1960
Farrer Memorial
Oration . . .

The Storage and Use of Irrigation Water on the Individual Holding

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THE FARRER MEMORIAL MEDAL is awarded annually to commemorate the work of Australia's great wheat breeder, William James Farrer, and to mark distinguished service to agricultural science. The oration by the recipient is an important item on the programme of the congress of the New South Wales Agricultural Bureau at which the award is made.

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We commemorate to-day the work of William James Farrer, that great pioneer wheat breeder whose contribution to the wealth and development of this continent has been exceeded by few others. Though Farrer devoted his talents to wheat breeding, he also exerted a profound influence on the development of agricultural science in Australia. For that, no less than for his efforts to help the wheat industry, we honour him to-day.

It has been the custom of previous speakers in this series to relate their subject matter to Farrer's work. May I suggest there is a modest affinity between Farrer's quest for drought-resisting wheats and our own work.

There are two principal methods of coping with drought. One is accept the environment and breed or select plants to suit it. That was Farrer's approach. The other method is to attempt to modify the environment so that existing species can be grown. That is the approach which has been adopted in the work to be discussed to-day.

Over the past eight years the University of Sydney has been engaged in a study of the economics of storing farm run-off for irrigation purposes.

Water Harvesting

The water harvesting project, as it is called, had its origin in the high return obtained from a pilot area in 1952, and, also, in our steadily mounting sense of frustration with the climate of the County of Cumberland, which seemed to defeat every orthodox attempt at growing better pastures or crops.

The weaknesses of the County climate from a farming point of view are the existence of a rain shadow over the farming sector, the capricious distribution of the rain throughout the year, and the variation in rainfall from year to year.

These characteristics are brought out by the three following diagrams. Fig. 1 is a map of the rainfall distribution prepared by the Weather Bureau. The lines or isohyets join places of equal rainfall. You will notice that, while parts of the extreme coastal fringe have an average as high as 48 inches, the main farming area between Parramatta and the Blue Mountains (Penrith is at the foot of the mountains) has an average of only 28 inches—in fact the 28-inch isohyet pretty nearly surrounds the farming lands of the County. Badgery's Creek is in the centre of that area and has an average of only 26 inches. The sharp falling-off in rainfall with increasing distance from the coastal escarpment is well illustrated by Fig. 1. Badgery's Creek is 26 miles due west of Macquarie Place, the official "centre" of Sydney. In that distance the average rainfall drops 21 inches.

Fig. 2 is a group of diagrams showing the variation in rainfall pattern from year to year. On the average, as one of the diagrams reveals, the rain is fairly evenly distributed throughout the year with a tendency towards more in the first half than in the second half; but the diagrams for the individual years show that there is no regular pattern of rainfall at all. The only constant feature is a tendency towards two heavy falls a year, but they can arrive in any month. It is this great variation in seasonal distribution of rainfall that has long handicapped farming in the County of Cumberland rather than a mere shortage of rainfall. Badgery's Creek has had a drought of six months in a year in which the total rainfall was 52 inches, twice the average.

Fig. 3 shows how the rainfall varies from year to year. It has ranged from a little under 13 inches to more than 66 inches. These variations are a further handicap, but they do not affect farming as badly as the frequent intermittent dry spells.

The County of Cumberland is the oldest settled part of Australia. Its comparatively undeveloped state is due largely to its badly distributed rainfall.

With the 1952 experience acting as a tempting bait, we began building dams to store farm run-off and found out we could store water at a cost competitive with the public schemes. We unearthed some 70-year-old records which strengthened our suspicion that there was a very high run-off at Badgery's Creek, and we then began to develop irrigated pastures to feed our dairy herd which had hitherto been supported by poor fodder crops and expensive purchased feeds. We quickly found how this policy improved our finances. At this stage I was fortunate on being able to enlist the co-operation of the Senior Lecturer in Agronomy (Mr. Frank Crofts) who has devoted himself to the problem of efficient use of the stored water.

The work divides itself naturally into two phases:

(1) The economic storage of run-off;

(2) The effective use of that water for irrigation.

Our farm storage system consists of 14 dams which are filled by gravity and two "turkey nests" into which water is pumped from storm-water creeks during storms. The total capacity of the system is 56,000,000 gallons. The farm itself has an area of 400 acres.

The eight-year period included the 1956-1958 drought, in which there was a complete absence of run-off for 20 months. This was the longest period without run-off for 50 years—a point which I was able to check from the well-kept records of "Maryland", Bringelly. The late Thomas Barker, who kept those records, noted every dam-filling rain from 1900 onward.

That drought showed us the value of marrying together the two forms of water harvesting—gravity and pumping. During the past year we have extended the underground irrigation main to Badgery's Creek so that it now serves a double purpose. Normally that main links our dams together and distributes irrigation water. In flood time it can be used to fill dams by pumping from the creek. During a storm the run-off finds its way by gravity into the dams, but the flow ceases shortly after the rain stops falling. The creek, however, continues in flood for a fortnight or more.

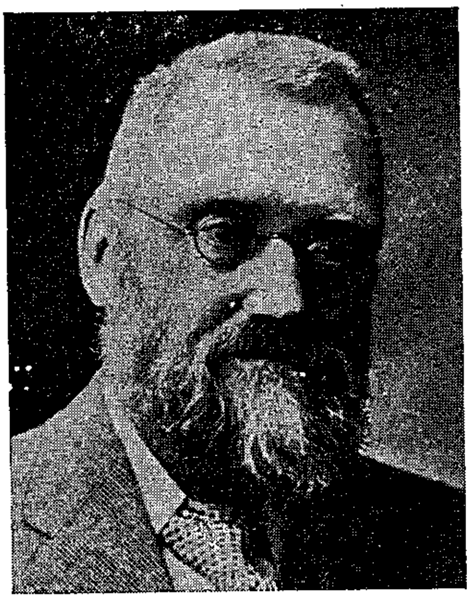
We therefore, get the full benefit of gravity filling, but when it can no longer help, we start pumping. The underground main links dams with a total storage capacity of 30,000,000 gallons. If the creek ran long enough we could pump that much additional water into the dams after the storm had ceased and there was no hope of getting any further intake by gravity. This dual system gives us the economy of gravity and the greater reliability of pumped supplies.

It has been suggested that the costs of storing water at Badgery's Creek have been unusually low and that they are not typical of what farmers in other districts might have to spend. That is true to some extent, yet there are numerous examples of individual farmers having surpassed us in economy of storage. We have certainly enjoyed a combination of favourable circumstances. We have good "holding" soils—C.S.I.R.O. work shows that there is no seepage loss at all from the turkey nest tank; in some districts the seepage loss exceeds the loss by evaporation. The Badgery's Creek soils constitute good structural material for building embankments. We can take all sorts of liberties with them. We can make banks with batters so steep as to court disaster from slumping in other districts. Earth-moving costs are low because of the large number of contractors available in the County and the keen competition that prevails.

The County has a high run-off rate; Abbott, in a paper to the Royal Society in Sydney 75 years ago claimed that the Nepean catchment discharged 39 per cent. of the rainfall into the sea. Badgery's Creek is in the Nepean catchment. If Abbott's figure is equally true for farming land, the University's 400 acres has a potential water yield of 90,000,000 gallons a year—twice as much as the dams alone hold. Admittedly our costs of water storage are low, but the important point is that we understand why they are. Once the various factors that influence costs can be identified—and that is what we have been doing—the costs can be readily assessed for other circumstances. It is the method of assessment that matters rather than our actual costs.

William James Farrer

—1845-1906—



Son of an English farmer, Farrer came to Australia in 1870 and was a surveyor on the staff of the N.S.W. Lands Department. In 1898 he was appointed to the staff of the Department of Agriculture following the recognition of the value of his experiments with wheat. For his work as a wheat breeder, Farrer has been termed "Australia's greatest benefactor", pioneering the development of varieties suitable to Australia and making possible the extension of our wheat-growing areas by millions of acres.

This question of water yield is one topic which deserves more consideration. Our aim has been to use the greater part of the farm as a catchment area to provide irrigation water for a third or a quarter of the total area. Up to date we have kept that catchment area in native grass in the belief that the plant cover would protect the soil from erosion and yet allow sufficient run-off.

