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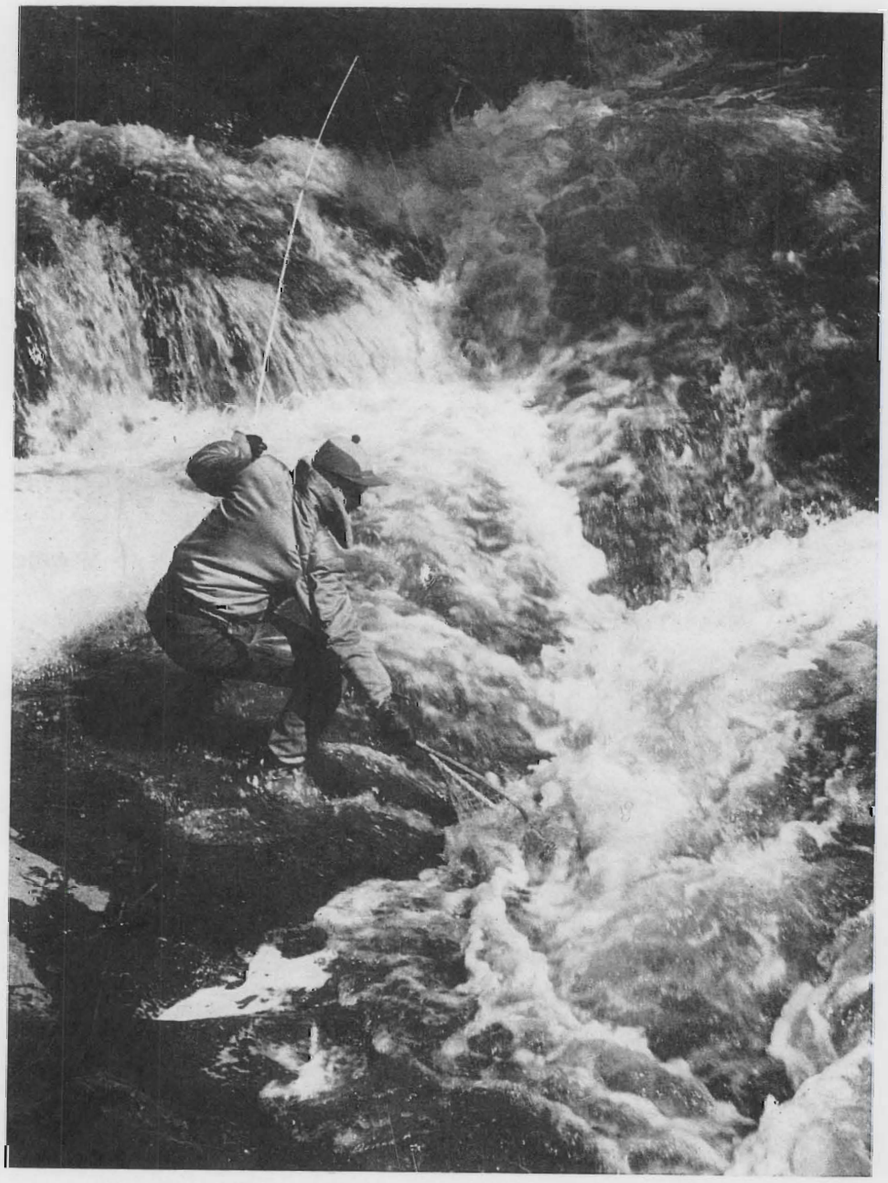

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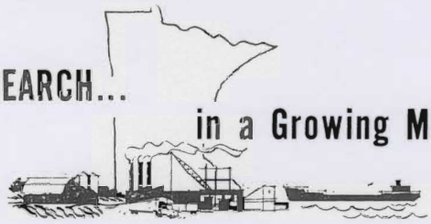
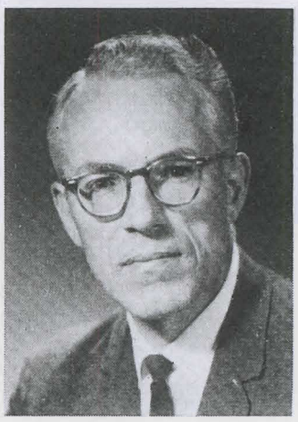
RESEARCH... in a Growing Minnesota



Has Man Polluted His Environment?



Dr. Hueg

Pollution is one of the great problems facing man today. The pollution problem increases daily. The threat of increasing numbers of people raises the question, will man be able to live on the polluted earth?

The pollution story has two sides. What would the earth be like in the 20th century if man had not been created or if he had lived on another planet? Would non-human phenomena have polluted the earth? Yes, for a phenomenon called eutrophication is going on independent of man. Eutrophication is a natural function resulting from the living and the dying of plants and animals, and shows itself most in lakes and streams.

The Minnesota Agricultural Experiment Station has been studying this phenomenon for many years. Actually our studies of organic soils are possible because of eutrophy which took place over thousands of years. We have interest to learn about survival of fish and wildlife in polluted habitat. We know the importance of safe water supplies for humans and domestic animals. We wonder what becomes of soluble nutrients from manures, and more recently from commercial fertilizers. We wonder what the long-run impact of the pollution problem will be on the continuance of the important livestock industry.

To come to grips with these problems a symposium on animal waste disposal was held at the University of Minnesota in late November. This symposium brought together people well informed on the problem through research. It also brought to light the regulation developed by the Minnesota Pollution Control Agency with particular respect to pollution from livestock. Those in attendance represented the industry concern, pollution and health groups, and the University. All agreed that they have a responsibility for education and research in this area.

In this article I have synthesized what I believe to be the high points of the symposium with the thought that this may be helpful in your thinking about the problem.

Let us first look at the magnitude of the animal waste problem in Minnesota. There are 4 million cattle, 2½ million hogs, ¾ million sheep, and 14 million chickens and turkeys in Minnesota. In round numbers they represent waste disposal equivalent to a population of 66 million people.

If I would stop here you might conclude that animal agriculture will eventually destroy the lakes and streams of Minnesota, if not its total environment. But have you given thought to the vast grasslands that abounded in the southern and western counties a century ago? Many books of early Minnesota history tell of the hoards of buffalo that were found on these grasslands. They also describe the streams and wallows that ran yellow and putrid from buffalo excretions. The environment of a hundred years ago was not pure and uncontaminated as many would like us to believe.

The 4 million cattle on Minnesota farms produce about 40 million tons of solid waste and 15 million tons of liquid wastes each year. This mass of waste contains about 290,000 tons of nitrogen and about 40,000 tons of phosphorus. But about one quarter of these wastes are dropped on pastures and rangelands just as the buffalo herds did in the natural environment of a century ago. About one half of the nitrogen content of these wastes is volatilized before it reaches the soil. It is estimated that the spreading of cattle wastes on crop land probably does not exceed 100,000 tons of nitrogen per year.

Experience has shown that to produce economic crop yields, abundant amounts of plant nutrients are required. About 200 pounds of nitrogen and 100 pounds of phosphate are needed to produce a 100-bushel corn crop. Actually this crop will remove

140 pounds of nitrogen and 25 pounds of phosphorus. On Minnesota's 18 million acres of crop land, nearly 1 million tons of nitrogen and 200,000 tons of phosphorus are removed each year. With present use of nitrogen and phosphorus ($250,000 tons and 90,000 tons respectively applied in 1968) Minnesota farmers would be justified in adding three times as much chemical fertilizer as they are at present if they are to break even on nutrient removal and maintain economic crop production.

Many of you are avid home gardeners. In order to keep your soil open and friable, you may buy a bale or two of peat each year. Have you given thought to how peat developed? Have you even thought of its importance to Minnesota?

In Minnesota there are 7½ million acres of peat and muck soils, about 1/7 of the surface area of the state. These peats are the organic residues of massive eutrophy that existed in the area over many thousands of years. This process is still going on as evidenced by the condition of many of Minnesota's 10,000 lakes. Actually you can observe eutrophication in many of these lakes even though there are no farms in the immediate vicinity.

Minnesotans have become increasingly alarmed and concerned about the pollution taking place in their lakes and streams. It has seemed natural to look to areas of concentrated livestock or farm use of fertilizers as the culprit. This is easier, especially if we have only remote interest in this vast economic resource.

In 1967 the Legislature created the Minnesota Pollution Control Agency which is made up of 7 citizen members. The Agency has authority for the control of water pollution, air pollution, solid waste disposal, and pollution related land use planning.

Regulation WPC-22 is presently under consideration and discussion by the Agency. This regulation relates to the prohibition of the promiscuous deposit of manure and other wastes that are capable of polluting water of the state and are directly related to or originate from the feeding of livestock or other animals. May I suggest that you secure a copy of this regulation from the Pollution Control Agency. Review it carefully and raise the appropriate questions with the Agency, livestock and farm groups, and other local and state citizen groups.

Pollution control is a concern to all of us. However, we need to be sure of all of the facts, and must base our decisions on information accurately obtained. Understanding must be created through research and education. Let us not through wrong assumptions condemn Minnesota's livestock industry which returns 1.2 billion dollars in cash farm sales to the economy of the state. Informed citizens can work together to control pollution. We in the Minnesota Agricultural Experiment Station want to contribute to this understanding.

William F. Hueg, Jr.

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Contents

Fungicides and D

Carl J. Eide and R. E. Kroll

Farmers and plant pathologists alike tend to think of disease resistance and fungicides as mutually exclusive means of controlling plant diseases. They seem to feel that a resistant variety needs no fungicide protection and that all susceptible varieties need the same applications of fungicides. These assumptions are not necessarily true, as any farmer or plant pathologist can see from his own observations and experience. That is, nearly everyone who has tried to control plant diseases has noticed that it is easier to control diseases with fungicides on some varieties than it is on others.

Surprisingly this fact, although often observed, has little experimental evidence to support it. To get such evidence, plant pathologists in the Minnesota Agricultural Experiment Station have made some studies.

