# PART III

# THE ECONOMIC IMPACT OF WATER SHORTAGE

CHAPTER 9

# THE COST OF THE DROUGHT: DEFINITION AND INITIAL ESTIMATES

The essence of drought is the potential shortage of water engendered by interaction between a climatic event and the adequacy of the safe yield of a system in relation to the level of demand. There are, as we have noted, a variety of courses open to the system manager in the face of such a potential shortage: Broadly, he may move to restrict demand or to increase available supplies; or he may choose to combine measures from both areas. Whatever course he selects will imply some cost to the community at large. This section and the next two attempt to appraise the cost of drought in relation to the size of the potential shortage faced by the town. They are based on data collected in Braintree, Fitchburg, and Pittsfield as part of the overall study.[1] It is obvious that, as our results rest essentially on data from only three towns, they should be viewed as indicators of orders of magnitude rather than as "hard" bases for actual planning.

Two interesting questions have, of necessity, been ignored in this study. First, one would like to know more about the relation between the mix of adjustments to shortage chosen by the manager and the resulting size and distribution of drought losses. That the distribution of losses between sectors will be affected by the choice of adjustments is clear enough. It

[1] In what follows, "costs" and "losses" and "costs and losses" will often be used interchangeably in referring to the economic penalties paid in connection with the drought. It is realized that the two words have some definite differences in meaning and even more pronounced differences in connotation. We shall attempt to use "costs" where business expenses, equipment purchases, etc., are at stake, and "losses" where physical destruction, production cutbacks, or administrative prohibitions are involved. The reader should, however, be prepared to read both words where one appears and the general study is being discussed; this might be thought of as the price of tedium avoided.

seems that the size of losses will, in general, also be sensitive to this choice because of differences between the sectors in the ability to react. Second, it would be interesting to know if the distribution of losses between sectors varied with the size of shortages in a regular way. (Some comments on this matter are included below, but we have assumed in making use of our data in a planning model that this variation may be ignored.) Neither of these questions could be explored owing to lack of money and manpower for data collection, for a large increase in the number of towns studied intensively would have been necessary to produce enough independent variation in the variables of interest.

The bulk of our data is drawn from interviews with water system managers and executives of individual firms in the industrial and commercial sectors. These were supplemented by interviews with other municipal officials and miscellaneous private-sector persons with special knowledge. (Losses from domestic sprinkling restrictions were estimated quite outside the data-gathering framework, using published demand function estimates.[2]) The largest part of the information gathered in the interviews is considered to be of high quality, but with the commercial sector results being distinctly weaker than those for the industrial and municipal sectors. Data on specific industrial actions and their costs are particularly strong; those on water use before and after the drought somewhat weaker. The remainder of this chapter, then, is devoted to defining, producing, and correcting the estimates of economic losses attributable to the drought.[3] First, we set out to clear up some fundamental conceptual questions concerning the existence and definition of drought losses. Next, we produce gross estimates of total losses for the 3 towns differing from the raw data essentially only by corrections for double counting. These figures may be thought of as slightly modified measures of drought impact as it is perceived by local economic actors. These results are presented as the industrial, commercial, municipal, and domestic sector totals, and also as the costs of adjustments designed either to increase supply or to restrict use.[4]

[2] Charles W. Howe and F. P. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," *Water Resources Research*, I (1965), 13–32 and Appendix E.

[3] The methods used in this study are related to the previous work of Kates, particularly that reported in *Industrial Flood Losses: Damage Estimation in the Lehigh Valley*, Department of Geography Research Paper No. 98 (Chicago: University of Chicago, 1965). That discussion of the nature and measurement of losses from interrupted production seems applicable to drought as well. The use of value added as a surrogate in the measurement of production losses is shown in Appendix A to be not only the most readily available but also the proper conceptual measure.

[4] The losses and costs turned up in our interviews were incurred, virtually without exception, during the period summer 1965 through summer 1966. We assume that these losses may, in fact, be identified with a single period of 12 months. We admit that other

Such gross figures are, however, economically misleading since they fail to take account of several potentially important aspects of the problem. Most important, the gross estimates do not reflect the investment aspect of many of the actions taken by businessmen. That is, inclusion of simply the capital cost of a water-use adjustment with a long life (for example, a cooling-water recirculation tower expected to last 30 years) ignores the implied future stream of benefits, positive or negative, resulting from the project's impact on future water costs. In addition, in order to make use of loss estimates in discussion of policy, it is necessary to be clear about which group is suffering. That is, we must adopt explicitly an accounting stance which proclaims that we are looking at things from a local, regional, or national point of view. Closely related to the stance we choose is the extent to which interrupted sales and production can be assumed to be eliminated from losses by deferral in time or transfer in space. For example, lost production at a local paper mill may be made up through use of otherwise slack facilities in another region. From the national point of view only a nominal loss is involved, though the local and regional accounts still record the full loss. Again, a local store may claim large sales losses on account of the drought, but these may represent only postponed sales and thus should not count in full as losses even in the local accounts. Both these matters are taken up in Chapter 10. There also are presented the fully corrected accounts for four combinations of discount rate, stance, and deferral assumptions, representing, we believe, the points of view of decision makers at various levels. Finally, Chapter 10 deals with adjustment of the several sets of data to eliminate self-supplied water users.

