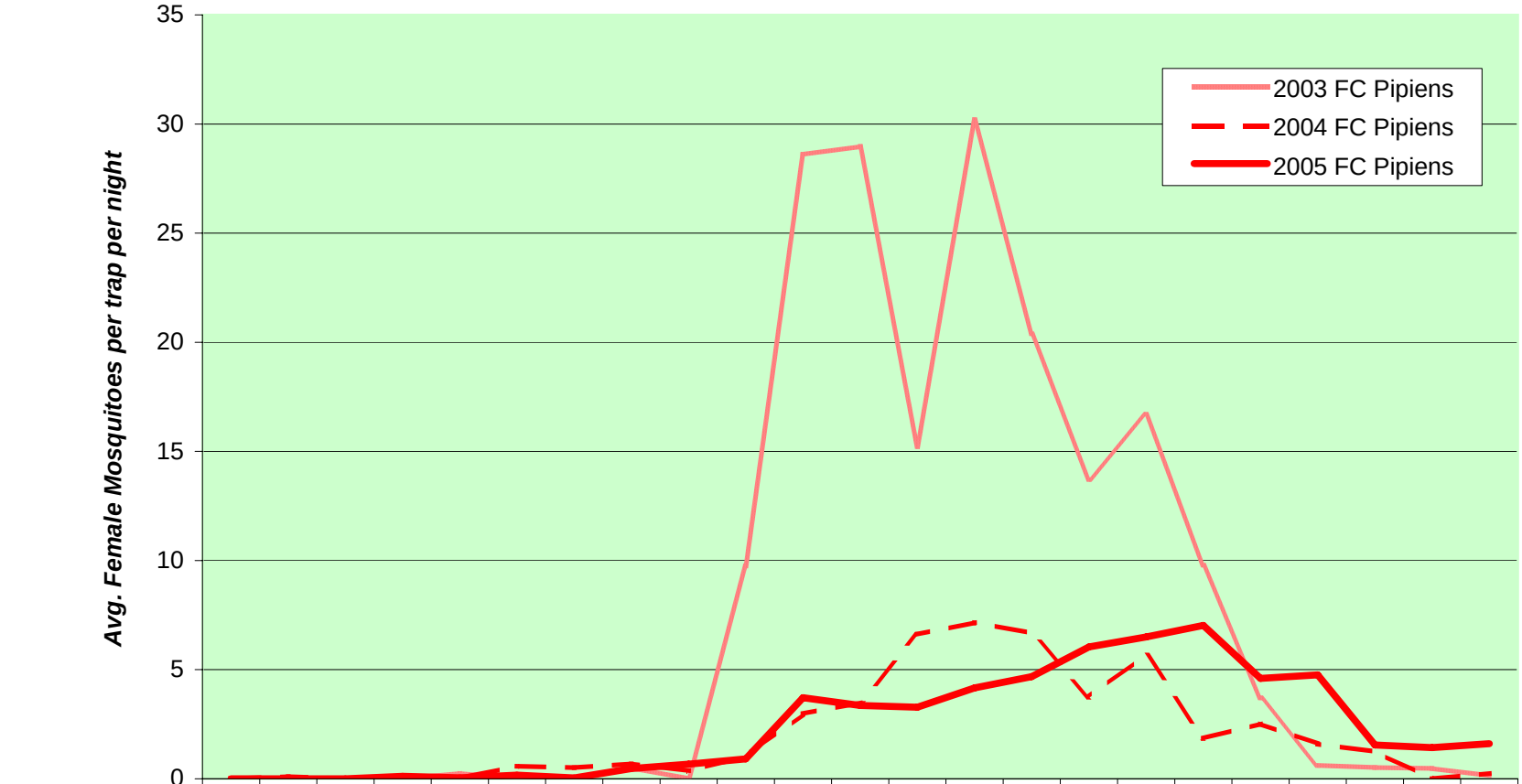
Figure 9
Fort Collins & Loveland
Culex tarsalis