Disease resistance necessary

Varieties of many crop plants are immune from certain diseases, while other varieties of the same crop are highly susceptible. Immune varieties seem to be the ideal answer to the problem of disease control, but unfortunately (with a very few exceptions) disease immunity has one serious drawback. This is the fact that the immune varieties are immune to only certain races of a certain pathogen and highly susceptible to others. A pathogen (fungus, bacterium or virus) may comprise a number of races, just

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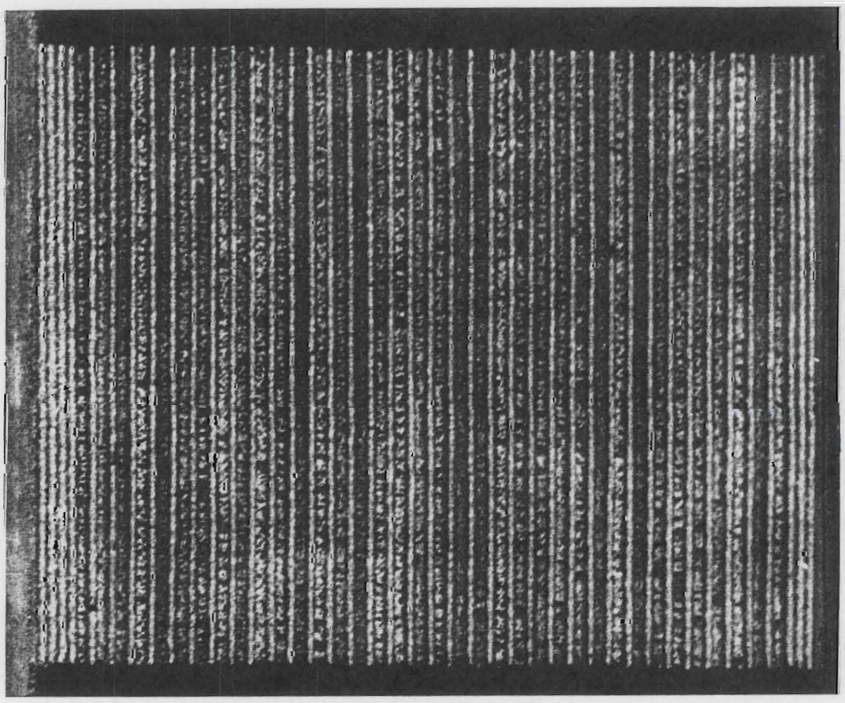


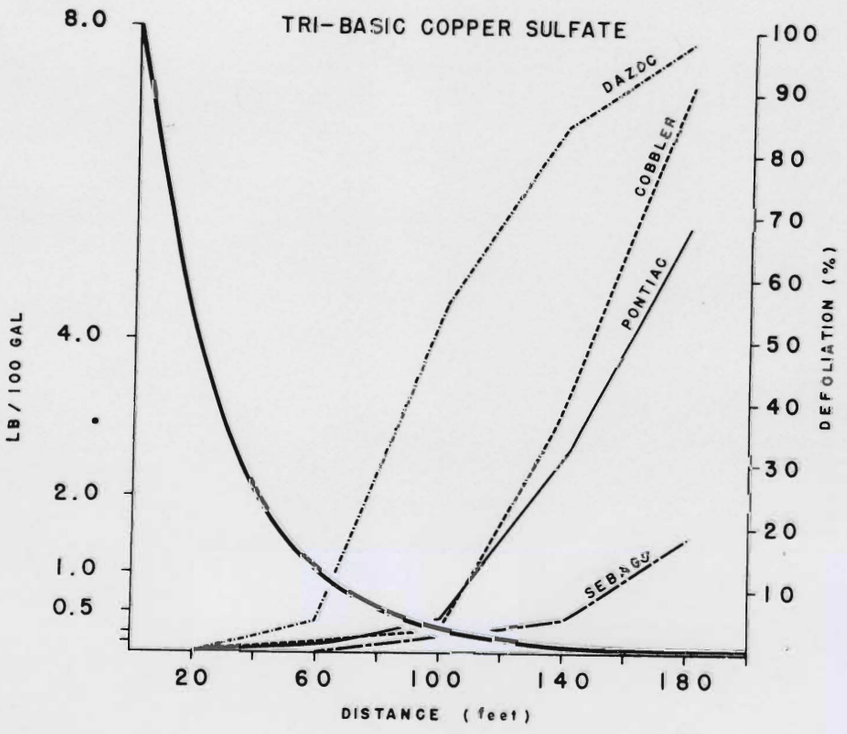
This aerial photo on infrared film shows foliage as white. Solid white rows are soybeans. Between the soybean rows are rows of potatoes of four standard varieties. Along most potato rows a constantly increasing amount of fungicide was sprayed. Note the increase of potato foliage where the amount of fungicide increased.

isease Resistance

as a crop may have a number of varieties. Races or varieties are all sufficiently alike to belong to the same species, but they differ in certain characteristics. Among other things, races of pathogens differ in their ability to produce the disease on different crop varieties.

Here is an example. The potato variety Kennebec, now widely grown in the Red River Valley, is immune to most races (15 or more) of the late blight fungus, *Phytophthora infestans*, but it is susceptible to Race 1. In 1966, when late blight was destructive in Minnesota, Race 1, usually not prevalent on other potato varieties, appeared on the variety Kennebec and caused widespread damage. This situation has occurred innumerable times on varieties of various crops, many of which were bred specifically for resistance to a certain disease. The sudden failure of resistance to stem rust in newly-introduced wheat varieties is a classic example and an old story to wheat growers.

But this is not the whole story of disease resistance in plants. Besides immunity to specific races of a pathogen, crop varieties may differ in the ease with which a pathogen penetrates them, or the time it takes for the disease to appear after penetration. Varieties may differ with respect to any of a whole complex of characteristics that tend to slow the development of a disease, both in a single individual or a population of plants. Such resistance has been referred to variously as "field resistance," "partial resistance," "generalized resistance," and even "horizontal resistance." Characteristically it is equally effective against all races of a pathogen, so



Relations of concentration of tribasic copper sulfate to defoliation of four varieties of potatoes by late blight. The figures along the base are the distances in feet along a row of potatoes. The solid curve shows the concentration of the fungicide.

Without fungicide both of these varieties of potatoes would have been destroyed by late blight. Here both varieties received a light application of fungicide. This amount of fungicide protected the variety at the left but did not protect the more susceptible variety on the right.

it is best described by the rather clumsy name "non-specific resistance."

Non-specific resistance is rarely so great as to make a variety completely free of the disease, and it is also affected easily by weather and other conditions that influence disease development. So, in an average year, the potato variety Sebago may have much less late blight than the variety Cobbler, but in a wet, cold year highly favorable for blight both will be heavily infected.

The incompleteness of non-specific resistance and its susceptibility to environmental influences made it unpopular among plant pathologists and plant breeders as a potential means for disease control. Besides inheritance was found to be controlled by many genes, but race specific immunity is usually controlled by one or a few factor pairs. This made the study of genetic ratios for race-specific immunity easy and attractive for plant breeders, while their plant pathologist collaborators took delight in identifying and classifying pathogenic races.

However, the occasional failure of race-specific immunity gradually turned the attention of breeders and pathologists back to the less glamorous, apparently inadequate non-specific resistance. Potato investigators were among the earliest to study non-specific resistance, because the late blight fungus could produce new harmful races with fantastic promptness every time a supposedly immune variety of potato was introduced.

With close acquaintance came a better realization of the potentialities of non-specific resistance. In average years a little resistance proved adequate to make the difference between a destructive epidemic and a mild one with little loss. Furthermore, it became apparent that a moderate degree of resistance was of value in increasing the effectiveness of other methods of control. This brings us back to the studies made with fungicides in the Department of Plant Pathology during the past three years.

The hypothesis basic to these tests is that to control late blight a smaller amount of a protective fungicide is necessary on a potato variety with a high degree of non-specific resistance than on one with less resistance. This hypothesis could be tested by planting a number of plots of each of 2 or more varieties differing in resistance and then spraying the several plots of each variety with different concentrations of the fungicide. A comprehensive test made in this way could involve a large number of plots.

To accomplish the same objective with less work a sprayer was built which will apply a constantly decreasing concentration of fungicide along a row of potatoes. The machine used, called an exponential sprayer, was made to reduce the concentration by one-half every 6 seconds. Moving at a rate of 200 feet per minute, this resulted in applying, at any given point along the row, a fungicide suspension one-half the concentration of that 20 feet nearer the starting point. Theoretically, at the end of a 200 foot row, the concentration of the spray was about 1/1000 that at the beginning of the row. Thus the plants in a single row 200 feet long were covered with spray suspensions of a wide range of concentrations.

Four common varieties of potatoes were sprayed. These were chosen because of their known differences in non-specific resistance to late blight. After they were sprayed with the fungicides, the plants were inoculated with the late blight fungus by spraying them uniformly with a suspension of spores. As the late blight disease developed, estimates were made of the defoliation caused by the disease.

The graph shows the defoliation caused by late blight as of Sept. 23, 1967, on single rows sprayed with tri-

basic copper sulfate. The smooth, solid curve shows the theoretical concentration of the fungicide in relation to the distance from the starting point. The other lines show the percentages of defoliation in four varieties at intervals along 200-foot rows.

It is apparent that at a concentration of 4 lb per 100 gallons (the recommended rate) blight was controlled on all 4 varieties. At lower concentrations control was progressively less, but was poorest on the susceptible variety Dazoc and most effective on the resistant variety Sebago. At the time these notes were made, the percentages of defoliation on non-sprayed rows of the same varieties were: Dazoc, 100 percent; Cobbler, 97 percent; Pontiac, 75 percent and Sebago, 75 percent.

By comparing defoliation in unsprayed rows with defoliation at a given concentration of fungicide, it is possible to express the effect of variety on the efficiency of the fungicide. Thus, at 140 feet there was about 15 percent control of the disease on the variety Dazoc, 62 percent on Cobbler, 57 percent on Pontiac and 93 percent on Sebago. At this point the concentration of the spray was about 0.06 lb/100 gallons. Observe that there was a higher percentage of control by the fungicide on Cobbler than on Pontiac, even though Cobbler is the more susceptible of the two varieties. However, the greater resistance of the Pontiac resulted in a total percentage of defoliation a little less than on Cobbler.

These results indicate that there is an association between non-specific resistance to late blight and ease of control with tri-basic copper sulfate. However, the correlation is not perfect and apparently is not only a matter of there being less disease to control on some varieties than on others. It was thought that the fungicide might adhere better to the leaves of Cobbler than to those of Pontiac, resulting in greater fungicidal efficiency, but analysis of residues on the leaves did not support this hypothesis. Whatever the reason or reasons are, they still remain to be discovered by further research.

Does this work have any practical significance? For example, it can be pointed out that when used at the recommended rate, tri-basic copper sulfate controlled blight on all four varieties. Inasmuch as the cost of application is greater than the cost of materials, little could be saved by reducing the dosage on the more resistant varieties.

This point is well taken. On the other hand, fungicides do not remain at their original concentrations after being applied to the foliage. They are washed off by rain and rubbed off by the friction of leaf upon leaf. The result is that after a few days, depending upon the weather, the original protective film is reduced. Figure 1 shows that Sebago is as safe when this residue is equivalent to 0.06 lb/100 gallons as Dazoc is at 1.0 lb/100 gallons. More frequent application is necessary to protect the more susceptible varieties.

Efforts have been made for many years to forecast the occurrence and severity of late blight on the basis of weather, past and predicted, and to warn potato growers of the necessity to spray or not to spray. It seems possible, with the information now available from the studies here described, to include the effect of variety in the information given to the grower. Accordingly, a man growing Cobbler would have to spray under certain conditions while the grower of Sebago could safely wait.