## DROUGHT COSTS AND LOSSES: PRINCIPLES AND PROBLEMS

Before we become involved with estimation techniques and actual numbers, it will be worth while to discuss some of the difficulties lurking behind the innocent question, "How much did the drought cost?" First, of course, we must specify the question more carefully by asking how much the drought cost *whom*? Clearly the resort owner on Cape Cod who had record business during the dry summers has a different view of the cost of the drought than does the lumber company in Pittsfield which believes it lost

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losses were almost certainly incurred in the early drought years, but we assume that these were not measured in our detailed study.

At certain points, as in the measurement of lost municipal revenues, we depart from our study data and have sufficient alternative information to estimate drought costs for any year in the 1963–66 period. In these instances we single out for inclusion the results for 1965 in Pittsfield and 1966 in Braintree and Fitchburg to reflect the earlier beginning and peaking of the drought in the West. We thus aim to maintain the figures on as close to an annual basis as possible.

a significant volume of timber growth on its woodlands. Similarly, the business in Fitchburg which lost orders because of a forced shutdown during the lowest river flows reckons a loss where the company in another state which picked up those orders sees a gain. If we agree, for example, that we are interested in how much the drought cost the people of Massachusetts, we would certainly have to net out the gains of the resort owner, but we would ignore the gains accruing to the out-of-state firm which benefited from the shutdown of production activity in Fitchburg.

However, even given a choice of "whom," not all our questions would be so easy to answer. Consider the possibility that production orders lost by one Massachusetts firm are made up by another within the state. What is the loss attributable to the drought? As we show below in Chapter 10, the answer to this question depends on the extent to which idle resources are available at the second firm; if otherwise idle resources are put to work making up the "lost" production, the loss from the state's point of view is very small. Another difficulty arises because some of the costs of the drought take the form of payments to specialized firms (such as well-drillers) for services rendered. Again, if reasonable resource mobility and full employment may be assumed, the increased activity (employment and production) of these firms can be said to represent a reduction in other forms of activity which society would, in the absence of the drought, have preferred to purchase. This activity then is a loss for society. If, on the other hand, the resources devoted to these activities would otherwise have been idle (e.g., the capital and labor inputs specialized to well-drilling), the extent of loss will be significantly smaller than the amount of activity called out by the drought.

Returning to the original question, we may note another difficulty: the reference point against which the costs are to be measured is not well specified. Thus, for example, do we mean to compare the drought period with a period of average precipitation or with one in which precipitation was slightly above or slightly below average. Surely our estimates of cost will be sensitive to this choice of zero point, but just as surely there is no particular reason for choosing one of these alternatives over the others. The information that the drought represented a loss for the people of Massachusetts of $X$ million dollars compared with a similar period in which the long-term mean precipitation fell in each year would be of no particular use to anybody.[5] It is simply not now an alternative to replace drought periods with periods of average rainfall; though such a possibility may, in the future, exist. The choice of a reference point is, then, related

[5] It might serve as a talking point in state efforts to obtain federal relief funds.

to the alternatives being considered for improving the situation (the contemplated "adjustments"). In our example, it might be reasonable to ask about the losses compared with a situation in which 10 percent more precipitation had fallen each year.[6] But we are interested in municipal water systems, and hence our reference point becomes one of zero shortage for each system being studied. In other words, we ask, in effect, how much the drought cost the people of Massachusetts compared with a situation in which no municipal water system suffered shortage.[7] In this context, of course, the losses and gains of farmers, lumbermen, and resort owners are irrelevant except as they trace to municipal water-system performance.[8]

## DESCRIPTION AND MEASUREMENT OF LOSSES FROM WATER SHORTAGE

In the evaluation of investment projects, a widely accepted criterion involves the present value of the stream of annual net efficiency benefits each project is expected to produce.[9] Net annual benefits are defined as gross efficiency benefits (e.g., total willingness to pay for project output) less the costs incurred in producing the annual output. It seems, therefore, reasonable to define water-shortage losses in broadest terms as gross annual benefits lost by disappointed users less costs avoided by the supplier. (Note that the user may also be the supplier, in which case, clearly, he loses gross benefits *and* avoids some costs.) In order that our measure of loss may have social significance, we must be careful to look at matters from a social rather than only a firm or household point of view.

An example of the application of this rule should make matters clearer. Consider first the problem of measuring the losses from lawn-sprinkling restrictions. Assume for simplicity that in normal periods only price is used to ration sprinkling water, but that as the result of drought, no sprinkling at all is permitted. If the system's (annual) demand curve for sprinkling water is $DD$ in Figure 18, then at price $P_o$ (domestic block rate), $w_o$ gallons per year will be demanded for lawn watering. Now, the total annual

[6] A 10 percent increase in precipitation is the figure most often quoted in discussing the possible payoffs from weather modification. See, for example, National Academy of Sciences—National Research Council, *Scientific Problems of Weather Modification* (Washington: National Academy of Sciences, 1964).

