As human population expands, the earth’s deserts become more important. Scientists are becoming more concerned about how these deserts may become more productive from a human point of view without being destroyed in the process. One of the purposes of the International Biological Program is to evaluate whether disruptions of a desert ecosystem, such as conversion to conventional agriculture, modifications to enhance recreational appeal, or the introduction of housing developments is advisable in terms of long-range human welfare. The scientists are attempting to discover how the desert animals, plants, soil and climate interact to produce a smoothly functioning ecosystem. This total effort involves biologists from 55 nations. USU scientists are presently centering their research at Curlew Valley in Box Elder County. Using the systems-analysis approach, they are attempting to measure the ecological factors and their interactions, then translate these into equations that can be programmed into a computer. Once the information can be digested by the computers, mathematical models can be developed which can predict how certain contemplated changes will affect deserts over time. Certain animals, such as jackrabbits, will be used as indicators and thus receive special attention. Read more about the overall approach to desert ecology in “Deciphering a Desert” in this issue of Utah Science.

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UTAH SCIENCE

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CHEMICAL SPRAYS?

Reducing water use by trees

Trees are luxuriant users of water. When water is readily available, a mature tree can remove at least 100 gallons of water per day from the soil. Only a very small amount of this water, at most 5 percent, goes into sustaining the life processes of the tree; the remainder is returned to the atmosphere through transpiration. Transpiration is a process quite similar to perspiration in humans, in which water vapor moves into the atmosphere through microscopic pores (called stomata) on leaves.

THE PROBLEM

For many years, managers of forested watersheds have been concerned with the excessive use of water by forest vegetation and have been seeking ways to alter forests to reduce transpirational loss of water. One obvious means is to remove part or all of the transpiring surfaces by cutting the forest. It has been amply demonstrated that clearcutting forests results in increases of annual water yields equivalent to 4 to 17 inches of rainfall. The size of increase apparently depends on the amount of summertime rainfall, the capacity of the soil to store water, and upon the local climate. The rainfall, soils, and climate in Utah suggest that the magnitude of water increases from forest clearcuts might be toward the lower end of the values given above—4 inches per year or roughly 116,000 gallons per acre.

Because of the high erosion hazard, the unpleasant aesthetics of clearcuts, and the non-commercial value of much of our timberlands, harvesting of timber may not be a feasible means to increase water yields in Intermountain forests. An alternative method of reducing transpiration might be to use chemical sprays to temporarily close stomates and thus reduce water losses. Such sprays could be economically applied by aircraft, the timing of application could be coordinated with short-range forecasts of drought, and the aesthetic and protective roles of an intact forest canopy would be preserved.

CHEMICAL SPRAYS

Several chemicals retard transpirational loss of water by causing the guard cells surrounding the stomatal opening to partially close. This restricts the outward movement of water vapor from the leaf. Such chemicals as phenylmercuric acetate (PMA) and decenyllsuccinic acid have been found to be effective antitranspirants for some field crops under greenhouse conditions. But, to date, only a few studies have been made of the effect of antitranspirant chemicals on water use of trees in the natural forest environment. One such study using phenylmercuric acetate spray on quaking aspen (Populus tremuloides Michx.) is nearing completion by the College of Natural Resources at Utah State, with the support of the Office of Water Resources Research.

ASPEN TEST

The study was done in a stand of aspen at 7,800 feet elevation in northeastern Utah. Two 1/2-acre plots in the stand were chosen and a trench was installed around each plot to minimize water movement by roots between plots. Soil moisture was measured at 12 points in each plot to a depth of 6 feet throughout the summer before treatment. In mid-June of 1967 and again in 1968, a water-base solution of phenylmercuric acetate, 0.01 molar concentra-

Figure 1. Soil moisture was measured with a neutron scattering instrument.

GEORGE E. HART is an Associate Professor in the Forest Science Department, Utah State University, Logan, Utah.
tion, was applied by helicopter at 400 gallons per acre to one plot.

It was important to know whether the agitation of the leaves and the downwash from the helicopter blades caused delivery of the spray to the undersides of leaves where aspen stomates are located. Florescent dye was added to the spray and examination after spraying revealed numerous dye-marks on the undersides of the leaves.

The PMA spray produced a partial closure of the stomates, even though a very dilute concentration was used. Stomate dimensions on treated and untreated trees were compared by using microscopic sections. A maximum reduction of about 40 percent in width was found on those leaves which received PMA spray. The effect of this chemical lasted about 5 weeks at diminishing rates.

A second test of the effectiveness of PMA as an antitranspirant was made by studying the rate of upward water movement. Water movement was estimated by timing the passage of a heat pulse which was introduced into the water-conducting tissue by hypodermic needles. We found quite a bit of variation between the six treated and six control trees in sap velocities, depending on the crown size, exposure to sun, and time of the year. But the overall averages of the daytime readings show a reduction of about 50 percent in those trees which were sprayed.

Another method of evaluating the effects of antitranspirant sprays is to compare the seasonal loss of soil moisture before and after treatment. The losses in soil moisture for each plot are given in Table 1.

TEST RESULTS

The differences between plots are quite small; and, because of the naturally great variation in soil moisture from point to point, we cannot conclude that spraying produced a sta-
Table 1. Soil moisture depletion in 6-foot profile, in inches

<table>
<thead>
<tr>
<th>Treatment year</th>
<th>Control plot</th>
<th>Sprayed plot</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966 (year before treatment)</td>
<td>9.6</td>
<td>10.6</td>
<td>1.0</td>
</tr>
<tr>
<td>1967 (June 28 through Sept. 20)</td>
<td>8.6</td>
<td>9.0</td>
<td>0.4</td>
</tr>
<tr>
<td>1968 (June 13 through Aug. 8)</td>
<td>3.1</td>
<td>3.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Figure 4. Water movement was estimated by timing the passage of a heat pulse which was introduced into the water-conducting tissues of the aspen trees by hypodermic needles.

We do observe that in 1966, without treatment, that the plot which was to receive the antitranspirant lost 1.0 inch more of soil moisture than the control plot. In 1967 and 1968, years when one plot was sprayed, the difference dropped to 0.4 and 0.3 inch. This suggests that a rather small savings, about $\frac{1}{2}$ inch, resulted from spraying.

Mercuric compounds, such as PMA, can have a toxic effect on plants and animals at high concentrations. When used at 0.001 molar concentration, we found no reduction in the production of total carbohydrates and no visible impairment of the aspen foliage. Water quality was sampled in a stream about 100 yards from the study area, and no mercury compounds were detected at a sensitivity of 0.05 parts per billion.

This study suggests that small reductions in water transpired by aspen can be obtained with a helicopter application of phenylmercuric acetate at low concentrations. This opinion is based, primarily, upon, measured differences in stomatal closure and in slightly reduced rates of sap movement. Because of the inherently great variation in soil moisture, we cannot state with certainty how much of a savings in soil water this treatment might produce.

Although we received some promising results with antitranspirant sprays in a small field test, it is not likely that this technique could be justified as a management practice to increase water yields under today's demand for water. The increased efficiency of higher concentration of sprays and the delivery of a finer mist and more complete saturation of the leaves must be examined both biologically and economically before this approach to water savings becomes a practice.
So you sometimes think you have problems! At least you can move into the shade if it becomes too hot in the sun. You can get a drink of water when you want it. And you can even decide to try a new state if you don’t like where you are.

Plants, from trees to lichens, aren’t so fortunate. Their problems all have to be solved on the spot. A plant either survives where it is, or it dies. And when “where it is” is in the desert or at high altitudes, a completed life cycle has to be a series of triumphs. Buttercups that germinate, grow, and blossom in the snow—desert plants that go from germination to seed production in a few days — these are among the extremes.

But most of us wouldn’t have to travel out of our back yards to find plants that show amazing ingenuity in solving growth and reproduction survival problems. A botanist at Utah State University, Dr. Ivan Palmblad, and his graduate students are studying some of Utah’s common plants. So far, they’ve been concentrating on the ecology of seed production. They have surveyed 105 species of plants in the state and have identified 15 that nature seems to have favored in a special way.

Curlyleaf dock is one of these 15, which have been blessed with germination polymorphism. This simply means that the members of this group are not bound to a single pattern of germination. Cheatgrass and pigweed come into the same category, which helps account for their persistence.

The germination versatility of these plants depends upon their producing two kinds of seed. One type

Figure 1. Some buttercups can germinate, grow, and blossom in the snow.

Figure 2. Curlyleaf dock produces two types of seed — quick and delayed germination. The latter type sometimes stays in the soil for years before deciding to grow.
will germinate all at once, just as soon as it has the temperature, moisture, and light conditions that it wants. The other will germinate only after considerable time (years, usually) has elapsed.

Occasionally one plant produces both kinds of seed, which can rarely be told apart by looking at them. A given population (several individual plants in a certain area) may produce one or the other seed, or it may produce both within a single season.

For example, a population of curlyleaf dock around Franklin, Idaho, regularly produces both quick- and delayed-germinating seed. The delayed-action seed helps a field, however, produces only seed once it wants. The other will flower, sego lily, tall larkspur, and desert parsley follow. After considerable time (years, usually) has elapsed, individual plants in a certain area) may produce two kinds of seed, which can rarely be told apart by looking at them.