We know now that these unirrigated areas can be improved, that they will support Bacchus Marsh subterranean clover. But what happens to the water yield? It is possible that the most valuable crop we can obtain from these areas is water. In many districts in southern New South Wales pasture improvement has been so effective in preventing run-off that dams can no longer be filled. This is equally true of the improved areas of South Australia.

It is one of the basic tenets of soil conservation that every endeavour be made to absorb as much water as possible where it falls or nearby. Hence the use of contour banks and pasture furrows. Water is blocked and impeded as much as possible to give it every chance to sink into the ground. It is led away gently to prevent it eroding the soil and run over a vegetated surface that constantly impedes the flow. Only as a last resort is any surplus trapped in dams.

This procedure is no doubt effective in preventing erosion of the soil, but does it necessarily make the best use of water? I have a long-standing but friendly argument with the soil conservationists on this point. They argue that any surplus water that sinks in too deeply for plant use eventually finds its way into the ground water supplies and emerges in a stream, creek or spring some distance away. They stress that it is crystal-clear—in other words, it does not carry any soil on its subterranean journey.

Farmers are no less philanthropic than any other section of the community—indeed, I'd say they were more generous than many town-dwellers. But I have yet to meet the farmer who is eager to spend money to absorb water into the ground to benefit some other person miles away—perhaps someone he does not even know. The whole concept is so charitable that the Income Tax Commissioner would surely volunteer to regard the expenditure as a deductible item—to be recovered, say, by adding it on to the income of the recipient of the water.

My chief argument against promoting absorption is that it does not greatly increase drought-resistance. Although the roots of pasture plants penetrate to great depths it is

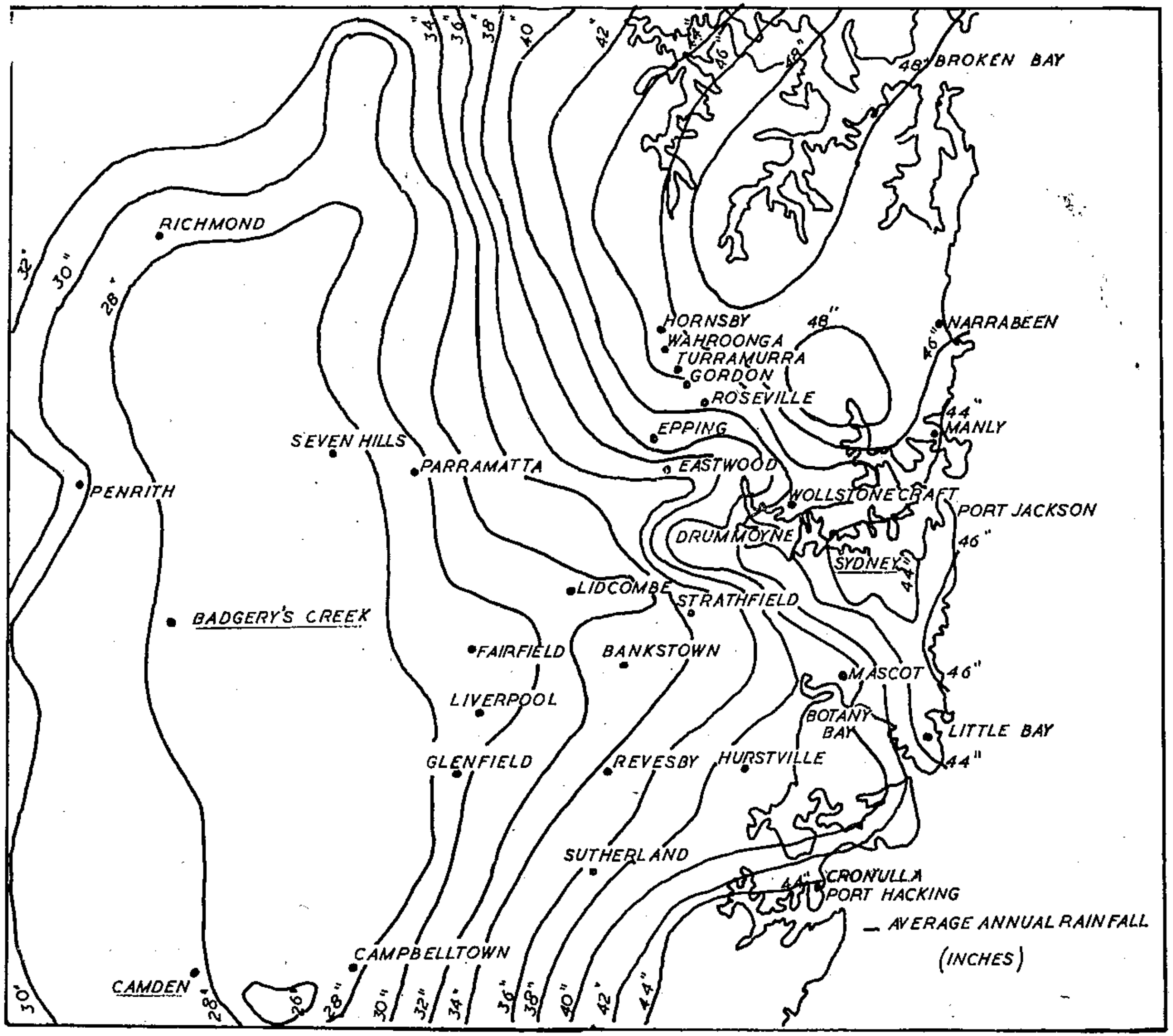


Fig. 1.—Variation in distribution of rainfall in the County of Cumberland (N.S.W.). It is to be noted that the so-called farming belt is also the driest area.

the moisture in the top 12 to 15 inches that controls productivity. Even the heaviest soil cannot accommodate more than $2\frac{1}{2}$ inches of water in the top 15 inches without water-logging. Lighter soils hold less; a pure sand can hold only $1\frac{1}{4}$ inches.

The heaviest rain cannot do more than saturate the soil and that ensures enough moisture for maximum growth for not much more than 10 days in mid-summer, even less when evaporation is severe.

Once the water has been absorbed into the ground it has passed from human control. On the other hand, water stored in a dam remains under man's control. It can provide enough moisture for a year's growth or more. It can be applied to any chosen area. Some of the heavy rains experienced at Badgery's Creek could furnish a two-year irrigation supply.

We have not actively promoted run-off beyond keeping our catchments in native grass, but I have often wondered whether we could use some of the features of a system developed by the late Mr. T. Barson, a B.H.P. engineer, to increase the run-off from the Wnyalla catchment before the Morgan pipeline went through. Barson used an elaborate system of herringbone drains which substantially increased the yield from short, sharp showers. In reading a description of his methods one can readily understand why the system, now abandoned, eventually caused erosion; but that is not necessarily inherent in the system. Erosion in the drains could be readily handled by a slight alteration in gradients and by grassing-over. Sir Richard Boyer has found that collecting-drains make water harvesting practicable even in a 10-inch rainfall.