[7] Our concern is actually with our 3 cities individually, though we compare different accounting points of view. We do not aggregate our estimates to the state level.

[8] For example, no municipal water system could take credit for the months of sunny weather which brought crowds to the beaches, but the failure of a system in a shore community could cost resort owners dearly if they had to shut down or truck in water.

[9] See, for example, Arthur Maass et al., *The Design of Water Resource Systems* (Cambridge: Harvard University Press, 1962), Ch. 2.

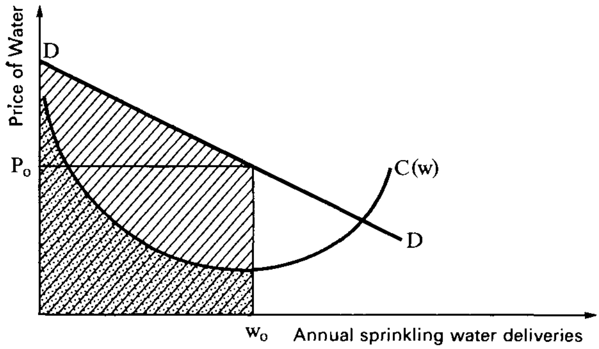


Figure 18. Losses from a total ban on lawn-sprinkling.

willingness to pay (*WTP*) for sprinkling water is the shaded area under *DD* up to $w_o$ or:

$$WTP = \int_0^{w_o} D(w)dw \qquad (9\text{-}1)$$

If $C(w)$ is the marginal cost of supplying sprinkling water, then the quantity:

$$C_A = \int_0^{w_o} C(w)dw, \qquad (9\text{-}2)$$

(the *cross-hatched area*) represents costs avoided by the supplier when sprinkling is forbidden. Total social loss from the prohibition of sprinkling is:

$$\text{Social Loss (net)} = WTP - C_A. \qquad (9\text{-}3)$$

It may be convenient to express this aggregate social loss in terms of its impact on various economic sectors. In this case, lawnowners lose $WTP - P_o w_o$, or consumer surplus, since they don't pay for water they don't use; and the water system loses $P_o w_o - C_A$, or lost revenue less costs avoided.[10] Our accounts are generally set up in a manner to reflect this sectoral impact of shortage.[11]

It is, of course, quite possible that the water system, if it is an arm of government, will attempt to make up the $P_o w_o$ loss through taxation. In that case the full burden of the loss will be shifted to the citizens, though

[10] We assume here that the costs avoided are measured from the social viewpoint. We also assume that the simple concept of consumer surplus is applicable. This seems reasonable in view of the small fraction of the household budget devoted to the purchase of water.

[11] A second example of loss calculation, that of business losses resulting from shut-down, is discussed in Appendix D.

there may be some redistribution of it from lawnowners to other taxpayers. It should be clear, however, that whether or not the community regains the lost revenue in taxes has no bearing on the size of loss, only on its distribution between sectors and citizens. Our tables reflect the initial impact, and no account has been taken of any later redistribution of burden. Note, finally, that in practice we ignore the costs avoided by the municipal systems; it seems reasonable to assume that they are very small, particularly in Massachusetts where the emphasis is on upland sources requiring little or no filtration or treatment.[12]

Other reported costs involve successful attempts temporarily to restrict use, as with save-water campaigns and temporary installation of water-saving equipment, or to augment supplies, as with emergency supply efforts. In connection with these efforts, society may avoid certain costs which reduce the net social opportunity cost of the actions taken.

The concept of "opportunity cost" itself tends, however, to become more cloudy when we discuss these successful efforts temporarily to restrict use or augment supply. We may very well look on the related expenditures as part of the cost of having created a concentration of population greater than naturally occurring climatic conditions will support, much as Kuznets and others have suggested that the national accounts of a developed country contain a number of items more properly thought of as costs of supporting an urbanized industrial society.[13] In the national accounts, then, the drought might very well appear as a stimulant to economic activity as numerous manufacturing and service firms answer the demand for equipment and talent aimed at relieving the situation. Are we, in effect, giving the drought a bad name by insisting that expenditures for temporary relief be counted as opportunity costs when other similar costs of urbanization, etc., are accorded the status of chosen "goods"? We generally assume that employment is full and that the turning of resources to the meeting of the drought crisis represents a social "evil."

We may summarize, then, our responses to the general problems posed above under the following points:

1. In assessing the costs and losses attributable to the drought we shall use as our zero point the situation in which the municipal system had

[12] By the same token the costs avoided may be substantial if extensive treatment is involved at the intake. They may also be larger, the deeper the drought, as the concentration of undesirable substances in the source increases with lower flows. Fuchs has estimated that the drought caused the Passaic Valley Water Commission to incur extra treatment costs of $399,000. See H. W. Fuchs, "The Economic Impact of Drought on Water Supply Systems in the Passaic River Basin, New Jersey," Master's thesis, College of Agriculture and Environmental Science, Rutgers, The State University, New Brunswick, N.J., May 1968.

