Research Report No. 34

THE CONTROL OF AQUATIC AND MARGINAL WEEDS - II

Notes and Abstracts

From the 8th Annual Meeting of the Weed Science Society of America

By
Leon D. Johnson

Department of Natural Resources
Bureau of Research and Planning

1968

INTRODUCTION

This report consists of notes on the highlights of the 8th annual meeting of the Weed Science Society of America, held February 5 to 8, 1968 in New Orleans, Louisiana. The theme of the program was Weed Control and the World Food Problem. A total of 295 papers were presented during five concurrent sessions. Sixty of these papers were directly concerned with the control of aquatic and marginal weeds. Included here are consolidated abstracts of papers that might have application to our aquatic problems in Wisconsin.

NOTES

Chemical Control:

There were no new developments in herbicides for aquatic use in 1967. Diquat and Endothall continue as two of the safe and efficient herbicides. Manufacturers faced with increased costs in obtaining label registration clearance for aquatic use, in a field of low monetary return. This picture may change because of the increasing importance of rice crops to feed world populations. Three rice crops per year, together with improved genetic strains and increased need for herbicides may open avenues for increased research into aquatic uses.

There is great concern, however over the tremendous quantities, tons of herbicides, that enter our rivers, lakes, and water supplies. While herbicides are generally non-toxic compared to other pesticides, the sheer bulk of material is cause for alarm. Increased efforts are being made to discover new means and to improve on the old ways for the control of aquatic vegetation.

Biological Controls:

Up until now biological controls for aquatic vegetation have been largely unsuccessful, and it is possible that success can never be attained. The grass carp, Ctenopharyngodon idellus previously thought to be a grass eater, is primarily insectivorus and eats weeds only as a last resort. The same is true for the Israeli carp, Cyprinus carpio which was the second species studied. Both fishes tend toward overpopulation and stunting and are unable to withstand low temperatures.

Experiments with the Marisa snail are being duplicated with Pomacea australis a fresh water snail from Brazil, because the latter can withstand colder temperatures. Snails however, tend toward heavy water pollution.

South American insects are being used experimentally for aquatic weed control. These include thrips, an aquatic grasshopper, and the Agrasicles beetle. The problems are poor tolerance to low temperatures, our inability to confine these insects to any particular area of control, and the fact that insects will only eat the immersed portions of plants.

Introduced disease may be a possibility for aquatic weed control. A heavy mortality of Eurasian water milfoil, Myriophyllum spicatum L. in Chesapeake Bay, Maryland, was tentatively diagnosed as caused by a virus. Further research here may be hampered by loss of personnel. No bacterial causations have been found in studies to date.

Mechanical Controls:

Weed cutters have long been used for vegetation control, but are time consuming, inefficient, and expensive. New tools and ideas, however, show mechanical means may yet become as efficient method of true control. Ultra sound is a new concept with up to six threshold cavitation, the surface of the cells are eroded away thereby killing the plants. Lasers are another approach (1) carbon dioxide lasers, (2) Argon lasers and (3) other chemical lasers, which build up heat and vaporization of plant tissue, thereby killing them mechanically.

The final concept under exploration is efficient use of aquatic vegetation. One method is to harvest weeds for food because the carbohydrate level of many aquatic especially rooted plants is high. Purification of domestic sewage by means of aquatics such as the water hyacinth or alligator weed found in some southern states is also under study. Methods formerly considered unrealistic are now considered feasible and are being studied.

Suggested References:

Herbicide Handbook of the Weed Society of America. 1967. Data on herbicide and desiccants arranged alphabetically by chemical name. 293 p. $3.00 each. May be obtained from Dr. F. W. Slife, Weed Science Society of America, University of Illinois, Urbana, Ill.

Herbicides and Vegetation Management. 1967. Symposium Proceedings Oregon State University, Corvalis, Oregon 97331. $2.50 each from OSU School of Forestry.

ABSTRACTS

Ditchbank Weed Control and Crop Production. J. R. Orsenigo, University of Florida, Everglades Experiment Station, Belle Glade, Florida.

The greatest benefit from ditchbank vegetation control programs was control of hosts of pests: bacterial and fungal diseases, insects, nematodes, and viruses of cultivated plants. These hosts include annual and perennial broadleaf, grass, and sedge weeds, as well as volunteer crop plants. Low dosage application of systemic herbicides (dalapon and 2,4-D) were most economical. Greatest economy was obtained with broadcast initial applications followed by periodic spot-treatment to problem areas.

Aquatic Weed Problems in Thailand. D. E. Seaman and Paitoon Kittipong, Syracuse University Research Corp., Syracuse, New York, and Rice Department, Technical Dlvision, Bangkhen, Bangkok, Thailand.

Among weeds found in Thailand are many species familiar to North Americans, including *Alternanthera philoxeroides*, *Ceratophyllum demersum*, *Eichhornia crassipes*, *Jussiaea repens*, *Marsilea quadrifolia*, *Pistia stratiotes*, and *Typha angustifolia*. *A. philoxeroides* and *P. stratiotes* are not as aggressive in Thailand as they are in the Southeastern U. S., and they appear to be restrained by insects. Submersed weeds of the genera *Elodea*, *Myriophyllum*, *Potamogeton* and *Vallisneria* are notably absent, their niches being filled by *Blyxa* spp., *Eriocaulon* sp., *Hydrilla verticillata*, *Limnophila heterophylla*, *Najas graminea*, *Ottelia alismoides*, and *Utricularia* spp.

