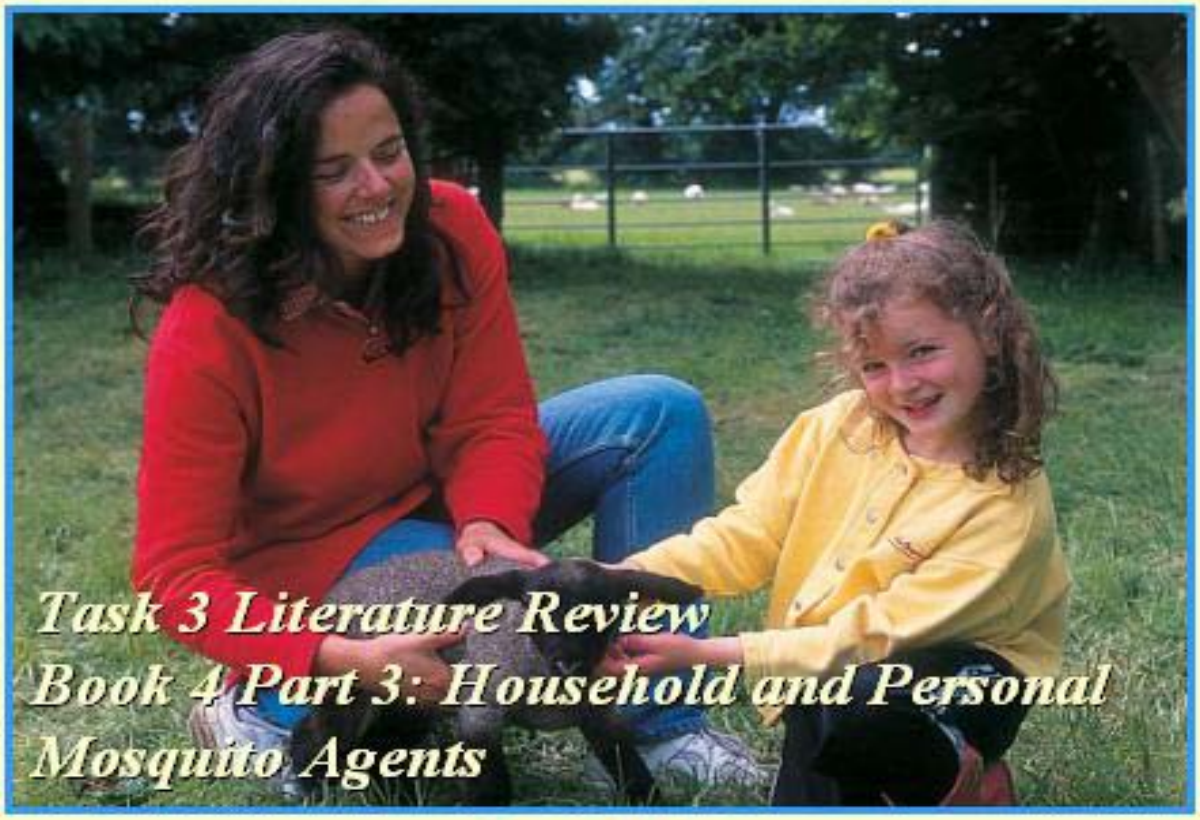
Suffolk County Vector Control & Wetlands Management Long Term Plan & Environmental Impact Statement



Prepared for:

Suffolk County Department of Public Works
Suffolk County Department of Health Services
Suffolk County, New York

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December 2004

SUFFOLK COUNTY VECTOR CONTROL AND WETLANDS MANAGEMENT LONG - TERM PLAN AND ENVIRONMENTAL IMPACT STATEMENT

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LIST OF ABBREVIATIONS AND ACRONYMS

AMCA	American Mosquito Control Association
CO_2	Carbon dioxide
DEET	N,N-diethyl-3-methylbenzamide
NIAID	National Institute of Allergy and Infectious Disease
NYSDOH	New York State Department of Health
PMRA	Pest Management Regulatory Agency
SD	standard deviation
SPF	sun protection factor
USEPA	United States Environmental Protection Agency
WNV	West Nile Virus

EXECUTIVE SUMMARY

A variety of factors attract mosquitoes to humans, including exhaled gasses, body heat, and chemicals released, often idiosyncratically, by human skin. Personal measures can be taken to interfere with the ability of a mosquito, seeking a blood meal, to find and become attracted to humans.

Most mosquito authorities agree that the most effective steps that can be taken involve housekeeping. Many mosquitoes that feed on humans breed in the general vicinity of homes – and may not travel very far in search of a meal. Therefore, steps taken to remove breeding locations at and near homes almost always pay dividends. Nearly all of these measures focus on removing the aquatic habitat needed for mosquito breeding. Preventing still, stagnant water from remaining undisturbed during warm weather is likely to reduce mosquito presence near one's home.