A given population (several individual plants in a certain area) may produce one or the other seed, or it may produce both within a single season.

Some plant species that do not produce two kinds of seeds compensate by putting forth tremendous numbers of the non-delayed type. Of the plants examined by Dr. Palmblad and his students, yellow allysum, mullien, and foxglove follow this route. Others, such as the sunflower, sego lily, tall larkspur, and desert parsley, also produce only one kind of seed. But their seeds are designed to survive adverse conditions and not to germinate until the environment is highly favorable.

Plants have been denied the mobility of animals, but ecologists are continually amazed by the diverse ways they use to cope with their exceedingly complex worlds.

Pesticides — the changing scene

JOSEPH C. STREET

In 1939 the Swiss scientist (later Nobel laureate), Paul Muller, discovered the insecticidal properties of DDT. In the following several years, this remarkable chemical underwent unprecedented exploitation as an insecticide because of its unusual combination of properties: wide scope of effectiveness, inexpensive manufacture, prolonged stability to the action of light and air which results in long-time residual activity, and relatively low mammalian toxicity. In reviewing the medical and agricultural uses of DDT, S. W. Simmonds in 1959 wrote:

The total value of DDT to mankind is inestimable . . . Except for the antibiotics, it is doubtful that any material has been found which protects more people against more diseases over a larger area than does DDT. Most peoples of the globe have received some measure of benefit from this compound, either directly by protection from infectious diseases and pestiferous insects, or indirectly by better nutrition, cleaner food, and increased disease resistance. Irrespective of future developments, the discovery of DDT will always remain an historic event in the fields of public health and agriculture.

Simmonds, in his conclusion, may have been even more prophetic than he anticipated since the current scene finds DDT, and the other chlorinated hydrocarbon insecticides that were developed on the basis of DDT's success, under attack and on trial as the most insidiously damaging of any of the host of chemicals cited as contaminating the environment. The reactions range from restrictions in various dairying areas to protect milk marketing (e.g., Arizona), to proposed statewide bans such as that being considered by the Wisconsin Natural Resources Department. The U.S. Food and Drug Administration has recently reduced tolerances for DDT in raw agricultural commodities, and the Department of Agriculture has cancelled many registrations for chlorinated hydrocarbon insecticide uses as well as reducing its recommendations for their use.

In the face of such trends and events, what is the future for these pesticides in agriculture? Is there any likelihood that pesticide usage generally will be modified? The answers can possibly be anticipated through an examination of the current challenges to the use of chlorinated pesticides and a consideration of the alternatives to their use in agriculture.

ENVIRONMENTAL QUALITY

DDT and the other chlorinated hydrocarbon insecticides are produced in large, though unknown, quantities throughout the world. The U.S. production has been roughly 270 million pounds yearly for the principal types (DDT plus the aldrin-dieldrin group) during the past 5 years. The application of these in the U.S. as estimated by disappearance from the market is about half the production. Although recent evidence indicates that the use of DDT itself has declined markedly, the overall use of chlorinated hydrocarbon insecticides has not changed greatly.

PROTECT your WATER, SOIL, and AIR — our basic natural resources — from accidental contamination by pesticides or other chemicals on the farm, in the forest, or in the city.

SEPTEMBER 1969
Application of the combined group continues to exceed that of all other classes of insecticides taken together.

Their popularity warrants special concern because many of the common chlorinated hydrocarbon insecticides are sufficiently stable to persist in the environment for several months or more. This could result in the carry-over from one crop year to the next of previously applied, but not yet completely degraded, persistent residues. A steady accumulation of residues in the environment thus seems a possibility with the continuing use of such pesticides. Such accumulation is feared by many, although the trend of residue levels in the environment is not known.

The consequences of a prolonged accumulation could be serious since plants do take up some residues from soil and water and pass these on, in turn, to animals consuming the plants. In this manner, foods and animal feeds can and have become contaminated with chlorinated insecticide residues. To date, such contamination has been generally minimal. It has, however, sometimes reached levels detectable in raw agricultural commodities, occasionally exceeding legal tolerances for the residues involved. Some examples are endrin in both carrots and soybeans, and aldrin (dieldrin) in potatoes grown in soils previously treated with those insecticides, and heptachlor epoxide in milk from cows that were fed alfalfa hay produced on land previously treated with heptachlor.

THE CUMULATIVE EFFECT IN ANIMALS

Though their accumulation in soils or water generates problems, the residues of these persistent pesticides have even more serious implications because they are also accumulated by plants and animals, and are magnified in concentration by organisms in food chains. The chemical and physical nature of these pesticides is such that they are readily absorbed but slowly metabolized (degraded) by organisms. Any excess over what can be degraded and excreted is stored in body fat.

Biomagnification of the pesticide residue concentration occurs as organisms at each level of a food chain consume lower members in quantities far exceeding their own biomass. In other words, each organism in the food chain ingests and burns up large amounts of food, with some of the pesticide residues in that food resisting degradation. These residues then concentrate in the lipids (fat) of the higher organism. The process repeats itself as that organism becomes food for a still higher organism, and so on. By this process animals near the top of food chains can develop substantial pesticide concentrations in their body fat; concentrations sufficient to poison the animal if the body fat reserve is suddenly required. Many migrating birds, for example, utilize most of their body fat reserves during migratory flights, and some occasionally appear to develop pesticide intoxication and die.

This biomagnification process occurs in humans as well as wildlife. The human population, however, en-
joins an important distinction from other animals—the pesticide residue levels in its food supply are legally regulated and carefully controlled. Consequently, the pesticide accumulation in human fat is kept within low levels not considered harmful.

REPRODUCTIVE DISORDERS

Effects of accumulated residues on wildlife reproduction are of special concern, since reasonable evidence from a few species indicates that these effects may occur with residue levels much lower than those producing death. Exposure of susceptible species to even relatively low levels of certain pesticide residues (notably DDE) may cause changes in biochemistry, physiology, or behavior that can be deleterious to the population as a whole, though less than lethal to the individual animal. Impaired bird reproduction by an induced thinning of egg shells and poor survival of newly hatched fish are cases in point.

Only a few cases of seriously threatened species in wildlife populations can be clearly attributed to persistent pesticide residues. Nevertheless, these cases are viewed by many as clear warnings that other species are probably endangered and that continued widespread use of such persistent chemicals might jeopardize much of the world’s animal and plant life.

RESIDUE PROBLEMS IN FOODS AND ANIMAL FEEDS

For those in agriculture the greatest problem with persistent pesticides has been in meeting the tolerance allowances for residues in raw agricultural commodities. Ironically, however, the problem has not primarily affected those who use the pesticides as a direct aid in crop production (the FDA surveys find only about 1.5 percent of crop samples with residues exceeding tolerance). Rather, it has been of most concern to farmers who must operate in areas of mixed, intensive agriculture whose crops and animals are thus exposed to indirect contamination. The dairymen, in particular, has been a frequent victim and, in some cases, has found it necessary to demand a legal restriction of certain pesticide uses in localized dairying areas. Indirect contamination has not been a serious problem to other livestock production.

As it concerns human health, contamination of foods by pesticide residues is not presently viewed as a serious problem. It should be emphasized, however, that this is the direct result of the many state and federal research, regulatory, and residue monitoring activities designed to protect the public health. While the wholesomeness of our foods is guarded by these activities, they do represent costly burdens to support as a price for use of pesticides.

A MURKY CRYSTAL BALL

Scientists generally agree that insecticides and other pesticides will continue to be used to meet most of our insect and other pest problems of the foreseeable future. The great demand for economical production of food and fiber makes pesticides essential and, on a world basis, increased use is anticipated.

Eventually, though, the DDT “family” of insecticides may promote their own disappearance from the scene. Their popularity has depended upon their unique capabilities and their low cost. But as they became more common, they also became less effective at safe levels of application. The intended victims were developing resistance. And since the insects that could survive the chemicals were the ones who reproduced — each year saw larger populations of more resistant insects. That, in turn, encouraged the use of ever greater quantities of insecticides.

Now knowledge of their effects in the general environment, however, makes such prodigal applications thoroughly undesirable. It seems clear that use of the persistent chlorinated hydrocarbon insecticides should be reduced as much as possible. But since control of some pests is best provided by highly persistent pesticides—one example is the protection of wood structures placed in the ground — they should remain available for such selective purposes.

Equipment for and methods of applying pesticides can probably be markedly improved. Such developments would promote more accurate placements of the chemicals, with less waste and smaller amounts being discharged into the general environment.

Efforts to develop selective, non-persistent pesticides will continue, probably on an increased scale. However, unless rather strong moves are instigated to replace or reduce usage of the persistent chlorinated hydrocarbon pesticides, newly developed products may appear only slowly in agriculture. The persistent pesticides are popular and used in large quantities because they are low in cost and, for many purposes, highly effective and relatively safe. Alternative materials will be used freely only if they are equally effective at equal or less cost. Programs to develop substitutes thus seem economically unsound while the present materials are available.

Besides, replacement pesticides can be expected to introduce their own peculiar hazards. For example, most now-available substitutes for the chlorinated hydrocarbon insecticides are considerably more toxic and present sharply increased hazards to the applicators and others who must handle them.