Broadleaf weeds of the genera *Aeschynomene*, *Cyanotis*, *Eclipta*, *Ipomoea*, *Jussiaea*, *Mimulus*, *Monochoria*, *Pentapetes*, and Sphenoclea, and various sedges of the genera *Cyperus*, *Eleocharis*, *Fimbristylis*, *Fuirena*, and *Scirpus* appeared the most common in transplanted rice, while grasses of the genera *Echinochloa*, *Ischaemum*, *Leersia*, *Leptochloa*, *Panicum*, *Paspalum*, and several wild *Oryzeae* seemed prevalent in broadcast seeded (floating) rice.

Chemical weed control is just getting started in Thailand.

Aquatic Weeds in Farm and Ranch Waters. O. W. Dillon, Jr., ARS, USDA, Soil Conservation Service, Fort Worth, Texas.

The climate and soils of the United States are so variable that many problems are encountered. Water temperatures range from cold, supporting trout, to warm, supporting bass, bluegills, channel catfish, minnows, etc. Total hardness varies from very low to over 150 ppm. Salinities vary from zero to more than sea strength. The pH range is from below 2.5 to over 10.5. With these, plus many other variations, aquatic weeds may be a problem. Because of the many variables, chemicals do not necessarily work from one pond to the other or from locality to locality.

Fish, such as mullet and Israeli carp, have successfully controlled many algaes. The Chinese grass carp show promise on many underwater weeds at Auburn University and Stuttgart, Arkansas.

The Interagency Ad Hoc Committee on Use of Herbicides in Aquatic Sites -- Its Objectives and Progress. R. B. Balcom, USDI, Bureau of Reclamation, Washington D. C.

The Interagency Ad Hoc Committee on the Use of Pesticides in Aquatic Sites was appointed by the Departments of the Interior and Agriculture to look into weed control. Often herbicides have not been registered for particular uses, because there has not been sufficient research to show that they can be used safely.

For this reason, few of the best chemical tools, including phenoxy compounds, have been registered where the water might be used for industrial, municipal, agricultural, and certain other purposes.

The task force group within the committee proposed labels for six phenoxy compounds, which covered four 2,4,-D and two silvex formulations.

Ecological Factors Influencing the Distribution of Aquatic Plants in North Carolina. E. O. Beal, Western Kentucky University, Bowling Green, Kentucky.

Extensive field studies on aquatic vascular plants in North Carolina show that their distribution is greatly influenced by factors such as pH, total soluable salts, percent organic matter, and chloride content. Aquatic plants are also characterized by a high degree of genetic variability.

Progress in Aquatic Weed Control in Central Illinois. R. C. Hiltibran, Illinois Natural History Survey, Urbana, Illinois.

There was no control of cabomba, *Cabomba caroliniana*, by the use of the registered herbicides. Application of 2,4-dichlorophenoxypropionic acid (2,4-DP) eliminated cabomba from the treated areas, but 12 weeks were necessary for elimination of the vegetation. As yet, the chemically related herbicides, such as 2,-(2,4,5-trichlorophenoxy) propionic acid, silvex, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) derivatives, or 2,4-dichlorophenoxyacetic acid (2,4-D), are ineffective. Liquid di *N*,*N*-dimethlcocoamine salt of 7-oxabicyclo(2,2,1)heptane-2,3-dicarboxylic acid (an amine salt of endothall) resulted in severe damage to the foliage, but did not give effective control. Spatterdock, *Nuphar advena*, and waterstargrass, *Heteranthera dubia*, was not controlled. Granular applications of silvex and 2,4,5-T reduced the plant population within the treated area and liquid applications of silvex and 2,4,5-T were less effective. Waterstargrass was eliminated from test areas treated with diquat cation at a rate of 1 ppmw.

Factors Affecting Control of Florida Elodea with Diquat in Southeast Florida Canals. J. W. MacKenzie, Chevron Chemical Company, Richmond, California, (Oregon State University, Corvallis, Oregon).

Successful control of Florida elodea with 0.5 ppmw diquat related directly to low density of plant infestation and absence of water movement. Variations in water chemistry were not related to degree of Florida elodea control.

The Degradation, Kinetics, and Persistence of Silvex Under Impounded Conditions
G. W. Bailey, J. D. Pope, Jr., and D. R. Cochrane, Federal Water Pollution Control Administration, USDI, Athens, Georgia.

The degradation kinetics of propylene glycol butyl ether (PBGE) ester of silvex (Kuron) and the persistence of silvex acid in water and sediment were studied. Concentrations were determined by gas chromatography.

The hydrolysis of PGBE ester of silvex to silvex acid was found to obey first order reaction kinetics, the specific reaction rate constants for three ponds were 0.094 hr. $^{-1}$, and 0.102 hr.$^{-1}$, and 0.140 hr.$^{-1}$. Fifty percent hydrolysis of PGBE esters of silvex occurred in 5-7 hours, 90% hydrolysis occurred in 16-24 hours, and 99% hydrolysis occurred in 33-49 hours.

The concentration of silvex acid in water initially increased, but was dissipated by the end of three weeks. Apparent adsorption of both the PGBE ester and silvex acid occurred on the sediment; essentially complete dissipation of both occurred by the fifth week following treatment.