The concern about the effects of pesticides on the health of man and the environment in general emphasizes the desirability of using minimum dosages where pesticides are necessary. By growing varieties of crops with non-specific resistance to diseases and knowing the requirements of these varieties for chemical protection, the hazard to health might be reduced and modest savings made in the cost of control.

Other instances of the effect of non-specific resistance on disease control can be cited. Potato varieties have been introduced in which rugose mosaic spread so fast that it was impossible to keep under control by destroying infected plants. Because this is the basic technique for meeting the tolerances in certified seed, the variety was abandoned.

These facts are becoming more and more apparent to growers, plant pathologists, and everyone interested in disease control. It is increasingly apparent that disease control is not a matter of employing one method or another. A combination is often, even usually, most effective. A certain degree of non-specific resistance is essential to the success of many other types of control and when absent often leads to increased disease problems.

AGRICULTURAL WASTE PRODUCTS can be made into products useful to man. For example, sugar cane stalks are made into wallboard, and oat hulls are transformed into valuable chemicals. Why isn't this sort of thing done more?

USDA scientists have made good paper from straw, and they have found ways to make useful products out of corn cobs and other wastes. But wastes such as these accumulate in small quantities at farms and at feed mills. It does not pay to transport them to central points for processing. Sugar cane stalks and oat hulls can be used because they accumulate in large quantities at certain factories.

AORTIC RUPTURE IN TURKEYS

Paul E. Waibel, Laverne M. Krista, Jay Sautter, and Robert N. Shoffner

The aorta, that big artery that receives blood directly from the heart, may burst if it is weak or if blood pressure becomes too high. Since this form of sudden death occurs in both men and turkeys, research scientists are studying it intensively. Our Minnesota team finds that heredity is a predisposing factor in turkeys.

Aortic rupture is a widespread and ever-present killer of turkeys. Other names for this malady are *internal hemorrhage* and *dissecting aneurysm*. A tear occurs along the posterior abdominal aorta near the kidneys and testes, and the hemorrhage that quickly follows usually fills the body cavity with blood.

Males suffer this fatal accident much more than females, and the larger, faster-growing males seem most susceptible. Death from aortic rupture occurs in turkeys most commonly when they are between 8 and 16 weeks old.

The Crop and Livestock Service reports that approximately 3 percent of the deaths of Minnesota turkeys are caused by aortic rupture. This may well be an underestimation since these reports are based upon problem flocks, while aortic rupture usually affects turkeys in healthy flocks.

The first published report of this malady appeared in 1952. Minnesota Diagnostic Laboratory records describe cases in the 1930's and 1940's. Explanation for an increased incidence in the early 1950's may relate to nutrition designed for maximum productivity (high energy diets, vitamin B_{12}, unidentified growth factor sources, and antibiotics), to genetic selection for greater muscling, and to disease stress and medication practices.

Natural aortic rupture is difficult to study experimentally because of its sporadic and unpredictable occurrence. For study purposes, we were fortunate to have a reasonable incidence of aortic rupture in some nutrition and physiology experiments; but in attempting to obtain similar results in further experiments by repeating all procedural details as precisely as possible, we obtained zero incidence.

An important practical finding was made around 1960. Results at South Dakota, Minnesota, and elsewhere showed that reserpine, a tranquilizing drug, could control the incidence of natural aortic rupture.

Investigators were happy to learn that *beta*-aminopropionitrile (BAPN) and diethylstilbestrol (DES) produce a malady similar to spontaneous aortic rupture in the turkey. BAPN was isolated from the flowering sweet pea as the cause of lathyrism (a bone disorder) in rats. DES is a synthetic compound with estrogenic activity. Minnesota research has utilized both of these compounds for arificial study of the problem. However, the differences between the experimentally induced and the natural occurrence left much to be desired in the study of the general problem.

Why the turkey?

Other than the turkey, man is the only species known to be affected by aortic rupture. The U. S. Public Health Service has been interested in the use of the turkey to study the problem and has supported our research program during the past 10 years.

It is believed that the turkey's susceptibility to aortic rupture is due to a combination of high blood pressure and weakness in certain of the aortas. A simple analogy is the automobile tire. Whether the tire blows out or not depends upon the strength of its weakest structural component and the amount of air pressure inside.

The turkey's blood pressure is high, averaging about 225 millimeters of mercury at 8 weeks of age. Blood pressure is increasing during this time, and by 20 weeks of age it may average 300 millimeters of mercury. There is a tremendous difference in blood pressure among individual turkeys; a flock averaging 300 millimeters of mercury may have some birds under 200 and others over 400.

Studies at the University of Wisconsin pointed out that some turkeys may have developmental or degenerative structural changes in their aortas. Fibrous thickenings called plaques appear in the interior layer of the aorta and have the effect of compressing and weakening the middle muscular layer. These changes have also been seen in Minnesota studies.

Blood pressure-aortic rupture studies

About 5 years ago we felt that the strain of turkey used might have some influence on the susceptibility to aortic rupture. The University of Minnesota Broad White turkey rarely had the problem, while certain commercial strains were involved more often. Therefore eggs were obtained from foundation stock of two commercial strains and hatched with eggs of the Minnesota strain.

There was a low incidence of mortality due to aortic rupture in all strains the first year. Both commercial strains had greater body weight gains and higher average blood pressures

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Turkey viscera with massive blood clots following death due to aortic rupture. Sex, age, nutrition, and heredity are considered contributing factors in development of this disorder.

than the Minnesota strain. The variation in blood pressure among birds from each source was so great that we decided to mate high-blood-pressure males and females and low-blood-pressure males and females within each strain to learn what would happen to progeny regarding blood pressure, aortic rupture, and body weights.

In the first generation, the high- and low-blood-pressure progenies in the three strains differed in blood pressure by 10 percent. Birds from high-blood-pressure parents experienced 8.7 percent, and those from low pressure parents had 2.0 percent mortality due to aortic rupture.

After three generations of selection, an average difference in blood pressure of 25 percent was obtained between the high and low lines. During the last two generations, 12 percent mortality occurred in high blood pressure lines, while only 2 percent occurred in the low blood pressure lines.

The research has demonstrated (1) that blood pressure is high and variable in the turkey, (2) that blood pressure may be altered by genetic selection, and (3) that incidence of aortic rupture is greater in birds selected for high blood pressure.

Future work on blood pressure stocks

The low and high blood pressure selections were made within three strains during the first three generations. We are now embarking on a selection program that will combine the high and low lines of the three strains into high, medium, and low lines of a new composite strain.

We plan to study performance characteristics such as growth rate, efficiency of feed utilization, egg production, fertility, and embryonic livability with the turkeys of high, medium, and low blood pressure. In addition to expected differential mortality due to aortic rupture, other morphological characteristics such as roundheart and leg and bone disorders will be observed closely.

As mentioned earlier, it has been difficult to study the natural aortic rupture syndrome due to its low incidence and sporadic occurrence. Our experience with the lines of high blood pressure indicates that a substantial and a fairly predictable incidence of aortic rupture may be attained. Thus it should now be possible to study nutritional, hormonal, pharmacological, and environmental effects on the incidence of aortic rupture without resorting to artificial stresses such as BAPN and DES.

Much remains to be learned regarding factors involved in the cause of aortic rupture. However, our work has already shown that one possible solution to the problem involves selective breeding to eliminate birds with dangerously high blood pressure.

Informed People Want the Best . . . .

Wood Floor Finishes For Homes

Robert D. Thompson

Few consumers know much about flooring finishes. Most have had no voice in the selection of the finishing system applied to the flooring of houses they build or buy. Clear finishing materials are complex chemical formulations which most consumers can not be expected to understand. In addition, the finishing job is usually subcontracted by the builder to an applicator or finishing company. You may ask: Why conduct consumer research on a matter which the consumer neither decides nor controls?

We went to the consumer with this research to find answers to the following three questions:

1. Are the finishing systems used for wood floors in Minnesota causing consumers to choose competitive flooring instead of hardwood flooring?

2. Would the consumer choose a quality finishing system after being informed of advantages and disadvantages of the several finishing systems available, and would he specify this finish to the contractors?

3. Would the consumer pay extra for higher quality finishes and if so, how much extra?

If most consumers could answer "yes" to these questions, then flooring manufacturers, through their associations, would be in a better position to promote quality finishing systems to the applicators and consumers. This would benefit consumers, and it would also benefit the hardwood lumber industry. Hardwood flooring lost about a third of its market between 1955 and 1963, and the need for this market is critical to the hardwood lumber industry, because much low-grade hardwood is used for flooring.

When I surveyed flooring applicators in the Minneapolis-St. Paul area recently, they admitted that finishing systems being used are inferior and result in consumer complaints and call-backs. Quality finishing systems are available, but the applicators thought they were either too new, too dangerous to apply, or too costly.

Polyurethene, a relatively new product with greatly improved wearing properties, can be dangerous to the health of the applicator when applied in a closed, heated house. It is also costly. Only one applicator in my survey was using this product.

Penetrating sealer is highly recommended by the flooring associations because it does not scratch, wears well, and any worn spots are easy to repair. But it must be applied in two coats with overnight drying after each coat; then it must be waxed. Because of all this time and labor, many applicators and builders consider it too costly.

The applicator is looking for fast-drying systems so he can lay the flooring one day, then sand and finish the next. This has resulted in the use by most applicators in this locality of one of two finishing systems:

1. Two coats of lacquer and a coat of paste wax. 2. A coat of gym floor finish (long-oil varnish) over a coat of lacquer (no wax).

Lacquer does not wear well and is easily permeated by liquids which stain the flooring underneath. These spots are unsightly and extremely difficult to remove. The gym floor finish is more durable, less permeable, dries overnight, and can be applied immediately over a first coat of lacquer. If waxing is omitted in the second system, either finish can be completed in one 8-hour day.

The Research Project

We next surveyed homeowners and potential homeowners by selecting respondents at random during the 1964 Annual Northwest Builders Show in the Minneapolis Auditorium. Questions were asked these consumers to determine the effect of finishing on their demand for hardwood flooring.

They were also asked to rate four 2-ft-by-4-ft clear oak flooring samples that had been prepared by a flooring applicator. The finishes on the samples were: .1 penetrating sealer, 2.

Robert D. Thompson is an assistant professor, School of Forestry.

Table 1. Consumer Ratings of Flooring Finishes
(1 is highest, 4 lowest)

Type of Finish	1st Rating Appearance Only	2nd Rating Advantages Revealed	3rd Rating Disadvantages Revealed
Penetrating Sealer	4	1	1
Polyurethene	3	2	2
Lacquer	1	4	3
Lacquer & Gym Floor Finish	2	3	4

polyurethene, 3. lacquer, 4. lacquer and gym floor finish. The polyurethene and gym floor finish were not waxed because this is the way they are finished by the applicators. Respondents rated the finishes three different times: first from appearance only, again after being told a few advantages of each, and finally after being told a few disadvantages.