Biological (or non-chemical) control of pests is frequently advanced as the ultimate and ideal approach. Several recent spectacular successes, such as near eradication of the screw worn in some areas by the sterile male technique, give hope that other important advances can be made. Some of the most enthusiastic advocates of biological control techniques still admit, however, that...
Figure 2. When food chains involve pesticides such as DDT as well as food, problems can result at any or all levels. Few chains of consumers are as clearly direct as that illustrated. But certain principles hold true regardless of complexity. As living material is transferred from one link to another, the widely spread pesticides that are carried along become increasingly concentrated (represented by the dots) at the higher levels. The larger the predator, the more he must eat. More food can equal more pesticide. And since DDT-type pesticides are metabolized slowly, the larger animals can eventually store impressive amounts in their body fat. When man is the last consumer in a chain, his cooking or processing procedures sometimes modify the amounts of pesticides that he actually eats. It should be realized that some of the pesticide is lost by degradation and excretion from each of the organisms in the chain.

effective chemicals will remain the mainstay of most pest control programs for the foreseeable future.

It now appears that the most effective, safe, and environmentally conscious programs of the future can be expected to consist of integrated biological and chemical aspects. But, the period of rather casual use of chemical pesticides, particularly the insecticides, is undeniably drawing to a close. The immediate future will probably find increasing emphasis on more selective use of all pesticides, along with stricter regulatory procedures to guarantee that uses are properly selective. Persistent chemicals like DDT will be tolerated only in much smaller amounts than at present, and their approved uses will be greatly restricted.

BEYOND NATIONAL BORDERS

The regulatory system for pesticides in agriculture in this country has successfully protected public health. That same system, however, is not adequate to safeguard the quality of our total environment, which is a considerably more complex problem. Because pesticides and other potentially polluting chemicals are produced and used in all parts of the world, environmental protection must be sought on a worldwide basis. This need is reinforced by recent findings that DDT is transported in the atmosphere for vast distances. It seems entirely possible that other, similarly persistent, compounds may be likewise transported from continent to continent.

Environmental scientists need to obtain much more information before any of the polluting chemicals can be put into a true perspective relative to their potential for damaging the environment. However, the experience with pesticides has clearly shown that attention to environmental quality is an important part of the overall evaluation of any new technology.
A WATER STORAGE STRUCTURE
FOR SMALL SYSTEMS

A. R. DEDRICK and C. W. LAURITZEN

Water storage is one of the most important segments of any water system. This is true, whether it be for a large irrigation project, power production, or culinary water systems. The size and design of storage facilities are governed by operational requirements, and methods and equipment developed for one purpose may be useful in other applications.

RAINTRAP ADAPTABILITY

At Logan, Utah, emphasis has been on the development of a system for providing livestock drinking water on rangelands as an integral part of range management (1, 2, 3, 4). This system, referred to as a raintrap, consists of a catchment area and a reservoir for storing trapped water. Several materials such as Butyl rubber, fiber glass, and galvanized steel, have been investigated for use as both the catchment apron and storage reservoir. The most recent development has been a storage reservoir made from a steel grain bin fitted with a plastic membrane liner to make it watertight. Although developed for a livestock range application, the storage reservoir is easily adaptable to other uses.

The site of the new football stadium at Utah State University had a spring area which required drainage. Since the flow from the drain was considerable—approximately \( \frac{1}{2} \) cubic foot per second—it was decided to collect the water and use it for irrigating the grass and shrubbery in the stadium area.

The use schedule of the stadium area made it necessary to store the drain water for convenient timing of application. A reinforced concrete-lined reservoir was first considered, but cost comparisons showed that a steel grain bin with a plastic liner would be more economical. Size

---

1 Numbers in parentheses refer to Literature Cited.

A. R. DEDRICK is an Agricultural Engineering Conservationist with the Southwest Branch of the Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Logan, Utah; and C. W. LAURITZEN is a Soil Scientist with the Southwest Branch of the Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Logan, Utah.

Figure 1. Storage tank during construction showing the concrete base, galvanized steel walls, and an asphalt coating on the part of the wall that will be below ground level.

SEPTEMBER 1969
information for the storage reservoir is shown in table 1.

**BIN CONSTRUCTION**

Installation of the vinyl-lined bin is illustrated in figures 1 through 5. The foundation for the bin consisted of a concrete base in the bottom of an excavation about 7 feet below ground level. The bin was erected in the conventional manner (figure 1). A ½-inch plastic hose, slit and slipped over the top edge of the steel, protected the liner from being cut by the top edge. The liner was then put in place and a ¾-inch plastic hose slit and placed over the liner and the smaller hose. In this manner, the liner was protected from being cut and was anchored securely to the top of the tank (figure 2). The liner covered the concrete base, the inside of the tank, and about 10 inches of the outside of the tank.

The 10-inch outside section was bonded to the steel tank.

The outlet through which the irrigation water will be withdrawn and an outlet for draining and cleaning the tank were plumbed into the concrete base. Rubber gaskets, placed between the concrete floor and liner and between the liner and the pipe flange, insured a watertight seal (figure 3). After the vinyl liner was in place, the roof was erected (figure 4). The completed storage tank before backfilling is shown in figure 5. A crew of three to four men was required to erect the bin storage tank.

The cost of the materials used in the construction is given in table 2 and labor cost in table 3. Labor cost (time) is based on the efforts of a crew that have had limited experience in installing such a structure.

**APPROXIMATE COSTS**

The approximate unit cost of the materials are: 30-mil polyvinyl liner about 20 cents per square foot; galvanized steel walls—about 65 cents per square foot; the roof—about 59 cents per square foot; and the concrete base—about 60 cents per

---

**Table 1. Description of steel grain bin lined with polyvinyl installed at Utah State University**

<table>
<thead>
<tr>
<th>Capacity</th>
<th>35,630 gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>24 feet</td>
</tr>
<tr>
<td>Depth</td>
<td>10.64 feet</td>
</tr>
<tr>
<td>(4 rings high)</td>
<td></td>
</tr>
<tr>
<td>Galvanized steel ring thickness</td>
<td>14 gage</td>
</tr>
<tr>
<td>Polyvinyl liner thickness</td>
<td>30 mil</td>
</tr>
</tbody>
</table>

**Figure 2. Polyvinyl liner over top edge of steel wall showing the cut plastic pipes which hold the liner in place. Roof trusses are in place.**

---

**Table 2. Cost of materials used in the construction of steel grain bin fitted with polyvinyl liner**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrugated steel grain bin, 14 gage, 4 rings high</td>
<td>$600.00</td>
</tr>
<tr>
<td>Galvanized roof for liner, 24 feet</td>
<td>$264.32</td>
</tr>
<tr>
<td>Polyvinyl liner, 30 mil</td>
<td>$276.61</td>
</tr>
<tr>
<td>Base for bin, concrete including plumbing supplies</td>
<td>$272.78</td>
</tr>
<tr>
<td>used in outlet</td>
<td></td>
</tr>
<tr>
<td>Asphalt coating on outside of bin below ground surface</td>
<td>$5.00</td>
</tr>
<tr>
<td>Plastic pipe used to hold vinyl liner over top edge of bin</td>
<td>$8.16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,426.87</strong></td>
</tr>
</tbody>
</table>
square foot. The cost per unit volume of storage was about 4 cents per gallon for materials and 2.3 cents per gallon for labor for a total cost of 6.3 cents per gallon.

The cost of the storage reservoir could be further reduced by eliminating some parts. Several bins of this type lined with polyvinyl are being used as evaporation tanks by the Agricultural Research Service at Logan, Utah. In these installations, the liner rests on an earth base rather than on a concrete slab. No measurable leakage has occurred during 2 years. In some instances, the roof might be eliminated, depending on the primary function of the tank. The roof was installed on the stadium reservoir for safety reasons.

The life of the tank is dependent upon several factors. The galvanized steel walls should last for 25 years or more, depending on the soil condition, especially if the outside is coated with asphalt to the ground line such as was done in the job described. The life of the polyvinyl liner—shaded by the roof in the case illustrated—should be 15 years or more. It is necessary to protect vinyl liners from the sun, if prolonged life is expected. If a liner with a longer service life is desired or if the tank is to be open, a butyl rubber liner should be used.

LITERATURE CITED


Table 3. Labor cost for construction of steel grain bin fitted with polyvinyl liner

<table>
<thead>
<tr>
<th>Item</th>
<th>Man hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation</td>
<td>15</td>
<td>$56.50</td>
</tr>
<tr>
<td>Backhoe</td>
<td>15</td>
<td>150.00</td>
</tr>
<tr>
<td>Construction of concrete base*</td>
<td>70</td>
<td>217.00</td>
</tr>
<tr>
<td>Erection of walls of bin*</td>
<td>80</td>
<td>200.00</td>
</tr>
<tr>
<td>Fitting of vinyl liner and installation of roof*</td>
<td>80</td>
<td>200.00</td>
</tr>
<tr>
<td>Painting asphalt coating on bin</td>
<td>4</td>
<td>13.70</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$837.20</strong></td>
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</tbody>
</table>

* Crew of three to four men required for these items

Figure 3. Outlet and drain in the bottom of the storage tank after the liner was in place.