Some Chronic Effects of Diuron on Bluegills. J. P. McCraren, O. B. Cope, and L. Eller, Fish-Pesticide Research Laboratory, Columbia, Missouri.

Twenty percent of the bluegill fingerlings collected from 3.0 ppm treated ponds at 3 days post-treatment displayed ruptured, hemorrhagic gill lamellae. Livecar fish in a 3.0 ppm pond succumbed during this period. No further bluegill mortality was observed in treated ponds. Hematocrit measurements of treated and control fish could not be correlated to treatment level. Best growth at termination was exhibited by the control fish and their progeny. Diuron residues were not detectable by cucumber seed bioassay in treated pond-waters after 28 days. Residues in treated-pond vegetation were detectable up to 95 days whereas residues in mud were measured at 122 days post-treatment by gas chromatography.

Analysis of Dalapon in Water by Gas Chromatography. P. A. Frank and R. J. Demint, ARS, USDA, Denver, Colorado.

An efficient and sensitive procedure for extraction and analysis of dalapon in water was developed. Water samples (500 cc) containing dalapon were acidified to pH1 with HCl, saturated with NaCl, and extracted with di-ethyl ether. Dalapon was extracted from the ether with 0.1N of $NaHCO_3$ solution adjusted to pH8 with NaOH. After acidifying the $NaHCO_3$ extract to pH 1 with HCl, dalapon was extracted from the bicarbonate solution with several small volumes of ether. The combined ether extracts were evaporated to a volume of 2 ml and converted to the methyl ester with 2 ml of an ether solution of diazomethane. Aliquots of the methyl ester of dalapon in ether were injected into a gas chromatograph equipped with an electron-capture detector. The chromatographic column employed was 5 ft. by 1/8 inch and was packed with 60-80 mesh HMDS-treated Chromosorb P coated with 10% FFAP. Recoveries of dalapon from water averaged 95%, and the minimum level of detection was 0.1 ng. There was no loss in column efficiency after 200 analyses.

Dichlobenil -- Fate in Aquatic Environment. A. Shadbolt, Thompson-Hayward Chemical Co., Kansas City, Kansas.

Dichlobenil, 2,6-dichlorobenzonitrile (Casoron) is extremely effective on Chara, but it is generally ineffective on filamentous algae. Early work indicated effectiveness as a pre-emergence herbicide. More recently, it has been found to be effective as a postemergent herbicide, although this requires a two week exposure. There was no activity on filamentous algae.

Dichlobenil is usually applied as a granular formulation either through the water or to exposed pond bottoms. With normal herbicidal rates of 10 to 15 pounds of active dichlobenil per surface acre, the levels found on the soil reach about 10-12 ppm, whereas the levels in the water seldom exceed 0.5 ppm. Fish accumulated 10% with 2/3 of the material in non-edible portions, the dichlobenil has disappeared to an unmeasurable level from both soil and water within a period of 60 to 90 days.

Dichlobenil when used as an aquatic herbicide does not adversely affect fish or food-chain organisms.

The Herbicide Dichlobenil in Two Fishpond Environments. O. B. Cope, J. P. McCraren, and L. Eller, Fish-Pesticide Research Laboratory, Columbia, Missouri.

Pond studies were conducted at Tishomingo, Oklahoma, with wettable powder dichlobenil and at Denver, Colorado, with granular dichlobenil to measure chronic effects on fish. Weeds were controlled at both locations, but regrowth occurred at 10 and 20 ppm dichlobenil after 3 months. Necrosis occurred in liver, kidney, and pancreas of Tishomingo fish, at 20 to 40 ppm. No damage to fish at 10 ppm.

Mode of Action, Persistence, and Fate of Endothall in Aquatic Environment. O. Keckemet and R. T. Nelson, Pennsalt Chemicals Corporation, Tacoma, Washington.

Various endothall (7-oxabicyclo/2.2.1/heprane-2,3-dicarboxylic acid) salts have been accepted and used for years as aquatic herbicides due to the following properties: (1) effective on broad range of weeds; (2) LD_{50} for majority of endothall salts is approximately 200 mg/kg; no harmful effect at 1,000 ppm on rats after 2 years of feeding; (3) inorganic salts safe to fish at 100 to 700 ppm; (4) not harmful to fish food organisms; and highly biodegradable.

When sprayed on leaves of terrestrial plants it induces callose formation in leaves.

In Elodea, endothall accelerates protoplasmic streaming in leaf cells and causes swelling of the cytoplasm. Chloroplasts become smaller and yellowish, and the lipoprotein complex disintegrates.

Endothall is rapidly and completely decomposed: (1) in soil by bacteria and fungi which utilize endothall as the source of carbon; (2) in terrestrial plants by plant metabolism; and (3) in water by metabolism by microorganisms, aquatic plants, and fish. Complete degradation to CO_2 and water occurs.

Some Pathology in Fish Exposed to Hydrolthol 191. L. Eller, Fish-Pesticide Research Laboratory, Columbia, Missouri.

Pond studies at Tishomingo, Oklahoma, were used to study pathogenic effects of dimethylalkylamine salt of endothall (Hydrothol 191) on bluegills (Lipomis macrochirus). Morphologic and systemic tissue alterations occurred involving the gill, liver, and testis at 0.3 ppm exposure.