The group interviewed consisted of 155 parties, a total of 198 persons; 114 were males and 84 females, varying in age from 18 to over 58 years; 125 were homeowners, 30 non-owners. They reported family incomes from $4,000 to over $25,000 per year.

Results

Only homeowners were asked questions relative to consumer satisfaction with hardwood flooring. Of this group, 86 were satisfied with their hardwood flooring, 18 had homes without hardwood flooring, and 19 were dissatisfied. Fourteen reasons were given for dissatisfaction having to do with finishing problems. All consumers were asked to rate the sample finishes; their choices are revealed in table 1. When they first saw the samples they preferred lacquer, but after being told the advantages their preference changed to penetrating sealer.

With 198 consumers rating, the majority ranked the finishes in the order shown above. Note how ratings changed as we gave these people additional information about the finishes. The final ranking by these people is the same as the ranking preferred by experts on floor finishes.

Some 121 parties stated that as a result of new insights obtained from us, they would insist on a particular type of flooring finish when they build. Thirty-one would not pay extra, but 113 would pay to get their choice of finishing system. Table 2 reveals the answers of the 144 who rated and the price they would pay to get their choice.

The contractor who finished the samples quoted the following prices per square foot, including sanding and finishing: penetrating sealer 20 cents, polyurethene 15 cents, lacquer and gym floor finish 12 cents, and lacquer 12 cents. Sanding alone is 8 cents per square foot, so the difference between the highest-cost and lowest-cost finishes for the average residence would be only $52.

Conclusions

The survey does indicate that finishing problems may be having an undesirable effect on the use of hardwood flooring. The competitive products for this market stress ease of maintenance for their products, with the implication that hardwood flooring is hard to maintain. The consumers generally like hardwood flooring and prefer quality finishes, which is brought out by the fact that they rated the finishes in the exact descending order of their cost. They also indicated they would be willing to pay extra to get the finish they wanted. No costs were given to the respondents, but over half would pay enough to get the best.

It appears that the flooring manufacturers and the associations should try to promote the use of better finishing systems; informing the consumer regarding quality and advising the applicators to use it could offer sizeable dividends. In my opinion, consumers who decide to use hardwood floors and the best finishes will get the most value and the greatest satisfaction.

Table 2. Amounts 144 consumers would pay extra for choice of flooring finish.*

If not given choice	Would not pay extra	Would pay extra up to $25	$50	$75	$100	$150 up	Total	Total
Would change builder	20	29	23	11	29	9	101	121
Might change builder	1	1	2	1	2	0	6	7
Would not change builder	10	2	2	2	0	0	6	16
Total	31	32	27	14	31	9	113	144

* 11 more persons listened but did not answer.

Silvertop, the Elusive Mystery

A. G. Peterson and Elymar V. Vea

When farmers in northern Minnesota began growing bluegrass for seed about 10 years ago, they learned about silvertop, a mysterious disease that caused bluegrass seed heads to dry up, lose their green color, and die before they could form seed. Although silvertop hit fewer than 3 or 4 percent of the seed heads in most fields, in certain other fields it destroyed as many as 80 percent. Growers were alarmed to learn that no one understood the cause of this disease nor how to control it.

We saw that something had to be done, and several years ago we began studies that at first only deepened the mystery. We thought that silvertop might be caused by the wheat stem maggot, which causes occasional white heads in wheat and timothy, so we dissected many silvertop-affected bluegrass stems. Not more than 1 or 2 percent showed injury typical of the wheat stem maggot. In most instances a small section of the grass stem inside of the leaf sheath and just above the top node was badly shrivelled. This injury to the inner stem caused the head to die and turn white. We could not imagine what might be causing the injury.

Dr. F. G. Holdaway, who was project leader at the time, employed one of our graduates, Dr. Karl Schurr, to work on the silvertop problem during the summer of 1962. Schurr did an excellent job of opening up the possibilities. He found that cutworms caused silvertop in some fields. These moth larvae cut off or partially severed the stems near the base of the plants. In a few other cases, silvertop was caused beetle boring in the stems, by the tiny by the wheat stem maggot, by a small larva of a moth, or by egg-laying punctures of a weevil.

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Schurr suspected that silvertop might also be caused by thrips, mealybugs, and a scutellerid bug. He and John Bean of the Department of Plant Pathology isolated a fungus, *Fusarium poa*, from many diseased plants, and this appeared to be another possible cause. Schurr also conducted tests with eight species of insects in field cages. Results were inconclusive. The cause of the most prevalent type of silvertop remained a mystery.

Insecticides Provide a Clue

In the meantime, we tested a number of different insecticides for control of silvertop. We selected insecticides which were effective against different groups of insects in the hope that by controlling some insects and not controlling others we might get some clues to the cause of the disease. DDT gave excellent control of silvertop, and we found a close correlation between the incidence of silvertop and numbers of thrips insects in our plots. Additional plant dissections revealed that thrips occurred frequently inside the leaf sheaths. At the beginning of this century both Osborn and Hinds had reported that thrips caused silvertop of bluegrass. Hinds said that a single thrips could cause the disease. We began to consider thrips a prime suspect.

During the next few years we continued our experiments with different insecticides, our studies with field cages, and periodic observations on many bluegrass fields. DDT reduced the incidence of silvertop in every experiment. We had found a control without knowing the cause.

Our work was hampered by a low incidence of silvertop. Many of our experimental fields had a disease incidence of less than 1 percent. Usually we found a close relationship between the numbers of thrips and the percentage of silvertop within our experiments, but some of the fields with the most thrips had little silvertop. Also, we could not find thrips in all of the silvertop plants. This bothered us. Furthermore, in cage experiments we repeatedly added up to 400 thrips per field cage (each cage covered a square foot) with no results. It was obvious that several different kinds of thrips were present. Perhaps we were working with the wrong species.

David Keith, who had been helping with the investigation, studied the cutworm which had been causing one type of silvertop. He correctly identified the species and worked out details of its life history and habits. But this cutworm was distributed only locally in the bluegrass fields and did not cause the most prevalent type of silvertop.

About this time we were fortunate in being able to employ a skilled taxonomist, Dr. Ke Chung Kim, for about 5 months to help us with some identifications. Kim worked for 2 months to identify the insects in a single collection made by taking 50 sweeps with an insect net in a bluegrass field. He found 125 different kinds of insects in this one collection. When he recognized 9 species of thrips from bluegrass, some of these had to be sent to Europe for positive identification. Later, Bruce Cutler, a graduate research assistant, continued with identifications and added to our collection of bluegrass insects.

Following Kim's work we tried additional experiments with single species and mixed populations of thrips. Still, we could not produce silvertop. Individual thrips confined on bluegrass stems in tiny cages of glass tubing produced no visible injury.

Then it occurred to us that the *Fusarium* fungus might provide the answer. Dr. R. D. Wilcoxson of the Department of Plant Pathology iso-

lated *Fusarium* from silvertop plants. Stems of healthy plants were inoculated with the *Fusarium* suspension. *Fusarium* cultures, alone and in combination with thrips, were placed on bluegrass in greenhouse cages. But none of these experiments produced any symptoms. When we sprayed a fungicide on some of our fields, the fungicide had no effect on the incidence of silvertop.

As the mystery deepened we came across various publications which reported that silvertop was caused by mealybugs, fruit flies, meadow plant bugs, and mites. None of these caused our most prevalent type of silvertop, however. When our coworkers in Agronomy and Soils reported silvertop more abundant following heavy applications of nitrogen fertilizer, it only added to the mystery. Silvertop was especially prevalent in clumps of grass at the sites of old cow droppings.

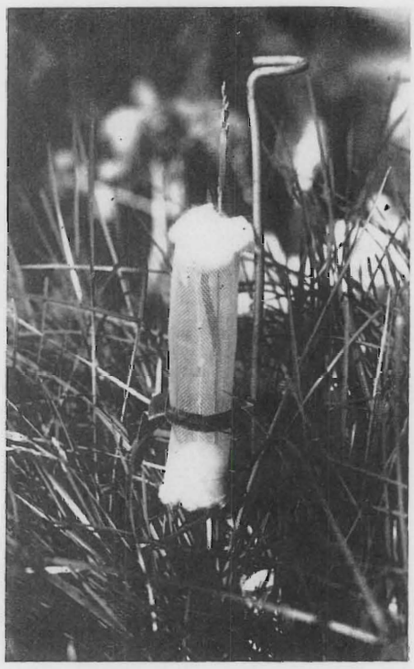
We continued cage experiments with different insects, insecticide trials, and periodic observations on commercial fields every year, but our progress seemed to be at a standstill. Finally, in late May, 1967, while making observations on Morris Hogglund's bluegrass fields near Monticello, we found an area where there was 100 percent silvertop. Heads were developing symptoms of silvertop as soon as they emerged from the boot. In this area black bugs of the genus *Capsus* were unusually abundant; we captured 30 to 70 per 20 sweeps of an insect net. As the season progressed, silvertop became prevalent in several fields in Roseau County. Capsus bugs occurred there, too — up to 50 per 100 sweeps of the net. We saw a direct relationship between numbers of bugs and incidence of silvertop.

Next, Canadian scientists reported that four species of plant bugs, including capsus adults, could cause silvertop. Further clues developed. Everett and George Helmstetter of Roosevelt, Minnesota, told us that silvertop seemed worse in bluegrass that followed spring wheat. Palmer Olson of Roseau observed that silvertop was prevalent in a small area of his field where wheat straw had been deposited by high water in the spring.

The Cause and the Remedy

We reasoned that insect eggs might overwinter in the straw of spring wheat, and so in September, 1967, we collected samples of wheat straw from Helmstetter's farm and from several other fields. We also collected flats of bluegrass sod from several locations. During February several capsus bugs hatched in the greenhouse from overwintering eggs in spring wheat, and others hatched from overwintering eggs in bluegrass.

Some seedheads of bluegrass die and whiten before they can form seed. That's silvertop.



Cages of this sort were used around single stems of grass.

We caged some of these capsus bugs individually for 24 hours on bluegrass stems. Within a week typical symptoms of silvertop developed! We tested several other species of plant bugs and leafhoppers that also hatched from overwintering eggs, but only grass exposed to capsus bugs developed silvertop.

Our main objective for the 1968 season was to obtain convincing evidence as to whether or not capsus bugs do cause the prevailing type of silvertop. We collected capsus bugs from Monticello and placed them on bluegrass in field cages at St. Paul. Two bugs per cage resulted in 28 of 34 heads developing silvertop; four bugs per cage caused silvertop in 70 of 76 heads. Capsus bugs from Monticello and Roosevelt, Minnesota, were used in two series of replicated cage studies at Roseau. Silvertop developed in 19 of the 20 test cages (see table). A single bug caused up to 42 silvertop heads.