Figure 4. Installation of roof after the liner was in place.

Figure 5. The completed storage structure with a 35,630-gallon capacity.
Deciphering a desert

LOIS M. COX

ECOLOGY — A PHILOSOPHY IN ACTION
Part 2

As an attitude towards nature and all living things, ecology provides a realistic perspective for the future. It is concerned with every participant in a given environment, from weather phenomena to soil organisms, and with the relationships that develop from their interactions. Ecology, therefore, embraces many sciences.

The diverse ecology-oriented research at USU is unified by a shared recognition of the interdependence that characterizes the natural world—including man. This series of articles illustrates that interdependence and shows how the ecological attitude benefits each of us.

Several ecologists at Utah State University are becoming involved in an effort that resembles trying to learn a foreign language from a reluctant teacher, with fragmentary textbooks. As part of the International Biological Program (IBP) for deserts, these ecologists are working in Curlew Valley — a part of the Great Basin desert in Utah and Idaho.

The questions that IBP ecologists are asking of their enigmatic teacher include: Why and how do your animals, plants, soil and climate produce your smoothly operating ecosystem? Which of your parts are least, and most, essential to the whole? Can you (the desert) be made more productive (from the human point of view) without being destroyed in the process?

When the research is completed — probably within a 5 to 10 year period — the scientists should be able to evaluate whether disruptions of a desert ecosystem, such as conversion to conventional agriculture, modifications to enhance recreational appeal, or the introduction of housing developments, are advisable in terms of long-range human welfare.

Unfortunately, no one can provide guaranteed valid answers to many-sided questions by invoking crystal balls, mediums, or ouija boards. So, until ecologists become more fluent in the language of the desert, they will have to continue breaking their big questions into little ones, answering those, and then resynthesizing toward the ultimate goal.

AN EXERCISE IN COOPERATION

That is the approach advocated by the International Biological Program (IBP). The IBP involves biologists from 55 nations, with each participating nation pursuing special interests. All of the programs, however, are coordinated toward the general goal of increasing food supplies while keeping the world a fit place for human life. And attaining that goal requires an understanding of the biological processes that produce and sustain the world we know.

The IBP was organized, at least partly, because of a growing realization that environments throughout the world are inextricably interdependent. A local problem can often be allayed with a quick technological “fix,” but this usually just shifts the place or time of the problem and may even add to its complexity instead of eliminating it.

For example, an industry may solve its waste disposal problem by dumping in the adjacent river. Downstream users of the water then have to figure out how to live with the pollution. Or offshore winds may keep a coastal town free of the air pollutants it produces, but farmers a few miles inland suffer crop damage. Or a shift to nuclear power may eliminate soot, only to pose the far more difficult question of what to do with the “hot” nuclear wastes.

When the United States decided to take part in the IBP, it sponsored two categories of long-term ecological research. One is concerned with human adaptability, the other with the environment.

The USU Curlew Valley work is part of the environmental effort, which includes research on the ecologies of grasslands, tundra, three types of forests, and deserts. Director of the United States’ IBP desert studies is Dr. David W. Goodall. Dr. Goodall, an ecologist specializing in systems analysis, is now a member of the USU Ecology Center.

DISSECTION AND RECONSTRUCTION

With the help of computers, the systems analysis approach allows a problem solver in any field to consider most, if not all, of the factors likely to influence a situation. For example, a desert ecosystem depends, as do all natural ecosystems, upon the sun’s radiation for the “go” in its energy budget. Some of the incoming energy from the sun is converted by plants to edible, energy-bearing tissues. The plant tissues are
then eaten by insects, birds, rodents, and other animals, some of whom are ultimately eaten by people. A systems analysis of a desert may thus have to incorporate 100 to 200 species of plants, 100 species of terrestrial animals, several hundred species of insects and birds, plus multiple weather phenomena, soil types and characteristics, and fluctuating bodies of water.

To do a systems analysis, the necessary facts about the factors and their interactions have to be translated into equations and programmed into the computer. Then the analyst can hypothesize certain changes and have the computer simulate, or predict, what would result. This technique has become indispensable to the Defense Department, large corporations, economists, and planners in many fields. Now ecologists are going to use it.

To maximize the productivity of their time and money, the IBP desert ecologists are trying to take several steps simultaneously. They plan to monitor "undisturbed," representative deserts and their inhabitants to get an idea of the natural seasonal and annual variations in each area. They also are designing in-depth studies of plants and animals that are especially significant to each type of desert.

The monitoring will provide quantitative, base-line data about the desert. The in-depth studies will define the operations of individual species—for example, precisely how much of what foods does a certain species of bird or insect need each day.

Results of the monitoring and the in-depth studies will eventually be converted into forms digestible by computers, and preliminary mathematical models of limited desert ecosystems will be derived. Once their validity is confirmed, these preliminary forms will be combined into the ultimate, comprehensive model of North American deserts.

With that kind of model, planners could predetermine instead of guess how contemplated changes (reseeding, irrigating, grazing, housing developments) would affect deserts over time. And desert lands such as Utah's approximately 40 million acres, will be increasingly coveted by an expanding population that wants to exploit its agricultural and housing potentials.

SOME SPECIFICS

Construction of an acceptably comprehensive model of North American desert lands will obviously require tremendous amounts of data and time. But all journeys start with a single step—and the IBP's first step is scheduled for 1970.

During that year, personnel from universities in Utah, Idaho, Wyoming, New Mexico, Arizona, and California will be gathering data from representative areas in Curlew Valley (in Utah and Idaho); Pine Valley (in southern Utah); Tucson Basin, Arizona; Hanford Reservation, Washington; and Jornada, New Mexico. In many cases, the worth of a specific project will not be realized until its results are combined with those of another done elsewhere by someone else. The interdependence of the parts of a desert is thus being mirrored by the ecologists who are trying to understand the whole.

Monitoring equipment (to measure micro- and macroclimates) will be installed, and standardized observations of plant and animal populations will be made within all five locations. At the same time, specific plants and animals will be studied both in the field and in laboratories. After monitoring for 1 year, the ecologists will have a base line against which they can check their preliminary equations and mathematical models. Consistent monitoring over 5 to 10 years will provide an increasingly valid base line for increasingly sophisticated models. The

Figure 1. Offshore winds may keep a coastal town free of the air pollutants it produces, but farmers a few miles inland suffer crop damage.
An ecosystem that is dependent on the sun's radiation can be likened to a community dependent on an external source of dollars. In each case, a disturbance at any level will affect the other levels, but it can sometimes be exceedingly difficult to estimate those effects beforehand.

For example, if the dollars coming to agriculture or to manufacturing are decreased drastically, how will it affect the local car dealer or grocer? Or, if shadscale or Indian ricegrass are removed from a desert ecosystem, how will the sparrow hawk or badger populations be affected? In both cases valid prediction is well nigh impossible because the effects are not direct. In the community, the effects are translated through such enterprises as a chemical manufacturing firm or a machine manufacturer. The desert's intervening "translators" might include kangaroo rats and grasshoppers.

Systems analysis techniques facilitate the necessary predictions. A systems analyst, given enough facts about enough relevant factors, can translate what is known about a
complex situation into equations. Programmed for those equations, a computer can then predict how a decrease in the production of an industrial concern will ultimately affect a "luxury" water sport business, or how a substantial destruction of shad scale will affect a skunk or coyote population. The computer's capabilities allow it to incorporate far more of the characteristically innumerable interactions than can be suggested in an illustration.

By turning to a systems analysis technique, personnel of the International Biological Program for the desert thus hope to accomplish the heretofore impossible. They expect that eventually (5 to 10 years) they will be able to predict for all levels of the desert ecosystem and with acceptable accuracy, the likely effects over time of any possible modification. Only then can we make truly intelligent judgments about how we can best utilize these fragile lands without pointlessly destroying them and their inhabitants in the process.

(The concept for this illustration was formulated by Fredric H. Wagner, Professor of Wildlife Resources.)
models, in all cases, will be based largely on the in-depth work.

For example, the Curlew Valley records may show that rabbits thrive every year in which the rainfall is heavier than average. If the model doesn’t predict this situation, the model would have to be examined for its source of error.

**USU in the IBP**

Most of the USU research contribution to the IBP desert work will be centered on the Curlew Valley. Shadscale, winterfat, big sagebrush, and cheatgrass are scheduled for field and laboratory investigation. The USU plant ecologists want to know why these plants grow where and as they do. They are now designing instruments to help them discover how variations in leaf temperature, wind, moisture, soil nutrients and light intensity and quality affect the growth of each species.

On the animal side of the desert’s energy budget, “least” chipmunks and black-tailed jackrabbits will receive special attention. These particular chipmunks are apparently one of the most important herbivores in Curlew Valley. The problem is to find out “why.” During 1970, ecologists at Utah State hope to define the existing population in a representative area, its activity patterns, and its mortality and birth rates. These data would then be correlated with information accumulated by other ecologists on weather, vegetation, and general habitat.

