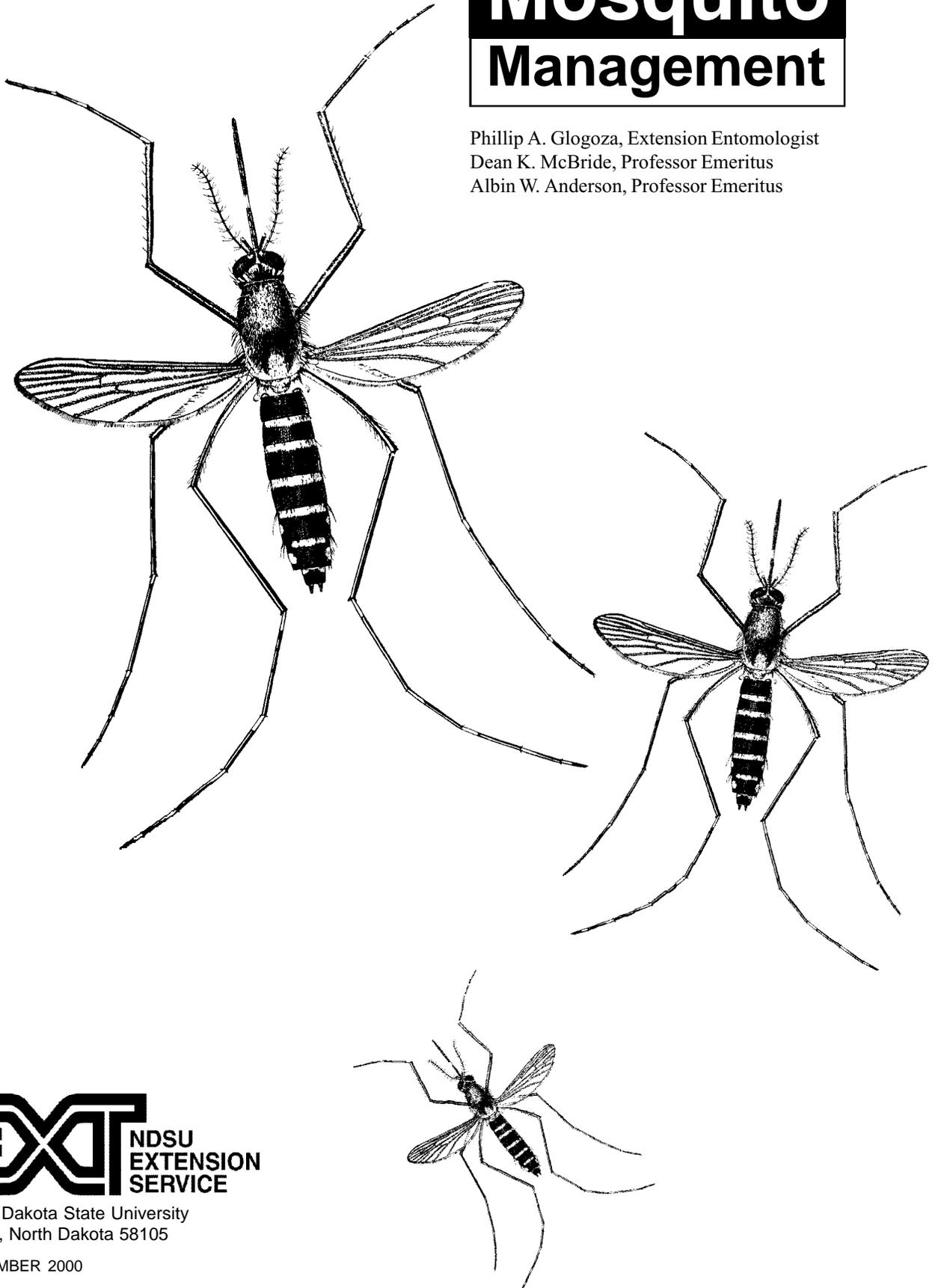


Mosquito Management

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DECEMBER 2000

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Disclaimer Clause

The information given in this publication is supplied with the understanding that no discrimination is intended and no endorsement by the NDSU Extension Service is implied. The authors have assembled the most reliable information available to them at time of publication. However, due to constantly changing pesticide laws and the fact that we have no control over insecticide use and the manner or conditions under which they are used, we assume no responsibility for personal injury, property damage, or other type of loss resulting from the handling or use of the insecticides listed herein.

The pesticide user is always responsible for the effects of residue as well as for problems that could arise from off-target movement of the pesticides being applied. Always read and follow carefully the instructions given on the pesticide label.

At least 43 species of mosquitoes are known to occur in North Dakota. Fortunately, only a few species cause annoyance. Nevertheless, their presence affects people engaged in outdoor activities during the warm months of the year. Mosquitoes also annoy livestock and cause weight loss, reduce milk production, and hinder reproduction.

Besides the nuisance biting activities of various mosquito species, there are several species in the genera *Culex* and *Aedes* that can transmit diseases such as St. Louis and Western equine encephalitis to humans and horses, and heartworm to dogs. While Western equine encephalitis does occur occasionally in North Dakota the disease is not common in the state. However, during the 1941 outbreak when encephalitis reached an all time high in the United States and Canada, 1,101 people and 2,552 horses contracted the disease in North Dakota with a mortality rate of 13 percent (139 deaths) in humans and 21 percent (549 deaths) in horses. Practically all cases were the Western type encephalitis.

The danger of outbreaks of diseases such as encephalitis (sleeping sickness) in people and horses is always possible. Fortunately, the North Dakota State Health Department maintains an encephalitis surveillance program in the state during high risk periods of the summer season. Their program includes surveillance efforts to determine the presence or absence of the West Nile virus in North Dakota.

Individual homeowners can do much to reduce mosquitoes in their yard areas. Such efforts should be supplemented by an area-wide community mosquito management program conducted by trained personnel.