Other commonly used mosquito control efforts near a house do not have universal approval. Some of the recently developed traps have been judged to be effective under certain conditions. However, the American Mosquito Control Association has withheld its approval of these traps, and has generally questioned their effectiveness. Similarly, insecticides and repellents used over small outdoor areas in an attempt to prevent mosquito bites, generally, do not seem to work well under most conditions. For example, citronella candles do not appear to be more effective than marginally-effective wax candles, despite their common use for this purpose.

One apparently effective means at discouraging mosquito bites is to apply DEET. Various concentrations of DEET, in a variety of formulations, have been shown to be effective as repellents; higher concentrations are effective for longer periods of time. However, DEET appears to have the potential for adverse health effects, especially for children. Therefore, the general recommendation is to use no product with more than 10 percent DEET on children.

No natural or other synthetic product has been shown to work as well as higher concentrations of DEET. At least one botanical product (BiteBlocker™) appears to be as effective as lower concentration formulations of DEET. However, some botanical products are garnering interest as potentially having adverse health impacts. For example, Health Canada is considering withdrawing its approval of citronella products that are applied directly to the skin.

Under all conditions, the amount of chemicals applied directly to the skin should be the minimal amount necessary to accomplish the desired repellent task, with more or stronger repellent being applied only as conditions warrant. Overapplication of repellents can be common, as many people believe using more of a formulation leads to maximum protection, whereas it may just lead to wasteful product usage and unnecessary exposure to the product.

1. Introduction

Certain stimuli are known to attract mosquitoes to humans. For daytime feeders, dark colored clothing and movement are most important for initial orientation to the host. As mosquitoes near the host, olfactory stimuli become more important. Over 300 metabolic products are released from the human body, including more than 100 from exhalations. Two are best known in terms of their ability to attract mosquitoes. Carbon dioxide (CO_2), released from human breath and skin, can be detected by mosquitoes at distances of up to 36 meters. Lactic acid, released from human perspiration, is another commonly recognized mosquito attractant. Skin temperature and moisture attract mosquitoes, as does increased perspiration, which results from temperature increases, and obviously increases moisture levels. It is also known that personal care products, including floral fragrances from perfumes, soaps, lotions, and hair care products serve as mosquito attractants. There is also a rough hierarchy regarding attractiveness to mosquitoes, with adults generally being more attractive than children, men more than women, and larger persons more than smaller people (Fradin, 1998).

People, therefore, often take countermeasures to try to reduce their chances of being bitten by a mosquito. Many of these protections and safeguards are subject to certain commercial or folklore-ish enthusiasms, or unsubstantiated personal observations. This section of the Literature Review is intended to remove some of the well-meant, but unsupported reports on the effectiveness of many mosquito repellent measures commonly used today.

2. Personal Repellents

2.1. Synthetic Chemicals

2.1.1. DEET

Products containing N,N-diethyl-3-methylbenzamide (DEET, formerly identified as N,N-diethyl-m-toluamide) are sold as liquids, lotions, sprays, and impregnated materials (*e.g.*, wrist bands). According to the US Environmental Protection Agency (USEPA) (2004), 70 companies make over 225 products containing DEET that are registered with USEPA. Fradin (1998) noted:

> "twenty years of testing of more than 20,000 other compounds has not resulted in another marketed chemical product with the duration of protection and broad-spectrum effectiveness of DEET."

Fradin and Day published data in 2002 that confirmed DEET was much more effective than other repellents, with a 23.8% DEET formulation protecting against mosquito bites for a mean time of five hours, compared to less than half-an-hour on average for most non-DEET products. One product containing botanical oils did, however, protect for an average of 90 minutes and up to three hours (see Bite Blocker™ below). These tests were conducted under laboratory conditions, where environmental conditions (temperature, humidity, and light-dark cycles) and the mosquito characteristics (species, degree of hunger, and age) were kept constant for all exposures. Fifteen subjects were used for each test. The results of the study are shown in Table 2-1. These data confirmed similar, less rigorous testing conducted by Consumer Reports (2000).

DEET formulations for skin applications contain varying amounts of DEET – from four to 100 percent. In September of 1998, USEPA determined that labels on products containing DEET could not be designated as "safe for kids." The American Academy of Pediatrics recommends that mosquito repellents contain no more than 10% DEET for application on children (Garrettson, 1997). Higher concentration DEET products have been recommended for intense insect biting conditions and when other factors, such as temperature and high humidity, tend to increase evaporation rates and the loss of repellent from the skin (Fradin, 1998).