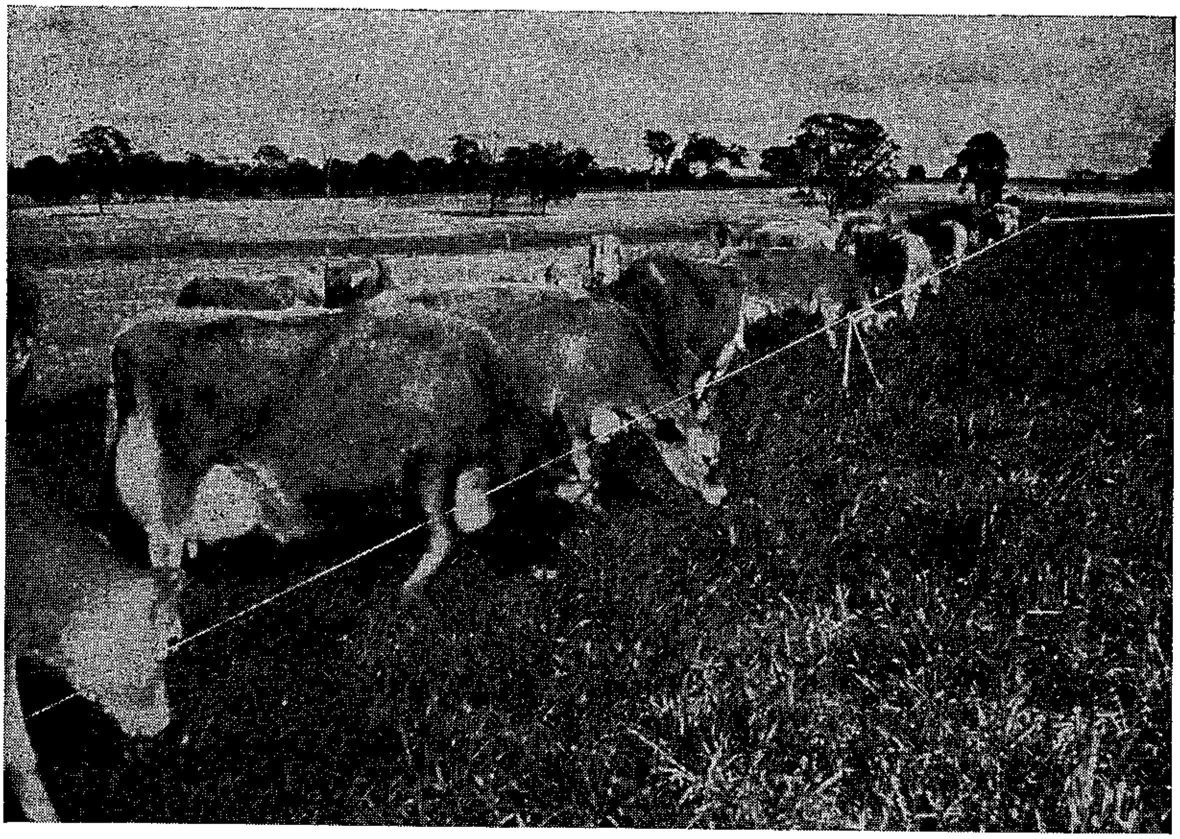
Both the Riverina and South Australia have suffered severely from drought in the past two years. Absorbing all the water has not saved them. At what stage does pasture improvement, by promoting maximum water absorption, change from a virtue to a vice?

It would be interesting to explore the possibilities of the Barson system in areas where pasture improvement has prevented dams from filling. It might be possible to hold the soil and still improve the run-off. Absorption often involves the application of more water when the soil least needs it.

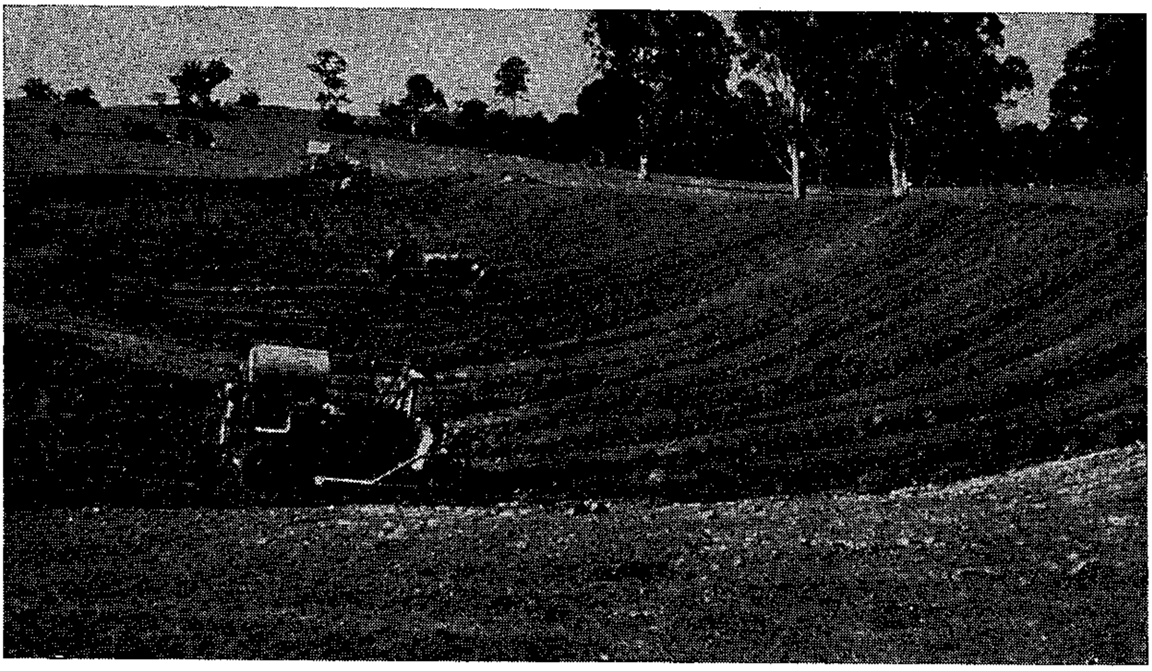
The water harvesting project has been a combined technical and economic one. I should like to underline the word "economic". While it was exciting to be able to collect so much water from a 400-acre farm we realised right from the outset that we had to justify our work on economic grounds. This is not always the case in research. Indeed, very little research is carried to the point where it can be analysed from an economic point of view. That job is usually left to the farmer. Has not the great pasture revolution come about this way? Were not farmers the pioneers of pasture improvement on a farm scale?

And there are numerous failures in the attempt by the farmer to apply on a farm scale the results of a promising experiment which has been carried out on plots. Let me illustrate from two recent experiments, results that look well on paper, but that could be uneconomic in practice.

In a recent experiment it was shown that dairy cows fed good quality hay gave a greater yield of milk than those fed inferior hay from the same crop. The obvious deduction was that it paid better to make good hay. But when the figures are studied from an economic point of view it appears that the better policy would be to make bad hay. The good hay was more palatable than the bad hay and the cows ate a lot more of it. When allowance was made for the difference in hay consumption it could be shown that the return per ton of additional *good* hay eaten was at £2 13s. a ton—less than it would have cost to make it. Actually, the best policy would be to make the best hay that one could—most farmers do this—ration it to the animals and sell the balance.



Strip-grazed pasture at Badgery's Creek. The pasture is perennial ryegrass and white clover.



Constructing a five-and-a-half million gallon dam across the lower reaches of a valley at the McGarvie Smith Animal Husbandry Farm.

Or take that work which has shown that the carrying capacity of typical merino country can be raised from one sheep to the acre to $3\frac{1}{2}$ sheep to the acre with phalaris and sub-clover. That seems to be quite sound and economical. However, a great wastage of feed occurs on the improved pasture in spring. If one goes a stage further and conserves all surplus feed for feeding out later on, the carrying capacity can be pushed up to 7 sheep to the acre—an exciting possibility surely, but on present figures it is not profitable to carry the development through to the final stage.

May I suggest that there is need for much more research to be carried through to farm scale. We have been fortunate in being able to devote an entire farm to our project. Now that our headquarters and most of our teaching have been transferred to Camden the Badgery's Creek property can be devoted exclusively to the project on a farm scale.

We set out in 1952 to find out whether it was possible to store farm run-off at a figure that would be economic for irrigation. At that time we were quite prepared to find that it would be prohibitively expensive. We shared the then prevalent beliefs that the only economic way to get irrigation water was by means of a public scheme and that water, once pumped, automatically became too dear for any other purpose than for stock and domestic purposes. We also were afraid that evaporation would take excessive toll of any stored water. This is probably a fair summary of the prevalent attitude towards farm water conservation in 1952.

We were not the first by any means to store water in farm dams for irrigation. It was certainly done in Biblical days, judging by an injunction in the Bible against letting a dam break through and damaging a neighbour's property. Ceylon had an elaborate water harvesting scheme by the twelfth century. The first dam built in Australia with a retaining wall—on Major-General Macarthur Onslow's property at Mt. Gilead—was intended for irrigation purposes.

There has been nothing new in what we did to conserve water. Our contribution, if any, has been to focus attention on the principles of economic storage—which are obvious enough in all conscience (engineers must have always been aware of them) and to try to work out the economics of using farm-stored water.

Some of the questions we are asked remind me of that passage in "As You Like It" where Rosalind inquires from Celia concerning Orlando. She asks ten questions in a row and then without pausing for breath, says, "Answer me in one word".

If I were to summarise our work at Badgery's Creek over the past eight years I could do so—not in one word—but in one sentence: "What can a farmer afford to spend on getting irrigation water by collecting supplies from his own farm?"