Effects of Herbicides on Estuarine Animals. C. W. Miller and J. I. Lowe, Bureau of Commercial Fisheries, USDI, Gulf Breeze, Florida.

Acute toxicity tests of the effects of pesticides on estuarine animals, oysters, shrimp, and fish have been conducted at our laboratory since 1958. Thirteen of 23 herbicide formulations evaluated in the past two years were toxic to one or more of the test species. Three of these, Pennsalt 283 and 2 formulations of the di(N,N-methylalkylamine) salt of endothall, were toxic to all species at a concentration of 1.0 ppm or less.

The Effects of Water Hardness on the Toxicity to Fish of Several Organic and Inorganic Herbicides. A. Ingles and E. L. Davis, Bureau of Sport Fisheries and Wildlife, USDI, Washington, D. C.

The effects of water hardness on the acute toxicities of a number of organic and inorganic herbicides to fish were determined in static bioassays. Total hardness levels, calculated as ppm $CaCO_3$, were 13.0, 52.2, 208.7, and 365.2. Bluegill sunfish were the principal test species. Organic herbicides tested included 2,4-D endothall silvex, penthachlorophenol, and dichlobenil. Inorganic herbicides included sodium arsenite and copper sulfate. Hardness had no significant effect on toxicity of the organic herbicides or the sodium arsenite. Toxicity of copper sulfate was decreased in the harder waters.

Herbicides in the Aquatic Environment. C. R. Walker, Bureau of Sport Fisheries and Wildlife, USDI, Washington, D. C.

Twenty-three different herbicides were listed which were important in fishery management programs. Although 17 herbicides are presently cleared for use in aquatic sites, the properties of the compounds and resultant restrictions of label recommendations limit their utility to fishery managers.

Aquatic Vegetation Developments on Lake Seminole (U. S. Army Corps of Engineers' Reservoir), Florida and Georgia. A. K. Gholson, Jr., U. S. Army Corps of Engineers, Chattahoochee, Florida.

Lake Seminole covers 39,250 acres. During July and September, 1958, two aerial (helicopter) contracts at a total cost of $22,809.18 were let to apply 2,4-D herbicides to the waterhyacinths on the Flint River Arm. An excellent kill resulted. Following the waterhyacinth-control program, the Flint River Arm became infested with alligatorweed.

At the present time it is estimated that the acreage of the major aquatic weed species in Lake Seminole is as follows: alligatorweed, 1,500 acres; giant cutgrass, 750 acres; waterhyacinths, 750 acres; Eurasian watermilfoil, 2,000 acres; pondweeds (Potamogeton species), 750 acres; water shield, 300 acres; lotus, 150 acres; banana lily, 200 acres; spatterdock, 50 acres; water lily, 300 acres; willow weed, 150 acres; cattail, 1,000+ acres; and maiden cane, 350 acres.

Aquatic Weeds and Man's Well-Being. F. F. Ferguson, Tropical Disease Section, USHEW, San Juan, Puerto Rico.

Aquatic vegetation harms human health in several ways, since water-related diseases are still part of our environment. Malaria has recently resisted both medicines and insecticides. Lately, active malaria cases in the United States were kept to fewer than a dozen annually; last year the figure was about 1600, almost all traceable to returning military personnel. Other diseases indirectly affected by aquatic weed conditions are: filariasis, various trematodiases (especially from the schistosomes), Chinese liver fluke, cattle liver fluke, Guinea worm, giant intestinal fluke, Asiatic lung fluke, and the broad tapeworm.

Waterweeds support other disease-pest arthropods: snipe flies, tabanids (horse, gad, deer, and greenheads), Clear Lake gnats, May flies, black flies, sandflies, and sewage flies.

Herbivorous Fish for Weed Control. J. B. Sills, USDI, Stuttgart, Arkansas.

The use of imported herbivorous fishes for aquatic weed control has met with some degree of success, but no species has been completely effective.

The grass carp, Ctenopharyngodon idellus has the reputation of consuming large quantities of aquatic plants, but observations in the United States indicate that it is primarily insectivorous and eats weeds only as a last resort.

The same was true for the Israeli carp, Cyprinus carpio now being used as a management tool in public waters in Arkansas.

Search for South American Insects to Control Aquatic Weeds. D. M. Maddox and L. A. Andres, Entomology Research Division, USDA, Albany, California.

Northern Argentina and southern Brazil are considered ideal for the study of potential plant-feeding insects to control aquatic weeds because of the area's floral and climatic similarities to the southeastern United States. Three species of insects have been studied in Argentina for the control of alligatorweed. Over 30 species of insects have been found attacking water-hyacinth in Uruguay. Insects have also been collected from water lettuce and water primrose.

Insects and the Control of Aquatic Weeds in the United States. L. A. Andres, Entomology Research Division, USDA, Albany, California.

Insects will probably find their greatest usage in controlling floating and emergent aquatic weeds. Efforts have been focused on foreign exploration for insects to control introduced weeds. The majority of aquatic weeds in North America are native, a fact which may lead to opposition to control by introduced insects. Insects cannot however be confined to a particular area, and it is therefore difficult to control the vegetation upon which they will feed.

Snails for Aquatic Weed Control. R. D. Blackburn and T. M. Taylor, ARS, USDA, Fort Lauderdale, Florida.

Marisa cornuarietis feeds voraciously on several species of aquatic weeds. Three small lakes in South Florida, stocked with snails at the rate of 4,000 per acre, were free of submersed aquatic weeds in 18 months. Marisa will survive in water temperatures of 48 to 103°F.