[13] See Simon Kuznets, *Economic Change* (New York: Norton, 1953), pp. 161–62, 195–97.

enough water available in its normal system to meet demand at existing prices. (We shall, however, begin by listing all the losses found in our interviews, only later removing those incurred by self-supplied water users.)

2. The fundamental principle of measurement is that the losses equal gross benefits not enjoyed less any costs avoided.

3. We assume that resources used in countering the drought's effect, as in the drilling of domestic wells, would otherwise have been employed in the production of goods and services which society would have preferred in the absence of the drought. (We do take account of the possibility that production "losses" may be shifted to areas or time periods in which unemployed resources are available.)

4. An attempt is made to show drought losses and costs as their impact is initially felt by the various sectors. Thus, for domestic sprinkling losses we include consumer surplus lost in the domestic sector and revenue lost (less costs avoided) in the municipal sector. This approach makes double counting a danger and we have been concerned to insure that our estimates of revenue lost by the water system do not include losses already counted in other sectors.

## ESTIMATES OF COSTS AND LOSSES: UNCORRECTED EXCEPT FOR DOUBLE COUNTING

In presenting results such as these loss estimates, we clearly have two primary responsibilities. First, we must explain in more or less detail how they were derived. And second, we must call to the reader's attention the particular results and patterns we feel are of greatest interest or of greatest relevance to our general argument. The latter duty is relatively the easier of the two, for the former involes us in difficult trade-offs between reader boredom and scientific correctness.

The problem of the appropriate degree of detail in discussing estimation procedures is particularly troubling where, as in this study, sources and methods vary widely across the sectors covered. The solution we propose is as follows: first, in the body of the text we discuss in a general way the different sectoral estimates, indicating especially those areas in which the methods involved significant departures from the compilation of survey interview results; second, accompanying the summary table will be a set of notes covering details of more limited interest; and third, certain matters will be the subjects of technical appendices which may be ignored by those not interested.

## GENERAL METHODOLOGY

The first set of estimates of costs and losses corrected only for double counting is summarized in Table 22 below. In the discussion following we adopt the same sectoral order as that in the table.

1. *The Industrial Sector.* Here, we have broken down our estimates into three subclasses: Business Losses, Investments and Other. Business Losses, the losses resulting from forced slowdowns or shutdowns in production due to the drought, were claimed very infrequently. Where claimed, they were estimated on the basis of value added (generally from *Census of Manufactures* data) that was lost during the interruption, corrected for water costs avoided. (See Appendix D.)

Investment includes the claimed capital costs of all permanent water-use adjustments. Examples of such adjustments are cooling towers for the recirculation of cooling water; wells drilled to increase the plant's independent supply capability; process-water recirculation systems; additions to existing dams; new dams; installation of air-cooled window air conditioners; and others. This category produced the largest single gross cost figure and was generally estimated directly from the interview results.

The Other category includes such disparate costs as those of dry-hole wells, attempted rain-making, and save-water campaigns. Again, most data were taken directly from the interviews. Save-water campaign costs were corrected for water costs avoided as required to justify our inclusion of lost revenue totals in the municipal sector.

2. *The Municipal Sector.* Three subclasses were distinguished here: Lost Revenue, Emergency Supply Costs, and the ubiquitous Other. In all three areas, the reliance on direct interview results was somewhat less than for the Industrial Sector.

Lost Revenue was estimated for each town on the basis of the projections of water demand for the drought years. (These projections were discussed in Chapter 5.)

The total loss of revenue to the town involved only the water which could have been sold had it been available. Any emergency supplies which were provided by the system were sold at the going rates. Thus, the applicable quantity of water for use in the calculation of lost revenue is simply the difference between observed consumption and projected demand. Thus,

$$\text{Lost Revenue}^{14} = (C_{it} - D_{it})P_w. \tag{9-4}$$

[14] The lost revenue reported is for 1965 in Pittsfield and for 1966 in Braintree and Fitchburg. This reflects our attempt to maintain losses on an annual basis.

In our estimates, $P_w$ was taken to be a weighted average of the domestic and industrial marginal block rates (see Table 21). The weights used were the approximate percentages of total demand accounted for by domestic and industrial use. This approach involves an implicit assumption that shortages were shared about equally, in terms of volume, between the industrial and domestic sectors. There seems to be no way to improve on this approach short of separate measures of projected demand and actual consumption for the two sectors, and we did not gather these data in the original study.[15]

TABLE 21. WEIGHTED AVERAGE WATER RATES FOR LOST REVENUE CALCULATION

| | Braintree | Fitchburg | Pittsfield |
|---|---|---|---|
| Percentage of domestic demand | 70 | 30 | 50 |
| Percentage of industrial demand | 30 | 70 | 50 |
| Domestic block rate (*per thousand gallons*) | $.47 | $.334 | $.00[a] |
| Industrial block rate | $.29 | $.134 | $.107 |
| Weighted average rate | $.42 | $.194 | $.054 |

[a] Flat rate.