Studies with individual capsus bugs in small cages proved that a single bug can cause silvertop by feeding for just one hour. Both adults and nymphs cause the disease. Each bug carefully selects a feeding site just above the top node and inserts its sucking mouth parts through the leaf sheath and into the inner stem. The sucking stylets penetrate the plant tissues quickly, and in 3 or 4 seconds the bug is ready to feed. As it feeds, it injects a toxic salivary secretion that causes the shrivelling of the inner stem. Each clump of silvertop heads, such as at the site of an old cow dropping, probably results from the feeding of one or a few bugs. The higher incidence of silvertop in thicker growth may result from better winter protection for the eggs or from the selection of heavier growth for egg laying.

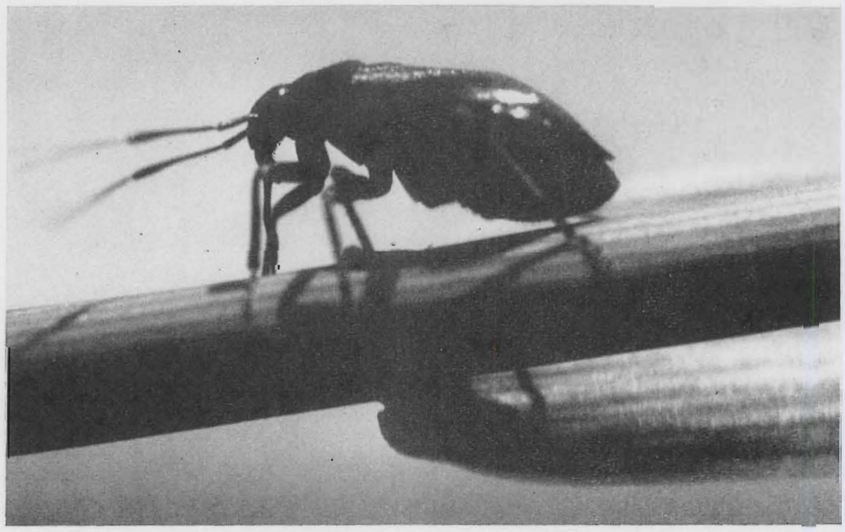
Very small populations of capsus bugs can cause considerable injury. We believe that it will pay to control them if they occur five or more per 100 sweeps of a 15-inch insect net. DDT may be used at 1 pound actual per acre, malathion at ¾ pound, or diazinon at ½ pound. Malathion or diazinon should be used, rather than DDT, on farms where there are beef or dairy animals. The insecticides should be applied just after the bluegrass heads emerge.

We express our gratitute to many farmers in Roseau and Lake of the Woods Counties for their splendid cooperation; to County Agents Norman Haugen and Otto Lee, to former County Agent William Provance, and to R. S. Rice and Frank Rykken of the Bluegrass Seed Producers Association for their continuous help; to Dr. E. F. Cook for assistance in identification of insects; and to Dr. L. J. Elling, Dept. of Agronomy, Dr. R. D. Wilcoxson, Dept. of Plant Pathology, and Drs. John Grava and R. S. Farnham, Dept. of Soil Science, for their suggestions and cooperation.

Incidence of silvertop resulting from confinement of capsus bugs on bluegrass in field cages near Roseau, Minnesota, 1968.

Capsus bugs per cage	No. silvertop heads/total heads			
Kveen field	Test. no. I	II	III	IV
1 Adult	8/35	3/14	15/21	12/12
4 Adults	26/26	13/14	6/21	11/11
1 Nymph	20/37	3/19	0/12	8/15
Control	0/24	0/20	0/13	0/13
Bjorkman field				
4 Adults	2/2	3/3	21/26	10/14
1 Nymph	42/47	29/29	9/15	20/41
Control	0/36	0/42	0/27	0/55

This bug, *Capsus*, causes silvertop in Minnesota bluegrass.



CONTROVERSY vs. CONSENSUS IN COMMUNITY NEWSPAPERS

G. A. Donohue C. N. Olien
P. J. Tichenor

Social issues in rural and urban America recently have focused new attention on the part played by newspapers and other mass media in fomenting and resolving public controversy. Editors and broadcasters must continually decide how — and whether — to report controversy in government, armed clashes between nations, confrontations between rival farm organizations, and disturbances in urban ghettos.

In making these decisions, editors of mass media are faced with potential praise as well as criticism from the public for nearly any course they follow. The press has been praised for advancing certain controversial causes and for helping cool tempers on other issues. It has been roundly criticized for needlessly stirring up controversies in some communities, and has been charged in others with failing to remind its readers of social injustices.

Ways of reporting conflict through mass media seem to pose a special problem in communities undergoing pronounced social change. Loss of population to larger cities, urban renewal projects, antipoverty legislation, farmer movements, and school mergers do not occur without some strains in the social fabric. Community citizens at various levels of public life and in different institutions have differing views on how community problems should be met. Debates develop, inside council chambers and outside. Viewpoints clash. Some controversies are settled quickly and others continue for months or years. Some are set aside, unresolved.

A historical tradition in journalism defines the community newspaper as a "watchdog" over government and special interest groups, protecting the interests of the average citizen. Such familiar names as "Sentinel," "Observer," "Guardian," and "Monitor" are often reminders of a frontier era when a first objective of the newspaper was to maintain an alert and wary guardian stance over an ever-encroaching government. A newspaper acting according to this view would quite naturally keep readers informed about conflicts between persons and interest groups in community government. They might also editorialize on these local issues.

On the other hand, there may be social forces pointing toward *avoiding* newspaper reports of local conflict, especially in smaller communities. In a town with a population of 1,500, for example, communication about local issues is relatively easy to handle on a face-to-face basis. The common saying that "everybody knows everybody's business in this town" might apply as well to *governmental* business. Compared with bigger cities, this smaller community has fewer organizations and arrangements for handling heated public disputes without disrupting social relationships. Disagreements about public affairs may be handled informally and, quite deliberately, kept out of papers.

News about controversy in local government was analyzed recently in a study of 88 nonmetropolitan community newspapers throughout Minnesota. Each community was a site of major governmental activity. All except three were county seats. The papers included 54 weeklies, 15 biweeklies and 19 dailies. Frequency of publication and newspaper circulation were both closely related to population of the town in which the paper is published. News about local government, controversial and noncontroversial, was studied for a one-month period.

Editors' views

Editors were asked, "What, in your opinion, are some of the main things your newspaper does for this community?" The replies, summarized in table 1, suggest that their overriding concern lies with providing information and news, with business and civic promotion holding strong second place. Only three of the 88 editors mentioned the "watchdog over government" idea and only two referred to community controversy as such. It seems, then, that these editors as a whole do not place a particularly high value on reporting debatable issues in government or other public life.

Weekly editors, especially, expressed the most pronounced views about the paper as a mechanism for maintaining social stability. The idea of developing a "community identity," or "mirror of the community" was mentioned by nearly a fourth of the weekly editors but by less than a tenth of the editors of larger papers. Similarly, weekly editors less frequently mentioned opinion leadership, education, and interest arousal as

Table 1. Editors' views of "some of the main things the newspaper does for this community."

	Weeklies N = 54 Percent	Bi-weeklies & Dailes N = 34 Percent
Provides opinion leadership, education	26	44
Provides news, information	76	68
Business and Civic Promotion	50	53
Development of community identity (self-image, "mirror of community")	24	9
Advertising	26	18
Interest Arousal	11	26

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things their papers do. Also, editors of larger papers more frequently said, in answer to another question, that local government reorganization was an appropriate topic for their own editorial pages.

Local government controversy news

All 88 papers reported something about local government during the month studied, but they differed sharply in reporting of government *conflict*, which meant opposed points of view from at least two persons, agencies, or interest groups in the community. Among the papers published daily, more than four-fifths carried at least one news article about conflict in local government during the month studied. That compares with two-fifths of the weeklies. Readers of larger papers, then, had at least twice the opportunity to learn about local controversial issues through news columns, compared with readers of smaller papers.

Table 2. Reporting of conflict in local government, according to type of newspaper.

	Percent of papers reporting conflict in local gov't.
Weeklies	41%
Bi-weeklies	47%
Dailies	80%

Does this image of serenity in small town weeklies indicate a scarcity of public conflict, or do papers actually "play down" conflict? Both factors may be involved. Local government in smaller, more rural communities generally tends to be more passive, with issues frequently settled informally before they arise in formal county board or city council meetings. Larger communities tend to have more purposive and aggressive governmental bodies and agencies which, as a matter of course, air debates in public sessions. Furthermore, it seems reasonable to assume that smaller papers may more frequently *avoid* reporting the disruptive side of local government and community life. Instead, they are more inclined to present an image of local consensus in a way geared to maintaining the basic, existing structure of the community.

Editor's power and conflict reporting

Editing a newspaper might or might not mean being influential in a community, but the Minnesota study does suggest that editors who are in the local power structure may regard community conflict in different ways. However, how an editor translates his own influentiality into conflict reporting seems to depend, again, upon the size of his newspaper and the size of the community.

In this study, the editor and the extension agent in each community were asked to name local persons who should be named to government planning and reorganization commissions. The editor was regarded as a member of the local power structure if he was named by either the agent or himself. Exactly half of the editors (44) were identified as members of the local power structure, according to this measure.

Table 3 shows that both power structure status *and* type of newspaper are related to reporting of local governmental conflict. *However, power status seems to have opposite consequences for the two groups of papers.* That is, power status seems to work *against* reporting conflict among weekly editors, and *for* conflict reporting among editors of larger papers. Considering all editors with power status, there is a sharp difference in conflict reporting between weekly and larger papers (32 vs. 73 percent). Among editors without power status, the difference between smaller and larger papers is negligible (48 vs. 53 percent).

Table 3. Reporting of conflict according to type of newspaper and whether the editor is in the community power structure

	Percent of editors whose papers reported conflict
Weekly editors, In Power Structure	32%
Weekly editors, Not in Power Structure	48%
Bi-weeklies & Dailies, In Power Structure	73%
Bi-weeklies & Dailies, Not in Power Structure	53%

These findings seem consistent with the different functions editors say they are performing. A weekly editor quite reasonably might act more in accordance with the news, civic, and promotional functions if he is in the power structure and therefore knows more about the social makeup of his community. A daily editor with power status, on the other hand, might be more familiar with the issues which, in his type of community, need to be reported so that all interest groups can keep informed.