Life Cycle and Breeding Habits

The most abundant mosquitoes in North Dakota are the *Aedes* (Figure 1) temporary pool water breeders. They lay their eggs singly on damp soil near water. Like all mosquitoes they pass through four life stages; egg, larva (four stages or instars), pupa and adult. In North Dakota they overwinter in the egg stage. All mosquitoes live in water continuously from the time the eggs hatch through the larval (wiggler) and pupal stages until the adults emerge. Multiple generations are possible. They are found in shallow water with abundant vegetation above and/or on the water surface, where there is a fluctuating water level, and they are protected from wave action. Roadside ditches are common breeding sites. They do not live in running water or deep, open waters of lakes and ponds.

Mosquito eggs, if not flooded one season, can survive for several years until they are flooded.

The other types of mosquito occurring in North Dakota are permanent water breeders (Figure 2). These permanent water types (*Culex*, *Culiseta* and

Anopheles) lay their eggs on the water surface. Several generations are produced each summer. The adults overwinter in protected areas.

The adults emerge from the pupal cases, the wings expand and after a few hours the exoskeleton becomes hardened enough for flight. The female then seeks a blood meal from man or animal; the blood aids in egg development. Adults often rest in weeds, tall grass or other vegetation but never reproduce there. After a few days the females return to their preferred pools to deposit eggs and the cycle begins again.

Depending on the amount of light and temperature, the cycle from egg to adult may take one to four weeks.

Adult mosquitoes are strong fliers. They can move long distances away from their breeding sites, although they usually go only far enough to find a blood meal. Mosquito movement is aided by winds and is a common method of wide area dispersal from rural to urban areas.

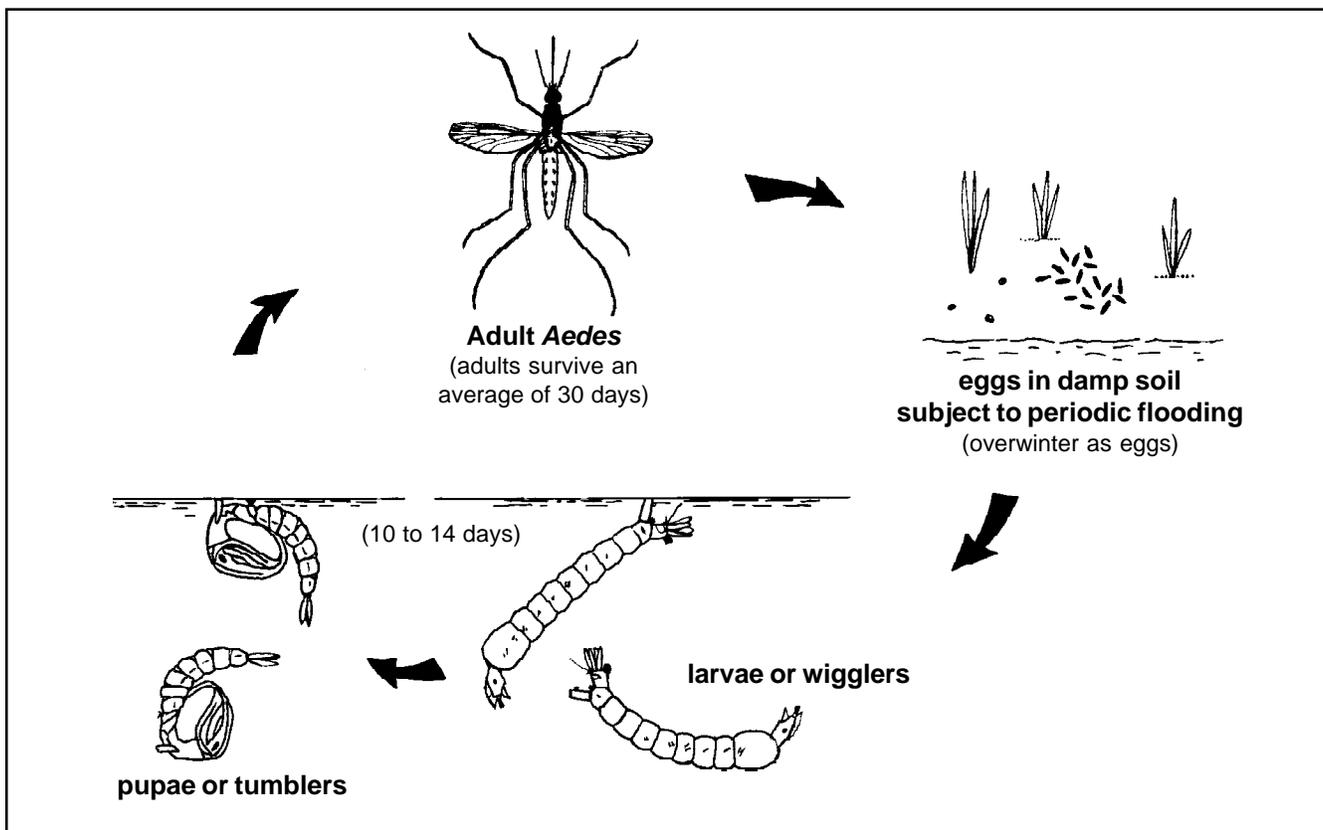


Figure 1. Life cycle of temporary water breeders (*Aedes*). Adult, egg, larva and pupa.

Mosquito Management

Indoor Control

Mosquitoes found inside the house can be killed with any good household spray labeled for control of flying insects indoors. Space sprays or aerosols containing synergized pyrethrins or synthetic pyrethroids are effective.

An aerosol bomb containing pyrethrum is easy to use. Best results are obtained if doors and windows are kept closed during and for five to 10 minutes after spraying. Only products labeled for flying insect control should be used. Residual spray products labeled for control of crawling insects are also often packaged in aerosol bombs; these products are hazardous if sprayed into the air, even if the windows and doors are open. Avoid spray on food, dishes and other eating utensils.

Be sure to keep windows, doors and porches tightly screened to exclude as many mosquitoes as possible.