Emergency supply costs were estimated from the data obtained in the interviews with system managers, and from such other bits and pieces as could be gleaned from newspaper search. These costs are restricted to costs for equipment (or its operation) directly related to attempts to increase the town's available water supply in the short run. Not included are costs of redistributing water in a desired pattern, as in hiring spray trucks to cart river water to thirsty shrubs and trees in town parks.

"Other" costs and losses include those redistribution costs mentioned directly above, as well as costs of investments intended for specific uses, such as a well for a town swimming pool. Town efforts to find new groundwater sources are included here since they seem somewhat longer-run in intent than truly emergency supply measures.

3. *Commercial Sector.* The Commercial Sector estimates are based entirely on data developed in interviews with managers of firms. The costs and losses are broken down into two categories: Business Losses and Investment. Business losses are again broken down into those claimed by nurseries and those claimed by all other interviewed firms. The figures given represent estimates of value-added lost, based on the businessmen's statements of their lost sales. The percentage of sales accounted for by

[15] It would require a large investment of time and effort to do so, since no separate records are kept on a sectoral basis, and it would be necessary to sum the consumption figures for all industrial-sector customers for quarterly billing periods.

value-added was estimated on the basis of *1958 Census of Business* data on payrolls and sales in retail trades claiming losses (New England and Massachusetts regional figures). This was supplemented by assumptions about the percentage of sales represented by rent, profit, and interest.[16]

4. *Domestic Sector.* Two categories of drought costs are presented here.

First, an estimate of the total capital costs of drought-related domestic well investment is provided, based on telephone interviews with well-drillers all over the state. Each well reported drilled and drought-related in our three towns is valued at $1,200. This includes $900 for drilling (our contacts were virtually unanimous in quoting this as the average cost of drilling a domestic well in Massachusetts) and $300 for pump and installation, connection, etc. This figure represents an attempt to average the high costs of the few wells probably drilled for total domestic use and the many drilled to provide an independent source of sprinkling water.

Second, sprinkling losses, the losses of consumer surplus resulting from a complete or partial ban on lawn-sprinkling, were estimated using the demand equation for sprinkling water estimated by Howe and Linaweaver for eastern, metered, public sewer areas.[17] Information on housing valuation for use with this equation was taken from the *1960 Census of Housing*.

5. *The Miscellaneous Sector.* Three subclasses are included in this final category: Farm Losses, Golf Club Costs, and Tree Losses. The first covers losses claimed for farms within the Pittsfield city limits by the Berkshire County Extension Agent. These seem primarily to be costs of feed purchases necessitated by hay crop failure. (This item is, of course, related to self-supply problems, and we eliminate it along with all other such items in Chapter 10.) Golf Club Costs were obtained in interviews with club officials and greenskeepers. Over 99 percent of the total here is made up of the capital costs of schemes designed to provide the clubs with self-supplied water for maintenance of greens and fairways. These costs include pumps, wells, ponds, piping, and isolation of inside and outside systems.

Tree Losses reflects city officials' claims of the value of city-owned trees destroyed by the drought. The accuracy of these estimates was impossible to check, both because of questions of valuation and of actual numbers of trees lost. It is not inconceivable that such losses could have been very high (e.g., the Pittsfield estimate is $100,000!) if many old and essentially irre-

[16] For our purposes, the assumption that the relation between sales and payrolls was constant between 1958 and 1965–66 did not seem particularly dangerous.

[17] See Howe and Linaweaver, "Impact of Price on Residential Water Demand," p. 13, and Appendix E.

placeable trees had been lost. Such trees would be, however, the least likely to suffer severe damage because of their highly developed, deep root structures. At a later stage, the Pittsfield figure is altered to bring it more nearly in line with the indicated total tree costs (costs of special watering plus losses) per capita in the other 2 towns.

## RESULTS

The estimates developed by the methods described above are summarized in Table 22, where we present an all-in picture of gross drought costs and losses corrected essentially only for double counting.

The most striking features of this table are noted below.[18]

1. Fitchburg, where the potential shortage was greatest, accounts for about two-thirds of the total losses measured. Braintree, with the smallest system deficiency, accounts for only about one-tenth.

2. The combined industrial sectors accounted for the greatest sectoral share of total losses (47.0 percent), while the combined municipal sectors accounted for another 30.2 percent. The commercial, domestic, and miscellaneous sectors were relatively much less important as 3-town totals.

3. Between the towns the pattern of sectoral importance varied. Consider, for example, the identity of the sector with the largest losses. For Braintree, which has little industry, municipal sector losses were 72.2 percent of the town total. For Fitchburg, industrial sector losses were 64.0 percent of the total. Indeed, Fitchburg's industrial losses alone were about 40 percent of the total losses for the 3 towns. In Pittsfield, the miscellaneous sector losses (including the heavy tree loss) accounted for 45.2 percent of the total. These figures suggest that for smaller losses the municipal sector can and does bear a large part of the burden of meeting the potential shortage, largely through the purchase of emergency supplies (91 percent of the Braintree municipal sector total is accounted for by emergency supply costs) but also through the sacrifice in revenue implied in the imposition of restrictions on uses such as sprinkling. These alternatives are, of course, substitutes for one another; the purchase of emergency supplies in sufficient quantity will eliminate the necessity for losing revenue through restricting use.