Assuming that patterns found here are representative of most community press performance in Minnesota, the findings neither condemn nor condone that performance. Instead, they help both editors and community leaders understand better how the press serves communities of different types. Weekly editors, perhaps, not only have different functions than their larger-town colleagues, but may be the first to recognize the differences. It might be argued that the small community press in Minnesota is missing an opportunity to encourage public discussion about major issues in the very places where the winds of change are blowing the strongest. But it should be added that community studies around the nation have indicated that the pattern of non-controversial reporting in weeklies found in this study is widespread, and it is also one which community leaders in general support. A frequent view expressed by the small community power structure is that major community decisions should be reported only after they are made.

Nevertheless, a common assumption of American government is that open public debate helps nourish a healthy, stable, and dynamic democratic process. Where the mass media do not stimulate that debate — because of lack of resources, independent decision of the editor, or community pressure — the community may need to seek other mechanisms for initiating, legitimizing, and defining new forms of action for community progress.

Livestock Disease Research

D. K. Sorensen

Financial losses to the livestock and poultry industries from disease and parasites amount to 2.8 billions of dollars annually according to USDA estimates. Most of this loss has to be passed on to consumers. Or to put it another way, whenever research finds a way to eradicate or lessen a major disease of livestock, the savings are worth millions of dollars to consumers.

The billion-dollar livestock and poultry industries of Minnesota have had their share of these losses. The ravages of bovine tuberculosis, brucellosis, hog cholera, and pullorum disease in poultry stimulated active research projects early in the history of the Minnesota Agricultural Experiment Station. Three of these disease problems are still being actively investigated — brucellosis in cattle and swine, cholera in hogs, and Salmonella infections in poultry. Minnesota research on poultry disease was described in the fall 1968 issue of this magazine by Dr. Benjamin S. Pomeroy.

The basic philosophy of animal health programs in the U.S. is to work without compromise toward eradication of each disease. Target dates have been established for the total eradication of bovine tuberculosis, bovine brucellosis, hog cholera, and pullorum disease in Minnesota within the next decade.

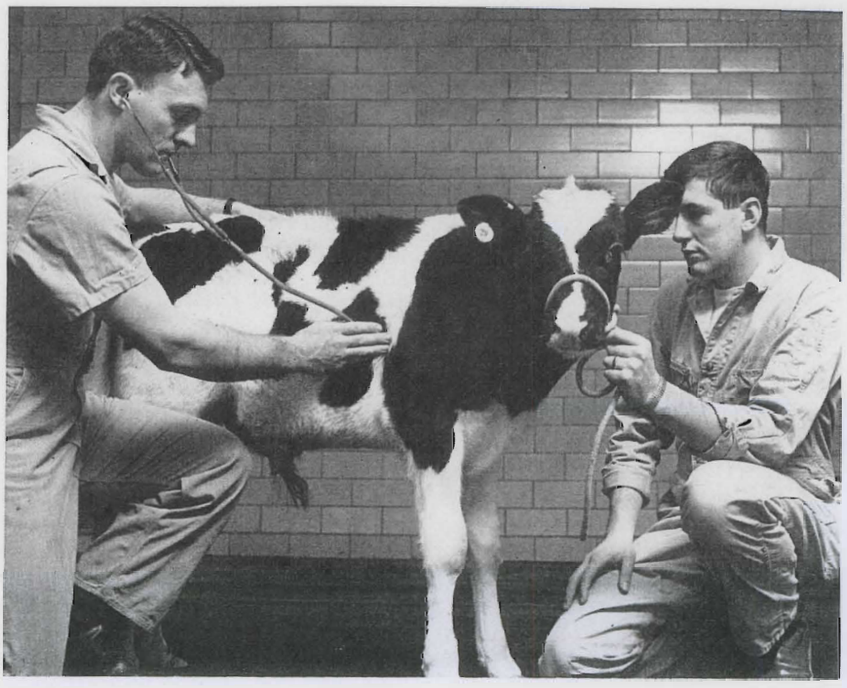
As these diseases are eliminated from our livestock and poultry, other problems take their place. Problems multiply as herds increase in size and live under more confined conditions. The research program in veterinary medicine has been greatly broadened here since the establishment of the University of Minnesota College of Veterinary Medicine. In our eight departments we now have approximately 50 active research projects financially supported by grants from the Minnesota Agricultural Experiment Station, the U. S. Department of Agriculture, the National Institutes of Health, and private industry.

Scientists in the College are conducting research on many livestock disease problems that cause serious economic loss. Research on the disease problems affecting our companion animals (horses, dogs, and cats) is also being done. A partial list of cattle diseases on which research has been conducted includes mastitis, shipping fever, congenital porphyria, vibriosis, infertility problems, brucellosis, ketosis, leukemia, bloat, calf diarrhea, polioencephalomalacia, trichloroethylene-extracted soybean oil meal toxicity, lead poisoning, engorgement toxemia, viral diarrhea-mucosal disease complex, and black leg.

Research on swine disease includes nearly all major diseases of swine, but a significant research effort was directed on hog cholera, edema disease, parakeratosis, colibacillosis, *Clostridium perfringens* type C enterotoxemia, salmonellosis, myoclonia congenita, nutritional anemia, swine dysentery, and swine brucellosis.

Disease problems of horses and dogs have not received as much attention, but research has been going on for these companion animals. For our canine friends, investigations on leptospirosis, hip dysplasia, dirofilariasis

The research that veterinary scientists carry out pays for itself many times over in savings to farmers and consumers.



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(heart worms), kidney diseases, and thallium poisoning are some examples of the diseases being researched.

The benefits to the livestock industry from these research results are immeasurable. Results from these investigations have contributed to the overall knowledge for each of these diseases. In some instances the research findings have had a major impact on the control of the disease. And in the end it is the consumer who benefits from all these advances.

The University of Minnesota has led in the development of diagnostic tests for brucellosis. Many of the serologic diagnostic tests used in the control and eradication of brucellosis were either developed or standarized here at the College of Veterinary Medicine and have assisted materially in the eradication program.

In the late 1940's and early 1950's a new disease threatened our livestock in Minnesota. Scientists here found that the cause of this disease was soybean oil meal that had been extracted with trichloroethylene. Research at Minnesota helped to explain the cause and mechanism of this toxicity and led to the prevention of the disease by use of another extraction process.

Lead poisoning is still a major cause of cattle deaths each year. Research at Minnesota has developed a rapid test for diagnosis and improved methods of treatment. This rapid test has enabled veterinarians to positively diagnose the disease earlier in an outbreak and thus has led to the prevention of additional cases and deaths of animals. Studies on improved methods of treatment have also resulted in a greater recovery rate of affected animals, thereby decreasing the economic loss from this disease. Again, the consumer benefits.

Bovine viral diarrhea currently is one of the major infectious diseases affecting beef and dairy cattle industries in Minnesota and the entire nation. Results of research studies have explained many of the basic mechanisms operating in this infection; and, based upon these findings, efforts are being directed toward improved methods of prevention and control.

Improved methods of laboratory diagnosis of bovine viral diarrhea have been developed at Minnesota. This has provided a means to positively confirm outbreaks in the state, to diagnose the disease earlier and more accurately, and thus to reduce economic loss. An effective vaccine is available for bovine viral diarrhea, so the important features for the successful control of this disease are accurate diagnosis and widespread use of the vaccine.

Infertility is becoming recognized as one of the major causes of economic loss in the cattle industry. Studies at the University of Minnesota College of Veterinary Medicine have done much to identify and to point out this major cause of economic loss. An investigation by Zemjanis and Wescott on infertility of cattle in East Polk, Pennington, and Red Lake counties in Minnesota provided a basis to accurately estimate the economic loss associated with infertility of dairy cattle in Minnesota. These investigators have reported that a conservative estimate of the annual loss due to infertility to the dairy industry of Minnesota exceeds 100 million dollars. Consumers will have to pay for that loss until research finds a way to eliminate it.

The College of Veterinary Medicine has a long history of research on swine diseases. In fact, we have been one of three leading universities in the Midwest in this research. Findings in these laboratories have contributed greatly to our knowledge on the diagnosis, treatment, and pathogenesis of hog cholera.

There have been many estimates on the costs of living with hog cholera on a national basis. The average estimate was 50 million dollars annually prior to the national hog cholera eradication program. In Minnesota in 1962, prior to the inauguration and participation in the national hog cholera eradication program, there were 214 herd outbreaks involving 23,815 pigs, of which 7,821 died. A conservative estimate of the economic loss to the Minnesota swine industry from hog cholera was $225,000 in 1962. Five years later in 1967, after Minnesota's participation in the hog cholera eradication program, our outbreaks of hog cholera were reduced to 48. The economic loss associated with hog cholera was estimated to be only $75,000 for 1967.

Scientists at Minnesota were the first to prove conclusively that vibrio organisms were the cause of swine dysentery. Parakeratosis was first reported and identified as a distinct clinical disease at Minnesota. Colibacillosis of newborn pigs has emerged as one of the principal diseases and causes of death of young pigs. Much of our knowledge on the pathogenesis of this disease is the result of research findings from Minnesota.

CROWNVETCH

R. G. Robinson

Farmers, would you like to sow a crop in your youth and harvest until you retire? Would you like a crop that sells for dollars per pound rather than the usual pennies per pound, and a crop that beautifies your farm and conserves the soil?

Suburbanites, would you like a beautiful plant that requires no mowing or hoeing and stops the washing of soil on that steep bank behind your garage?

Highway engineers, would you like a plant that ends mowing, soil washing, and maintenance problems on steep roadside banks?

Mining corporations, would you like a crop that produces beef rather than complaints on your abandoned strip-mine lands?

Nurserymen, would you like a crop that will bring over five hundred dollars per acre?

Crownvetch can do all these things for growers *in some parts of the United States;* but unfortunately, *research at the Agricultural Experiment Station at Rosemount reveals a less encouraging outlook for the prospective grower of crownvetch in Minnesota.*

What is Crownvetch?

Crownvetch is a perennial legume with viny stems that grow about 3 feet long. Its small purplish-pink to white flowers are arranged in clusters the size of a quarter. The unique advantage of crownvetch over most alfalfa varieties and most crop clovers is the spreading root growth which thickens thin stands with new shoots.

The plant is named from the vetch-like leaves and cluster of upright seed pods that resemble a crown. Botanically, it is not a vetch *(Vicia).* Instead it belongs to another genus and is named *Coronilla varia.*

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Adaptation

The soil fertility requirements of crownvetch are similar to those of alfalfa. It is not a wetland nor acid-soil crop; good drainage and a soil pH of 5.5 minimum (6 to 7.5 preferred) are essential. At Rosemount, plantings on slopes and level land have been satisfactory. Plantings on a south-facing slope were slightly better than those on a north-facing slope. The plant is reported to tolerate shade quite well.

Much of the success with crownvetch has been in Pennsylvania and areas where winters are milder than Minnesota's. It is hardy here but kills to the groundline, in contrast to alfalfa, the upper crown of which overwinters. So growth of crownvetch appears later in the spring, giving weeds time to establish ahead of it in April and May. Because of this, crownvetch for forage or seed production should not be sown on fields infested with thistles and other serious weeds.

