Table 6. General recommendations for ground application of insecticides for adult mosquito control.

Speed	—Most labels recommend a vehicle speed of 5–10 mph (8–16 kph). An increase in speed must be accompanied by a proportional increase in discharge. (See Tables 1, 3, and 4).
Swath	—Most labels recommend a swath of 300–350 ft. (90–107 m.) or one average city block. (See Tables 1, 3, and 4).
Wind	—Most labels state to apply in winds of 5 mph (8 kph) or less.
Temperature	—Apply at temperatures above 60–65 ° F (16–18° C) with good inversion conditions.
Time-of-day	—Apply from early evening to early morning to coincide with periods of greatest mosquito activity. This is also the period of optimum wind and inversion conditions.
Calibration	—Calibrate equipment prior to initial use and periodically thereafter. Check setting before each use.
Droplet Size	—For ULV machines determine droplet size initially and periodically thereafter to see if it conforms to insecticide label criteria. (See Table 2).
Formulation	—Use only according to label recommendations. Consult manufacturer for information on storage of formulated insecticides (See Tables 1, 3, and 4).
Discharge Rate	—Use only according to label recommendations. For ULV machines, changes in insecticide temperature usually require a change in flowmeter setting. (See Tables 1, 3, and 4).

A MOSQUITO MANAGEMENT PROGRAM FOR THE NORTH PLATTE VALLEY OF NEBRASKA

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The North Platte Valley of Nebraska extends from the Wyoming state line to the head end of Lake McConaughy, an area approximately 125 miles long and varying from 5 to 20 miles wide. Within this area, ditch irrigation has been practiced since about 1912. The mosquito problem first came to national attention during World War II when a prisoner of war camp was located approximately 5 miles east of the City of Scottsbluff. Surveys conducted by the staff of Malaria Control in War Areas (U.S. Public Health) under the direction of Dr. John L. Rowe showed that this area had a very high mosquito population; but no *Anopheles* were found and no control work was recommended in spite of the fact that the prisoners complained about the mosquitoes.

In the late 1940's the Center for Disease

Control decided to carry on research on mosquitoes in an irrigated area. Dr. John Rowe, remembering his experience at the Scottsbluff Prisoner of War Camp, succeeded in having a research station established at Mitchell, Nebraska, from 1949 until 1953. This group succeeded in identifying the principal sources of mosquitoes, especially the role of irrigated pastures.

Interest in mosquito control during the 1950's and 60's varied from year to year, but at no time was there a concerned effort for a planned mosquito control program. In 1972 there was a major flood in the Valley and emergency funds from the Governor of Nebraska were used for chemical control in Scotts Bluff County. Since that time, the Scotts Bluff County Health Department has been involved in a limited control program. To date, this program has involved ULV fogging in the communities and larviciding wherever breeding areas have been found.

In the past several years there has been an increased number of complaints about mosquitoes. People are moving out of the cities and into rural areas of high mosquito populations. During the summer of 1976, it was possible to walk into irrigated alfalfa fields and count over 1000 specimens landing and attempting to bite.

As a result of pressure by concerned citizens in the summer of 1976, the Scotts Bluff County Board requested that a detailed study of the mosquito problem be made. This study was prompted by suggestions of a county-wide aerial spraying program.

Studies by the Scotts Bluff County Health Department indicated that at least 58,000 acres produce mosquitoes during any given year. The best price for aerial spraying obtained in 1976 was 55¢ per acre. One application would cost $31,680, and at least 3 applications would be necessary, a total of $95,040. When the County Commissioners examined the cost, they felt that an aerial spraying program would not be economically feasible, especially when the problem would still be there the next year. In a period of 5 years, approximately $1,665,249 would be spent and the problem not solved.

Based upon total cost plus the fact that there would be no source reduction, the aerial spraying was ruled out. It was then decided to approach the problem from a pest management view and to attempt to model the mosquito problem.

In developing a mosquito management program, the intuitive broad aims must be put into a logical and precise form. However, it must be recognized that the complex ecosystem often fails to give management strategies of sufficient sensitivity for a sophisticated mosquito management operation.

Mosquitoes can be managed, but management is people-oriented, and successful mosquito management depends largely on people. The mosquito management philosophy is relevant to all control activities.

With the mosquito management approach, some form of model is necessary for understanding the components and assessing their relative value. In developing such a model, the so-called "compartmental" approach was used. The compartments represent space-time units which occupy a volume of space for a finite time and its associated states. Figure I is a model explaining extrinsic variables—water and climate which result in mosquito production.