Two research projects will be devoted to the pervasive black-tailed jackrabbit. One on food consumption will include five rodents and be managed by Idaho State and University of Wyoming personnel. The other will be an extension of an in-progress USU study. The USU investigators will be measuring relative growth rates of comparable rabbits captured in different states. They will also correlate variations in the reproductive rates of black-tailed jackrabbits with weather, vegetation, population density, and other ecological factors in Curlew Valley and elsewhere.

Three species of birds common to Curlew Valley will be studied in detail both in the field and in the laboratory. This research will involve telemetering the heart rates of free-living horned larks, sage sparrows, and western meadowlarks. The kind and amount of food consumed and its utilization in the body will be determined with reference to the influence of weather, sex and age.

Research on growth and survival patterns of desert insects and annual grasses is to be started on other sites by personnel from the other cooperating universities. Insects, especially grasshoppers, warrant intensive study because they are so critical to the desert’s normal energy budget as both consumers and suppliers. The grasses fill another vital niche since they convert radiation, moisture, and soil nutrients into food for other desert inhabitants.

Although algae generally are thought of as associated with watery environments, certain species thrive in arid desert soils. To date, however, no one has found out precisely how these algae fit into the energy budget of a desert. A USU ecologist...
hopes to help solve this puzzle in Curlew Valley. After defining which algae species are present, he will concentrate on those known to be able to “fix” atmospheric nitrogen. These algae somehow convert gaseous nitrogen into inorganic nitrogen salts that can be used by plants. His experiments will utilize variations in light quality and quantity, pH, salinity, and temperature to check on algal activities. The USU algae work will be coordinated with the overall program, but particularly with research by a California scientist. The Californian, drawing his samples from all the research sites, will be investigating the possible role of algae in helping to stabilize desert soils.

The sun’s radiation is so definitive of any desert’s existence, that a USU biometeorologist will begin directly investigating its influence in Curlew Valley in 1970. Because a desert typically supports a vegetation of low growing herbs and grasses with more or less randomly spaced shrubs or cacti, air flow and radiation can vary widely within small distances.

The investigator will therefore work initially on a microscale, measuring incoming radiation in terms of what is available to individual plants for photosynthesis. Air movements (wind) will be monitored above and within plant communities. Attention will also be given to variations in radiation intensity—their extent and the reasons for their occurrence within a small, sagebrush-dominated ecosystem. Surface temperatures of plants and soils will be recorded and correlated with the radiation and wind data.

**TOWARD A SYNTHESIS**

Successful completion of the research and monitoring projects proposed for the first year of the IBP desert program will make ecological history. The complexities of a desert ecosystem will have begun to move toward a computerized translation. Final conclusions about how a desert keeps its energy budget in balance, however, will require far more details about far more elements than can be acquired in a year. But with continued cooperation among the scientists and their institutions, the desert will eventually be deciphered. Then computers and simulation techniques can be put to work to help us make sensible use of these lands — without destroying their character.

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**WILDLIFE NOTES**

The raccoon dips its food in water to facilitate digestion, not to wash it. The animal has poorly developed saliva glands.

Charles Darwin once raised 82 separate plants, belonging to five different species, from a mud ball taken out of the plumage of a bird.

The largest catfish in the world, the paraiba of South America, reportedly grows to 10 feet in length and weighs up to 500 pounds.

The Arctic tern covers more than 22,000 miles on its annual round trip from the Arctic to the Antarctic.

Most wild turkeys can be sexed and aged by the size and other characteristics of the lower leg.

The lead-colored bushtit spends 40 days, working with a quarter-inch bill, to build a pendant nest 10 inches long.

Conservation efforts have increased the American elk population from 50,000 to 250,000 in the past 50 years.

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**FOUR KEYS TO PESTICIDE SAFETY**

1. **READ THE LABEL ON EACH PESTICIDE CONTAINER BEFORE EACH USE.** Follow instructions; heed all cautions and warnings. Why read the label each time? Because the chemical nature of pesticides and their uses vary greatly. You should refresh your mind each time on the material’s specific uses.

2. **APPLY PESTICIDES ONLY AS DIRECTED.** Apply them only to the crops specified, in amounts specified and at times specified in label instructions, or by your agricultural authorities.

3. **DISPOSE OF EMPTY CONTAINERS SAFELY.** It is almost impossible to remove all material from a container. “Empty” containers contain small amounts of pesticides which could harm children or animals who might get into them. It is best to dispose of empty containers by burying them at least 18 inches deep in an isolated area provided for this purpose away from water supplies.

4. **STORE PESTICIDES IN THEIR ORIGINAL, LABELED CONTAINERS.** Keep them out of the reach of children and irresponsible people. They cannot be properly identified unless they are in original labeled containers. Lock pesticides in a shed away from feed, seed, and other farm supplies.

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**SEPTEMBER 1969**
In writing of electricity and its uses in fishery research, a very brief review of the principles of electricity may be in order. There are two basic types of electric current, alternating and direct; both are of interest in electric fishing. Either of these currents may be continuous or interrupted. In practice, interrupted direct current is generally capacitor discharged. The essential difference between the two currents is that alternating current has a continuing change in polarity or direction of flow; whereas, with direct current the conventional flow is from positive (anode) to negative (cathode).¹

Most electric current to houses in the United States is 110 volt, 60 cycle, alternating; whereas the number of cycles in electric fishing machines ranges from 60 to 450. A cycle is one complete period of reversal from positive to negative and back again per second. Direct current may not be transformed to a higher or lower voltage. Commercial direct current is generally either 110 or 220 volts. A volt is defined as the unit of electromotive force or potential difference, which will cause a current of 1 ampere to flow through a conductor with a resistance of 1 ohm. An ampere is defined as the standard unit for measuring an electric current; that is, the amount of current driven by 1 volt through a resistance of 1 ohm. A watt is defined as a unit of electric power equal to a current of 1 ampere under 1 volt of pressure (volts x amps = watts); also $I^2R$ and/or $V^2/R$.

HISTORY OF ELECTROFISHING

The effects of electric current on the orientation and movement of fish was first described by Mach (1875), Herman (1885), and Hermann and Mattias (1894). Although electric fishing attracted serious attention after the First World War (1918), most of the progress has been made since World War II (1946). A British patent for electric fishing was first granted in 1895; the earliest reliable date of an electric screen in the United States was 1917. Pulsed electric current was first used in the late 1920s (Vibert, 1967).

USES OF ELECTRICITY IN FISHERIES

Electricity has many uses in fisheries research and management, some slight and others quite important. These include: (1) controlling fish movements and activities by electric screens; (2) activity records;

¹ According to Webster an electrode is either terminal of an electric source, an anode is the positive terminal, and a cathode the negative terminal. For easy reading the term electrode here generally applies to either of the two poles of alternating electric current. The terms cathode (negative pole) and anode (positive pole) apply to direct current.

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Figure 1. Electrical "shocker" equipment can be used on small streams to sample the fish populations without damage to the fish themselves.
do not inevitably wim toward termed galvanotaxi. when a new timulu is applied. narco is.
ward the po itive pole or repelled from th negative pole; or (3) they electrified tuna hooks and whaling electric current: kellet al 1954). This r action is transver e to the line of force they
movement thi term d electro­
ting of th entire body when the
migrating fish; and (8) harvesting
timelines which are bru hy and/or turbid.

When the conductivity of the water is less than that of the fish, current lines are deflected toward the fish. When the conductivity of the water is greater than that of the fish, the fish deflects the lines of force into the surrounding field and consequently there is greater density in its vicinity than elsewhere.

FACTORS AFFECTING ELECTROFISHING
In electric fishing the essential factors are: (1) the type of current and waveform; (2) resistance of the water; (3) number and size of electrodes; (4) size and species of fish; (5) topography and dimension of the body of water; (6) the size of the machine producing the current; and (7) the experience and efficiency of the operators.

Two monographs have been developed by Cuinat (1967) to aid builders and operators of electric equipment (figures 2 and 3). When the number of electrodes and the water resistance is known, an estimate may be made of exterior resistance, voltage, current and power requirements.

The resistance of the water is governed by its temperature and the amount of electrolytes that it contains. Some high mountain lakes have a resistance of 10,000 ohms/cm³; sea water has a resistance of about 10 ohms/cm³. When the resistance is high, it takes a high volt-

DIFFERENT CURRENT EFFECTS
Direct current capacitor discharges have the greatest neuro-physiological effect on fish. Next in effectiveness is a continuous flow of alternating current and lastly, a continuous flow of direct current. Capacitor discharges have the maximum physiological effect on the nerves and the weakest residual effect on the fish. For this reason this type of current is particularly suitable for electric fishing (Burnett, 1959). Some investigators, however, have found that continuous flow direct current is more efficient in streams which are brushy and/or turbid.

In a laboratory study by Haskell and Adelman (1955) rapid (180 per second) pulses of direct current produced movement toward the electrode at about 20 percent lower voltages than did slow (1 per second) pulses. Very high pulses produced quicker anesthesia and less reliable movement toward the anode. However, this is not always true. In highly resistive waters high pulse rates are effective in producing reliable movement toward the anode.