	4/24-30	5/1-7	5/8-14	5/15-21	5/22-28	5/29-6/4	6/5-11	6/12-18	6/19-25	6/26-7/2	7/3-9	7/10-16	7/17-23	7/24-30	7/31-8/6	8/7-13	8/14-20	8/21-27	8/28-9/3	9/4-10	9/11-17	9/18-24	9/25-10/1
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
2003 FC Tarsalis	0.00	0.00	0.00	0.75	4.75	4.75	15.25	70.25	23.56	232.81	147.83	278.42	164.84	120.29	96.74	69.13	22.16	13.97	5.48	0.62	0.26	0.05	0.00
2003 LV Tarsalis	1.00	0.06	0.29	3.23	7.97	2.34	3.48	6.38	10.59	90.22	81.33	124.94	89.94	74.19	40.26	40.19	6.44	5.82	1.97	0.52	0.07	0.00	0.00
2004 FC Tarsalis	0.00	0.40	0.11	0.52	0.15	0.30	0.93	0.93	0.59	2.37	5.76	15.26	14.00	11.74	19.91	13.35	16.24	3.34	2.74	1.31	0.46	0.06	0.17
2004 LV Tarsalis	2.00	0.73	0.67	0.45	0.23	0.50	1.06	0.32	1.50	1.79	3.38	16.46	8.71	8.54	14.06	20.59	17.85	5.68	2.53	1.16	0.23	0.08	0.09
2005 FC Tarsalis	0.00	0.00	0.00	2.00	1.95	0.67	1.00	1.87	4.80	7.61	27.65	58.02	58.48	30.31	22.39	20.78	18.43	12.28	7.03	5.44	0.50	0.26	0.00
2005 LV Tarsalis	0	0.00	0.00	2.00	2.19	0.95	0.85	2.40	16.08	17.14	25.03	54.62	76.71	35.17	23.49	27.75	21.64	11.36	6.58	4.62	2.39	0.50	0.11