There has been much criticism of our unwillingness to answer that question right at the outset. But that is the most difficult question of all. The answer will certainly run into more than one word. Further, the complete answer hinges upon the productivity attainable, the measurement of which has been our main aim.

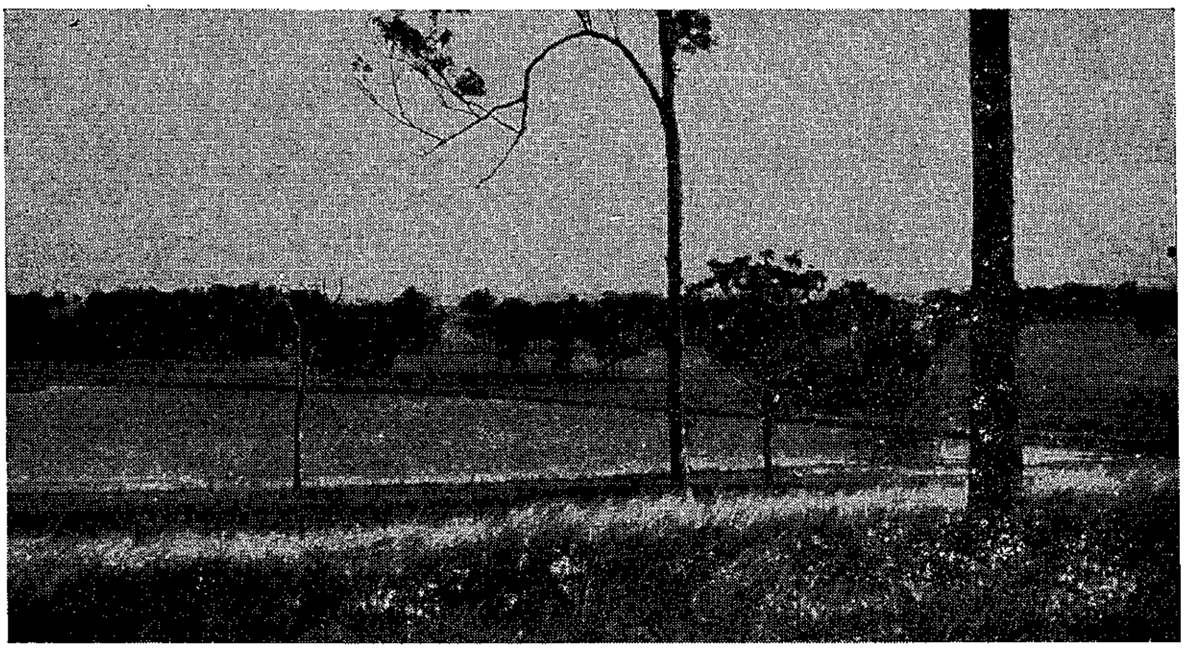
The first phase of our work was straightforward. It was not difficult to decide what constituted the principles of economic conservation, to work out the cost of conserving the water and to allow for the effect of several variables upon the cost. Nor was it much more difficult to arrive at the costs of spray irrigation with farm conserved water.

We encountered our first substantial difficulty in trying to decide how much we could afford to spend on water. The rates charged for water on public schemes were of little value as a guide. The sharp rise in land values when the irrigation channels reach a district was a clear indication that irrigators considered water was worth more than the rate charged for it. Furthermore, the circumstances were quite different from those that prevailed in a normal flood irrigation district.

It was clear, however, that the allowable expenditure on water was likely to be largely determined by the return obtained from it. No one could tell what that would be.

In a sense the water harvesting project has drawn attention to the great ignorance

Contour drains increase the catchment area of dams. These drains are built to the critical grade of 1 in 200 at which neither siltation nor erosion occurs. The lower drain in the picture was constructed in 1944 and to date (1960) has required no maintenance.



A 40,000,000 gallon dam which paid for its construction and the irrigation plant through savings in concentrate purchases in the first year.

that prevails on many of the economic aspects of farming. For example, we have had many sheepmen visit Badgery's Creek. They are not interested in dairy-farming. They want to know whether they could use water harvesting in their industry. Has it any place in fighting drought? Could it be used effectively to build up drought reserves? Or is it better to cope with drought as so many try to do—with a financial reserve instead of feed? An obvious starting point is to ask: What does drought cost you? How many can answer that question fully, taking into account the full ramifications of drought, in addition to their drought feed bill?

Or, a question for the beef-raiser: How much of your gross returns can you afford to spend on feed? What proportion of the milk cheque can a dairy-farmer in the Milk Zone spend on feed and still stay in business?

These are surely practical questions. The answers are of great importance financially. But how many can give a direct and dependable answer, supported by a convincing financial analysis?

We should have been able to complete the water harvesting project in a few years. It should have been possible to set out the costs of conservation and someone should have been able to say where the dividing line lay.

Apart from the cost of water, no one seemed to have any firm, acceptable evidence on whether spray irrigation of pasture was profitable. The only evidence was in the nature of opinions, without any supporting evidence and invariably of a negative kind.

So we were driven into a study of the economics of irrigation in general. It was the only way to find out what water was worth. And then, before we could get anywhere near an answer we had to discover what water could do.

The simplest overall test of the system, it has often been said, would be run a farm on a water harvesting basis and make a profit. We have done that, but I am not sure that such a method yields information with a wide application. Later on in this address I shall attempt to express the economics of the system in more general terms.

It is pertinent, in view of the controversy that has surrounded the project to set out what has been achieved to date.

The work has given a simple measure of the economy of farm storage, namely, the storage-excavation ratio—the number of cubic yards of water stored for each cubic yard of soil moved. It was no great intellectual feat, but it has stimulated many farmers to look anew at their farms and work out for themselves the probable cost of storing run-off for irrigation. The measure also provides a ready means of comparing the cost of farm-stored water and that of supplies from public schemes.

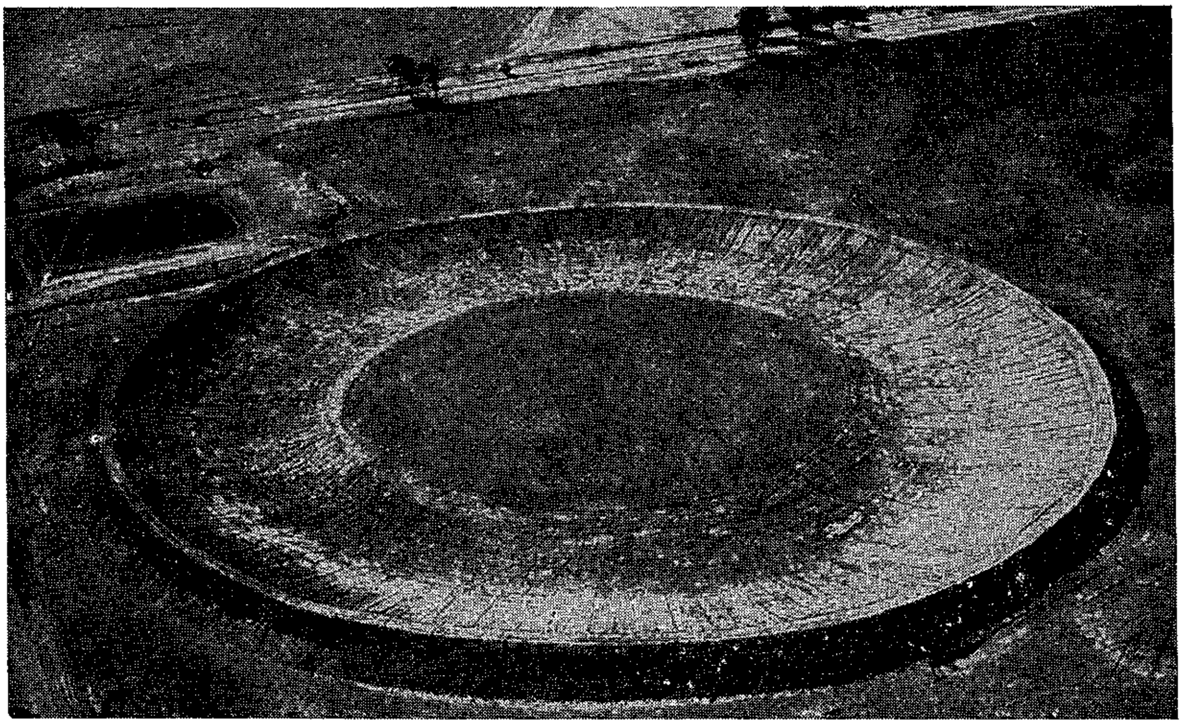
The project does suggest that evaporative losses are less serious than many imagine—for several reasons:

1. Evaporative figures do not usually take into account the direct replenishment by rain falling on the surface of the dam. When the rainfall is subtracted from the evaporation at Badgery's Creek the net loss is reduced from 43 to 17 inches a year.