4. The items most closely and dramatically connected with drought in the public mind—especially losses due to lawn-sprinkling bans—are relatively unimportant in the overall picture. On the other hand, emergency

[18] We identify these losses with the percentage shortage for 1966 for Fitchburg (22.8 percent) and Braintree (9.7 percent), and with the 1965 shortage for Pittsfield (14.1 percent), since, as noted already, the drought impact occurred earlier in the western part of the state.

supply costs, also well publicized, are fairly important as a single source of costs (16 percent of the grand total).

One of the most interesting features of the corrections applied below will be their effect on the relative importance of the various towns and sectors in contributing to total losses. As the totals become in general smaller, it will also be true that shifts will occur in the identity of the "big losers."

## TYPES OF ADJUSTMENT TO SHORTAGE: MAGNITUDE OF RESULTING LOSSES

One interesting way of looking at the raw-loss data summarized above is to ask to what extent they resulted from one or the other of the two broad types of adjustment open to system managers—restriction of demand or augmentation of supply. Tables 23 through 25 supply the answer to this question.

Table 23 summarizes the cost and loss totals related to measures to increase supply. Table 24 deals with measures to restrict use. Table 25 is reserved for items unclassified under the other two headings.[19] The very few items which could not be so classified (only 3.5 percent of the Table 22 total) are dominated by farm losses. These seemed to involve only passive response to the precipitation shortfall and hence to be unrelated to either form of active response.

The most interesting results obtained by separating costs on this basis include the following:

1. Costs of measures to restrict use, and losses resulting therefrom, are quantitatively more important than those related to attempts to increase supplies (57.4 percent of the Table 22 grand total as opposed to 39.1 percent). This is primarily the result of the inclusion under the former category of both the many industrial-sector recirculation projects in Fitchburg and the municipal-sector lost revenue estimates there. These two items together account for 62 percent of the use-restriction costs and 41 percent of the all-in grand total (Table 22) of costs and losses.

[19] Specific cost and loss items were classified under one of the headings if they represented either the direct cost of a measure designed to achieve that end or if they represented the losses or costs created by such measures taken by the same or another agent. Thus, losses from sprinkling restrictions belong under "Restrict Use" as they result from measures to that end taken by the city.

Emergency supply costs, for obvious reasons, belong in the "Increase-Supply" category. Since "use" must be seen as withdrawals, the installation of recirculation equipment restricts use. The drilling of a well by any agent is seen as a measure to increase supply since we are interested here in the total capacity of the local region to support withdrawals, not only in the public system. Later we shall eliminate from consideration all items relating to self-supplied firms, though not actions to provide some self-supply taken by customers of the municipal system.

TABLE 22. ALL-IN GROSS LOSSES,[a] CORRECTED FOR DOUBLE COUNTING

| Sector | Braintree | | | Fitchburg | | | Pittsfield | | | Sector totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of grand total |
| Industrial | | | | | | | | | | | |
| Business losses[b] | — | | | 171,400 | | | — | | | 171,400 | |
| Investments | 2,500 | | | 549,000 | | | 70,200 | | | 622,500 | |
| Other | 2,500 | | | 30,000 | | | 17,800 | | | 50,300 | |
| Subtotal | 5,000 | 2.6 | 0.6 | 751,200 | 64.0 | 89.0 | 88,000 | 20.5 | 10.4 | 844,200 | 47.0 |
| Municipal | | | | | | | | | | | |
| Lost revenue | — | | | 173,100 | | | 54,900 | | | 228,000 | |
| Emergency supply | 125,000 | | | 144,200 | | | 12,000 | | | 281,200 | |
| Other | 12,900 | | | 5,200 | | | 15,000 | | | 33,100 | |
| Subtotal | 137,900 | 72.2 | 25.4 | 322,500 | 27.5 | 59.5 | 81,900 | 19.1 | 15.1 | 542,300 | 30.2 |
| Commercial[c] | | | | | | | | | | | |
| Business losses nurseries | 8,600 | | | — | | | — | | | 8,600 | |
| Business losses—other | — | | | 3,000 | | | 3,000 | | | 6,000 | |
| Investments | — | | | 6,100 | | | 12,000 | | | 18,100 | |
| Subtotal | 8,600 | 4.5 | 26.3 | 9,100 | 0.8 | 27.8 | 15,000 | 3.5 | 45.9 | 32,700 | 1.8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | | | | | | | | | | | |
| Wells reported | 24,000 | | | 31,200 | | | 50,400 | | | 105,600 | |
| Sprinkling loss[d] | 14,200 | | | 29,400 | | | — | | | 43,600 | |
| Subtotal | 38,200 | 20.0 | 25.6 | 60,600 | 5.2 | 40.5 | 50,400 | 11.7 | 33.8 | 149,200 | 8.3 |
| Miscellaneous | | | | | | | | | | | |
| Farm losses[e] | — | | | — | | | 45,000 | | | 45,000 | |
| Golf club costs | — | | | 25,000 | | | 48,700 | | | 73,700 | |
| Tree losses | 1,200 | | | 6,000 | | | 100,000 | | | 107,200 | |
| Subtotal | 1,200 | 0.6 | 0.5 | 31,000 | 2.6 | 13.7 | 193,700 | 45.2 | 85.7 | 225,900 | 12.6 |

| | | Percentage of GT[f] | | Percentage of GT | | Percentage of GT | Grand Total |
|---|---|---|---|---|---|---|---|
| Town: totals | 190,900 | 10.6 | 1,174,400 | 65.4 | 429,000 | 23.9 | 1,794,300 |