Table 2-1 - Protection Times of Insect Repellents (Fradin and Day, 2002)

PRODUCT	ACTIVE INGREDIENT	COMPLETE PROTECTION TIME		CATEGORY OF PROTECTION
		Mean	Range	
OFF! Deep Woods (SC Johnson)	DEET, 23.8%	301.5±37.6	200–360	A
Sawyer Controlled Release (Sawyer)	DEET, 20%	234.4±31.8	180–325	B
OFF! Skintastic (SC Johnson)	DEET, 6.65%	112.4±20.3	90–170	C
Bite Blocker for Kids (HOMS)	Soybean oil, 2%	94.6±42.0	16–195	D
OFF! Skintastic for Kids (SC Johnson)	DEET, 4.75%	88.4±21.4	45–120	D
Skin-So-Soft Bug Guard Plus (Avon)	IR3535, 7.5%	22.9±11.2	10–60	E‡
Natrapel (Tender)	Citronella, 10%	19.7±10.6	7–60	E‡
Herbal Armor (microencapsulated) (All Terrain)	Citronella, 12%; Peppermint oil, 2.5%; cedar oil, 2%; lemongrass oil, 1%; geranium oil, 0.05%	18.9±13.3	1–55	E§
Green Ban for People (Mulgum Hollow Farm)	Citronella, 10%; Peppermint oil, 2%	14.0±11.3	1-45	E
Buzz Away (Quantum)	Citronella, 5%	13.5±7.5	5-30	E
Skin-So-Soft Bug Guard (Avon)	Citronella, 0.1%	10.3±7.9	1–30	E
Skin-So-Soft Bath Oil (Avon)	Uncertain	9.6±8.8	1–30	E
Skin-So-Soft Moisturizing Suncare (Avon)	Citronella, 0.05%	2.8±3.4	1-15	F
Gone Original Wristband (Solar Gloooow)	DEET, 9.5%	0.3±0.2	0.17–1.33	G
Repello Wristband (Repello Products)	DEET, 9.5%	0.2±0.08	0.17–0.63	H
Gone Plus Repelling Wristband (Solar Gloooow)	Citronella, 25%	0.2±0.09	0.17–0.48	H

*Plus–minus values are the mean ±SDs of the times to the first bite in the tests of all 15 subjects. DEET denotes *N,N*-diethyl-3-methylbenzamide (formerly known as *N,N*-diethyl-*m*-toluamide), HOMS Home Operations and Management Systems, and IR3535 ethyl butylacetylaminopropionate.
†The mean complete-protection time of each repellent was significantly different ($P<0.05$ by analysis of variance and Tukey's tests) from those of all repellents in different categories of protection (A, B, C, D, E, F, G, and H).
‡The complete-protection time also differed significantly from those of Buzz Away, Skin-So-Soft Bug Guard, and Skin-So-Soft Bath Oil.
§The complete-protection time also differed significantly from those of Skin-So-Soft Bug Guard and Skin-So-Soft Bath Oil.
¶This product contains mineral oil, isopropyl palmitate, dicapryl adipate, fragrance, dioctyl sodium sulfosuccinate, butylated hydroxytoluene, and carrot oil.

Another issue with DEET is a loss of effectiveness of sunscreens in conjunction with DEET use. DEET-based repellent applied sequentially with sunscreen reduced the sun protection factor (SPF) of the sunscreen by 33.5 percent. The repellent contained 33 percent DEET and the sunscreen had an initial SPF of 15. Combination DEET/sunscreen products are marketed, and these have been suggested to provide the SPF stated on the label (Fradin, 1998).

DEET underwent reregistration by the USEPA in 1998. Adverse reactions to the use of products containing DEET noted at that time included skin reactions, particularly at concentrations above 50 percent, and eye irritation. In exceptional cases, central nervous system reactions occurred, particularly in children, ranging from slurred speech and confusion to seizures and coma (USEPA, 1998).

One study reviewed 9,086 cases of DEET exposure that were reported to 71 poison control centers from 1985 to 1989. Fifty-four percent of callers had no symptoms. Most calls that reported symptoms concerned inhaled repellent or repellent sprayed into the eyes. The study found no correlation between the severity of the symptoms and age, sex, or DEET concentration of the product. Twelve percent of the reports were generated by events that required treatment at a health care facility. Of those treated at formal health care facilities, 81 percent were sent home immediately, but five percent eventually required hospitalization. Of those for whom follow-up was available, 99 percent had no long-term sequelae, pathological condition resulting from a disease (Veltri *et. al.*, 1994).