2. The manner of use ensures that a high percentage of the vulnerable water—the shallow water—is used up before evaporation can take heavy toll of it. The shallow water is used up first. It is also the cheaply stored water.

3. There is surely a strategy of water use. If there be a staircase of dams in a valley the rational policy is to use up the lowest first. If a rain then falls the empty dam gets the benefit from the entire catchment above it. On the other hand, if the top dam be used first and a rain then arrives, the top dam traps the run-off from its own catchment only; that from the lower catchments runs to waste.

Roads are often good sources of water for filling dams. The illustration shows a table-drain discharging water into a culvert which feeds a roadside dam at Badgery's Creek.



A 26,000,000-gallon turkey nest dam on a farm in Western Australia. The turkey nest proved an economic system of storing water on flat country. Doubling the size of a turkey nest dam cuts the storage cost per acre-foot in half.

4. There would appear to be appropriate policies of water use in both the summer and winter rainfall areas. In the summer rainfall areas the chief problem is a dry autumn, winter and spring. On the other hand, dams are most likely to be replenished in summer. The most vulnerable water, the shallow water, would be used up almost straight after replenishment if the autumn were dry. Winter evaporative losses are low so that a high proportion of the stored water would be available for spring use. If the autumn were wet there would be no need to use any of the stored water and any evaporative losses would be replenished.

In the winter rainfall regions the dams are most likely to be replenished in winter. At first glance the prospects are not inviting, but the answer may be in using stored water on subterranean clover, the shallow water being used up shortly after replenishment in order to prolong spring growth, a certain quantity being sacrificed to evaporation during summer, and the remaining deeper water being used to start off part of the subterranean clover at an early date so that the pasture can give good winter feed. In the district of Katanning in Western Australia, where the evaporation is 66 inches a year, the indications were that such a policy, together with the use of cetyl alcohol, could cut the net sacrifice to evaporation to 17 inches a year.

The water harvesting project has drawn attention to the surprisingly low cost of low lift pumping. When the turkey nest system of storing water on flat country was being developed it was found that an acre-foot of water could be lifted a foot in height for less than a shilling. This figure has an extensive application. Under certain circumstances it could greatly increase the area that could be commanded by flood irrigation—sometimes a lift of a few feet is all that is necessary to serve a large area.

Another by-product of the work has been the demonstration of how much water can be saved in farm dams and especially by using storm-water creeks. The creek from which we fill the 8,500,000-gallon turkey nest is so insignificant that a man could straddle it. The creek is so unimportant that no one has even given it a name. It drains 735 acres of neighbouring farm land. It runs only in very heavy rains and stops within a few hours of the cessation of the storm. It seldom runs for more than three or four days a year. The quantity of water required to fill the turkey nest is equal to a run-off of $1\frac{1}{2}$ per cent. of the rainfall from that creek's catchment. If Abbott's figure is correct, that the area has a 39 per cent. run-off, that tiny creek could fill 26 turkey nests like ours—enough to irrigate an area half as large again as the entire farm.

Finally, the water harvesting system is operating profitably on numerous town supply farms. On one property, well run by orthodox standards, the improvement was more than sufficient to pay for the entire capital cost of a 40,000,000-gallon dam and the irrigation plant in the first season.

The Use of Farm-Stored Water

Farm-stored water makes irrigation possible, but the circumstances differ from those in a normal irrigation district where holdings are small, the enterprise is completely dependent on irrigation, water supplies are virtually unrestricted, and water is cheap.

By contrast, the water harvester is likely to have a larger holding, his main enterprise is usually independent of irrigation, he has only limited water supplies and water is likely to be somewhat more costly.

The regular irrigator's ultimate limiting factor is the area of his holding. The maximum return is likely to be obtained when he aims at a high return per acre.

On the other hand, the water harvester's best criterion is probably the return per acre-foot of water. For that reason it may be better business to use the water on one area in summer and on another in the winter. Return per acre may be a poor criterion in such circumstances.

It is doubtful if the usual distinction between full-scale and supplementary irrigation has any genuine meaning. We are certainly not engaged in supplementary irrigation despite Burton's assertion in the Water Research Foundation Bulletin. The concept of supplementary irrigation is an attractive one on paper—the landowner waters occasionally to patch up deficiencies in the rainfall. In practice, such a system is likely to be costly in relation to the returns and there is always the temptation (not always resisted) to wait too late or put on too little.

Our basic problem has been to determine the role of irrigation in a livestock economy. The advantages in a town milk supply system arise from the high cost of alternative feeds, the need to keep up a high level of feeding throughout the year, and the fact that a high proportion of feed produced can go into immediate use—there is less need to indulge in the wasteful, costly system of fodder conservation.

Perhaps I should explain that phrase. Sears in New Zealand showed that roughly half the nourishment in a crop at the instant of mowing was lost by the time that conserved feed was digested by the animal. To this loss must be added the high cost of feeding-out; silage, for example, is more costly to feed out than to make. Fresh feed. harvested by the grazing animal, is much cheaper than stored feed.

The first irrigated pastures at Badgery's Creek consisted of ryegrass and various clovers. They gave good feed in the spring and summer but were disappointing in the winter. The overall position was certainly better than the previous state of affairs and we could quite well have settled for a system of storing the spring surplus as hay and feeding it along with bought concentrates in winter.

However, the ryegrass did not survive beyond the first year and we finished up with swards of white clover—valuable, but treacherous feed.

At this stage Crofts came into the picture. His first move was to measure the rate of feed production throughout the year of the ryegrass-clover combination. His figures confirmed the dearth of winter feed and he suggested we should set as our goal the provision of year-round grazing.

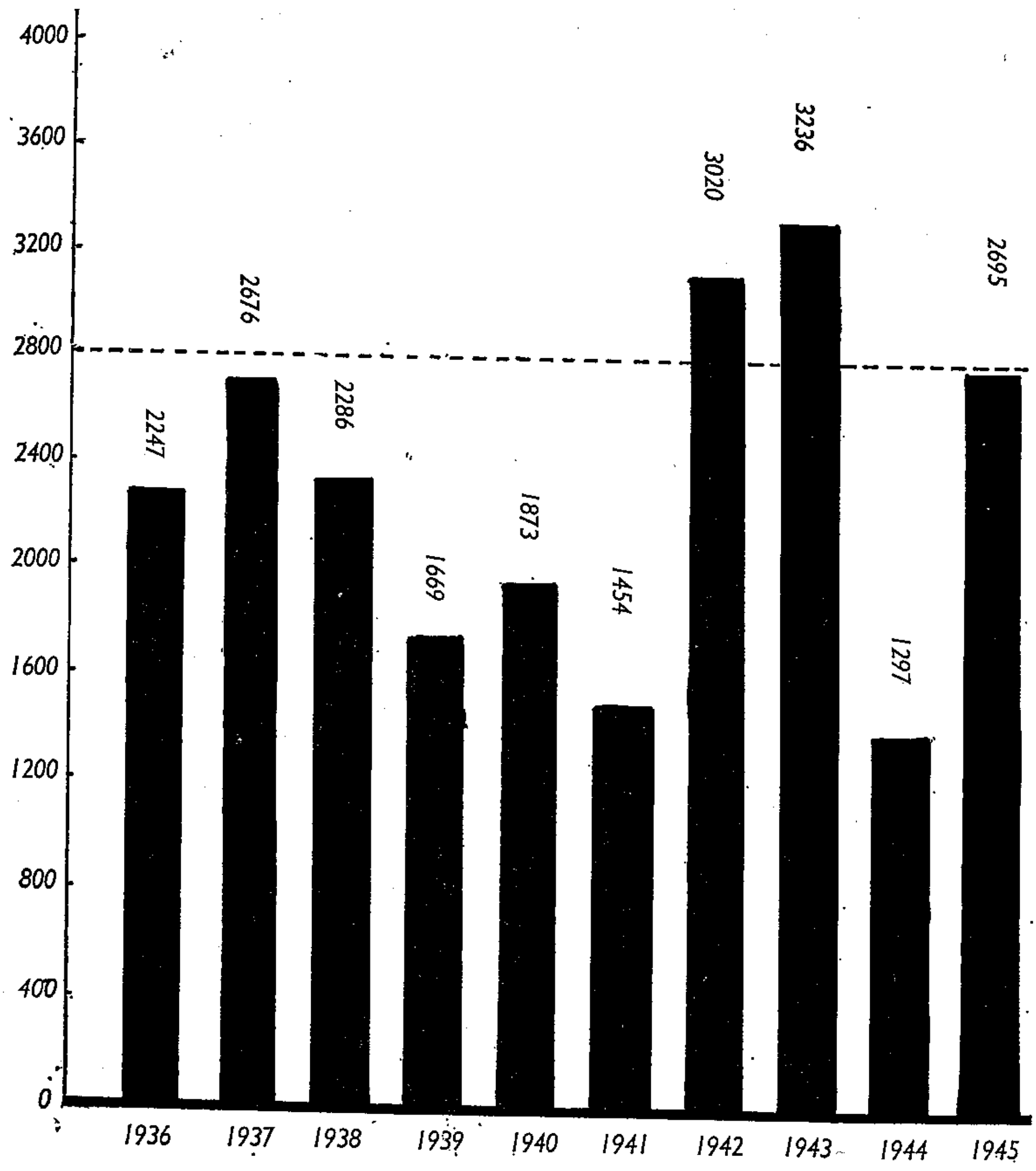
Time prevents a full description of his work which is now reaching the stage where the goal is well in sight.