Pomacea australis d'orbigny, a large fresh-water snail from Brazil, has been found to feed voraciously on a wide range of submersed aquatic weeds. Since the snail is found in all areas of Brazil, it may tolerate lower temperatures than does Marisa.

Observations on Diseases of Watermilfoil and Other Aquatic Plants, Maryland, 1962-1967. H. J. Elser, Department of Chesapeake Bay Affairs, Annapolis, Maryland.

Eurasian watermilfoil (Myriophyllum spicatum L.), which infested more than 100,000 acres of Maryland's part of Chesapeake Bay and tributaries in 1963, was reduced to a very low level by 1967. Two diseases are thought to be the cause, but the responsible organisms have not yet been discovered.

Pathological conditions of unknown cause also affected (Potomogeton perfoliatus L.), (Ceratophyllum demersum L.) and (Potomogeton crispus L), (Ulva Lactuca L.) and (Zostera marina L.), and (Vallisneria americana Michx.)

Milfoil Disease in Chesapeake Bay. Miss Suzanne Bayley and C. H. Southwick, Johns Hopkins University, Baltimore, Maryland.

In late 1966 and 1967, Eurasian watermilfoil (Myriophyllum spicatum.) showed a decrease that has probably totalled 90% to 95%.

Termed "Northeast disease", the gross pathology especially the changes in petiole and leaf morphology, suggested an environmental toxicant or viral pathogen. Work has shown that the disease can be transmitted by a bacteriologically sterile filtrate passed through a 0.2 micron filter. This indicates a virus, virus-like particle, or endogenous toxin as the causative agent. The pathogen is probably a virus.

Aquatic Weeds for Nutrient Removal. Mr. Clayton Phillippi read paper of C. W. Sheffield Orange County Department of Water Conservation, Orlando, Florida.

The paper points out, by using natural means such as aquatic plants, that there is an excellent chance this will be an economical way to remove the nitrogen and phosphorus nutrient compounds from various effluents, such as sewage entering the waterways in Florida.

In lieu of radically eliminating hyacinths and other floating plants they are being used under controlled conditions for beneficial purposes.

Nutritive Value of *Justicia americana*. C. E. Boyd, Agricultural Experiment Station, Auburn University, Auburn, Alabama.

An investigation of the nutritive value of the aquatic macrophyte, *Justicia americana*, was conducted near Auburn, Alabama. On July 1, the standing crop was 6,000 lb/A dry weight. Fresh shoots contained 16.6% dry matter, and dry meals prepared from the samples averaged 14.20% ash, 16.7% crude protein, 3.87% ether extract, 25.9% cellulose, and 4.9% lignin. Preparation of leaf-protein concentrate of dry meals from this plant might be feasible under certain circumstances.

Control of Water Chestnut (*Trapa natans* L.) in Maryland, 1964-1967. H. J. Elser, Department of Chesapeake Bay Affairs, Annapolis, Maryland.

Control has been both chemical and mechanical. In 1966 and 1967, experiments with a combination of dicamba and 2,4-D were begun. This combination appears more efficient than 2,4-D alone.

When using an aquatic weed harvester all cut plants were removed from the water so there could be no spreading of the infestation. Single, widely scattered plants were hand pulled.

Investigation of Effects of Large-Scale Applications of 2,4-D Upon Aquatic Fauna and Water Quality. G. E. Smith and B. G. Isom, TVA, Muscle Shoals, Ala, and Chattanooga, Tennessee.

Anopheles quadrimaculatus Say mosquito larvae, confined to laboratory insectary pans, survived 2,4-D treatments at the rate of 100 ppm, and adults from these larvae were carried to the F_2 generation. No difference in hardiness or reproductive ability could be detected between adults coming from 2,4-D treated larvae and those not treated.

Extensive pre-and post-monitoring data indicate that high application rates of 2,4-D for watermilfoil control on TVA reservoirs have not produced adverse effects upon aquatic fauna or water quality.

Diquat for Aquatic Weed Control in Florida. W. D. Hogan, Chevron Chemical Co., Orlando, Florida.

Diquat is not a new herbicide, since it is entering its ninth year of testing and has had a Federal label registration since 1962. Diquat is of interest to applicators in the field of aquatic weed control for several reasons: (1) it has a wide spectrum of activity on weeds; (2) it has a high toxicity threshold to fish at about 20 ppm; (3) it is rapidly absorbed by plants; and (4) the treated water can be used for human or animal consumption, swimming, spraying, or irrigation after 10 days.

A Status Report: Ecology and Control of Watermilfoil in the Northeast.
J. M. Cortell, Wellesley Hills, Massachusetts.

Watermilfoil (Myriophyllum sp.) represents the number one aquatic nuisance in the Northeast. Development of shoreline property, industrial wastes, increased population demands for recreational use, and agricultural intensification have brought about a nutrient-enriched environment in which watermilfoil apparently flourishes.

The geographical distribution of the various species of watermilfoil in the Northeast follows a definite geological pattern related to pH and alkalinity. Myriophyllum heterophyllum, M. humile, M. farwellii, M. pinnatum, and M. alterniflorum are found in acid and soft water always below 50 ppm alkalinity. M. exalbescens, M. verticillatum, and M. spicatum are found in hard-water lakes and ponds above 50 ppm alkalinity but can spread to waters as low as 20 ppm alkalinity.