Repellents

Mosquitoes are attracted by perspiration, warmth, body odor, carbon dioxide, and incandescent light. Repellents can protect humans from mosquito bites for one to five hours, depending on the type used, amount of perspiration and rubbing of the skin, and abundance of mosquitoes. Cover the area of skin to be protected evenly, because mosquitoes will find and bite untreated spots. Spray on the outer clothing and on exposed parts of the body. Keep repellents away from the eyes, nostrils and lips. Repellents may damage plastics, synthetic fabrics, nail polish and certain painted or varnished surfaces. Repellents used in commercial products include DEET (N, N-Diethyl-Metatoluamide), permethrin, citronella, eucalyptus, and other "natural" ingredients.

DEET is the most common and effective repellent. Products are available in varying concentrations, ranging from 7.5 to 95 percent DEET. Both can be determined easily because the active ingredients and

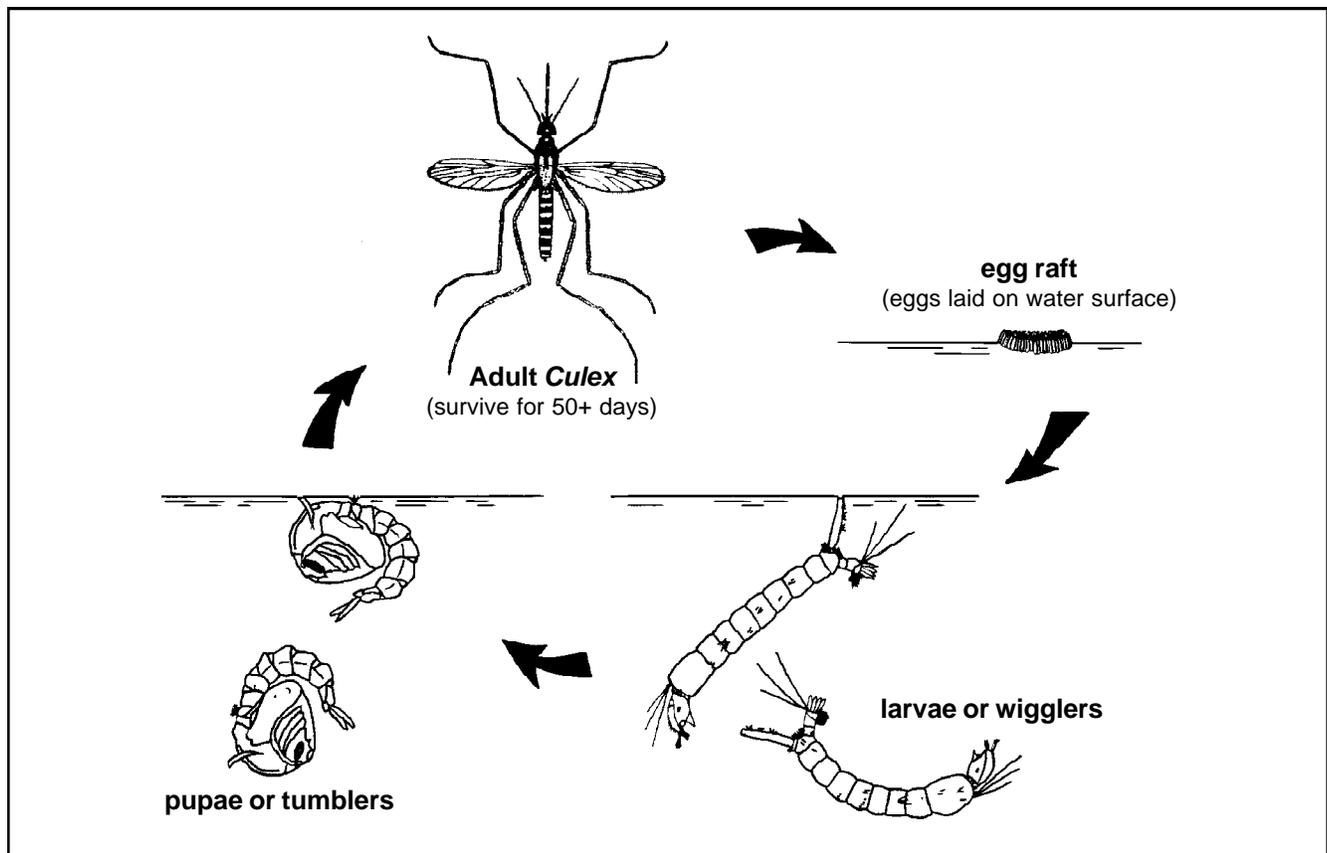


Figure 2. Life cycle of permanent water type breeders.

percent concentration are on the product label. Lower concentration products are generally adequate for most outdoor activities. DEET should not be used indiscriminately as severe allergies can develop. **It is recommended that only products containing lower concentrations of DEET (less than 15%) should be used for children.**

Permethrin is a repellent that is applied to **outer clothing only** and is **not applied to skin**.

Repellents that contain citronella, eucalyptus, and other “natural” ingredients provide only moderate protection against mosquito bites. Their benefits are weak and short-lived, lasting as little as 10 to 20 minutes. All of these products are less effective than DEET.

Potential Adverse Reaction to Repellents:

Repellents may be absorbed through the skin and in rare instances cause illness. Some individuals may experience skin irritation or allergic reactions after exposure to any of the repellent products. There have been a small number of reports of adverse reactions following repeated topical applications of products containing DEET. Symptoms reported in cases involving small children were headache, crying, irritability, confusion, mood changes, and nausea. Ingestion of DEET has resulted in symptoms such as low blood pressure, seizures, and unconsciousness. These cases were the result of deliberate ingestion of the product or accidental ingestion by children.

Other Methods for Repelling or Trapping

Mosquitoes: Several area repellents are currently available and may be used to discourage activity by mosquitoes around patios or yards. The active ingredients in these products are most often citronella. While these products should not be used indoors, their greatest benefit may be when used in screened-in porches or other areas where air movement is limited. Controlled research studies conducted in an open area found that they were ineffective at reducing the biting pressure of mosquitoes (Lindsay et al. 1996).