Varieties

Penngift, the first variety of the crop, was released in 1954 by the Pennsylvania Agricultural Experiment Station. Dr. Fred Grau, former extension agronomist, found a strange "weed" on the Robert Gift farm. Mr. Gift said that the plant had appeared on the farm about 1905, after his father planted some alfalfa from Europe. The descendants of this "weed" are Penngift.

Chemung variety was released in 1961 by the USDA Soil Conservation Service. It originated from a composite of several seed collections grown for 15 to 20 years at the SCS Plant Materials Center, Big Flats, New York.

Emerald was released in 1961 by Iowa State University and the USDA Soil Conservation Service after 20 years of natural selection in Iowa. The original seed was collected in Russia in 1911.

Trials sown in 1963, 1964, and 1965 at Rosemount showed that Emerald and Chemung established stands more quickly than Penngift, due to their greater seedling vigor. On the other hand, greenhouse studies by the Minnesota Department of Highways and University of Minnesota Department of Horticultural Science indicated that roots and rhizomes of Penngift made more growth than those of the other varieties.

Winterhardiness of the three varieties was usually satisfactory, but Penngift was the least hardy. Penngift is earlier blooming and produces the most seed, but the other varieties produce more forage.

Stand Establishment

New plantings of crownvetch are made by setting plants or cuttings (crowns) in 2- x 2- or 3- x 3-foot spacings or by sowing seed.

At seed costs of 3 to 10 dollars per pound, minimum sowing rates are desired. Recommendations for broadcast seedings range from 5 to 20 pounds per acre. We use 10 pounds.

Germination of good crownvetch seed is lower than that of most crops and may average 50 percent plus 30 percent hard seed. Seedlots that have much hard seed should be scarified and tested again for germination before planting.

Thiram (Arasan) seed treatment increased emergence and seedling survival in tests by the Soil Conservation Service in Iowa.

Special inoculant for crownvetch seed can be obtained from inoculant manufacturers; inoculants for vetch, alfalfa, clovers, and other legumes are not effective on crownvetch. Some authorities recommend using skimmilk or syrup instead of water to moisten the seed when inoculating.

Slow germination, weak seedlings, slow growth, and weeds make stand establishment the greatest obstacle to success with crownvetch. Research at Rosemount using herbicides, companion crops, and mowing gave no sure method of obtaining a good stand. With few exceptions, stands obtained the first or second year by us and Minnesota growers would be unsatisfactory for any other crop. However satisfactory stands may develop in a few years if the site is adapted to crownvetch and not too weedy.

Late August sowings in oat stubble; with rye, oats, or field bromegrass; and alone winterkilled or were not able to compete with weeds in the spring. Germination in the spring from these August sowings was often good but weeds prevented successful establishment. Some Nebraska research suggests that September-October sowings may not have been successful because the inoculant bacteria winterkilled.

Broadcasting or drilling seed between corn, soybean, or sunflower rows after the last cultivation about July 1 usually failed because the seedlings did not develop sufficiently to overwinter. However the best establishment in our trials came from a July 2 sowing in corn 10 inches high.

Trials of late April and May sowings with several companion crops (oats, flax, annual ryegrass, annual bromegrass, yellow mustard, and rye) indicated that rye and yellow mustard were best although oats and flax were satisfactory. Spring-sown winter rye produces few heads but helps to control weeds.

We used a grain drill with partitioned box and placed the companion crop seed and crownvetch + ground corn mixture in alternate compartments so that the two crops were sown in alternate rows. The crownvetch + ground corn mixture was proportioned so that the proper grain drill setting for the larger-seeded companion crop also sowed the desired amount of crownvetch. A grass seed attachment can be used for broadcasting or for alternate row sowing without blending if the tubes from the grass seed box are inserted into the furrow openers. One-half inch or less is the best planting depth for crownvetch.

EPTC (Eptam) at 3 pounds per acre applied before planting and disked in gave much better stands of crownvetch than did companion crops, and usually good enough stands to allow seed harvest the year after planting. Both crownvetch and yellow mustard grown in alternate rows showed good tolerance to trifluralin (Treflan) in a 1967 trial at Rosemount. This promising companion crop-herbicide combination needs further research and does not have USDA approval.

Seed Production

Seed yields at Rosemount are shown in table 1. These high yields are from small plots with little harvesting loss and adequate bees for pollination. Minnesota growers on large fields, often with bee hives in the field, have harvested from zero to 150 pounds per acre.

Weeds are a major cause of abandoned seed crops. Another cause of seed crop failure is heavy vegetative growth between bloom and harvest when summer rainfall is high. Seed pods do not develop fully when buried in this abundant growth.

The major problem in seed harvest is uneven ripening and pod shattering. Green leaves and all stages of flower and seed maturity occur on the plants in August and September. The crop is usually windrowed to allow weeds and green plants to dry before combining. Defoliant sprays to kill the green leaves may eliminate the windrowing operation. Paraquat applied August 2 at Rosemount resulted in completely brown foliage by August 4.

Seed yields in 1966 from crownvetch sown in 1963 and in 1967 from crownvetch sown in 1965 at Rosemount

Variety	1966	1967
	pounds per acre	
Chemung	426	412
Emerald	540	258
Penngift	598	630
LSD (5%)	—	63

Other defoliants have also been reported effective.

The combined seed pods are usually piled in a shed and turned every day until they are dry enough to dehull. Crop dryers could probably be used. Dehulling is accomplished with seed dehullers or huller-scarifiers. A hammer mill can be used, but considerable seed breakage occurs.

Minnesota growers of Registered and Certified seed are listed in the Fall Seed Directory of the Minnesota Crop Improvement Association.

Forage Production

Although once considered poisonous, crownvetch is now used as a forage crop. Most research has shown it to be less palatable and less nutritious than alfalfa. The viny growth is difficult to mow, so its major feed use is as pasture. Bloating of cattle on crownvetch pasture has not been a problem.

Summary

Does crownvetch offer Minnesota something that the more easily and cheaply grown alfalfa, clovers, and grasses do not? Yes, a new ornamental plant and perhaps an erosion-preventing cover for steep banks. However, we do not know whether crownvetch will survive all winters under the exposed conditions on these banks. Furthermore, the slow start of this plant in the spring requires both the roots and the dead foliage from the previous year to prevent erosion from spring rains. Its major advantage over common legume crops is its ability to spread by root growth. Our first planting made in 1956, is still *slowly* spreading in a fence row.

For seed production, present high prices offer enticing returns, but a large acreage has been established for commercial production. Until more successful establishment methods are found, demand for seed may not increase enough to maintain adequate prices.

For forage, crownvetch does not offer any special characteristic or site adaptation not already available among the common legumes and grasses.

Production Ecology in Trout Streams

How good your fishing is in the future may depend on studies such as this one by University of Minnesota biologists.

Thomas F. Waters

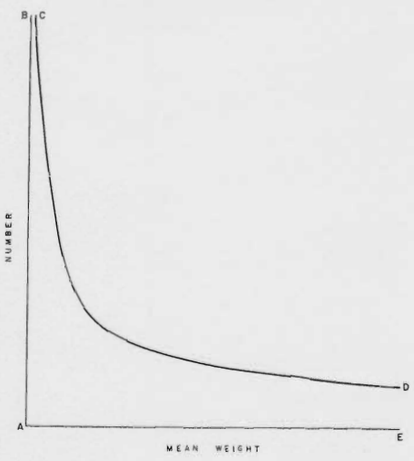
Somewhere on a northern Minnesota trout stream, an angler's fly line whispers through the cool air. The waters are bright, running fast and cold. With the thrill of expectancy, he anticipates the rush of a striking trout. The angler is a solitary sort — rarely telling his friends or family *exactly* where he's going — and does not wish an audience to his sport. For solitude is an essential element of this fragile natural resource; the trout stream surrenders quickly to any mistreatment by mobs, highway construction, pollution, poor grazing, logging, or cropping practices, insect treatment, or other "multiple uses;" it is not a resource for mass recreation.

The sport itself is centuries old, and equipment and techniques, as well as the angler's philosophy, have changed little since the middle ages. But beneath the water's surface, a complex organization of phenomena must take place, over several years and perhaps over acres of watershed and miles of stream, in order to produce the sudden, rattling explosion of a striking trout that the angler loves so well.

Good knowledge of *what* happens and *who* is doing it has only been gained in the last few decades. But often the question of why one trout stream can supply many more trout than another, with the same phenomena taking place in both, continues to baffle the student of trout stream ecology. Knowledge of the *rate* at which these phenomena take place — the dynamic character of the stream community — appears to hold the key. And this knowledge is just beginning to appear in only tantalizing amounts.

Gradually, students and managers of our natural resources are forsaking emphasis on lists of distribution and abundance of animals and plants, and they are becoming more interested in this dynamic character of natural ecosystems. Although considerably more difficult to measure, the *annual production* of the fish population, for example, is obviously of greater value to the fishery manager responsible for setting a harvest quota than is a list of species and numbers present at any given time. Growth rates, reproductive rates, mortality and survival, and food consumption rates, as well as production rates, and the environmental factors affecting them, are all part of the dynamic character of a population.

The growth-survivorship (or Allen) curve for measuring the production of a year-class of fish or aquatic invertebrates.



"Production ecology" is the quantitative study of such dynamic aspects. The student seeks not "What?" and "How many?", but "at what rate?" He is, in essence, attempting to determine and measure the various transformations of *energy*, commencing with sunlight as the source, through a population or community. The main goal is the rate of production of stored energy, and what happens to it, in the population concerned.

Of course, the rate of energy stored is not the sole concern of the resource manager. This is true particularly with a *recreational* resource — for cultural instead of economic factors frequently dominate management objectives. Our trout angler is not nearly so concerned

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Electrofishing measures fish populations.

with how many calories of radiant energy are represented on the business end of his fly line as he is with how well they strike and fight and, hopefully, grace the supper table. The manager, however, knows that that event is accomplished at the end of a longer line of energetic phenomena about which he would like to know more.

Fish Production Rate Measurement

Little more than 25 years ago, with the publication of Raymond E. Lindeman's classic expression of the production ecology concept formulated here at the University of Minnesota, the actual measurement of animal production rates in nature was considered almost impossible. A major breakthrough occurred five years later in the method developed independently by two fisheries biologists, William E. Ricker of Canada and K. Radway Allen of New Zealand. Simply, their mathematical model stated that production is growth rate multiplied by population biomass, in terms of pounds per acre per year. This is, of course, the *total* elaboration of fish flesh, irrespective of its fate or whether it survives to the end of the year — the true definition of production rate.