Watermilfoil in the Northeast is primarily controlled with 2,4-D and silvex. Some use of diquat, endothall, and mechanical cutting is reported.

The Phase of the Eurasian Watermilfoil Problem in the Chesapeake Bay.
J. H. Steenis, Bureau of Sport Fisheries and Wildlife, USDI, Laurel, Maryland.

The Eurasian watermilfoil (Myriophyllum spicaturm) was collected in the Baltimore Harbor of Chesapeake Bay in 1902. In 1959, there were some 50,000 acres of established growth; in 1960, 100,000 acres; and in 1962, 200,000 acres.

Status of Eurasian Watermilfoil in the Currituck Sound Area, 1967.
T. E. Crowell and J. H. Steenis, Division of Inland Fisheries, N. C. Wildlife Resources Comm., Raleigh, North Carolina, and Bureau of Sport Fisheries amd Wildlife, USDI, Laurel, Maryland.

Eurasian watermilfoil (Myriophyllum spicatum) was first discovered in the Currituck Sound in 1964. Currituck Sound is a unit of approximately 98,000 acres. By 1967, 12,000 acres were infested with a blanket growth, and 80,000 acres were in the initial establishment stage.

Eurasian Watermilfoil--Florida's New Underwater Menace. R. D. Blackburn and L. W. Weldon, ARS, USDA, Fort Lauderdale, Florida.

Eurasian watermilfoil (Myriophyllum spicatum L.) has recently become established in Lake Seminole at Chattahoochee and in the Crystal-Homosassa River Basin. The Crystal-Homosassa River Basin is estimated to have 3,000 partially, to heavily, infested acres.

Some Characteristics of In tation and Evaluation of Bipyridyl Treatment for Control of Eurasian Milfoil in Lake Seminole, Georgia. J. M. Lawrence and H. H. Funderburk, Jr., Agricultural Experiment Station, Auburn University, Auburn, Alabama.

A 750-acre infestation of Eurasian watermilfoil (Myriophyllum spicatum possibly accidentally or purposely introduced by aquarium plant collectors, was discovered in one arm of Lake Seminole in June, 1966. By November, 1966 this species occupied approximately 1,500 acres of the Spring Creek area of the reservoir and had replaced an established stand of Potamogeton crispus.

Preliminary treatment with diquat (10-lb cation) plus paraquat (10-lb cation) along a straight line in a 10-acre area of a boat channel in April, 1967, produced 100% kill over 40 acres of surrounding area. Approximately 75% of the area remained free of watermilfoil for the remainder of the summer, but reinfestation of Potamogeton crispus occurred following the death of the watermilfoil.

The Spread and Control of Eurasian Water milfoil (Myriophyllum Spicatum L.) in TVA Reservoirs. G. E. Smith, TVA, Muscle Shoals, Alabama.

In spite of chemical control efforts from 1962 through 1965, Eurasian watermilfoil spread from about 2,000 acres on two TVA reservoirs to about 8,000 acres on seven reservoirs. In 1966, a massive herbicidal control program was carried out with two helicopters operating from 152-foot river barges and using a 20 percent granular butoxyethanol ester of 2,4-D which was applied at the rates of 40 and 100 pounds acid equivalent per acre. Regrowth and reinfestations are occurring at a rapid rate. Satisfactory control, in essence, means there must be 100 percent kill or eradication.

Translocation of Solutes in Three Species of Myriophyllum. D. E. Seaman and J. D. Baldia, Syracuse University Research Corporation, Syracuse, New York, and University of California, Davis, California.

A comparative radioautographic study of translocation revealed a strong transpiration stream and apoplastic acropetal movement of basally applied ^{45}Ca (as $CaCl_2$) and ^{14}C-labeled atrazine, simazine, and diuron in Myriophyllum brasiliense, which has stomatous emersed leaves. M. exalbescens and M. verticillatum submersed species do not have stomates, but they may allow water to escape slowly through apical openings in their leaflets in response to excess root or turgor pressures. All three species translocated photosynthetic assimilates via phloem tissues to roots and meristems following applications of urea-^{14}C or $Na_2{}^{14}CO_3$ to exporting apices or side branches.

Absorption and Distribution of Picloram-^{14}C in parrotfeather (Myriophyllum brasiliense Camb.) C. L. Foy, K. F. Falkenstein, D. L. Sutton, and S. W. Bingham, Virginia Polytechnic Institute, Blacksburg, Virginia.

Picloram-^{14}C, nonmetabolized at least in part, was readily absorbed and translocated in parrotfeather following application to foliage or roots, as determined by counting, autoradiography, and chromatography.

Foliarly-applied picloram was readily transported (presumably via the phloem), excreted from roots of treated (donor) plants of emersed parrotfeather, and reabsorbed by untreated (recipient) plants growing in the same nutrient medium. Carbon-14 was translocated both acropetally and basipetally.

In submersed plants, accumulation of ^{14}C was greatest in the shoot (the portion growing most actively), whether picloram-^{14}C was administered through shoot or roots.

Permeability of Epiderman Membrane of American Pondweed to Herbicides. P. A. Frank, ARS, USDA, Denver, Colorado.