Evaluations of electronic and ultrasonic repeller devices have indicated there is no significant effect on mosquito behavior that results in reduction or elimination of biting activity. Traps which use ultraviolet light as an attractant (“black light bug zappers”) are not effective in reducing the biting mosquito population. However, there are modifications of this trapping concept currently being marketed that use CO₂,

Mosquito Repellent Guidelines

- Use just enough repellent to cover exposed skin and clothing. Do not use repellents under your clothing. **Do not apply permethrin-based products to your skin.**
- Frequent re-application and saturation is unnecessary for effectiveness. Prolonged use should be avoided.
- Always keep repellents out of the reach of children. Children should not be allowed to use repellents without adult supervision. **Repellents should not be used on infants.**
- Never use repellents on cuts, wounds, abrasions, or on sunburnt or irritated skin.
- Do not apply repellents to eyes and mouth. Do not spray directly over the face. Avoid application near food. **Do not apply to the hands of young children;** they are more prone to putting their fingers in their mouths.
- Avoid breathing spray mist or vapors in enclosed areas such as cars, tents, etc.
- After returning indoors, wash treated skin with soap and water or bathe. this is more important when repellents have been used repeatedly on a given day or on consecutive days.
- Do not reuse empty containers. Do not incinerate aerosol cans.

octenol, and other chemicals to attract mosquitoes more effectively. The scented geranium plant, *Pellargonium* spp., more commonly known as the Citrosa “Mosquito Fighter” plant, has not proven to be effective at repelling mosquitoes from an area.

Area-Wide Management

Mosquito management on an area-wide basis is a complex problem which should be directed by professionals with support from the private sector. The administration of community programs must be flexible. This flexibility should, however, be based on established principles of good mosquito management. A number of techniques are available, depending on the target species involved and the priorities which have been established. For example, the control of species involved as disease vectors can be quite a different problem from that of species which are strictly nuisance biters.

Health Education

All good public health programs must include education of the public for understanding and support. This is especially important for mosquito control programs, because homeowners can help greatly by eliminating breeding sources of mosquitoes on their own property. In areas where extensive breeding occurs in containers on private property, the effectiveness of any community-wide effort directed at public property alone will be reduced or destroyed without homeowner participation. It is, therefore, of utmost importance to inform citizens of ways to help.

Survey for Breeding Places

An effective community-wide mosquito management program cannot be planned or implemented until a survey is made to locate the major breeding places of problem mosquitoes. Mosquito surveys take a great deal of time and work but are well worth the effort. Though mosquitoes usually require standing water for breeding, it is not true that mosquitoes will be produced in every body of standing water. A survey will identify those breeding sites which must be eliminated or treated. This will avoid unnecessary intrusion upon areas which need not be treated, thereby preserving the environment and saving the taxpayers' money. **Since the most efficient management programs concentrate on control of mosquito larvae rather than adult mosquitoes, the survey is an essential prerequisite.**

Source Reduction and Habitat Alteration

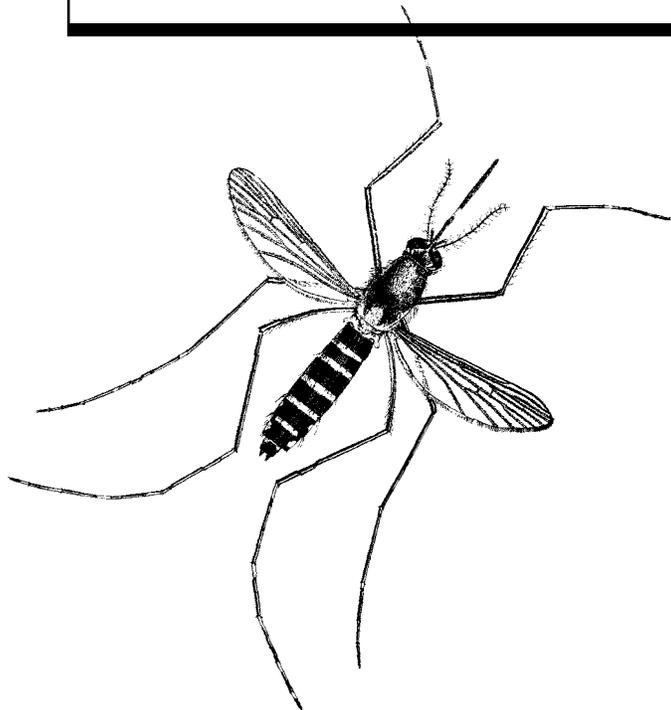
Many mosquito problems can be permanently reduced by either eliminating breeding places or altering the habitat to reduce the potential numbers of larvae which could survive. This might mean clearing a shoreline of vegetation which could provide a natural harbor for larvae. Eliminating a source of organic pollution will alter a breeding place to not only deprive larvae of nutrients but also to provide an environment favorable for mosquito. Under no circumstances should a body of water be drained or an area filled until permission has been obtained from the local drainage board and until the area has definitely been established as a breeding site for problem species.

The following practices may be used to reduce mosquito breeding sites:

1. Ditch and clean stagnant streams to ensure a continuous flow of water to eliminate border vegetation which produces habitat for mosquito development.
2. Drain or fill back-water pools and swamps where stagnant water accumulates. Sanitary landfills which can often be used in such locations will eliminate mosquito breeding sites and improve the value of the land. Check with the North Dakota State Health Department before establishing such landfills.
3. Since all mosquitoes breed in shallow quiet water, remove vegetation and debris from along the shores of the lakes and ponds to discourage mosquito breeding. Such bodies of water should have a steep clean shoreline with as little vegetation as possible. Weed killers may be used in some cases to eliminate or prevent emergent plant growth.

