A COST ANALYSIS FOR VOLUNTARY COMPLIANCE WITH THE ENDANGERED SPECIES ACT FOR *AEDES SQUAMIGER* CONTROL IN TWO CALIFORNIA COUNTIES

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Introduction.

The Endangered Species Act (ESA) has impacted both Marin/Sonoma Mosquito Abatement District (MSMAD) and Alameda County Mosquito Abatement District (ACMAD) as well as other districts throughout California and the United States. The impact on the two San Francisco bay area districts has manifested itself in increased pesticide costs and the need for additional manpower to control mosquito populations. Hidden costs are also incurred by the districts as well as to the environment with the implementation of the act. It is the intent of this paper to outline some of the costs for voluntary compliance with the ESA.

History.

In many ways protecting endangered species and controlling pest and disease carrying mosquitoes is a zero-sum effort. Increased expenditures for third generation pesticides consumes savings generated through long term source reduction projects. There are costs and benefits to be realized with a variety of approaches for control. It is our goal to balance the reduction of mosquito populations with the various costs while minimizing the impact on endangered species.

The ESA requires that the Environmental Protection Agency (EPA) ensure that registered pesticide use will not jeopardize endangered species or adversely modify critical habitats. At the outset of the program, 1980-1984, EPA consulting with the U.S. Fish and Wildlife Service (USFWS) evaluated specific pesticides on a case-by-case basis for potential biological harm. This approach was taken to task in a 1986 report titled "The Environmental Protection Agency's Implementation of the ESA with Respect to Pesticide Registration" (Anon., 1986). The report stated that the previous process was too slow and recommended a "cluster" approach be implemented. This grouped similar use materials together for biological evaluation.

On May 8, 1988 an amended plan was reported in the Federal Register outlining the new program. After each pesticide in a cluster was evaluated EPA would ask the USFWS to review the clusters and provide biological opinions on whether jeopardy existed. As a result of public input that highlighted various inequities, the cluster approach was discarded in favor of a species based model for biological consultations. This program is outlined in the Federal Register, June 21, 1989.

Under this program endangered species will be ranked on factors detrimental to their existence. Those species needing the greatest protection will be given priority consideration. There are three major differences between the cluster approach and the new species based approach. Instead of issuing a "may affect" determination for a particular use of a pesticide based on the highest registered application rate, EPA will use this rate only as a screening mechanism for further evaluation. If the highest rate application indicates that the pesticide "may affect" an endangered species, EPA will then determine the lowest registered application rate that "may affect" the species. Also under the cluster approach, once a "may affect" determination was made EPA would request from the USFWS a biological opinion only for that use. If a suspected jeopardy existed, all products of that pesticide for that use were subject to use limitations. In contrast, under the species based program, once the lowest registered application threshold is determined this rate will be used in consultation with USFWS and will be limited only to the specific application rates that "may affect" a listed species.

Under the new program, the EPA will also take into consideration application methods, timing, and use patterns and integrate this information to provide the USFWS with a more realistic package with which to make biological determinations.

Local Response.

Previous efforts by both districts to control *Aedes squamiger* (Coquillett) have relied on two major approaches, source reduction and

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organophosphate pesticide applications with an emphasis on source reduction. Over the year source reduction projects to minimize *Aedes squamiger* populations have been undertaken by both districts with a significant decline in the overall number of this species. Alameda County MAD placed an emphasis on disking cracked-ground seasonal wetlands, previously known as dry-diked areas while Marin/Sonoma MAD concentrated on constructing tidal recirculation ditches to allow for increased tidal exchange in stagnant pothole areas within the Petaluma Marsh and other tidal marsh areas. Both techniques disrupted the ovipositional substrate making it unacceptable for breeding habitat.