Membranes one cell in thickness were prepared from stems of American pondweed by digestion with pectinase and fitted in modified Hemmings' filters. Internal and external surfaces of the membranes were exposed separately to solutions of radio-labeled herbicides and the quantities of herbicide diffusing through the membranes determined by scintillation counting. Herbicides known to be effective on submersed aquatic weeds diffused most readily through the membrane. This group included endothall dichlobenil, silvex, and fenac.

Effects of Various Control Treatments on Carbohydrate Levels in Carex. F. L. Timmons, R. D. Comes, and L. W. Weldon, ARS, USDA, Laramie, Wyoming, Prosser, Washington, and Fort Lauderdale, Florida.

Rank-growing species of carex (Carex spp.) greatly reduce the flow of water in irrigation and drainage canals in Colorado, Nebraska, Wyoming, Montana, and the Dakotas. Research in Wyoming has revealed that five herbicidal and burning treatments give adequate to excellent control of carex along canals.

DNBP-fortified fuel oil applied every 3 or 6 weeks caused the greatest reduction in total carbohydrates in roots followed closely by the reduction caused by 2,4-D at 80 lb/A in 2 or 3 repeated applications. Dalapon at 20 lb/A did not reduce carbohydrates. The final percentage reductions in stand or carex were 99 for 2,4-D and DNBP-fortified fuel oil, 94 for amitrole, 65 for dalapon, and 45 for LP gas-burning.

Evaluation of Simazine as an Aquatic Herbicide in Ponds. J. R. Whitley and J. G. Dillard, Missouri Department of Conservation, Columbia, Missouri.

Treatment of ponds with simazine for two consecutive years in early spring at a concentration of 1.0 ppm prevented the growth of higher aquatic plants and Chara. Phytoplankton and filamentous algae were nearly eliminated in treated ponds. Dissolved oxygen concentrations were similar in treated ponds and in untreated ponds. Turbidity increased in simazine-treated ponds during the second year.

Largemouth bass and redear sunfish grew at a normal rate in simazine-treated ponds during the first year. Redear sunfish grew normally during the second year, but growth of largemouth bass was poor. Reduction of basic production and increased turbidity were factors which influenced the growth rate of bass in the second year. Aquatic vegetation which developed in these ponds during the third year was very similar to the plant growth in them before treatment.

A Technique for Collecting Soil-Water Interface Samples for Chemical Analyses. J. M. Lawrence. Auburn University, Auburn, Alabama.

An all-plastic sampler was developed capable of collecting surface residue to a depth of 1/4 inch over approximately 0.5 square foot of lake bottom. The sample-collecting chamber was cocked on board a boat, the sampler was lowered to the bottom on a rope, and the collecting chamber was activated by a messenger dropped along the rope. The sampler was then retrieved by the rope, and the contents of the collecting chamber were removed into a plastic pan or bag. Leakage of collected muck was nil so long as the sampler was underwater. The sampler resembled a large hypodermic syringe very closely.

Influence of Simazine on Apparent Photosynthesis of Aquatic Plants and Residue in Water and Fish. D. L. Sutton, D. A. Durham, S. W. Bingham, and C. L. Foy, Virginia Polytechnic Institute, Blacksburg, Virginia.

Simazine inhibited oxygen evolution within 24 hours in nutrient cultures of duckweed (*Lemna minor* L.), elodea (*Elodea canadensis* Michx.), and parrotfeather (*Myriophyllum brasiliense* Camb.). Residue in fish from treated ponds was highest in the viscera, intermediate in the skin, and lowest in the meat. Fish were free of simazine once the water was free of chemical.

The Effects of Diuron on Several Species of Vascular Aquatics. R. N. Hambric, Texas Parks and Wildlife Department, Houston, Texas.

Diuron dosages were computed as pounds of total material per surface acre, using 80% wettable powder. Diuron at 1 lb/A controlled southern naiad, *Najas guadalupensis* bladderwort, *Utricularia inflata*; American lotus, *Nelumbo lutea*; watershield, *Brasenia scheberi*; waterprimrose, *Jussiaea diffusa*; sparse marginal stands of *Bidens* sp.; and rice cutgrass, *Leersia* sp. Diuron at 2 lb/A controlled coontail, *Ceratophyllum demersum* L., chara, and unsprayed marginal stands of *Sagittaria* sp. Control of spatterdock, *Nuphar advena*, with 1 and 2 lb/A varied from fair to good. Spraying with 3 pounds of diuron in 40 gallons of water controlled burreed, *Sparganium* sp., but a light spraying was ineffective. Two lb/A applied to a 6-acre corner plot in a 30-acre lake controlled southern naiad, bladderwort, and pondweed *Potamogeton* sp. in about half of the entire lake. Diuron at 1-1/3 lb/A plus ammonium lignin sulfonate (Orzan A) at 1-2/3 lb/A controlled coontail and a fineleaf variety of pondweed, *Potamogeton* sp.

The Toxicity of Silvex to Aquatic Fauna. E. W. Whitney, U. S. Fish and Wildlife Service, Athens, Georgia.

The ponds were treated with silvex at the rate of eight pounds acid equivalent per surface acre.

Fish kills were observed in 50% of the silvex applications. Gizzard shad (Dorosoma cepedianum), bluegill (Lepomis macrochirus), and largemouth bass (Micropterus salmoides) were the principal species affected. Death occurred within 10 hours. Carnivorous fish with less body area were less susceptible. There was no spawning success.