Backyard Checklist

- Remove water holding containers such as old tires, tin cans, buckets, drums, and bottles.
- Cover trash containers to exclude rain water.
- Clean clogged roof gutters and drain flat roofs.
- Empty wading pools at least once a week and store indoors when not in use.
- Properly care for backyard pools; schedule proper maintenance while on vacation.
- Change the water in bird baths and fountains at least once a week.
- Consider stocking ornamental pools with fish.
- Fill in or drain low areas in yards to discourage puddles.
- Keep drains, ditches, and culverts clean of weeds and trash to allow proper drainage.
- Repair leaky outdoor faucets and pipes.
- Trim shrubs and trees to discourage mosquitoes from resting on foliage.



Chemical Management Techniques

Chemical control is, at best, a temporary expedient which should be limited to situations which offer no other alternatives. In general, chemical control can be divided into two major operations. The first, larviciding, is the most efficient and effective and should be the backbone of any good chemical program. The second, adulticiding, is less efficient and should be used strictly for supplemental or emergency purposes. Detection of active transmission of a mosquito-borne disease is an example of such an emergency. The North Dakota State Health Department routinely monitors levels of arbovirus transmission throughout the state and may be contacted for information on the status of disease transmission.

A number of insecticides have been registered for use in mosquito control. The relative value of chemical control varies with the mosquito species and environmental conditions at the location where control is to be applied. Because each situation differs, care must be taken to select the proper insecticide for a particular situation. Some factors to be considered include: effectiveness against target species (resistance problems); relative toxicity to man and domestic animals (impact on non-target organisms); contamination of garden or fruit; cost; availability in quantities needed; need for residual action in some situations; chemical stability; flammability; ease of preparation; corrosiveness; and offensive odor, staining etc.

Resistance can be a problem in mosquito control, especially when using some of the organophosphate compounds. However, before assuming that resistance is the cause of poor control, it must be established that poor control is not caused by other factors such as improper identification of mosquitoes, spray techniques, lack of knowledge about insect habits, or faulty source reduction procedures. Any decrease in susceptibility should be substantiated in carefully controlled tests before changing either the toxicant or the application procedure.

Pesticide Safety Measures

The key to the safety of humans and other nontarget organisms is knowledge of the hazards involved in handling and applying pesticides. The relative toxicity of pesticides is often measured using acute oral LD₅₀ values. These values represent the lethal oral dose of pesticide required to kill 50 percent of a test animal population (usually laboratory rats). They are given in milligram of toxicant per kilogram of body weight of the test animal. Table 1 lists the acute oral LD₅₀ values for the insecticides registered for mosquito control in North Dakota.

All pesticides must be handled in such a way that any possibility of harm to nontarget organisms (including man), either through contamination of food and water or by contact, is kept to a minimum. Always **read the label** before using any pesticide. **Follow all directions carefully** when you prepare and apply the pesticide.

- Wear protective clothing to avoid prolonged or dangerous exposure to pesticides.
- Take care to avoid contamination of foods or drinking water of man and animals.
- Keep application equipment clean and in good condition.
- Store pesticides only in their original containers with the proper label and out of reach of children and animals.
- Dispose of empty containers properly and know the emergency measures for treating accidental poisoning and cleaning up of spills or other pesticide contamination.

Many chemical insecticides registered for use in mosquito control are toxic to birds, fish, and other wildlife, so appropriate precautions must be taken. In addition, most of these insecticides are toxic to bees exposed to direct treatment or to residues on crops. In making applications, exercise care to avoid getting any of these insecticides on food or feed crop areas. Instructions on the label will give precautions or restrictions while using insecticides for mosquito control.

Larval Control

Mosquito breeding sites that are undesirable or impossible to alter or eliminate may be treated with an appropriate larvicide. Table 2 lists the mosquito larvicides recommended for use in North Dakota. Larvicides should be applied only at sites where mosquito larvae of the proper target life stage are present. In addition, the degree of control obtained with larvicide applications often depends on the amount of pollution and the type and amount of vegetative cover present. Where cover is heavy, granular formulations frequently provide better control than emulsions or oil sprays. Repeated treatments with some of these insecticides may be needed, especially after heavy rainfall. Generally, three or four treatments each season will be needed. For proper mixing instructions, application rates, and precautions, all label directions should be read and followed carefully. Application rates may vary de-

Table 1. Toxicity and hazard of selected insecticides.

| Insecticide | Oral (Rat) ¹ LD ₅₀ (mg/kg) |
|--|---|
| Moderately Toxic | |
| tralomethrin* (Saga) | 99 |
| deltamethrin* (Suspension) | 128 |
| chlorpyrifos* (Mosquitomist, Dursban, Empire) | 135 |
| fenthion* (Baytex) | 255 |
| carbaryl (Sevin) | 307 |
| naled (Dibrom) | 430 |
| Relatively Non-Toxic | |
| cyfluthrin* (Tempo) | 500 |
| malathion (Fyfanon*) | 885 |
| pyrethrins | 1500 |
| resmethrin* (Scourge, Oblique) | 2000 |
| temephos* (Abate) | 2030 |
| permethrin (Biomist*, Permanone) | >4000 |
| sumithrin* (Anvil) | >10,000 |
| methoprene (Altosid) | >30,000 |
| Bacillus thuringiensis var. israelensis (Bactimos, Teknar, Vectobac, Mosquito Dunks) | non-toxic |
| Bacillus sphaericus (VectoLex) | non-toxic |

* to be applied by licensed, certified pesticide applicators

¹ George W. Ware. 1994. The Pesticide Book, 4th edition. Thomson Publications; Fresno, CA.