According to Halsband (1967) the initial reaction of a fish to interrupted direct current, with pulses of a square wave form or in the shape of capacitor discharges or quarter-sine waves, is spasmodic quivering of the body. Other observers believe the initial reaction of fish subjected to above threshold currents is extremely varied. The second, according to Halsband, is that the fish turns and swims toward the anode. This is only true when the pulses have a rapid growth and a slow decay. When the pulse has a slow growth and a rapid decay, the fish swims toward the cathode. In marine (salt water) fish, however, the movement is toward the anode. Other workers believe the “slow growth and rapid decay” pulse shape is the most effective in fresh water.

In theory, fish lying parallel to the lines of force in an alternating current should face the positive and negative electrodes as many times per second as the current alternates. This is obviously impossible because of the time-response element. In practice, alternating current repels fish from both electrodes and their response is erratic and more or less random.

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Example: fishing with two anodes in water with resistivity of 10,000 ohm/cm.

With a ruler join the left-hand column at "2 anodes" with 10,000 ohms in the resistivity column. The reading from right to left will be:
- approximate total tension necessary = 540 V
- approximate external resistance = 150 ohm
- approximate corresponding intensity = 3.6 A
- approximate corresponding power = 2 kW.

(Keeping approximately the same tension for a given water resistivity it is admitted that the cathode is far from perfect there is a marked decrease in fishing efficiency around each anode when the number of anodes is increased simultaneously.)

Figure 2. This diagram shows the DC current and voltage requirements when electric fishing under ordinary conditions (fresh water with high resistance). The cathode consists of two to three grids, each about 1/2 meter square. The anodes are rings about 30 to 40 centimeters in diameter. The distance from the anode to the cathode is greater than 20 meters. The stream is wider than 2 meters.

(Same instructions as in Fig. 2 With the use of a very good cathode, the fishing efficiency around each anode hardly decreases when the number of anodes used is increased simultaneously.)

Figure 3. Given the same stream conditions, a 20-percent gain in efficiency can be obtained by increasing the size of the cathode to 10 square meters of wire netting and making each anode 40 to 45 centimeters in diameter.

As water conductivity increases the power demand increases and a generator already fully loaded shows a voltage decrease. When a direct current generator is loaded to capacity an increase in the number of anodes, and consequent increase in total size of the anodes, causes a voltage decrease. However, the number of anodes can be increased without showing a voltage decrease if the generator is not loaded to capacity. From a practical standpoint, a number of small anodes rather than one large one often should be used. This increase the area of the electric field and decreases the danger to fish and operators. The number and/or size of the anodes can be increased until the generator is operating at full capacity, and still further if there is a greater than required voltage gradient around the anodes. In general these statements apply to alternating as well as direct current. In practice, alternating current machines have the same number and size of electrodes connected to each pole.

4 In sea water, which averages about 500 times the conductivity of most fresh water, electric fishing is restricted almost entirely to the use of pulsed current because the use of continuous flow current requires an inordinately large power unit.
When capacitor-discharged or interrupted direct current is used, three factors must be considered: (1) the pulse rate; (2) the shape of the pulse; and (3) the duty cycle. The pulse rate is the number of charges per second, and the duty cycle is the period of time within a second that there is a flow of current. A pulse rate of 96 and a duty cycle of 33 1/3 was used effectively by Taylor, et al. (1957), and Roelfs-son (1958).

The voltage gradient required to capture fish with alternating current is about one-half that needed with direct current. In a comparative stream study between alternating and direct current in New York State it was found that alternating may be twice as effective (80 percent recovery) as irregular intermittent direct current (Webster, et al, 1955). Most portable electric generators in the United States today (both types) range in power from .4 to 5 KW (Patten and Gillaspie, 1966), although good results in Israel are reported with a machine supplying up to 7.5 KW (Vibert, 1967).

The conductivity of water and water temperatures are more or less a straight line relationship; that is, as the temperature of the water increases, the conductivity of the water increases at an equivalent rate. Bruscheck (1967) found that in Austrian streams this was true except in the spring when the conductivity of the water rose less rapidly than the temperature because of the small amount of electrolytes in the snow melt. The response of brook trout to direct electric current is low in cold water, but increases with the temperature to 50 F. As the temperature increases farther, the response decreases (Elson, 1942). At 70 F trout response to direct current may range from poor to unsatisfactory (Webster, et al, 1955).

HAZARDS TO FISH

While it has been frequently stated that electric shocking machines are not harmful to fish (health, reproduction, or growth), this statement carries the strong inference that they are being used according to recommended standards. It can be easily demonstrated that fish can be killed with electricity in their natural environment, as well as under laboratory conditions (Hauck, 1949; Pratt, 1954; Godfrey, 1956). Risks to fish vary with the type of current, frequency (in the case of alternating current), time of exposure, intensity of the field and, perhaps most important of all, experience of the operators.

It is significant that threshold levels of current density diminish as the size of the fish increases; it also varies with type of body covering. This is because large fish intercept a greater potential difference (voltage) than small fish. In an alternating current field fish sometimes take a position which is across the lines of force between the two electrodes thereby minimizing the potential difference. Continuous direct current tires fish less than alternating or pulsed direct current, and the time of complete paralysis, after the current is off, is shorter for continuous direct current than for other types of current. Mortality in fish increases with the frequency rise in pulse (capacitor discharged) current.

PHYSICAL SET-UPS

Authorities are generally agreed that the cathode can rarely be too large; that is, within reasonable limits. It is also agreed that the cathode should be distributed over the widest possible ground surface and that it should be in contact with the ground in a number of places. If the cathode is not being used as a barrier to fish movement it need be placed on the bottom only. When it is to be used as a ground and as a fish barrier, it should be in contact with the bottom as well as being placed in such a manner as to present an electric field against moving fish. From a practical standpoint, it is easiest and generally best to use two or more cathodes for this latter type of operation. In any event, a number of small cathodes connected in parallel are better than one large one (Cuinat, 1967). McGrath, et al. (1965), believe that in extreme conditions of very high or very low water conductivity the use of two negative electrodes 5 feet apart results in increasing the potential gradient at the anode by up to 50 percent.

The cathode may consist of one to several pieces of grating of metallic material. At Utah State University we use chicken wire netting which works well. It is inexpensive and can be stored compactly. It is the opinion of Cuinat (1967) that their is little practical difference between the relative conductivity of copper, iron, and steel when used as electrodes. From a practical standpoint the cathode should be placed as near the generator as possible. Often times the cathode can be placed outside the field of electric fishing activity. This reduces potential hazards to both operators and fish.

In general, a number of small anodes are superior to large ones. The anodes are connected by single wires. The operators have more mobility when using this setup and quite often the anodes can be electrified dipnets which function both as a producer of an electric field and a method of capture. This latter method has been in use at Utah State University since the middle 1950s. When the dipnets are electrified, fish should be held in them for only a short time.

When using alternating current the size of the two electrodes should be equal. In practice, especially in swift mountain streams, oval shaped electrodes perform well.
SAFETY PROCEDURES

Danger to personnel is minimal if recognized safety precautions are followed. The exception perhaps is the person with a cardiac condition. In the United States there are no laws regulating the safe use of electric fishing machines. It is, in fact, difficult to find good agreement regarding safe practices. A few general rules are well recognized, however, and should be followed.

1. Operators should wear either rubber boats or waders.
2. Operators should wear rubber gloves; heavy duty high voltage lineman gloves are recommended.
3. Familiarity with the operation of the equipment and the principles of electric fishing should be understood by operators.
4. Electric generators designed for commercial or domestic use may have one side of the output grounded to the frame. This creates a hazard when the machine is used for electric fishing, since it can cause the supporting unit, (boat, truck or even earth) to become “live”. This ground should be disconnected. In addition to the hazards involved in using a grounded machine, its performance may be erratic.
5. All electrodes and dip net handles should be made of non-conductive material or be insulated.
6. Pressure activated electric safety switches should be available to one operator. In addition, the electric line should have a plug which can be quickly disconnected. This is necessary since on rare occasions safety switches malfunction.
7. An electric generator should have a knife-blade (or other) type switch and a fuse box or circuit breaker.
8. Multiple grounding in direct current machines at times produce unpredictable electric fields in the vicinity of the generator and in the area between the anode and the cathode. This should be kept in mind by operators, especially if there are observers.
9. One person should be in charge and his authority should not be questioned during an operation.

ELECTRIC FISHING IN LAKES

An electric shocking machine operated in deep water (too deep to wade in) requires a different physical setup than ones used on shallow streams or ponds. This is called a boom shocker. Both personnel and equipment are carried by a boat or barge. This means that operators, generators and all electrodes are housed in a very compact space. Further, a boat is a considerably less stable working base than land. Collectively, this means that procedural discipline must be precise, caution extreme and mental alertness acute.

Most generators used put out 230 volts and 1500 to 5000 watts in a 60Hz alternating current. Sometimes only two electrodes are used; one over the bow and the other near the stern. Generally, however, either four (figure 1) or six electrodes are employed. This tends to increase the size of the field and decreases the intensity (voltage gradient). The forward electrodes are attached to one terminal and the aft ones to the other. The total surface area of the electrodes attached to the respective terminals should be equal. The electrodes may be a solid ¼-inch rod or a flexible cable. Heavy one-piece rods tend to remain more nearly vertical and therefore deeper than lighter flexible cables, but they have inherent problems in shallow water, in heavy plant growth, or when backing down. The efficiency of a boom shocker is relatively low; perhaps 5 to 25 percent. Only under unusual circumstances can it be used as a quantitative tool. However, it can be a very effective device for general collections where netting or other methods fail (Smith, et al, 1959).