Maximum residue levels in fish and fish-food organisms were reached at 24 hours after treatment. This decreased to negligible amounts by one to three weeks after treatment. The highest residue value recorded was 19 ppm from one sample of forage fish.

Benthic organisms showed an overall pattern of significant increase in numbers after silvex treatments.

Silvex destroyed the normal phytoplankton population which consisted of numerous species. Euglena sp. and dinoflagellates replaced these species.

Rotifers and crustaceans decreased following silvex application. However, they regained their normal population size within one to three weeks.

A Summary of a Study of the Persistency and Residues of Some Herbicides in Surface Waters. W. K. Averitt, University of Southwestern Louisiana, Lafayette, Louisiana.

The methyl amine salt of 2,4-D was applied to a series of test areas, at the rate of 4 pounds of acid equivalent per acre to control water hyacinth.

All tests indicated the same general trend. The concentration immediately after spraying for one test was 739 ppb and rose to 802 ppb on the second day, with a decrease to 446 ppb on the third day to be followed by a more severe drop to 74 ppb on the fourth day. There was a continual, gradual decline until 102 days at which time no 2,4-D could be detected as residue.

Test plots involving silvex and Esteron 99 produced similar results with 2,4-D.

Control of Duckweed and Azolla with Diruon. R. N. Hambric, Texas Parks and Wildlife Department, Houston, Texas.

Diuron dosages were computed as total material per surface acre using 80% wettable powder. Even distribution was not necessary. Common duckweed, Lemna minor L., and azolla, Azolla caroliniana Willd., were eradicated by spraying the lake-surface with diuron at 1/2 lb/A. Dense mats containing a combination of common duckweed; azolla; giant duckweed; Spirodella polyrhiza (L.) Schleid.; watermeal, Wolffia papulifera Thompson; frogbit, Limnobium spongia (Bosc) Steud.; and Wolffiella floridana (Smith) Thompson were controlled on several lakes at 2/3 and 1 lb/A.

With treatments as haavy as 2 lb/A, diuron dispersed more than 100 feet into thickly timbered, untreated areas and eliminated thick growths of duckweed. Water overflowed from one lake through an adjoining 5.7-acre lake, then through a 1.75-acre lake, eliminating dense growths of duckweed from all three lakes (16.55 acres) in 2 to 4 weeks. Water qualities in the lakes investigated were in the following range: temperature 79° F to 92°F, p^H 6.2 to 8.8 units, and total alkalinity 20 to 225 ppm. Willow and cypress trees growing in the treated waters were not affected and fish were not killed.

Comparative Effects of Aquatic Herbicides on Duckweed. V. Knudson, Michigan State University, East Lansing, Michigan.

A study of the comparative effects of aquatic herbicides upon duckweed (*Lemna minor* L.) was conducted in cement pools. Diquat, liquid potassium endothall, DMC salt of endothall, copper sulfate, and methyl octanoate were tested. The most effective treatments were DMC salt of endothall and diquat.

The Use of an Amine Salt of Endothall in Irrigation Canals. E. J. Bowles and O. Keckemet, Pennsalt Chemicals Corporation, Tacoma, Washington.

The mono-*N*,*N*-dimethylcocoamine salt of 7-oxybicyclo-(2.2.1) heptane-2,3-dicarboxylic acid (amine salt of endothall) was applied to moving water in several irrigation canals at varying concentration-time combinations in six western states. Generally, an application of 3 ppm for 3 hours provided commercially acceptable control of most submersed aquatic weeds, including *Potamogeton* spp., for distances downstream as far as 20 miles. Cotton yields were not affected by 6 irrigations of 10 ppm each.

Laboratory Studies of the Synergism of Various Compounds Applied to Alligatorweed Control. S. L. Solymosy, University of Soutnwestern Louisiana, Lafayette, La.

Laboratory studies of the synergistic action of various chemicals seem to be necessary to determine if certain compounds combined with others would increase their herbicidal potential relative to alligatorweed. Effectiveness of 2,4-D was increased considerably by adding acetic acid to the spray formula. Early experiments related to alligatorweed also showed that the chemicals were more effective when applied to underwater parts of the plant. Satisfactory results were obtained with several combinations, among others, β-hydrobutyric acid and 2,4-D, hydantoic acid and 2,4-D, and as a result of a follow-up investigation of the blackstrap molasses for herbicidal potential, the various combinations of aconitic acid, itaconic acid and 2,4-D.

Review of Experiences with Use of Phenoxy Herbicides and Organic Acids for Control of Alligatorweed. W. E. Fletcher, University of Southwestern Louisiana, Lafayette, Louisiana.

Floating mats of alligatorweed have been treated with sprays of 2,4-D mixtures including diglycolic, aconitic, itaconic anf sulfamic acids with good results. Late summer and fall applications of the combination sprays have produced up to 90 percent control with a single application. Application to the stem portions in the field studies has apparently proven more effective than foliar applications.

Organic Acids as Herbicidal Adjuvants with Phenoxy Herbicides in the Control of Elodea Sp. J. A. Foret, University of Southwestern Louisiana, Lafayette, Louisiana.

The treatment yielding the most consistent control of Elodea Sp. was a combination of 2 lb. of 2,4-D (P6BEE), 2 lb. of silvex (P6BEE), and 1 gallon of blackstrap molasses (which contains aconitic and itaconic acids) per acre injected into the mat of growing Elodea sp.