Table 2. Larvicides for use on mosquito breeding waters.

| Insecticide | Formulations* | Remarks |
|--|---|---|
| <i>Bacillus thuringiensis var. israeliensis</i> (B.t.i.): | | |
| Aquabac | 200 G, 1.2% AS | A bacterial larvacide that is non-toxic and will not harm non-target, beneficial organisms. Higher rates are recommended in water with high organic content (e.g., sewage disposal systems, waste lagoons). Pretreatment is recommended when larval populations are high, aquatic vegetation is dense, or the water is highly polluted with organic material. |
| Bactimos | 10% Briquets | |
| Mosquito Dunks | 10% Briquet | |
| Teknar HP-D | 1.6% | |
| Vectobac | 0.2% CG, 0.2% G, 12% AS | |
| <i>Bacillus sphaericus</i> | | |
| VectoLex | 7.5% CG, 51% WDG | A bacterial larvacide that is effective against <i>Culex</i> mosquitoes and others. It is non-toxic and will not harm non-target, beneficial organisms. It has proven effective in wastewater, stormwater, drainage, marsh, and pond habitats. |
| methoprene | | |
| Altosid | SR 5 and SR 20 (liquid concentrates); XR (2%), XRG (1.5%), and briquets (8.6%); pellets (4.25%) | Methoprene is an insect growth regulator (IGR). It is active against 2nd, 3rd, and 4th instar larvae. It has no effect when applied to pupal or adult mosquitoes. The effect on larval mosquitoes is developmental. Treated larvae continue to develop normally to the pupal stage, at which time they die, preventing them from emerging as adult mosquitoes. |
| aliphatic petroleum distillate** | | |
| Golden Bear | GB-1111 | Specially refined oil for use as a mosquito larvacide. This product is applied around borders of aquatic areas and in shallow water. Do not apply to fish hatcheries. Petroleum oils may produce an unsightly appearance and should not be used when this condition is objectionable. |
| temephos | | |
| Abate | BG (1%, 2%, and 5%), pellets | An organophosphate insecticide that can be used in conjunction with other larvacide programs. Application rates vary with water's organic content. When applied at label rates there is no effect on non-target organisms. |
| poly (oxy-1,2-ethanediyl) α-isooctadecyl-ω-hydroxyl | | |
| Agnique | 100% MonoMolecular Film | AGNIQUE® MMF uses a non-toxic, physical action to control both disease-carrying and nuisance mosquitoes. It has the ability to spread quickly and completely across the water's surface. This film reduces the surface tension of the water and makes it difficult for the larvae and pupae to attach. The film also blocks their breathing tubes causing the larvae and pupae to drown. Resting males and egg-laying females that come in contact with the film will also drown. When the correct amount has been applied, there will be no breaks or gaps in the film from which mosquitoes can emerge. |

* G = granular; WDC = water dispersible concentrate; CG = celatom granular; AS = aqueous suspension; WDG = water dispersible granule; XR = extended release; XRG = extended residual granule; BG = Biodac (recycled paper) granule.

** to be applied by licensed, certified pesticide applicators

pending on the extent of vegetative cover and/or degree of pollution of the water to be treated.

Granular larvicides can be applied from the air over unpopulated areas. Granules can also be applied by crank-operated spreaders similar to those used for spreading seeds and fertilizers. Knapsack or other hand sprayers which can be carried by field workers may be used for liquid formulations. Power sprayers may be satisfactory if advantage is taken of the wind so that the larvicide drifts into desired water areas. Avoid larvicide treatment of fish-bearing waters.

Adult Control

Thermal Fogs

Fogging provides a rapid, temporary control for adult mosquitoes but has little residual effect. Thermal fog generators break up the insecticide by means of hot gases or superheated steam to produce a fog or smoke. They are effective only when there is little or no wind in the evening or night. Table 3 lists the

insecticides recommended for use as thermal fogs. With the increased use of ultra-low volume (ULV) cold aerosol application techniques, thermal fogs have become less desirable for reasons stated in the ULV section.

Mist and Residual Sprays

Mist and residual sprays are applied in water or oil with mist blowers, pump sprayers, power backpacks, or hand sprayers. Mist blowers are power sprayers that produce an air mass across liquid spray droplets, breaking them up and blowing them into the treatment area. In addition to the kill of active adult mosquitoes, small amounts of material are deposited on vegetation, providing some residual control. Table 4 lists the insecticides recommended for use as mist and residual sprays. For proper mixing instructions, application rates, and precautions, all label directions should be read and followed carefully.

Residues from spray deposits remain active for several days to several weeks. The duration of activity is affected by environmental factors such as rain, high

Table 3. Insecticides for use as thermal fogs for adult mosquito control.

| Insecticide | Formulations* | Remarks |
|---|--------------------|---|
| chlorpyrifos** | | |
| Mosquitomist | One ULV, 1.5 ULV | Apply a 300 foot swath with a vehicle speed of 5 mph. Product is applied in No. 2 fuel oil, diesel, or kerosene-type fuel. |
| malathion** | | |
| Fyfanon | 96.8% ULV | Deliver 40 gallons per hour at a vehicle speed of 5 mph to treat a swath width of 300 to 400 feet. Variation in fuel oils necessitates testing oil solubility and sludge to prevent clogging valves of the thermal fog machine. Large droplets or undiluted Fyfanon ULV will permanently damage automobile finishes by leaving spots. |
| naled | | |
| Dibrom | 87.4% C | Deliver 40 gallons per hour at a vehicle speed of 5 mph to treat a swath of 300 to 400 feet. Faster speeds with greater delivery rates are labeled. Apply in No. 2 fuel oil or diesel oil. If applied incorrectly, naled concentrate will spot certain automobile finishes. |
| sumithrin + piperonyl butoxide** | | |
| Anvil | 2+2 ULV, 10+10 ULV | Apply product diluted in diesel fuel using vehicle mounted, thermal ULV equipment. Rate of application and appropriate dilution will vary with formulation selected. |

* ULV = ultra low volume; C = Concentrate

** to be applied by licensed, certified pesticide applicators

temperatures or exposure to strong sunlight, which may reduce their longevity. Residual sprays can be applied as barrier treatments to tall grasses, weeds, shrubs, fences, and other harborages surrounding

parks, playgrounds, residences, or even subdivisions to help reduce adult mosquito populations. For best results, treat areas just before the period of maximum use.