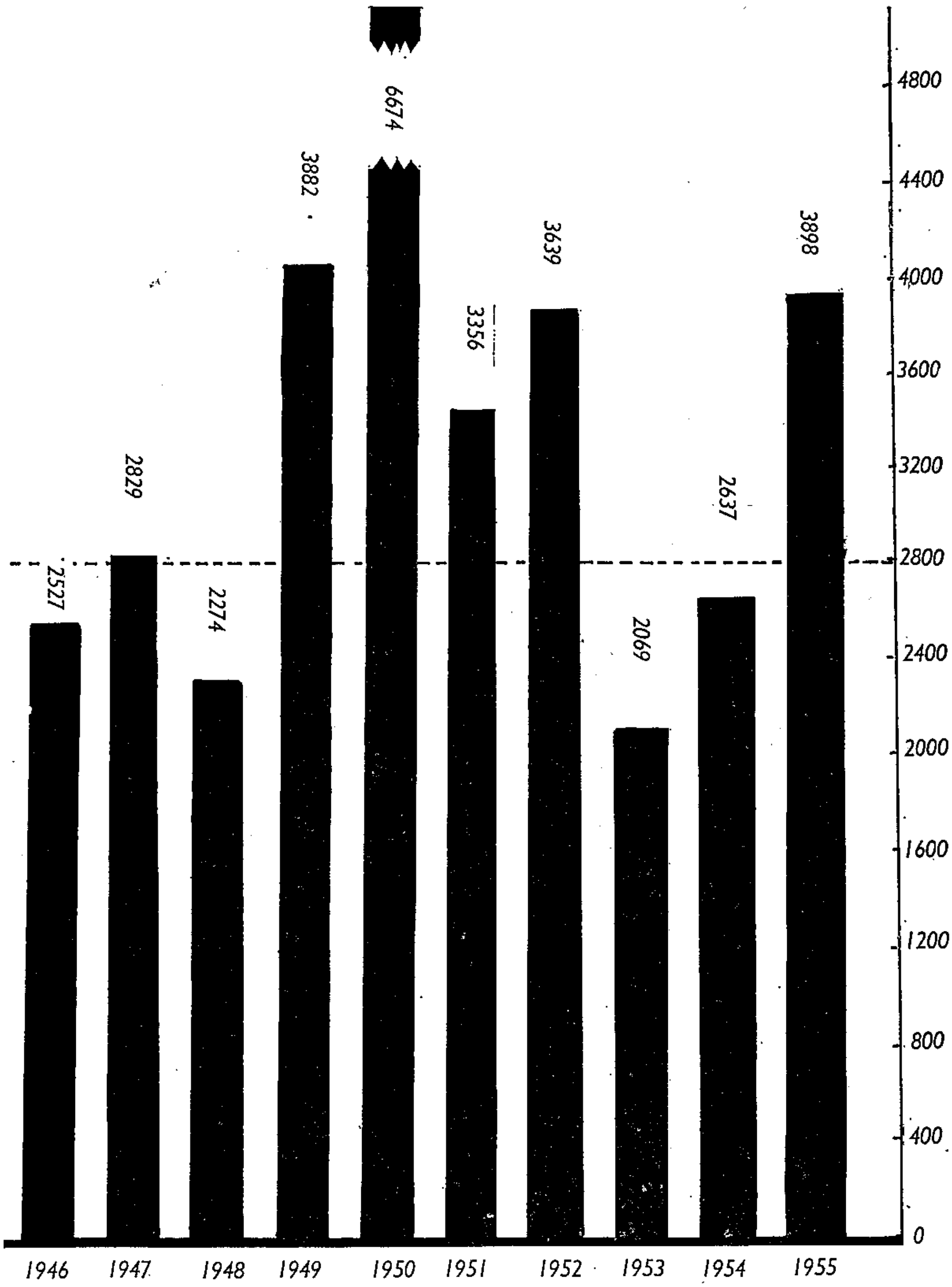
Crofts tried out every possible species as a winter feed producer and found oats were outstanding. But we did not want to uproot good clover swards to grow a crop and then have a bare paddock on our hands in the spring. His answer to this problem was the sod-seeder which allows oats to be sown in a clover sward without destroying the clover and leaves a clover sward to carry on when the last grazing or hay has been taken off the oats in the spring. But sod-seeding oats in any sward can be disappointing unless the soil is rich in nitrogen. Crofts has shown that nitrogen fertilisers can be economically used to give substantial yields.

Other factors necessary for success are to use much heavier seedings than usual—we use 4 bushels now and get twice as much feed as from 2 bushels—to plant in damp ground (we irrigate beforehand if the soil is dry), to remove any competitive growth by severe grazing or mowing and to start planting in the tail end of February.

Oats sod-seeded into clover with nitrogen can carry a cow in milk to the acre from April to the spring. Crofts has come to light with an interesting relationship; we can expect to obtain a pound of milk for each pound of dry matter that the oat-clover combination produces. The first oat paddock to be grazed this winter on one of the

Fig. 2.—Variation in annual rainfall on McGarvie Smith Animal Husbandry Farm, Badgery's Creek.





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Camden Farms carried a ton of dry matter to the acre—equal to about five tons of greenstuff—and produced a ton of milk to the acre at the first grazing. The second grazing has given slightly more; a third is coming away now.

Such relationships are extremely valuable. I wonder how long it will be before agrostologists can furnish us with a similar figure for pasture? It would greatly shorten our task if we could as readily convert pasture yields to meat, wool or milk.

Crofts has adopted paspalum and white clover as the most productive summer pasture to date. Paspalum has a high potential for growth in the heat but deteriorates rapidly as feed if allowed to grow tall; it also shades out the white clover. During the past summer this combination carried 80 cows in milk on 35 acres for several months on end without any hand feeding of any kind. The procedure was to strip graze every nine or ten days, to allow a strip big enough to avoid the necessity for the cows having to graze the pasture bare, to mow and water immediately after grazing.

We aim to dispense with fodder conservation, except to avoid the wastage of feed—if we have a surplus we conserve it. We hope to dispense altogether with hand-feeding even the feeding of hay or silage except for emergency purposes. We feel we shall have reached the zenith of our development when we conserve feed only to dispose of a surplus that would otherwise go to waste and when we call on such conserved feed only to cope with an emergency. We expect to produce our regular feed requirements "off the ground" the whole year round.