The New York State Department of Health (NYSDOH) recommends that consumers use products with the lowest concentration of DEET that provides adequate protection. Many consumers of insect repellents believe that applying greater quantities or stronger formulations will increase the protective properties of the product. However, it is often the case that using lower concentrations at the application rates specified on the label will provide adequate protection – i.e., no insect bites for the outdoor exposure. NYSDOH has found that DEET concentrations as low as five percent can provide good protection from mosquito bites for about four hours under conditions defined as "low" mosquito activity (NYSDOH, 2001). The NYSDOH guidance document cites the two-part approach of Young and Evans (1998) for more "demanding" conditions. Young and Evans suggest use of a time-release DEET product directly on the skin and treatment of clothing with permethrin (permethrin is discussed below). This approach provides adequate protection over longer periods of time in areas with large and aggressive populations of mosquitoes.

In 1998 the USEPA concluded

> "as long as consumers follow label directions and take proper precautions, insect repellents containing DEET do not present a health concern."

To address its concerns regarding the use of DEET, USEPA (1998) requires that all products containing DEET be labeled with the following information:

- Read and follow all directions and precautions on this product label.
- Do not apply over cuts, wounds, or irritated skin.
- Do not apply to hands or near eyes and mouth of young children.

- Do not allow young children to apply this product.
- Use just enough repellent to cover exposed skin and/or clothing.
- Do not use under clothing.
- Avoid over-application of this product.
- After returning indoors, wash treated skin with soap and water.
- Wash treated clothing before wearing it again.
- Use of this product may cause skin reactions in rare cases.

The following additional statements will appear on the labels of all aerosol and pump spray formulation labels:

- Do not spray in enclosed areas.
- To apply to face, spray on hands first and then rub on face. Do not spray directly onto face.

The NYSDOH (2001) adds the following precautions for the use of products that contain DEET:

- Avoid use of DEET products on skin damaged by sunburn, cuts, rashes, or other skin conditions, such as psoriasis or acne.
- Do not use sunscreens or moisturizers that also contain DEET if the repellent is not needed.

2.1.2. Avon Skin-So-Soft™

Avon Skin-So-Soft™ bath oil has acquired a reputation as an effective mosquito repellent. Avon initially denied that the product was effective for this "off-label" use, but now aggressively markets Skin-So-Soft™ as an insect repellent. A comparison of three different Skin-So-Soft™ products with four DEET formulations demonstrated substantial differences in the effectiveness of the products. The maximum protection time for any Skin-So-Soft™ product was 60 minutes compared to six hours for the strongest DEET product. The Avon bath oil and suncare products had a maximum protection time of 30 minutes. The mean protection time for the bath oil was 10 minutes. The suncare product had a mean protection time of only three minutes, suggesting little repellent effect for most of the study participants. The Skin-So-Soft Bug Guard Plus™ had a mean protection time of 23 minutes (Fradin and Day, 2002).

2.1.3. Permethrin

Pyrethrum is an insecticide produced from the crushed and dried flowers of daisies (*Chrysanthemum cinerariifolium*). Permethrin is a pyrethroid, the synthesized equivalent of pyrethrum. It is a contact insecticide, which also has some repellent properties. Repellents

containing permethrin are for use only on clothing, shoes, bednets, and camping gear. Permethrin is a highly effective and long-lasting insecticide that also kills ticks and other arthropods. Clothes treated with permethrin will to repel mosquitoes for up to two weeks if not laundered. The human toxicology of permethrin is addressed in Book 6 of this Literature Search. NYSDOH (2001) issued the following cautions associated with the use of products containing permethrin:

- Immediately wash with soap and water if accidentally applied to the skin.
- Apply to clothing in a well-ventilated area, protected from the wind.
- Do not apply to clothing that is being worn. Do not saturate clothing. Hang treated clothing outdoors to dry for at least two (2) hours before wearing.
- Do not treat clothing more than once every two (2) weeks. Keep treated clothing in a separate bag when not in use.

2.2. Natural Repellents

The effective ingredients of "natural" or "botanical" repellents are derived from plants. They are regulated differently than chemical repellents, such as DEET and permethrin. Their potential to cause short or long-term health effects is, therefore, not tested to the extent required for chemical repellents. Most of these plant-based products have not had their efficacy tested, but those that have been tested protect for less than two hours, on the whole (Fradin and Day, 2002). Approximately 70 companies offer over 230 different natural insect repellents as alternatives to DEET. Plants whose essential oils have been used as repellents include:

- citronella
- cedar
- verbena
- pennyroyal
- geranium
- lavender
- pine
- cajeput
- cinnamon
- rosemary
- basil
- thyme
- allspice
- garlic
- peppermint

2.2.1. Oil of Citronella

Oil of citronella was originally extracted from the grass plant *Cymbopogon nardus*. Citronella is considerably less effective than DEET, providing, on average, less than 20 minutes of protection (Fradin and Day, 2002).