Let us examine Figure I in detail. In order to have mosquitoes we must have water. Where does the water come from? First, we have rain—over which we have no control. However, in the North Platte Valley, rain is a very minor source of water for mosquito breeding. This area has less than 20in. per year and, normally, it is well distributed through the year. Our major source of water is man-made—agricultural practice. Our agricultural practices cause water problems for 3 areas:

1. Irrigation Canal Seepage. In the area of study, there are 3 major canals. Irrigation companies state that up to 50% of the water is lost between diversion and the point of delivery! Most of the soils in Scotts Bluff

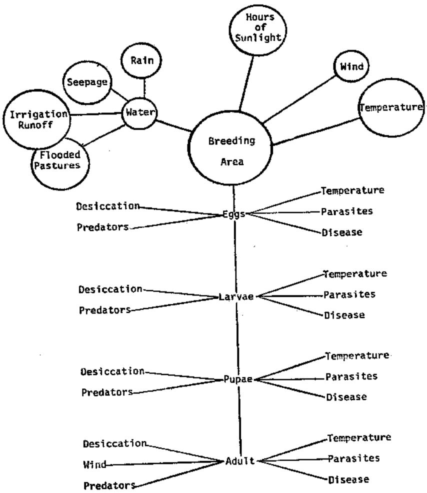

Fig. 1.

County are sandy, thus seepage is wide-spread. Hundreds of acres of good agricultural land cannot be used for economic agricultural production. Much of this land produces mosquitoes. Lastly, but of great economic importance, is the seepage water. How much of it is beneficially used? Possibly 5% is utilized by wildlife—other 95% forms swamps and marshes. True, some of this seepage water is returned to the Platte River where it is again diverted into irrigation systems, but again, this is only a very small amount. At present, many government agencies—both state and federal—are saying that we are going into a critical water shortage. These same agencies are saying we must have more irrigation water. What is the answer to the seepage problems? First, these major canals were constructed at least 50 years ago. Without doubt, they represented the best engineering technology of the day. Nevertheless, through seepage, they lose large volumes of water. True, the irrigation companies attempt to seal the ditches with bentonite, but since the ditches are dry 6 to 8 months a year, this is an annual expense. With modern engineering expertise, there is no excuse for this excess seepage. True, the lining of canals is expensive, but the long range economic return is great.

2. Irrigation Run-Off. Good conservation irrigation practices plus good maintenance of drainage ditches would eliminate mosquito breeding related to irrigation. Too many irrigation farmers believe that they must use all the water they are allotted regardless of crop needs. To a degree, this is a matter of education—the workers in the Extension Service and the agricultural experiment stations recognize this problem, but are faced with a communication and education problem. However, with a growing water shortage, higher charges for irrigation water plus educational programs, this problem can be solved. The drainage problem is somewhat more complex. In Nebraska, there are 4 statutory methods for the establishment of drainage districts. A drainage district is a political subdivision with the ability to tax. However, since most people do not like to pay taxes, the directors of drainage districts are reluctant to tax themselves. This attitude results in only the minimum of maintenance. The rebuilding of drainage systems would greatly reduce the mosquito breeding problem plus make the water more available for reuse.
3. For many years, the flooding of pastures several times per growing season has been practiced. Unfortunately, these are native pastures and no attempt has been made to level the land. The principal of pasture flooding is to rapidly cover the area with 1 or 2 in. of water and then allow it to drain off. This is done over a 2 or 3 day period so that the grasses are not killed. Due to the fact that there are always depression areas which do

not drain and where water remains for 5 to 10 days, large populations of *Aedes vexans* are produced. Over the years, many of these depression areas, some of which are several acres in size, have developed stands of grasses and plants which are not utilized by cattle. In addition, some of the areas are devoid of vegetation and there has been a movement of soils into the root zone, thus, these depression areas are devoid of any vegetation. The overall results are that not only are these pastures producing very large mosquito populations, but resulting in a decreased area for pasturing cattle. Also, it must be remembered that large populations of mosquitoes put cattle under stress.

Good land management practices which require the irrigated pastures to be leveled would eliminate the mosquito breeding. Again, this would cost money, but the cost benefit ratio would be very favorable because not only would the mosquito breeding areas be removed, but better pastures would result and more animals per acre could be pastured. Lastly, the cattle would not be used as a source of blood meals by the mosquitoes.

We have outlined a water and land management program for mosquitoes. This management program is expensive and can only be done over a period of years. Education is the key to this type of program as it involves major changes in agricultural and economic philosophy. Leadership in a mosquito management program is a critical factor. Such a program involves agricultural leaders, banks, health agencies plus an understanding by the local agri-business community.

Lastly, it must be remembered that since a mosquito management program such as we have outlined can only be accomplished over a period of years, some attempts must be made to give the people some relief from the mosquitoes. Therefore, some control by chemical and biological control methods will be necessary until the water and land programs can be fully implemented.