One consequence of the Crofts system is that we do not have such great surpluses of feed as formerly. Now that we know the rates of growth of the different pastures at different times of the year—under irrigation—it is possible to trim the acreage irrigated to actual needs and in that way conserve our main reserve, which is water.

Crofts' work has led to a remarkable improvement in the economy of water use. We have surveyed previous rainfall records with a view to determining how much water we are likely to need, taking as our criterion the worst summer and the worst winter in the past 20 years. The indications are that 16 million gallons will see us through the worst summer and six million gallons through the worst winter—a total of 22 million gallons if we experienced a bad winter and bad summer in the one year (a most unlikely happening).

When the 1956-58 drought began we had 200 acres under irrigation during the first summer and we were milking 60 cows. The indications are that we can now look after such a herd in another summer with only 30 acres. The effect on water economy is obvious.

On present figures we can reckon on being able to milk two cows to the acre in summer and one to the acre in winter. This means that in order to provide for a steady level of feeding throughout the year, the area of winter pastures (oats in clover) should be twice the area of summer pasture.

Several advantages flow from this arrangement. In summer the permissible spacing between waterings is about eight days. In winter waterings can be twice as far apart.

In summer when the waterings must follow in quick succession the area to be watered is small and the job is manageable. In winter when the pace of watering is reduced a larger area is needed to feed the herd and its irrigation can be handled without any greater stress.

The system also leads to more efficient use of irrigation plant. Apart from the extra sub-mains or underground mains the sprayline that serves the summer pasture can equally well handle a larger area in winter, in that the number of spraylines is decided by the area to be done and the time available.

Let us now turn to the basic question: "Does it pay?"

It is perhaps, easier to indicate where irrigation will not pay. I doubt, for example, if it is wise to advocate irrigation as a drought relief measure.

Any form of irrigation involves a fairly substantial outlay. Irrigation that is used only occasionally is likely to be extremely costly. Furthermore, those who install plant for occasional use are inclined to leave watering until it is too late and to put on too little when they do water.

The main role of irrigation is to provide a means of substantially increasing production or cutting costs. In the Kempsey district, for example, one dairy farm had an output that fluctuated around 8,000 lb. commercial butter before the installation of an irrigation plant. Irrigation increased and stabilised production at 18,000 lb. commercial butter. On the North Coast the output of a farm oscillated between 15,000 lb. and 25,000 lb. butter per annum with an average of about 20,000 lb. Irrigation increased production and held it at 30,000 lb. a year. It is suggested that these properties made much more effective use of irrigation than those who installed plants for use in the occasional dry season.

On general principles it would seem that the opportunities for economic irrigation are greatest where:

(1) A high return per acre is obtainable.

(2) Production per acre without irrigation is low.

(3) Irrigation is likely to be of value in most years.

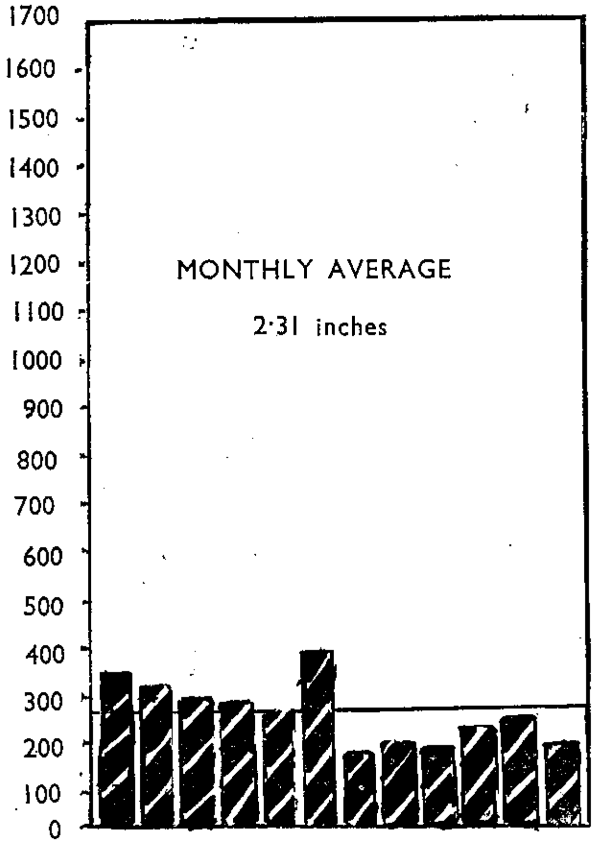
Any form of irrigation involves a substantial increase in operating costs over the natural state. But costs represent only part of the story. High costs can be justified if the increase in productivity is sufficient. An important advantage of irrigation is the stabilising effect on yields. That need not guarantee stable returns—there are still prices to be taken into account—but it is at least a flying start.

The higher returns obtainable from dairy cattle make it easier to show a margin of profit from dairy cattle than from beef cattle.

The scope for irrigation is greatest where the existing level of production is low. Land that is already highly productive because of a favourable combination of rainfall and fertility offers less attractive possibilities. In the Waikato in New Zealand, for example, irrigation increased pasture yield by only 20 per cent.—not enough some say, to warrant the cost. On the other hand, no one questions the value of irrigation in the town milk supply areas of New Zealand.

A high and reliable rainfall dispenses with the need for irrigation. There is now available a method of surveying rainfall records in order to assess the irrigation need in a whole series of years.

Such surveys should be undertaken before opinions are passed on whether irrigation can be of any value in a district. A high average rainfall does not in itself rule out the possibility of a substantial response; rainfall distribution is often more important than the total amount. We have had six months of drought in a year when we registered 52 inches of rain.



Monthly average rainfall on McGarvie Smith Animal Husbandry Farm, 1936-1953.

The usual criticism has been that the University work is being done in a town milk supply economy and that it has no application outside that industry. The greater facilities we now possess for experimentation with other animals will allow us to extend the work.

The town milk industry can make more effective use of irrigated feed because of the need for a high year-round level of feeding.