A recent evaluation of the safety of citronella products was completed by Health Canada's Pest Management Regulatory Agency (PMRA), the federal regulatory body responsible for the registration and re-evaluation of pesticides in Canada (Health Canada, 2004). The agency re-evaluated the available information for citronella-based personal insect repellents that are applied directly to the skin. The PMRA is now recommending that citronella-based insect repellents that are applied to the skin be phased out, although registration may be reconsidered if data are provided to address uncertainties, and what were described as "endpoints of concern". The recommendation does not apply to other uses of citronella, such as in candles, as a food additive, or as a scenting agent in cosmetics.

As citronella-based products repel insects for about half an hour, additional applications are necessary under nearly all circumstances. This means that the chemical exposure multiplies with time. Although the PMRA identified no imminent health risks associated with the use of these products, the manufacturers did not provide adequate safety data to meet the regulatory burden associated with continued registration of the products (Health Canada, 2004).

The PMRA identified a number of concerns linked to citronella oil. It cited the presence of methyleugenol in citronella oil, which was shown to be carcinogenic in animal studies. It also referenced laboratory animal tests that, at high dose levels, were said to indicate a "potential for reproductive and developmental toxicity as well as fetal sensitivity." The PMRA was, therefore, unable to approve the use of citronella-based personal insect repellents as acceptable, when applied directly to the skin (Health Canada, 2004).

2.2.2. Bite Blocker™

Bite Blocker™ is a plant-based insect repellent that was released in the United States in 1997. It combines soybean, geranium, and coconut oils. Bite-Blocker was found to be 97 percent effective after three and a half hours against *Aedes* mosquitoes under field conditions, which was better than the 86 percent effectiveness results from 6.65 percent DEET (Fradin, 1998). In

another test, BiteBlocker™ was also found to provide an average of 200 minutes protection (Lindsay *et. al.*, 1996). Fradin and Day (2002) found it to be effective for 90 minutes on average, with a maximum protection period of three hours. Consumer Reports (2000) found it was the only plant oil product it tested to offer significant protection; the minimum protection time was one hour, and the maximum protection was for four hours, a result that fell between those of seven and 10 percent DEET formulations.

2.2.3. Oil of Eucalyptus

A botanical product that uses oil of eucalyptus is marketed under two brands: Repel Lemon Eucalyptus Insect Repellent (WPC Brands) and Fite Bite Plant-Based Insect Repellent (Travel Medicine). These products were introduced after the original studies for the Fradin and Day research were completed. The authors tested the eucalyptus based products, although only six subjects were used (Fradin and Day, 2002). The repellent had a mean complete-protection time of two hours and a maximum protection time of over three and a half hours. Oil of eucalyptus appeared to offer approximately the same degree of protection as 6.65 percent DEET.

2.3. Personal Repellant Guidelines

The American Mosquito Control Association (AMCA) (undated), which stresses the need to provide personal protection when exposed to mosquitoes, therefore provides the following guidelines to follow when using personal insect repellents.

- Wear long sleeve shirts and pants outdoors during peak mosquito activity time periods.
- Apply repellent sparingly only to exposed skin or clothing.
- Keep repellents away from eyes, nostrils, and lips: do not inhale or ingest repellents or get them into the eyes.
- Avoid applying high concentration (greater than 30 percent DEET) products to the skin, particularly of children.
- Avoid applying repellents to portions of children's hands that are likely to have contact with eyes or mouth.
- Pregnant and nursing women should minimize use of repellents.
- Never use repellents on wounds or irritated skin.
- Use repellents sparingly; one application will last approximately 4-6 hours. Saturation does not increase efficacy.

- Wash repellent-treated skin after coming indoors.
- If a suspected reaction to insect repellents occurs, wash treated skin, and call a physician. Take the repellent container to the physician.

3. Space Repellants

Space repellants are used to protect individuals inside the home or in the yard. They are most effective indoors. Outdoors, the insecticide particles disperse rapidly and, therefore, may not be effective.

3.1. Pyrethrum and Pyrethroids

Many household aerosols contain synergized pyrethrum, an insecticide made from the dried flower heads of *Chrysanthemum cinerariifolium,* or a synthetic, pyrethroid equivalent such as allethrin, resmethrin, etc. (Occupational Health Services, Inc., 1987). Natural pyrethrins and pyrethroids are contact poisons that affect the nervous system of the insect. As insects can quickly detoxify them, synergists are usually added to maintain their potency (EXTOXNET, 2003).