Week/Date

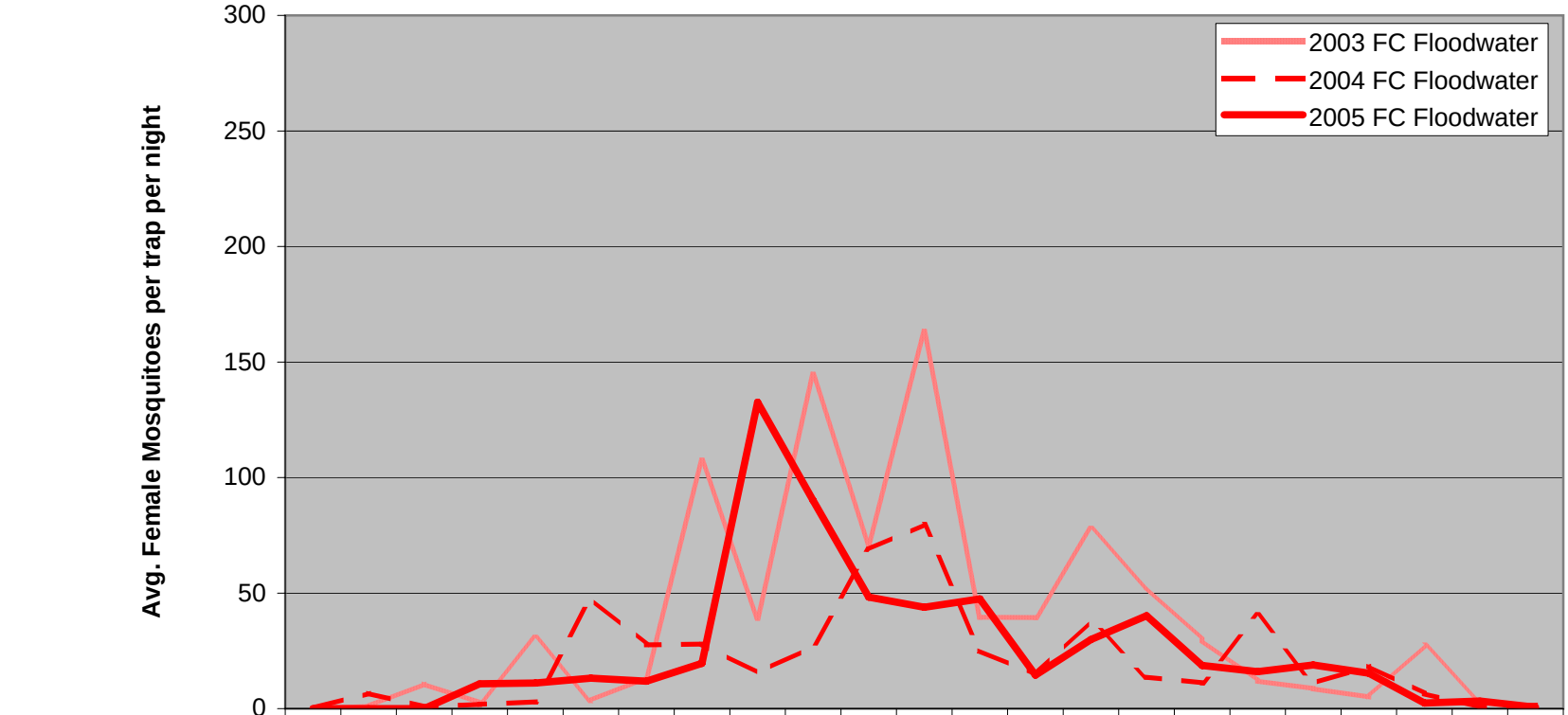
Figure 10
Fort Collins
Culex pipiens



	4/24-30	5/1-7	5/8-14	5/15-21	5/22-28	5/29-6/4	6/5-11	6/12-18	6/19-25	6/26-7/2	7/3-9	7/10-16	7/17-23	7/24-30	7/31-8/6	8/7-13	8/14-20	8/21-27	8/28-9/3	9/4-10	9/11-17	9/18-24	9/25-10/
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
2003 FC Pipiens	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.50	0.00	9.75	28.60	28.97	15.23	30.19	20.39	13.72	16.69	9.78	3.70	0.62	0.52	0.48	0.14
2004 FC Pipiens	0.00	0.10	0.00	0.05	0.03	0.58	0.51	0.68	0.37	1.02	2.98	3.49	6.61	7.16	6.67	3.74	5.71	1.85	2.52	1.59	1.25	0.00	0.25
2005 FC Pipiens	0.00	0.00	0.00	0.11	0.05	0.17	0.04	0.47	0.67	0.91	3.72	3.36	3.28	4.17	4.68	6.04	6.50	7.03	4.60	4.76	1.55	1.43	1.61

Week/Date

Figure 11
Fort Collins
Floodwater (i.e., Nuisance) Mosquitoes



	4/24-35/1-7	5/8-145/15-25/22-25/29-66/5-116/12-16/19-26/26-77/3-9	7/10-177/17-27/24-37/31-88/7-138/14-28/21-28/28-99/4-109/11-19/18-29/25-1																				
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
2003 FC Floodwater	0.00	1.00	10.67	2.50	30.75	3.50	13.50	107.5	39.11	144.6	71.13	163.2	39.52	39.42	77.90	52.66	29.69	11.91	8.63	4.97	27.48	3.33	0.52
2004 FC Floodwater	0.21	6.60	0.78	1.86	2.98	47.83	27.59	27.90	15.44	26.90	68.83	79.72	25.07	14.67	38.21	13.65	11.18	40.51	10.89	18.34	6.46	0.69	1.50
2005 FC Floodwater	0.00	0.00	0.00	10.78	11.10	13.21	11.87	19.64	132.5	90.11	48.24	43.87	47.48	14.48	29.91	40.22	18.68	15.97	18.87	15.32	2.41	3.26	0.61

COLORADO MOSQUITO CONTROL, INC.

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