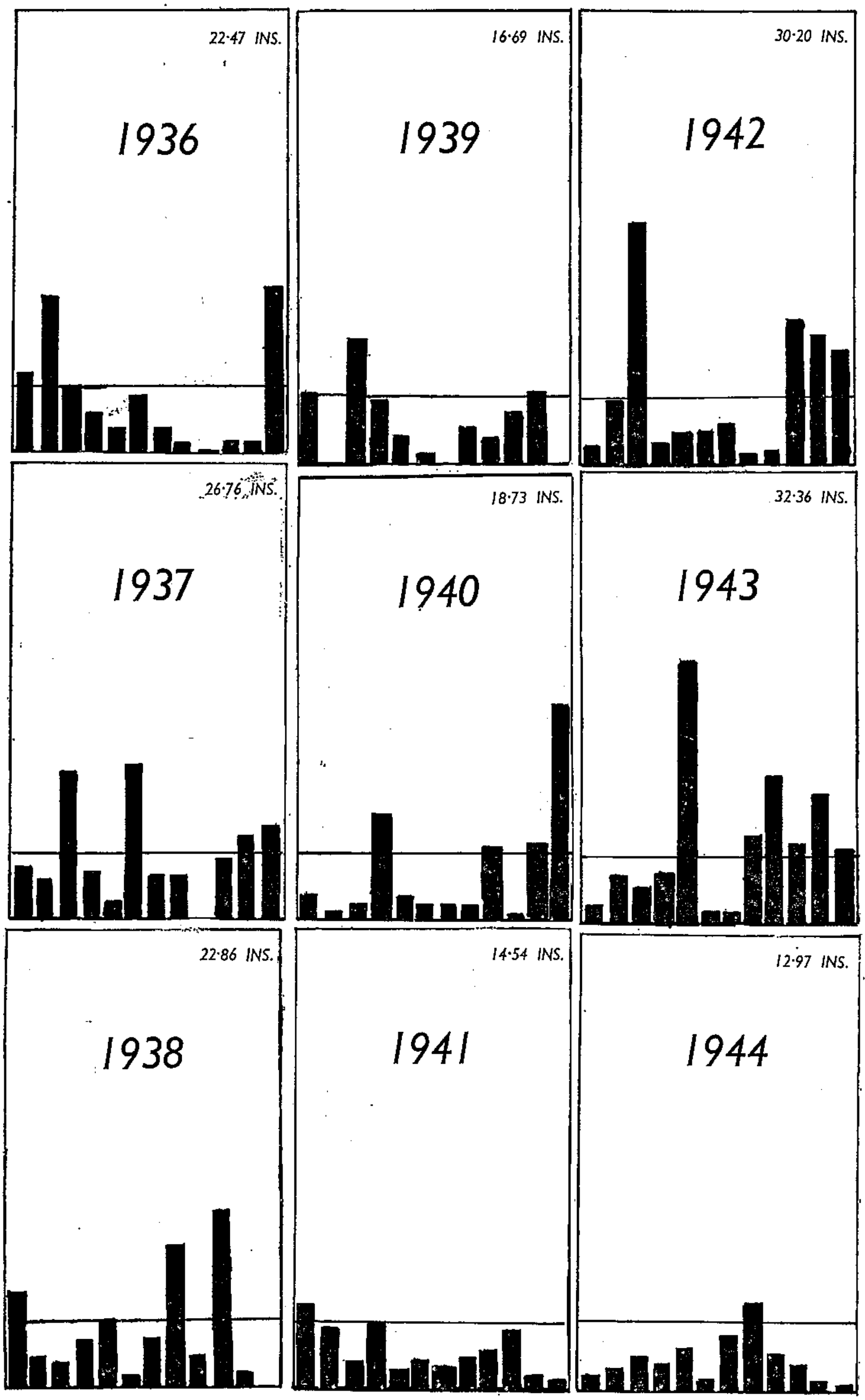
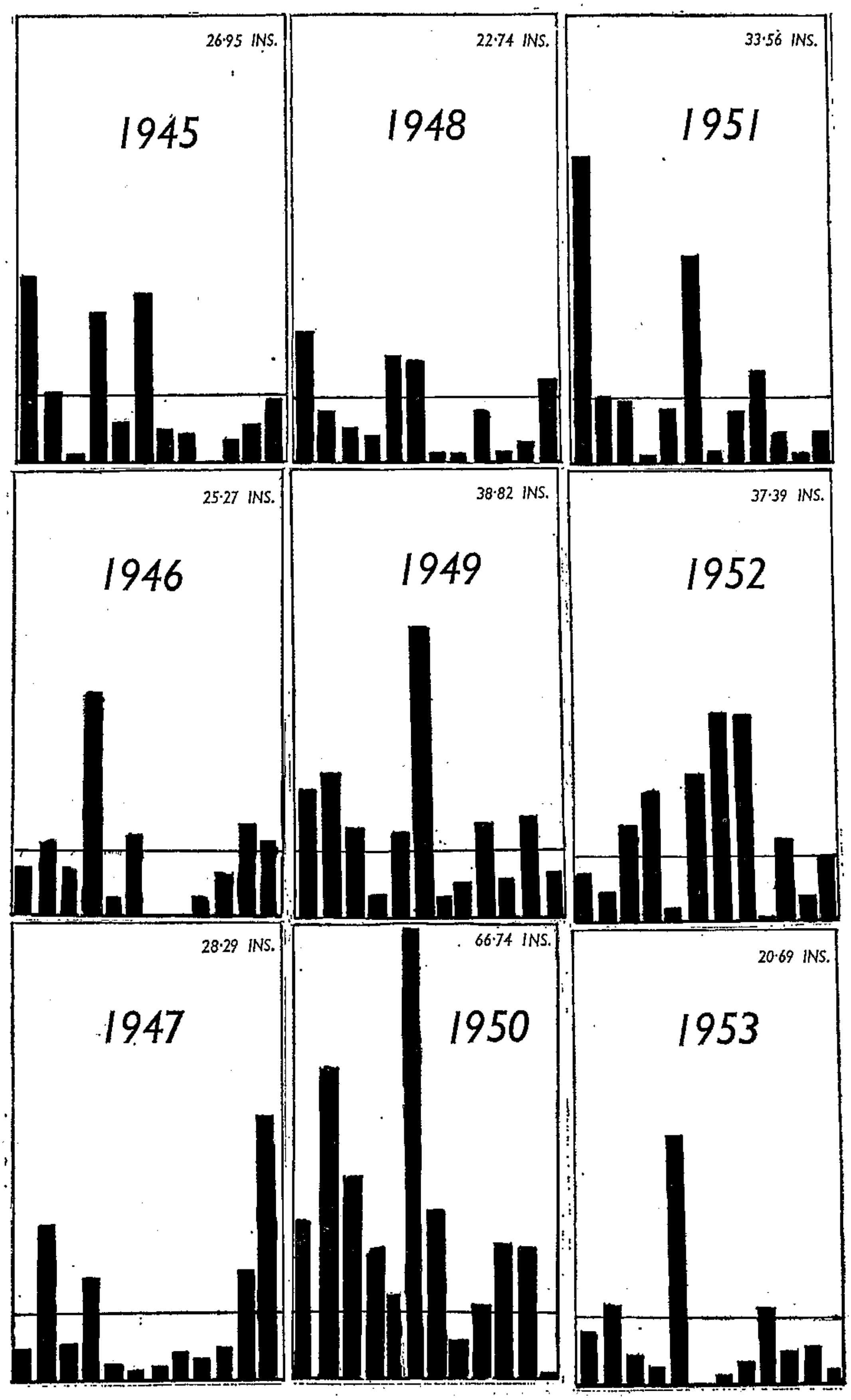


Fig. 3.—Variations in rainfall pattern from year to year.


26·95 INS.
1945
22·74 INS.
1948
33·56 INS.
1951
25·27 INS.
1946
38·82 INS.
1949
37·39 INS.
1952
28·29 INS.
1947
66·74 INS.
1950
20·69 INS.
1953

That need does not exist with other animals and there may be less opportunity with them to cash in, for example, on the ability to produce a large bulk of high quality winter grazing.

I mentioned earlier the possibility of another method of assessing the economics of irrigation.

I have long thought that the pattern of farm costs may be sufficiently fixed to allow us to determine with reasonable accuracy what percentage of his income a farmer could afford to spend on feed.

Livestock raisers may obtain feed from several sources:—

1. By grazing.
2. By growing feed.
3. By purchase.

Some get their feed from one source only. Others get it from all three.

The chief cost of grazing is the interest on capital tied up in pasture land.

The cost of grown feed includes all the costs of growing it—labour, seed, fertilisers, tractor costs, etc.

The cost of purchased feed needs no explanation.

Let our definition of "cost of feed" include all these items.

After careful study of our own costs I decided that if I could hold the cost of feed down to 50 per cent we could stay in business and make a reasonable level of profit.

That relationship appears to hold in both the butter and town milk industries.

Cornell University costings of the New York milkshed a few years ago, when producers were making profits, showed that their total expenditure on feed was 47 per cent of their income. Last year a similar survey showed that producers were losing money and that their expenditure on feed from all sources was 51 per cent.

A rough analysis of the Bureau of Economics figures on the wool industry in the pastoral areas of South Australia indicates that expenditure on feed was 49.5 per cent of revenue when reasonable profits were being earned.

An inquiry directed to the New Zealand Meat and Wool Board's Economic Service, which keeps close tab on cost changes, has brought back the reply that they consider that expenditure on feed could be allowed to rise as high as 60 per cent of revenue without eliminating profits.

It may seem a far cry from the dairy industry to the poultry industry, but in a recent survey of the latter industry in Victoria it appears that the dividing line for feed costs in egg production is also about 50 per cent of revenue.

If my general thesis is correct, that the cost structure of the animal industries is sufficiently fixed to allow the definition of a threshold value for feed costs, then the way is open for us to predict the required level of production for profitable operation.

It can be shown that the total costs of spray irrigation under conditions of little or no static head are roughly about £14 an acre. This, of course, represents the cost of irrigated feed. Doubling that figure will give us the necessary increase in return over the non-irrigated state for profitable operation. We would need to obtain roughly £28 to £30 worth of extra animal products to the acre.

If we value city milk at 3s. 4d. a gallon, butter at 4s. 3d. a lb., beef at 2s. 6d. a lb. carcase weight, we need to increase production by 180 gallons of milk to the acre, 141 lb. butter to the acre, and by 240 lb. carcase beef to the acre to make good business of spray irrigation of pastures.

This could give us also an answer to our central question: "What can a farmer spend on getting water?"

If the increase in production exceeds the target, the value of that surplus represents what water is worth.

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