The toxicology of pyrethroids is discussed in Book 6 of this Literature Search. However, in general, "pyrethrins and pyrethroids are of low chronic toxicity to humans and the most common problems in humans have resulted from the allergenic properties of pyrethrum" (EXTOXNET, 2003).

3.2. Citronella

Oil of citronella is the active ingredient in many of the candles, torches, or coils that may be burned to produce a smoke that repels mosquitoes. These can be used outdoors, but only in situations where there is minimal wind. Commercially available three percent citronella candles, five percent citronella incense, and plain candles were evaluated for their ability to prevent mosquito bites (Lindsay, *et. al.*, 1996). The report found that persons near the candles had 42 percent fewer bites than people with no protection. However, the study also found that burning ordinary candles reduced the number of mosquito bites by 23 percent. They found no difference between the efficacy of citronella incense and plain candles. Fradin (1998) suggested that the plain candles might act as a decoy by producing heat, moisture, and CO_2.

4. Mosquito Attraction Devices

AMCA has determined that mosquito attraction devices marketed for residential use trap and kill mosquitoes. However, AMCA has not yet determined if this means that the devices reduce the number of biting mosquitoes in an area. It is possible that the devices actually serve as mosquito attractants under some conditions, and so may increase the degree of mosquito presence (AMCA, undated).

4.1. BugZappers

A study of electric, ultraviolet light "bugzappers" found no benefit for outdoor mosquito control, and actually suggested they have deleterious, counterproductive impacts. Nearly half of the insects caught were non-biting, aquatic insects. Nearly 15 percent were predators and parasites of biting insects. Only 31 out of 13,789 insects were classified as "biting flies," 0.22 percent (Frick and Tallamy, 1996). This indicates that, in fact, the machines do much more harm than good in their attempts to control noxious insects.

4.2. Propane Powered Mosquito Traps

Propane powered mosquito traps such as the Mosquito Magnet™ and the Mosquito Deleto™ rely on the use of heat and CO_2 to attract mosquitoes. The devices operate without the need for batteries or external power. Carbon dioxide is catalytically produced, by converting propane to CO_2, water vapor, and heat. Mosquitoes, attracted to the CO_2 and heat, and an optional octenol attractant, fly into a tube where they are sucked into a collection bag. A thermoelectric generator uses the excess heat from the propane combustion process to generate electricity to run the trap's fan. Several popular units are compared in Table 4-1.

Table 4-1 - Comparison of Propane Powered Mosquito Traps

Products	Mosquito PowerTrap/ Eliminator	Mosquito Magnet	Applica SonicWeb™	Mosquito Deleto Trap Home Version	Mosquito Trap
Power Source	Burning Propane & Electricity	Burning Propane & Electricity	Low Voltage Electricity	Burning Propane	Burning Propane & Electricity
Power Supply	Propane Tank NOT Included	Propane Tank NOT Included	Everything Included	Propane Tank Not Included	Propane Tank & Ext. Cord NOT Included
Coverage/Area	¾ Acre Depends on Wind	¾ to 1 Acre Depends on Wind	1 Acre Protection in Every Direction	½ Acre Depends on Wind	¾ Acre Depends on Wind
Primary Attractants	Carbon Dioxide (CO_2), Heat & Octenol	Carbon Dioxide (CO_2), Heat & Octenol	4 Genetic Lures: +Heartbeat Sound +Octenol scent +Heat/body temp +Design contrast	Carbon Dioxide (CO_2), Heat & Octenol	Carbon Dioxide (CO_2) & Heat
Elimination Method	Vacuum	Counterflow Vacuum	Web Trap™ Adhesives	Adhesive Panels	Vacuum
Key Facts	- Wind affects efficacy - Unattended burning propane	- Wind affects efficacy - Unattended burning propane	+Effective, worry-free operation in wind or weather + Total Protection in Every Direction	- Wind affects efficacy - Unattended burning propane	- Wind affects efficacy - Unattended burning propane
Retail Price	$347	$495-$1295	$299.85	$199.99	$350
Accessory Costs	Propane Tank $50 Propane Fuel $12 Octenol $5.95	Propane Tank $50 Propane Fuel $12 Octenol $19.90/3 Nets $24.90/3	Accs. kit = $19.99	Propane Tank $50 Propane Fuel $12 Octenol $12.99 Adhesives $14.99	Propane Tank $50 Propane Fuel $12

From the SonicWeb website (http://www.sonicweb.com/comp.html), Applica Consumer Products, Inc.