[a] In several cases, original calculations (or even original information) included a range of possible values. These ranges depend in most cases on the nature of the assumptions made about the seasonal pattern of demand and the like. In all such cases, the figure in Table 22 is the simple average of the extremes of the range.

[b] Industrial business losses were estimated differently, depending on the nature of the information contained in the claim. In some cases, value-added per day per man was projected ahead from the *1963 Census of Manufactures*. This was used where shutdowns were estimated in days. In other cases, value-added unit prices were estimated and used to value estimated lost production in physical terms. Both sorts of calculations were corrected for savings on water purchases and withdrawals.

[c] Commercial business losses were estimated on the basis of claims of lost sales made in interviews. These figures were corrected to value-added by using an estimate of value-added as a percentage of sales. This, in turn, was derived from figures on wages as a percentage of sales in various affected areas of retailing from the *1958 Survey of Business* and from assumptions about the size of profits (36 percent), rent (10 percent), and interest (4 percent) relative to sales.

[d] Domestic sprinkling loss calculations are explained in detail in Appendix E.

[e] Farm losses were estimated by the Berkshire County Extension Agent as $1,500 per farm for 30 commercial farms within the city limits.

[f] GT = grand total.

TABLE 23. LOSSES RELATED TO MEASURES TO INCREASE SUPPLY[a]

| | Braintree | | | Fitchburg | | | Pittsfield | | | Sector totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of grand total |
| Industrial | | | | | | | | | | | |
| Business losses | — | | | — | | | — | | | — | |
| Investments | 2,500 | | | 92,300 | | | 70,000 | | | 164,800 | |
| Other | 2,500 | | | 24,000 | | | 4,600 | | | 31,100 | |
| Subtotal | 5,000 | 3.0 | 2.6 | 116,300 | 36.1 | 59.4 | 74,600 | 35.1 | 38.1 | 195,900 | 27.9 |
| | | (2.6) | (0.6) | | (9.9) | (13.8) | | (17.4) | (8.8) | | (10.9) |
| Municipal | | | | | | | | | | | |
| Lost revenue | — | | | — | | | — | | | — | |
| Emergency supply | 125,000 | | | 144,200 | | | 12,000 | | | 281,200 | |
| Other | 12,900 | | | 5,200 | | | 15,000 | | | 33,100 | |
| Subtotal | 137,900 | 82.6 | 43.9 | 149,400 | 46,4 | 47.5 | 27,000 | 12.7 | 8.6 | 314,300 | 44.8 |
| | | (72.2) | (25.4) | | (12.7) | (27.5) | | (6.3) | (5.0) | | (17.5) |
| Commercial | | | | | | | | | | | |
| Business losses nurseries | — | | | — | | | — | | | — | |
| Business losses—other | — | | | — | | | — | | | — | |
| Investments | — | | | — | | | 12,000 | | | 12,000 | |
| Subtotal | — | | | — | | | 12,000 | 5.6 | 100 | 12,000 | 1.8 |
| | | | | | | | | (2.8) | (36.7) | | (0.7) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic | | | | | | | | | | | |
| Wells reported | 24,000 | | | 31,200 | | | 50,400 | | | 105,600 | |
| Sprinkling loss | — | | | — | | | — | | | — | |
| Subtotal | 24,000 | 14.4<br>(12.6) | 22.7<br>(16.1) | 31,200 | 9.7<br>(2.6) | 29.5<br>(20.9) | 50,400 | 23.7<br>(11.7) | 47.7<br>(33.8) | 105,600 | 15.0<br>(5.9) |
| Miscellaneous | | | | | | | | | | | |
| Farm losses | — | | | — | | | — | | | — | |
| Golf club costs | — | | | 25,000 | | | 48,400 | | | 73,400 | |
| Tree losses | — | | | — | 7.8 | 34.1 | — | 22.8 | 65.9 | — | 10.5 |
| Subtotal | — | | | 25,000 | (2.1) | (11.1) | 48,400 | (11.3) | (21.4) | 73,400 | (4.1) |
| | | Percentage of GT | | | Percentage of GT | | | Percentage of GT | | Grand Total | |
| Town totals | 166,900 | 23.8<br>(9.3) | | 321,900 | 45.9<br>(17.9) | | 212,400 | 30.3<br>(11.8) | | 701,200 | (39.1) |

[a] Two sets of percentage figures are given for each subtotal. The set *not* enclosed in parentheses represents the percentage calculated, wholly within that table. For example, in Table 23, Fitchburg's industrial sector subtotal ($116,300) is 36.1 percent of the town total of increase-supply measures ($321,900) and 59.4 percent of the total for the industrial sector over the three towns ($195,900). The percentage figures *in* parentheses relate the sector and town subtotals to the all-in totals of Table 22. Thus, the $116,300 figure is 9.9 percent of the all-in Fitchburg total ($1,174,400) and 13.8 percent of the all-in industrial sector subtotal ($844,200).