Table 4. Mist sprays with some residual action for adult mosquito control.

| Insecticide | Formulations* | Remarks |
|-----------------------|--|--|
| carbaryl | | |
| Sevin | 4 L, 4 F, XLR, 50 WP, 80 WSP, 80 S | Treat when adult mosquitoes are active in the early morning or at dusk. Do not allow public use of treated areas during application or until sprays have dried. |
| chlorpyrifos | | |
| Dursban | 50W**, Pro**, and various homeowner formulations | Homeowner formulations will no longer be available after Dec., 2001. The residual spray solution is applied to outside building surfaces and vegetation listed on labels. |
| Mosquitomist** | Two ULV | |
| cyfluthrin** | | |
| Tempo | 2 EC, 20 WP | Spray solution is applied to damp areas beneath shrubs, in areas of tall grass or weeds, and on other surfaces where mosquitoes rest outdoors. Do not apply to food crops or fish inhabiting waters. |
| deltamethrin** | | |
| Suspend | 4.75% SC | Spray solution is applied to surfaces where adult mosquitoes rest. It may be used on walls in areas such as carports, garages, storage sheds unoccupied horse stables and pet kennels. Lawn and ornamental application is permitted; do not apply this product to edible crops. |
| malathion | | |
| | 50% EC, 57% EC | Application is made to surfaces where mosquitoes rest during the day. Car finishes may be damaged; wash exposed finishes immediately. |
| permethrin | | |
| permethrin | RTU formulations | Treatments may be made as mist or surface applications. Mist treatments may be applied in structures and livestock facilities. For indoor treatments, vacate treated areas after application and ventilate prior to re-entering. Outdoor surface treatments should be applied to areas where mosquitoes rest. Spray surfaces to the point of run-off. Treat no more than once every two weeks. |
| Permanone** | 10% EC | |
| pyrethrins | | |
| various | many formulations available | Diluted Sprays and RTU formulations may be used indoors to treat walls, ceilings and other areas where mosquitoes may rest. Outdoors, direct sprays into tall grass, shrubbery and around lawns where mosquitoes hover or rest. Apply while the air is still and avoid wetting foliage. Applications should be made prior to use of the treated area. |
| Pyrenone | 100 EC | |

* WP= wettable powder; EC = emulsifiable concentrate; LC = liquid concentrate; SC = suspended concentrate; S = sprayable; RTU = ready to use; F = flowable; L = liquid, XLR=extra long residual, ULV =ultra low volume.

** to be applied by licensed, certified pesticide applicators

Cold Aerosols

Ground equipment capable of producing ULV cold aerosols is available. These machines produce a very tiny droplet of high concentrate insecticide which results in a greater area coverage with less dosage. This type of application is designed to kill active adult mosquitoes and provides little or no residual control. Like the thermal fog generator, the cold aerosol machine should be used during the time the adult mosquito is most active. This means from twilight until about midnight, when atmospheric conditions are usually best (lack of wind).

A ULV application is generally the preferred space treatment for adult mosquito control. The cold aerosol method has certain advantages over thermal fog generators. Less insecticide is applied, resulting in fewer pollution problems. Smaller holding tanks and consequently smaller vehicles are needed since smaller quantities of insecticide are used. There is a reduced traffic hazard when compared to the near-zero visibility created by fog applications. ULV ground applications, however, are somewhat less effective than thermal fogs in heavy vegetation, because the larger ULV droplets tend to be filtered out more rapidly. Table 5 lists the insecticides recommended for use as ULV cold aerosols. For proper mixing instructions, application rates, and precautions, all label directions should be read and followed carefully.

Aerial Application

Application of adulticides by fixed-wing aircraft or helicopter is also common and is useful under emergency conditions or if treatment areas are too large or are inaccessible for economical treatment with ground power equipment. Best results are obtained in areas without dense tree cover so that spray particles can penetrate the low shrub zone where the greatest mosquito activity occurs. To obtain uniform coverage of an area, carefully preplanned flight patterns, altitudes, and air speeds are essential. Applications should not be made over a food or feed crop area or populated areas unless the insecticide is labeled for that use. Label directions regarding application over fish-bearing waters should be followed. Table 6 lists the insecticides recommended for aerial application. For proper mixing instructions, application rates, and precautions, all label directions should be read and followed carefully.

Aerial Spraying for Mosquitoes Over Populated Areas

Approval of two separate governmental units in North Dakota is required by law prior to aerial spraying of pesticides over any incorporated city. These agencies are the FAA Flight Standards District Office in Fargo and the North Dakota State Department of Health in Bismarck.

For FAA approval, the pilot who will be doing the spraying must complete an application that describes the aircraft, the pilot's experience, the area to be sprayed and potential flight hazards. Pilot requests for application information and forms should be made to:

**FAA Flight Standards District Office
1801 23rd Av. N Room 211
Fargo, ND 58502
Phone: (701) 235-5191**

Officials of the municipality to be sprayed must obtain approval from the North Dakota State Department of Health. Information required for approval of spraying includes the following:

1. Target pest to be controlled.
2. Aerial applicator name, pilot's name, address and phone number.
3. Name of pesticide, concentration to be used, rate and method of application.
4. Proposed date of treatment.
5. Date and method of public notice.
6. Signature(s) of public official(s) accepting responsibility for the spraying.