Fish react to the electric field of a boom shocker by (1) attempting to escape; (2) dashing about near the surface; (3) lying immobilized at the surface; (4) becoming narcotized and sinking to the bottom; or (5) drifting with the current. Fish that come to the surface must be netted quickly because they recover rapidly, or the boat moves away from them (Loeb, 1955). The horizontal field of a boom shocker is relatively small, and water depths of more than 8 to 10 feet are generally considered excessive.

LAKE SAFETY

There are a number of reasons why boat-carried electric shockers are more dangerous than land-based ones. Falling overboard into an electric field sometimes poses a difficult rescue problem. The footing may be treacherous, space to move in is limited, rough weather or objects in the water are navigation hazards, noise from the generator and boat motor are distracting, and limited visibility (at night) is frustrating (Loeb, 1957).

For these and other reasons the following safety precautions should be observed:

1. Always wear Coast Guard approved life jackets
2. Low-cut, easily removed rubber footwear should be worn. Hip boots are too heavy to swim in and too hard to get off in the water.
3. The boat should be kept neat, store all gear and eliminate booby traps.
4. The light source should not be connected to the circuit that has the safety switches in it.
5. There should be a guard rail around the boat, except across the stern, that will strike the operators not lower than eight inches above the knees.
6. There should be warning devices or signs on or near the boat for observers or people in the water. This is especially important at night.
7. The bottom of the boat or the cat-walks should be covered with non-skid material.

8. The operators should avoid excess fatigue or drowsiness, and be constantly alert.

9. One person should be in charge and his authority should not be questioned during an operation.

**ELECTRIC FISH SCREENS**

Electricity also is used to divert fish around or away from potential hazards such as turbines and irrigation ditches. An electric fish screen can be imagined as an electrified wall of water. In practice there are three types of electric screens: (1) those intended to stop or turn back fish; (2) those designed to direct fish into safe areas (passageways, lifts, traps, etc.) (Maxfield, et al, 1969) (McLain, 1957; McLain and Nielsen, 1953; and Maxfield, et al, 1959); and (3) those designed to kill (Applegate, et al, 1952).

The theoretical basis of successful fish screens of the types 1 and 2 is that the fish must be gradually introduced to the unpleasant situation of an electric current, allowed to learn how to avoid it, and then behave as desired. It is important to avoid panicking the fish or destroying their swimming ability (Hartley and Simpson, 1967). Screens for upstreams migrants are comparatively simple, since even if the fish is partially immobilized it will drift back downstream and out of danger. Downstream screens are considerably more complex. An example are those electric screens that are intended to prevent young salmon from entering turbines, or irrigation ditches located in the Columbia River drainage. The third type of screen, designed to kill, was used to combat the sea lamprey in streams tributary to the Great Lakes.

**ELECTRICITY AS AN ANESTHETIC**

Electricity may be used to narcotize fish for such operations as tagging, weighing, examining, and treating. Hartley (1967) uses continuous flow direct current because, although it is the least effective type of electricity for this operation, it is the safest for both operator and fish. The fish are quickly paralyzed by direct current and can be maintained in this condition by half the initial voltage gradient. A rheostat in the circuit expedites the operation. Fish recover even after several hours of narcosis. From short duration paralysis they almost instantly recover.

**LITERATURE CITED**


Now we have—

**Freeze-dried Sauerkraut**

Sauerkraut has long been popular in the United States where total consumption reached 200,000 pounds in 1962. Production has dropped since then, however, although total consumption has increased. In recent years sauerkraut has been imported from Germany, Holland and Yugoslavia to meet the U.S. demand.

Food technologists at Utah State University have long been interested in developing new food products. Foods which are easily preserved, stored well under a wide variety of conditions and are easily prepared are of special interest to commercial processors. The researchers were especially interested in studying the merits of dehydrated sauerkraut.

Three bacteria are the mainstays in converting shredded cabbage into good quality sauerkraut: *Leuconostoc mesenteroides*, *Lactobacillus plantarum*, and *Lactobacillus brevis*. *L. mesenteroides* starts the fermentation process by converting the sugars present in the cabbage into lactic acid, acetic acid, alcohol, carbon dioxide, dextran and mannitols.

The fermentation continues until the acidity reaches 0.7 to 1.0 percent, at which time *L. plantarum* becomes predominant and continues the acid production until the acidity reaches 1.5 to 2.0 percent. *L. plantarum* ferments cabbage without the production of gas and removes the bitter flavor produced by *L. mesenteroides*. The third bacteria, *L. brevis*, raises the acidity to 2.4%, which results in a sharp acid flavor.

Four experiments were conducted to test the effect dehydration of

Bozeman; James W. Mullan, Fishery Management Biologist, Bureau of Sport Fisheries and Wildlife, Vernal, Utah; and Galen H. Maxfield, Fisheries Research Biologist, Bureau of Commercial Fisheries, Seattle.

Sauerkraut has on the chemical and physical properties, when freeze-, conventional hot-air-, and microwave dehydrators are used.

Pilot plant (commercial) production was simulated by adding 2 percent salt to shredded cabbage obtained from a local sauerkraut factory. The cabbage was divided into three treatments with four 20-pound replications in each treatment. Each replication from one treatment consisted of shredded and salted cabbage treated with 700 ml of cabbage juice inoculated with *L. mesenteroides* that had been incubated for 2½ days at 68 F. Another treatment of four replications was treated identically except the inoculated juice contained *L. plantarum*. The third treatment was allowed to ferment naturally.

The fermentation tanks, to which the 20 pounds of treated or untreated cabbage was added, were 4 feet high and 4 inches in diameter. When the acidity reached 1.5 to 1.8 percent, the contents of each tank were removed and analyzed for pH, color, ascorbic acid, soluble solids and lactic acid.

Bacterial inoculation with *L. mesenteroides* or *L. plantarum* did not improve the quality of sauerkraut.

Dehydration by any of the methods tested caused browning and reduced the ascorbic acid, lactic acid and soluble solids, and increased pH. These changes were less evident following freeze dehydration.

Sauerkraut dehydrated by conventional hot-air was shrunk and darker in color than that from the same sample dehydrated by the freeze-dry process. Sensory evaluation of reconstituted conventional hot-air dehydrated or freeze-dried product compared favorably with a canned commercial product.

Microwave dehydration caused extreme browning and considerable loss of ascorbic acid in some samples.
Previous articles in *Utah Science* (September 1968 and June 1969) discussed the growth rates and the amounts and estimated costs of feed required for raising dairy herd replacements. These articles were based on the use of common feeds including whole milk. This article provides information on the use of commercial milk replacers as a substitution for salable milk in the ration of a dairy calf.

**COLOSTRUM ADVANTAGES**

At birth, many animals, including dairy calves, do not have a natural immunity to disease. Colostrum (the first milk secreted after calving) is rich in gamma globulins which contain antibodies. These antibodies, when absorbed directly from the digestive system into the blood, help a calf to resist infections. After about 24 hours following birth, the calf loses its ability to absorb gamma globulins, thereby losing the effectiveness of colostrum in disease resistance. Because of the many diseases affecting calves, it is desirable that calves be given colostrum during this critical first 24 hours of life. Although it does not afford complete protection from disease, it certainly helps.

Colostrum has other characteristics which make it especially beneficial to young calves. It has laxative properties which help start the digestive system of the new calf functioning. It is higher in protein, fat, some minerals, and some vitamins (especially vitamin A) as compared to normal milk. The proper feeding of colostrum correctly starts the calf and is desirable whether whole milk or a milk replacer is used later.

Good management practices should always be used in raising calves. Clean, sanitary, dry, and draft free housing should be provided. Regular care and attention is required. Calves should be treated at the first symptoms of disease. The amount of milk or milk replacer should be properly controlled since overfeeding can readily cause a scouring condition. When milk replacers are used, particular attention to good management practices is needed.

**RAISING CALVES ON MILK REPLACERS**

In the calf raising program at Utah State University, most calves receive whole milk until 6 weeks old. Approximately 380 pounds of whole milk are used in raising a calf. Non-salable milk (but fit for raising calves) is fed when available. Extra colostrum also can be fed. However, since colostrum is considerably richer than regular milk, the amount fed is decreased. Rich colostrum should be diluted with an equal amount of

![Figure 1](image-url)  
*Figure 1. It is very important that newborn calves be allowed to nurse their mothers or be fed her colostrum milk for the first 24 hours after birth.*
water. Nonsalable milk should be utilized in both a whole milk and milk-replacer system of raising calves.

When a good milk replacer is used, there is no need to feed salable milk. The author conducted a study at the University of Maine where calves were allowed to receive their dam's milk for the first 4 days of their lives. On the fifth day they were immediately switched to a milk replacer. No milk was fed after this date. The calves were allowed access to a calf starter and hay. A maximum of 4 pounds of starter was fed. In these studies the replacer was fed until 7 weeks of age and the calf starter fed until 16 weeks of age. No deaths occurred and there were only a few instances of scour. In nearly all cases, the scours lasted for only 1 or 2 days. Treatment consisted of a slight reduction in amount of milk replacer fed plus treatment with an antibiotic when necessary.