Various propane-powered mosquito traps were tested in a large cage with laboratory-reared mosquitoes, as well as in the field (Kline, 2002). The study was conducted in 1997 with early models of different propane powered traps. The data indicated that 71 percent of the *Aedes aegypti* and *Ochlerotatus taeniorhynchus* mosquitoes released into the large cage were trapped. Units equipped with "counterflow geometry" were most successful in capturing mosquitoes. In the Gainsville Florida field collection trial, the five most commonly captured species were: *Ochlerotatus canadensis, Anopheles crucians, Coquillettidia perturbans, Anopheles quadrimaculatus,* and *Culex salinarius* (is this still the Kline, 2002 study?). In another test, Smith (2001) compared three Mosquito Magnet units and one Flowtron unit for American Biophysics Corporation, the manufacturer of the Mosquito Magnet. The research was conducted at the Florida A&M University campus. Out of a total of 11 species collected, *Ochlerotatus taeniorhynchus* and *Anopheles crucians* represented the majority of mosquitoes collected. Also

collected were *Culex salinarius, Ochlerotatus infirmatus, Culex quinquefasciatus, Culex nigripalpus, Aedes albopictus, Aedes, vexans, Coquillettidia perturbans, Stomoxys calcitrans,* and other *Culex* species.

A test of eight commercially available traps was conducted on the campus of Florida A&M University (Smith, 2003). The study found significant differences in the numbers and species caught among some of the traps, with the Mosquito Mega-Catch™ and the Mosquito Magnet Liberty capturing over two times more mosquitoes than the next best trap. The Sonic Web collected considerably fewer mosquitoes than any of the other traps. The Mosquito Magnet Liberty also captured more species (16) than any other. Diversity of mosquito capture can be important if more than one biting species is an issue for the homeowner. Table 4-2 presents the capture results from the experiment. Although the Mega-Catch™ appears to have had better capture rates than the Mosquito Magnet, however, the Mega-Catch™ was tested *with* attractants and the Mosquito Magnet *without* attractants (Smith, personal communication, 2004). The difference in performance of these two units, however, was not statistically significant (Smith, 2003).

Table 4-2 - Total Number Mosquitoes Captured by Trap

Models tested	Total Mosquitoes Captured (rounded)
MegaCatch Ultra	2800
Mosquito Magnet Liberty	2500
Lentek	1100
Flowtron	450
Mosquito Deleto	450
Dragon Fly	400
Sonic Web	100

From Smith, 2003

The Mosquito Magnet Liberty was tested for its ability to reduce ambient populations of mosquitoes. The traps were found to capture mosquitoes, resulting in a population reduction over the treatment period. However, the population decline at the two treatment sites did not differ from a similar population decline found at two control sites (Smith, 2003).

Generally, mosquito control professionals are becoming convinced that trapping mosquitoes is not efficient enough to control mosquito populations sufficiently to prevent biting complaints.

This is especially true when mosquito populations are dense and aggressive biters (W. Crans, Rutgers University, personal communication, 2004).

4.3. Sonic Attractants

A device marketed as the SonicWeb™ by Applica Consumer Products, Inc. is purported to attract mosquitoes by a combination of sound, smell, sight, and heat. Its signature attraction is the low frequency sound emitted by the device that the manufacturer claims is attractive to mosquitoes. The manufacturer also maintains that the device itself is designed to attract mosquitoes with "ultraviolet reflection and contrasting stripes." The unit also emits octenol and heat, which are commonly accepted attractants. In the test by Smith (2003), the SonicWeb™ unit was the poorest performing of seven tested.

Scientific studies have repeatedly shown that electronic mosquito repellers do not prevent host-seeking mosquitoes from biting (Foster and Lutes, 1985; Schreck *et al*., 1984; Schreiber *et al*., 1991; Crans, 1996). In fact, the American Mosquito Control Association was so upset with what its members perceived of as unsubstantiated product claims that it began legal proceedings against some manufacturers of these products on the basis of false advertising (Curtis, 1994). Alt`hough unsuccessful, the Federal Trade Commission did take notice of the claims and has required alterations to the language that upset mosquito control professionals.

5. Vaccination

Vaccination with a harmless relative of the West Nile Virus could possibly protect people against the deadly disease. Australian scientists successfully immunized mice against WNV using a DNA vaccine that led to live and replicating Kunjin virus in the animals. Although Kunjin virus is genetically similar to WNV, it only rarely causes illnesses in humans and is not fatal. When mice were given the Kunjin DNA vaccine, they "were solidly protected against disease", even when injected with lethal doses of WNV (Bhattacharya, 2003).