A few years after this, Allen, in his classic study of the brown trout population in New Zealand's Horokiwi Stream, presented a graphical modification of this method that increased greatly its application. In this method, the number of fish in a year class is plotted on the ordinate, while the mean individual weight of the fish is plotted on the abscissa. The result is nearly always close to an exponential curve in shape (Figure 1). The curve is most properly termed a growth-survivorship curve, or, popularly, an Allen curve.

The total production of the entire year class is equivalent to the area under the Allen curve (ABCDE in the figure). When the area under the curve is divided into annual increments, and the increments for the several year classes present in one year are added, the sum is the annual production. These methods — the mathematical model and the graphical modification — are now rather widely used in studying fish populations, particularly in trout streams where periodic population estimates can be made relatively easily by electrofishing.

The Fish's Food — Invertebrate Production Rates

Natural diets of stream trout are almost wholly made up of invertebrate animals -- usually aquatic insects — that are produced in the stream along its stony or gravel bottom. In season trout eat some dry-land insects that fall into the water, but this source is usually minor. The angler's dry fly, for example, most commonly imitates the adult stage of an aquatic insect, rather than a terrestrial form. Thus, a major question is how much stored energy in the form of aquatic invertebrates is being produced by the stream system in a period of time. This rate alone will set virtual upper limits to the rate of trout production.

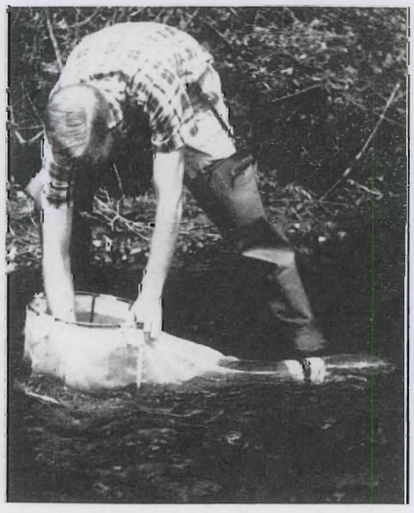
Ricker's and Allen's methods for fish production rates, being broadly applicable in theory, can be as validly applied to insects and other aquatic invertebrates. A major requirement in this method — growth rate — is difficult to obtain, however, unless the age of the animals can be determined accurately. This is relatively easy in fish (whose scales have annual rings), but is more difficult among invertebrates, and it presents a major limitation in application of the method to invertebrates.

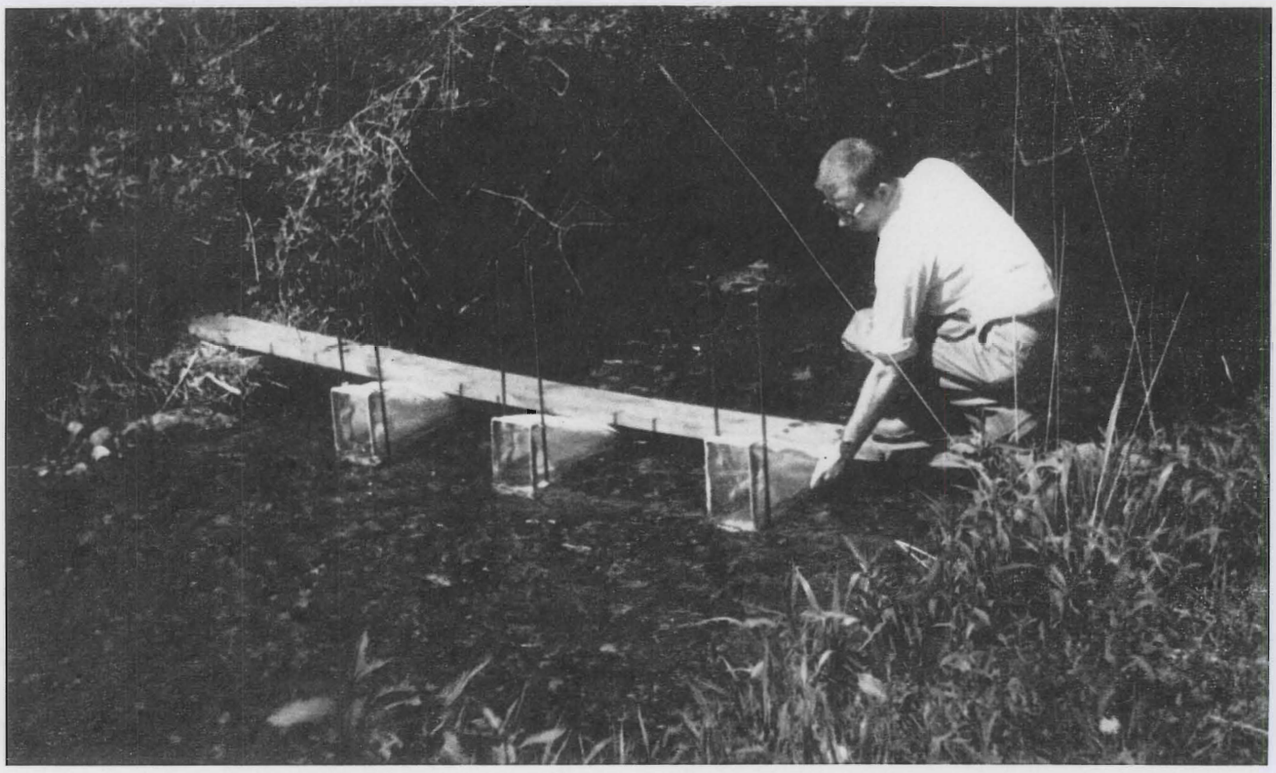
Studies of Mayflies and Shrimp

In the Department of Entomology, Fisheries, and Wildlife, certain studies in the fisheries research program have concentrated on the production ecology of a small, highly productive brook trout stream, Valley Creek. One aspect of these investigations was the estimation of the production rate for a single kind of stream mayfly, *Baetis vagans*, a species common in many trout streams and one that is often imitated by the angler's dry fly. This estimate included the application of Ricker's and Allen's methods, and it was the first such estimate of a stream invertebrate's production to be made, so new is this type of research.

The result was about 100 pounds of mayflies per acre, annually — a figure that includes tremendous numbers of organisms that, at their maximum size, each weigh only about 0.0002 ounce. *Baetis vagans*, however, is not the dominant member of the invertebrate

Samplers measure invertebrates on bottoms of streams.





Drift nets are used to study movements and behavior of aquatic invertebrates.

fauna, nor even an important item of the trout diet, in Valley Creek; that position is held by the freshwater shrimp, *Gammarus pseudolimnaeus*, a small crustacean so abundant in the stream that it constitutes nearly the entire diet of the brook trout.

On the basis of various comparisons with the mayfly *Baetis*, the freshwater shrimp production was calculated to be most likely about 20 to 40 times that of the mayfly — or on the order of 2,000 to 4,000 pounds per acre, annually. Other aspects of this research program indicate an annual brook trout production of about 150 to 200 pounds per acre per year. And considering that these fish require about 6 to 8 times their production in natural food, and considering that they will perhaps consume something like half the food produced, the above figures of 2,000 to 4,000 pounds of invertebrates (mostly the shrimp, *Gammarus*) produced per acre per year seems, although rough, in the right order of magnitude.

In comparison with other known production estimates, these data for shrimp appear high. One reason may be that streams appear to be one of the most productive types of ecosystems, perhaps because the current is available as a rapidly acting mechanism to supply nutrients or food and carry away wastes. Another undoubtedly is that Valley Creek is near the high end of the range of productivity, even among other streams.

The Plants — Primary Production

The next logical point of interest is the production rate of the next lower trophic level, the food of the invertebrates or the primary producers. In this type of stream, the main primary producers appear to be algae (mostly diatoms) attached to stones and a few rooted aquatic plants such as some of the mosses and watercress. However, from even our limited knowledge of primary production rates in streams, it does not seem likely that these could supply the energy at a rate sufficient for the high production of freshwater shrimp. Since these shrimp are primarily detritus feeders, consuming such materials as leaf fragments from the watershed, it seems certain that the invertebrate fauna in this case has as its primary energy source the terrestrial environment rather than the stream itself.

It is becoming more and more evident that many if not most streams fall into this category; the external source of primary production appears to be quantitatively of major importance. Obviously, the rate of supply of this food source is extremely difficult to measure; and, while several researchers are working on this problem, no data are yet available.

Productivity of Trout

It is barely possible at this time to classify trout streams on the basis of the level of fish production rates; the number of estimates available from various parts of the world can be counted on the fins of a brook trout.

At the top of the list in productivity is New Zealand's Horokiwi Stream, with a brown trout production rate of close to 500 pounds per acre per year, although some workers feel that this is somewhat of an overestimate. Next appear streams like Valley Creek with probably 200 pounds per acre per year in a good year. A few other streams in the western U. S. and Great Lakes area, rated as excellent trout fishing streams, run about 100. And a single estimate of a relatively infertile granitic mountain stream in England was slightly over 10 pounds per acre annually.

In Minnesota, we can probably expect the soft-water streams of the North Shore country to run about 10 to 25 pounds per acre per year, while the highly productive streams of the east and south-east will probably produce 50 to 100 and upwards, with some centrally located streams somewhere in between. Unfortunately, virtually no data have been obtained on the invertebrate or primary production rates in these streams at present.

Low production rates do not necessarily mean that a particular stream is of low quality; an isolated small creek, for example, may provide high quality angling for the few fishermen who visit it. There is often little relationship between biological productivity and the cultural values in trout fishing. But greater knowledge of production biology will certainly help us in attempts to use these high-quality resources most effectively — for example, to retain low-productivity, high-quality streams in a wilderness or primitive-classified area.

And of course, we are writing here about productivity in the natural stream. Interference by man, either inadvertently, or in deliberate management by stocking, habitat modification, and legal restriction, can change the situation — but that's another fish story.

The trout that finally took the fly of our Minnesota friend a while back probably *did* grace his supper table. Trout are good eating. And although the energy chain is thereby extended to yet another trophic level, we'll call a halt with the trout. The trout fisherman may be too difficult to locate.

Financial Statement

MINNESOTA AGRICULTURAL EXPERIMENT STATION

RESEARCH FUND EXPENDITURES

YEAR ENDED JUNE 30, 1968

Expenditures by Source

	Percent	Amount
Federal Funds	16.8	$1,331,172
State Appropriations	59.9	4,749,517
Gifts and Grants	14.4	1,143,647
Fees, Sales, Miscellaneous	8.9	709,894
Total	100.0	$7,934,230

Expenditures by Object Classification

	Percent	Amount
Personal Services	67.5	$5,356,383
Travel	1.7	136,765
Equipment, Lands, Structures	6.6	523,384
Supplies and Expense	24.2	1,917,698
Total	100.0	$7,934,230

Expenditures by Location

	Percent	Amount
University Campus-St. Paul	90.0	$7,138,263
Branch Stations-Within Minnesota	10.0	795,967
Total	100.0	$7,934,230

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