Calves on the milk replacer gained 1.04 pounds per day from birth until 8 weeks of age. This compares favorably with an average daily gain of 1.12 pounds for calves at USU which received whole milk for 6 weeks. The calves receiving milk replacer made satisfactory gains and were in thrifty condition. Several weeks after weaning they appeared normal in size and condition.

For ease of measuring, most milk replacers are reconstituted at the rate of 1 part replacer to 9 parts water, which gives a liquid containing 10 percent solids. Whole milk contains approximately 12 percent milk solids. Thus 420 pounds of whole milk has about the same nutritional value as 50 pounds of milk replacer when reconstituted to 500 pounds.

Milk replacers on the market today may be as good as but cannot be expected to be better than whole milk. Some are definitely inferior. Figure 3 illustrates the comparative feeding value of milk replacer. To use figure 3, a line should be drawn horizontally from the price of milk to the sloping line, then vertically to the value of milk replacer. For example, milk replacers costing $13, $17, or $21 per 50 pounds can be used in place of milk valued at $3, $4, or $5 per hundred pounds, respectively. This figure can be used to determine whether the use of milk replacer is economically feasible. Since milk replacers usually require extra time for reconstituting, a value for this time should be included. Figure 3 does not include a value for the extra time involved.

RECOMMENDATIONS

Companies selling milk replacers recommend that calves be fed 25 pounds of dry milk replacer during the first 4 to 5 weeks of life. After colostrum feeding, salable milk need not be fed. Milk replacers can be used from the time the calves are 3 to 5 days of age. When calves are weaned at 4 to 5 weeks of age a good calf starter is essential and must be fed according to recommendations. A good calf starter is more digestible by calves and is higher in protein and lower in fiber than the concentrates fed to older animals. Milk solids are usually included in a calf starter. At 4 months of age, the rumen has developed sufficiently for the young heifer to handle ordinary herd concentrates.

Whole milk has all of the advantages of milk replacer except costs. If calves can be weaned from milk replacers at 4 to 5 weeks of age, they certainly would be expected to do as well on whole milk. If a calf is raised on 25 pounds of milk replacer, the same results would be expected from 210 pounds of whole milk. At Utah State University we have been feeding 380 pounds of milk per calf. To get the same growth response from milk replacer would require 45 pounds of dry replacer. The extra milk or milk replacer results in a greater growth response and thrifter calves but does add to the cost of raising calves.

SUMMARY

When economically advantageous, calves can be raised on milk replacer. In feeding value, 25 pounds of milk replacer will equal about 210 pounds...
of whole milk. Generally, extra time is required for reconstituting a milk replacer thus a value for time should be added to the cost of the replacer. Calves can be successfully weaned from milk or milk replacer at 4 to 5 weeks of age. However, they will not be as thrifty as when weaned at a later date. Later weaning adds slightly to the cost of raising calves. Differences noted in early life of calves because of feeding milk replacer nearly always disappear by 6 months of age if good feed is provided after weaning.

Calves can be successfully weaned from milk or milk replacer at 4 to 5 weeks of age. However, they will not be as thrifty as when weaned at a later date. Later weaning adds slightly to the cost of raising calves. Differences noted in early life of calves because of feeding milk replacer nearly always disappear by 6 months of age if good feed is provided after weaning.

Figure 3. A comparison of the price of salable milk versus the value of a milk replacer based on feeding value only.

**WILDLIFE NOTES**

- Pronghorns alert other members of the herd to danger by raising the white hairs on their rumps in much the same manner Indians used mirrors for signaling.
  - "Wild rice, once the main staple of nomadic Indians, is now the world’s most expensive cereal."
  - The polar bear, unlike his cousins, does not take a long winter nap and spends most of his time searching for food.
  - Sand dollars dine on microscopic life and in turn are eaten by flounder, cod, haddock and starfish.
  - Although no larger than a thumbnail in size, the female peeper frog lays approximately 1,000 eggs.
  - The eyes of an ostrich have been known to weigh more than twice the weight of its brain.

**MISS YOUR MARK . . . HOW TO POISON A DUCK**

You may be accidentally poisoning more ducks than you’re bringing down on the wing. Research at Utah State University is confirming results from other universities and commercial companies showing that spent lead shot can be deadlier than some just leaving a shot gun, regardless of marksmanship.

A duck foraging under water won’t or can’t discriminate against lead shot. It apparently can’t tell the difference between a shot and a seed, eating either with equal eagerness. And even two or three No. 6 lead pellets can prove fatal to a large duck when the lead compounds reach its vital organs.

Work done by Utah State graduate students, under the direction of personnel of the Utah Cooperative Wildlife Research Unit, indicates no immediate simple solution. Smaller size shot sink in to the mud at slower rates and thus remain available to waterfowl longer and in greater numbers after each season. But one small shot is less dangerous than one of the larger size. Larger shot, on the other hand, sink below the birds’ normal foraging depth faster than small shot. And there are obviously fewer shot per shell scattered over the marsh when larger size shot are used.

At the Bear River Migratory Bird Refuge, though, substantial quantities of various size shot were found to be accessible to the birds for 3 or more years after the initial deposit. So, until someone manages to develop a non-toxic, ballistically sound shot, “misses” will continue to take severe post-season toll of waterfowl.

As an interim measure, it might be worth considering the use of only No. 4, or larger, shot. This wouldn’t solve the problem, but it should at least reduce the numbers of birds that escape being shot but then fall victim to the lead pellets scattered over marsh lands each season.

**UTAH SCIENCE**
NEW COMPOUNDS BLOCK INSECT GROWTH PATTERN

Four new “hybrid” synthetic ethers tested for their ability to block normal insect growth and development promise in a new approach to insect control, a U.S. Department of Agriculture entomologist reports.

The experimental compounds show several hundred times greater potency than the insects’ own hormones or biologically-similar synthetic compounds tested earlier.

Dr. William S. Bowers of USDA’s Agricultural Research Service found that the compounds prevented yellow mealworms and milkweed bugs from developing into adults from their pupal or nymph stages. The most active compounds synthesized by Dr. Bowers at the ARS Insect Physiology Pioneering Research Laboratory, Beltsville, Md., were the 3, 4-methylenedioxyphenoxy ethers of 6, 7-epoxygeraniol and their corresponding ethyl-branched homologs.

These new hybrid compounds should be superior to hormones and hormone-like synthetic compounds tested earlier because of their greater potency and ease of synthesis in the laboratory.

Amounts of the compounds as small as 10 nanograms applied to the insects’ abdomens resulted in overgrown nymphs or pupae instead of normal adults. (A nanogram is one-billionth of a gram.) Some of the treated insects combined both mature and immature traits. For example, treated milkweed bugs developed half-size wings with nymphal coloration and immature genitalia. Treated mealworms molted into intermediate forms — half pupa, half adult. All the treated insects subsequently died in their abnormal state, unable to mature or reproduce. So active are these compounds that exposure of mealworms to the fumes from the compounds produced the same effects.

These compounds do not kill insects like conventional insecticides even when applied at 1 million times the strength used in Dr. Bower’s tests. However, they may be as effective as certain conventional insecticides since treated insects are unable to develop into normal adults, and die without reproducing. Ways of employing the new compounds in practical applications remain to be developed.

DEHYDRATED CELERY NOW PUffED

Quick-cooking dehydrated celery with good flavor, texture, and color can be made by the U.S. Department of Agriculture’s explosion-puffing process.

The product is ideal for dehydrated soup mixes and other prepared foods, and is also crisp and tasty enough in the dry state to be eaten as a snack.

Celery is one of the latest foods to which this process has been adapted. The new product was developed at the Eastern utilization research laboratory of USDA’s Agricultural Research Service in Philadelphia, Pennsylvania. The process consists essentially of a conventional drying in two steps, between which the vegetable pieces are exploded from a heated pressure chamber. The explosion imparts to the pieces a porous structure that not only facilitates their final drying, but also their subsequent reconstitution. The dehydrated celery pieces are fully rehydrated after simmering in water for about 6 minutes instead of the half hour or more usually required for conventionally hot-air dried pieces.

Explosion puffing was developed at the ARS Eastern laboratory several years ago, and has been adapted to many other foods, including carrots, potatoes, beets, apples, and blueberries.

In making dehydrated celery by this process, the hearts — which cannot be dried without browning — are first separated from the stalks and packaged as a premium product. The stalks are cut into 3/16-inch slices, and blanched 6 minutes in sodium bicarbonate solution. This destroys the enzyme peroxidase and helps preserve the green color of the celery. After this treatment the slices are dipped in sodium bisulfite to retard browning, increase the retention of vitamin C, and prevent microbial growth during the drying.

After partial dehydration (to 35 to 40 percent moisture), the celery is held overnight at 38 F in plastic bags to permit an even distribution of the remaining moisture. The slices are then exploded from the pressure chamber at 35 pounds per square inch and returned to the dryer for final drying to 4 percent moisture or less.

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