In 2003 the National Institute of Allergy and Infectious Diseases (NIAID), which is part of the National Institutes of Health, created a vaccine against WNV by replacing parts of a related virus with proteins from the WNV. Two candidate vaccines were reported to be protective in rhesus monkeys (Pletnev, *et. al.*, 2003). In one, where proteins from dengue type 4 virus were replaced by West Nile virus proteins, the hybrid virus vaccine protected monkeys from West Nile infection, and will be used in planned human clinical trials (NIAID, 2004). This viral vaccine approach is preferred because it triggered high levels of WNV antibodies without measurable levels of virus in monkeys (NIAID, 2003).

A vaccination for horses was developed less than a year after the initial outbreak of WNV, but this development does not forecast a similarly rapid process for human vaccine development. Human safety considerations and effectiveness requirements usually require much more time than an animal vaccine would, and the particularities of flaviviruses make WNV human vaccine formulations more difficult than for animals (Barrett, 2001).

6. Household Protection Methods

It is an axiom of mosquito control that many effective measures need to be undertaken by householders, not organized vector control agencies. This is because many species of concern prefer to breed in domestic settings, and it is clear that individual homeowners can police their own properties much more effectively and efficiently than public agencies can.

6.1. Standing Water

Standing water is a common and easily controlled contributor to local mosquito populations. Individuals are encouraged to eliminate standing water in trash cans, old tires, rain barrels, etc. *Anopheles* mosquitoes often breed in standing water puddles. *Culex pipiens*, the mosquito believed responsible for West Nile Virus transmission in the northeastern US, tends to breed in standing water containing organic matter around houses (Vogel, 2002). *Aedes triseriatus*, the "treehole" mosquito, will often substitute similar, synthetic environments for its preferred egg-laying habitat, such as tires and other semi-enclosed water collection areas. *C. restuans* also breeds in these kinds of environments, and will bite people within and around the house (Crans and Mahmood, undated). A recent invasive species, *Ochlerotatus japonicus,* was discovered in Suffolk County in 1998 (Peyton et al., 1999), and prefers to breed in containers located in the shade of trees or manmade canopies that cover water. Discarded tires, buckets, or other basins are its favored breeding grounds. Control of these breeding points and other potential mosquito habitat around the house can reduce personal discomfort and even impact human disease threats.

6.2. Screens

Window and door screens are an obvious means of preventing the entry of mosquitoes to the home. They should be tightly fit and be in good condition. Several experts claim that the widespread use of window screens is primarily responsible for the eradication of malaria in the United States (Spielman and D'Antonio, 2001; Reiter, as cited in Budiansky, 2002). It is also thought that *Culex* mosquitoes, the presumptive transmitter of WNV, prefer to enter houses late at night if seeking human prey (A. Spielman, Harvard School of Public Health, personal communication, 2004). Window screens can prevent the mosquitoes from being able to access

people as they sleep, therefore, and so may prevent many potential WNV cases (W. Crans, Rutgers University, personal communication, 2004).

6.3. Household Guidelines

The report by Toxics Action Center and Maine Environmental Policy Institute provides steps one can take in mosquito prevention around one's own home (Sugg and Wilson, 2001). They are as follows:

- Remove any unnecessary items on your property that can hold stagnant water, such as old tires. If you use old tires for farming or gardening, drill holes in them and empty them regularly.
- Empty water from buckets, toys, and containers, and store them in places where they will not collect rain.
- Make sure your dry-docked boat's drain is open so as not to collect rainwater and/or make sure that the cover is tight and has no standing water pockets. Keep your canoes and kayaks stored upside-down.
- Drill holes in the bottoms of recycling bins and any other containers that must be kept outdoors.
- Drain the water from birdbaths, fountains, wading pools, plant pots, and drip trays twice a week.
- Check for other ways water may be collecting around your house, such as puddles beneath air conditioners.
- Clean out your gutters and fix gutters that sag or do not drain completely. Check for areas of standing water on flat roofs.
- If you have a swimming pool, outdoor sauna, or hot tub, make sure rainwater does not collect on the cover. However, make sure the pool is tightly covered if chlorination and aeration will be stopped for any substantial length of time.
- Clear vegetation and trash from any drains, culverts, ponds, or streams on your property so that water drains properly.
- Keep grass cut short and trim shrubs to minimize hiding places for adult mosquitoes.
- Eliminate standing water in your basement.

Additional guidelines are provided by an Ohio State University Extension publication (Lyon and Steele, 1995):

- Place tight covers over cisterns, cesspools, septic tanks, fire barrels, rain barrels and tubs where water is stored.

- Do not over-apply lawn and garden irrigation, causing puddling in low areas.
- Fill tree hoes with Treekote and mortar after draining.

Dutchess County Cooperative Extension publication (1991) recommends the addition of goldfish to ornamental ponds to consume mosquito larvae. They stress that the fish should not be added to natural ponds.

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