It is this same disruption of habitat, especially with regard to disking that is being called into question by advocates of more stringent regulations to protect endangered species. These recent environmental restrictions and changes in philosophy concerning source reduction as viewed by regulatory agencies have limited the amount of new source reduction projects and in some cases eliminated them. Source reduction has been an accepted alternative to chemical application for mosquito reduction by both the districts and regulatory agencies for many years.

Cost effective mosquito control could be achieved by utilizing the proper tools out of the source reduction toolbox for sound water management practices. This is especially evident from the success of the Petaluma Marsh project in Sonoma and Marin counties. Source reduction has also been shown to be the most economically sound approach to mosquito abatement versus a chemical control approach (Sarhan et al. 1980). In the Petaluma Marsh from 1968-1972 tidal recirculation ditching was responsible for reducing pesticide use by over eighty percent (Telford and Rucker 1973). Fenthion usage in 1972 was reported, at that time as only nine gallons for all mosquito suppression. Over five thousand acres of tidal salt marsh was enhanced by better tidal flow. With increased scrutiny by regulatory agencies and the elimination of some source reduction tools both districts fell back to a pesticide approach for *Aedes squamiger* control in the late 1970's and early 1980's.

With the concern expressed by the May 1988 ESA proposal, organophosphate based pesticides were discontinued by both districts during the 1988-1989 season to voluntarily comply with the provisions of the Act as modified in 1989. The districts' response to these restrictions has been to control the remaining *Aedes squamiger* populations using the "third generation" pesticides or biological control methods. *Bacillus thuringiensis* var. *israelensis* (serotype H-14) and Methoprene are becoming the mainstay of both districts' pesticide treatment regime.

In the past inexpensive organophosphate insecticides proved to be the most immediately effective method of reducing larval populations of this mosquito. The shift to biological control agents has increased pesticide budgets almost eight to ten fold in some cases. There are also a number of indirect environmental costs associated with the biological control approach, especially for reducing saltmarsh mosquito populations, specifically *Aedes squamiger*, in that multiple applications are necessary to achieve total control.

The reason for this will become evident with a short discussion of *Aedes squamiger* biology. *Aedes squamiger* is a univoltine species with larval activity beginning after fall rains. Eggs aestivate during the summer and hatch on high tides and the first rains of the winter season. Successive cohorts of eggs develop on each storm event as water levels rise to flood previously dry areas. Eggs are deposited by the previous winter's adult population along contour lines defined by receding flood water. The interval pattern of rain/high tide and length of dry periods affect where and at what height eggs will be deposited in the marsh. Six distinct hatches of *Aedes squamiger* were observed following high tides and heavy rains from October to February, 1953 to 1954 (Telford 1958), but previous observations found only three hatches.

Organophosphate control efforts over the years were planned to treat fourth instar larvae late in the breeding season, taking into consideration the synchronization of pupation which generally begins in early February. Quick effective control could be realized using low cost organophosphate pesticides with a one treatment approach just prior to pupation.

Bacillus thuringiensis var. *israelensis* (*Bti*) was chosen by both districts as the major operational control agent in voluntarily compliance with the ESA. Methoprene was used on a restricted basis at test plot locations since it was a member of the original larvicide cluster and had generated questions regarding potential detrimental affects on food chain organisms. *Bti*, a consumable mosquitocide needs to be applied at specific times to maximize its effectiveness. Variable feeding rates based upon water or ambient temperature and larval physiology directly affect mortality rates. Through previous studies it was found that there is an inverse relationship between mortality rate and increased physiological age, i.e younger instar larvae are more susceptible to *Bti*. Higher application rates of *Bti* are necessary due to the slow physiological development and treatment at ambient temperatures of 8-11° C. As a result, multiple treat-

ments at high dosage rates were required during the 1988-1989 season to achieve acceptable *Aedes squamiger* mortality rates in contrast with a one time application (at low dosage rates) of a contact organophosphate insecticide.

Increased disturbance of breeding habitat is inherent using the "acceptable" or "biorational" control approach. Direct increased costs to the districts were sustained in both increased surveillance time and higher pesticide cost as well as the indirect environmental costs of increased perturbation of breeding habitat which is coexistent with endangered species habitat.