Municipality requests for application information and forms should be made to:

**Director
North Dakota State Department of Health
Division of Air Quality
Box 5520
Bismarck, North Dakota 58506-5520
701-328-5150**

Table 5. Cold aerosols for use in ULV ground equipment for adult mosquito control.

| Insecticide | Formulations* | Remarks |
|---|-------------------------------------|---|
| chlorpyrifos** | | |
| Mosquitomist | One ULV, 1.5 ULV, Two ULV | Applications to residential, recreational, and non-cropland sites are made during the cool hours of the night or early morning while mosquitoes are active. Application rate will depend on formulation selected. |
| malathion** | | |
| Fyfanon | 96.8% ULV | Deliver 1 to 4 gallons per hour at a vehicle speeds ranging from 5 to 20 mph to treat a swath width of 300 feet. At 5 mph, the flow rate of Fyfanon is 1 to 2 fluid ounces per minute. Refer to the label for additional rates and ground speed. Large droplets or undiluted Fyfanon ULV will permanently damage automobile finishes by leaving spots. |
| naled** | | |
| Dibrom | 87% EC | Product is for mosquito control in residential areas, municipalities, tidal marshes, woodlands, agricultural areas, livestock pastures, feed lots, and pastures including dairy cattle. It is not necessary to avoid farm buildings, dairy barns, feed or forage areas. Treat shrubbery and vegetation where mosquitoes may rest. Apply using vehicle mounted, non-thermal ULV equipment. Rate of application will vary with formulation selected. If applied incorrectly, naled concentrate will spot certain automobile finishes. |
| Trumpet | 78% EC | |
| permethrin + piperonyl butoxide** | | |
| Aqua-Reslin | 20% EC | Apply using vehicle mounted, non-thermal ULV equipment. Apply when there is a light breeze (<10 mph). Apply early morning and evening. This product is not to be used within 100 feet of lakes and streams. Do not apply directly to water or wetlands (swamps, bogs, marshes, and potholes). Allow 24 hours before retreating. Rate of application will vary with formulation selected. |
| Biomist | 1.5% S, 4% S, 3% S, 12% S, 30% S | |
| Permanone | 10% EC, 31-66 EC, RTU | |
| pyrethrins | | |
| Pyrenone | 100 EC | Apply the undiluted product using vehicle mounted, non-thermal ULV equipment. Apply when there is a light breeze (5 to 10 mph). Apply early morning and evening. Application of this undiluted product to any body of water is prohibited. |
| resmethrin + piperonyl butoxide ** | | |
| Scourge | 4% + 12 %, 18% + 54% | Spray parks, campsites, woodlands, athletic fields, golf courses, residential areas, and municipalities. For use with non-thermal truck or backpack equipment designed to deliver fog particles. Do not spray cropland or feed, avoid application over lakes, ponds, and streams. The 18% + 54% formulation may be mixed with refined soybean oil, light mineral oil, or other suitable solvent or diluent. |
| sumithrin + piperonyl butoxide** | | |
| Anvil | 2+2 ULV, 10+10 ULV | Apply product using vehicle mounted, non-thermal ULV equipment. Rate of application will vary with formulation selected. |

* EC = emulsifiable concentrate; S = sprayable; RTU = ready to use; ULV = ultra low volume; C = Concentrate.

** to be applied by licensed, certified pesticide applicators

Table 6. Adult mosquito control using aerial equipment.

| Insecticide | Formulations* | Remarks |
|--|-------------------------------------|--|
| chlorpyrifos** | | |
| Mosquitomist | One ULV, 1.5 ULV, Two ULV | Aerial applications are made at an altitude of 300 feet. Rates per acre will depend on formulation selected. Applications to residential, recreational, and non-cropland sites are made during the cool hours of the night or early morning while mosquitoes are active. |
| malathion** | | |
| Fyfanon | 96.8% ULV | Apply at a rate of 2.6 to 3.0 fluid ounces per acre over cities, towns, and other areas where automobiles, trailers, trucks, and pleasure boats are present. Large droplets or undiluted Fyfanon ULV will permanently damage automobile finishes by leaving spots. |
| naled** | | |
| Dibrom | 87% EC | Aerial application must be made with closed cockpit aircraft. Air speed should be in excess of 100 mph. Rate of application will vary with formulation selected. Product is for use in mosquito control in residential areas, municipalities, tidal marshes, woodlands, agricultural areas, livestock pastures, feed lots, and pastures including dairy cattle. It is not necessary to avoid farm buildings, dairy barns, feed or forage areas. Treat shrubbery and vegetation where mosquitoes may rest. If applied incorrectly, naled concentrate will spot certain automobile finishes. |
| Trumpet | 78% EC | |
| permethrin + piperonyl butoxide** | | |
| Aqua-Reslin | 20% EC | Apply at an altitude of 165 feet when there is a light breeze (<10 mph). Apply early morning and evening. This product is not to be used within 100 feet of lakes and streams. Do not apply directly to water or wetlands (swamps, bogs, marshes, and potholes). Allow 24 hours before retreating. Rate of application will vary with formulation selected. |
| Permanone | 31-66 EC | |
| Biomist | 1.5% S, 4% S, 3% S, 12% S, 30% S | |
| resmethrin + piperonyl butoxide** | | |
| Scourge | 4% + 12 %, 18% + 54% | This product is used in specially designed aircraft capable of applying ULV spray formulations. Spray parks, campsites, woodlands, athletic fields, golf courses, residential areas, and municipalities. Do not spray cropland or feed, avoid application over lakes, ponds, and streams. The 18% + 54% formulation may be mixed with refined soybean oil, light mineral oil, or other suitable solvent or diluent. |
| sumithrin + piperonyl butoxide** | | |
| Anvil | 2+2 ULV, 10+10 ULV | For use in residential and recreational areas around inlets, creeks, swamps and marshes. Rate of application will vary with formulation selected. |

* EC = emulsifiable concentrate; S = sprayable; RTU = ready to use; ULV = ultra low volume; C = Concentrate.

** to be applied by licensed, certified pesticide applicators

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Spackman, Everett W. 1985. Mosquito Control. University of Wyoming Ag. Extension Bulletin B-847.

Ware, George W. 1994. *The Pesticide Book*, 4th edition. Thomson Publications; Fresno, CA.

Emergency Telephone Numbers

Police _____

Doctor _____

Hospital _____

Fire _____

Poison Control Centers

North Dakota Poison Hotline
1-800-222-1222

Minnesota Poison Hotline
1-800-732-2200

In Case of a Pesticide Spill Call: 1-800-472-2121

Information Needed:

- Location of incident.
- Identity of material involved.
- Time incident occurred.
- Source of spill.
- Volume of material and duration.
- Movement of material — present and anticipated.
- Nearby surface water wells.