For the purpose of comparison we have chosen two locations, one in Alameda County (Ora Loma) and Hales Property in Marin County. Data were compiled from the three previous control seasons (October - April); 1986-1987, 1987-1988, and 1988- 1989. Prior to the 1988-1989 season, organophosphates and Golden Bear oils were used in the marshes by both districts while only biologicals and oils were used during the 1988-1989 season. Due to the importance of the independent variable, rainfall, on hatching success of *Aedes squamiger*, direct comparisons cannot be inferred from such a small data set. Additional data from subsequent years will be necessary to make statistically significant conclusions.

Nevertheless, certain trends and comparisons in costs for treating these areas can be examined with this in mind. The usage of fenthion, GB-1111, and *Bti* for the three previous *Aedes squamiger* control seasons in Marin County demonstrate the continuing trends. Fenthion usage dropped from one gallon in 1986-1987 to zero in 1988-1989, while International Toxic Units (ITU's) of *Bti* substantially increased from less than one billion during the 1986-1987 and 1987-1988 control seasons to over 900 billion during 1988-1989. Golden Bear oil use remains relatively stable between 500 and 1,750 gallons since this is the product of choice for *Culiseta inornata* (Williston) treatment. Some use of oil was reserved for treating *Aedes squamiger* pupae but this was minimal due to the increased effort to treat early instars.

Alameda County MAD experienced a similar trend in pesticide use for *Aedes squamiger* control over the same period (Fig. 1). Once again, there is a general decline in organophosphate and larviciding oil usage and a corresponding increase in biorational insecticide use.

Intrusion frequency is also increased with the use of biological control agents. Examination of ACMAD's work experience over the past two seasons at the Ora Loma property shows 31 inspections and three treatments during the 1987- 1988 season and 29 inspections and eight treatments

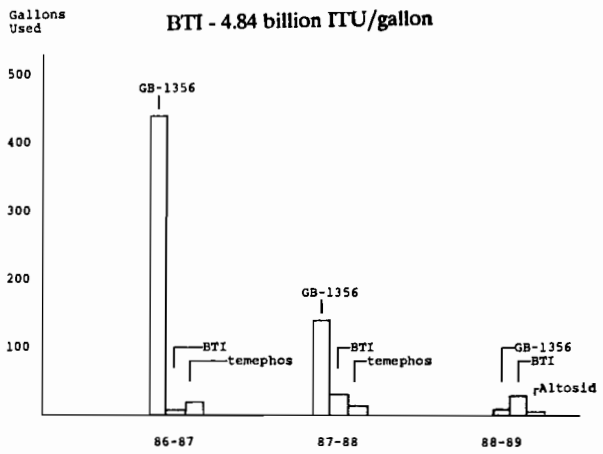

Figure 1. ACMAD's insecticide usage over the last three seasons for the control of *Ae. squamiger*.

during the 1988-1989 season. A similar experience was noted by MSMAD at the Hales property in Marin County with two inspections and one treatment during the 1987-1988 season and five inspections and four treatments during the 1988- 1989 season.

Surveillance time is increased significantly using the biorational approach to larviciding. Subsequent trips (post treatment) are necessary to evaluate the effectiveness of the biological application. Greater presence in the marsh with all- terrain vehicles (ATV's) increases the indirect costs of marsh disturbance, short-term damage to resident vegetation, an increased potential for oil or hydraulic fluid leaks or spills, disruption of endangered species habitat, greater potential for incidental take of endangered species, and greater risk for employee injury, (increased man-hours in a higher risk category resulting in increased insurance costs).

Since the biological control philosophy is not restricted to just *Aedes squamiger* control, the increased costs for biologicals is reflected in the districts' overall pesticide budgets. Figure 2 shows the dollar amount spent by Marin/Sonoma MAD on pesticides for the past ten years. The dramatic increase in funds allocated to pesticide acquisition is principally due to the high cost of these biologicals and the need for more frequent applications.

A cost per acre comparison for fenthion and other non-organophosphate alternatives is shown in Table 1. It is obvious that biorational insecticides are several times greater in cost than the organophosphate, fenthion.

If we look at a price comparison between fenthion with other non-organophosphates in Table 2, we see a low of three times to a high of sixty-two

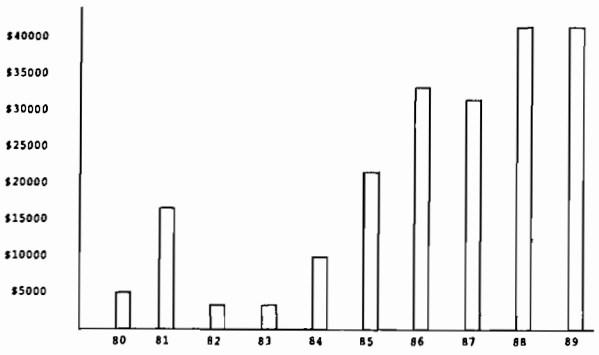

Figure 2. MSMAD's pesticide expenditures over the last ten years.

Table 1. Cost/acre values for various insecticide treatments used in the control of *Aedes squamiger*.

Treatment	Application Rate Low	High
Fenthion Liquid	$0.30	$1.18
Altosid 150-day Briquets	$3.48	$4.64
Vectobac-G Granules	$2.33	$18.60
Vectobac-12AS Liquid	$1.77	$7.06
GB-111 Oil	$5.04	$8.40
Bti-Sand Granules	$4.15	$16.60
Altosid-Sand Granules	$3.31	$4.10
Vectobac-12AS + Altosid Briquets	$5.25	$11.70

Table 2. Comparative costs of fenthion against biorational and oil insecticides at two different application rates for the control of *Aedes squamiger*.

Treatment	Fenthion (0.025 lbs AI/A) Low	High	Fenthion (0.050 lbs AI/A) Low	High
Altosid 150-day Briquets	12X	15X	6X	8X
Vectobac-G Granules	8X	62X	4X	31X
Vectobac-12AS Liquid	6X	24X	3X	12X
GB-111 Oil	17X	28X	8X	14X
Bti-Sand Granules	14X	55X	7X	28X
Vectobac-12AS + Altosid Briquets	18X	39X	9X	20X

times the cost for materials alone using the biological control approach.

Caveat.

We have all been reassured that there will be no new federal taxes, but the fact remains that our constituents are bearing the burden of increased pesticide budgets and manpower needs to comply with the Federal mandate of the endangered species act. The public will probably have to pay for protecting endangered species indirectly since a recent survey of southern California residents conducted by the Los Angeles Times (December 10, 1989) found that the majority would "tolerate significant life style and economic inconveniences to protect the environment but would not pay higher taxes to help save endangered wildlife". Similarly voluntary contributions from California tax returns are not encouraging. Approximately one million dollars was contributed in tax year 1987 and approximately $909,000 in tax year 1988. These funds are for the protection of all endangered species, plant and animal, within California.

The Saltmarsh Harvest Mouse (*Reithrondontomys raviventris*) and California Clapper Rail (*Rallus longirostris obsoletus*) were originally placed on the endangered species list primarily due to loss of habitat and not as a result of detrimental affect by pesticides. Recent articles in the San Francisco Chronicle (January 22, 1990) report continued illegal destruction of wetland habitat by developers and private land owners around the bay area.

It is the goal of the mosquito abatement districts to voluntarily comply with the ESA before it becomes mandatory to exhibit good faith and willingness to work with the USFWS, California Department of Fish & Game and EPA to protect endangered species while suppressing saltmarsh mosquito populations. It is, however, our constituents who are indirectly footing a portion of the bill to protect these species.

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