TABLE 24. LOSSES RELATED TO MEASURES TO RESTRICT USE[a]

| | Braintree | | | Fitchburg | | | Pittsfield | | | Sector totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of grand total |
| Industrial | | | | | | | | | | | |
| Business losses | — | | | 171,400 | | | — | | | 171,400 | |
| Investments | — | | | 457,500 | | | 200 | | | 457,700 | |
| Other | — | | | — | | | 13,200 | | | 13,200 | |
| Subtotal | — | | | 628,900 | 74.6 (53.6) | 97.9 (74.5) | 13,400 | 7.8 (3.1) | 2.1 (1.6) | 642,300 | 62.3 (35.8) |
| Municipal | | | | | | | | | | | |
| Lost revenue | — | | | 173,100 | | | 54,900 | | | 228,000 | |
| Emergency supply | — | | | — | | | — | | | — | |
| Other | — | | | — | | | — | | | — | |
| Subtotal | — | | | 173,100 | 20.5 (14.7) | 75.9 (31.9) | 54,900 | 32.0 (12.8) | 24.1 (10.1) | 228,000 | 22.1 (12.7) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial | | | | | | | | | | | |
| Business losses nurseries | — | | | — | | | — | | | — | |
| Business losses—other | — | | | — | | | 3,000 | | | 3,000 | |
| Investments | — | | | 6,100 | | | — | | | 6,100 | |
| Subtotal | — | | | 6,100 | 0.7<br>(0.5) | 67.0<br>(18.7) | 3,000 | 1.8<br>(0.7) | 33.0<br>(9.2) | 9,100 | 0.9<br>(0.5) |
| Domestic | | | | | | | | | | | |
| Wells reported | — | | | — | | | — | | | — | |
| Sprinkling loss | 14,200 | | | 29,400 | | | — | | | 43,600 | |
| Subtotal | 14,200 | 92.2<br>(7.4) | 32.6<br>(9.5) | 29,400 | 3.5<br>(2.5) | 67.4<br>(19.7) | — | | | 43,600 | 4.2<br>(2.4) |
| Miscellaneous | | | | | | | | | | | |
| Farm losses | — | | | — | | | — | | | — | |
| Golf club costs | — | | | — | | | — | | | — | |
| Tree losses | 1,200 | 7.8 | 1.1 | 6,000 | 0.7 | 5.6 | 100,000 | 58.4 | 93.3 | 107,200 | 10.4 |
| Subtotal | 1,200 | (0.6) | (0.3) | 6,000 | (0.5) | (2.6) | 100,000 | (23.3) | (44.3) | 107,200 | (6.0) |
| | | Percentage of GT | | | Percentage of GT | | | Percentage of GT | | Grand Total | |
| Town totals | 15,400 | 1.5<br>(0.8) | | 843,500 | 81.9<br>(47.0) | | 171,300 | 16.6<br>(9.5) | | 1,030,200 | (57.4) |

[a] See note to Table 23.

TABLE 25. LOSSES UNCLASSIFIED WITH RESPECT TO CAUSE[a]

| Sector | Braintree | | | Fitchburg | | | Pittsfield | | | Sector totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of town total | Percentage of sector total | Corrected costs ($) | Percentage of grand total |
| Industrial | | | | | | | | | | | |
| Business losses | — | | | — | | | — | | | — | |
| Investments | — | | | — | | | — | | | — | |
| Other | — | | | 6,000 | | | — | | | 6,000 | |
| Subtotal | — | | | 6,000 | 66.7 (0.5) | 100 (0.7) | — | | | 6,000 | 9.5 (0.3) |
| Municipal | | | | | | | | | | | |
| Lost revenue | — | | | — | | | — | | | — | |
| Emergency supply | — | | | — | | | — | | | — | |
| Other | — | | | — | | | — | | | — | |
| Subtotal | — | | | — | | | — | | | — | |
| Commercial | | | | | | | | | | | |
| Business losses nurseries | 8,600 | | | — | | | — | | | 8,600 | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Business losses—other | — | | | 3,000 | | | — | | | 3,000 | |
| Investments | — | | | — | | | — | | | — | |
| Subtotal | 8,600 | 100 (4.5) | 74.1 (26.3) | 3,000 | 33.3 (0.2) | 25.9 (9.2) | — | | | 11,600 | 18.4 (0.6) |
| Domestic | | | | | | | | | | | |
| Wells reported | — | | | — | | | — | | | — | |
| Sprinkling loss | — | | | — | | | — | | | — | |
| Subtotal | — | | | — | | | — | | | — | |
| Miscellaneous | | | | | | | | | | | |
| Farm losses | — | | | — | | | 45,000 | | | 45,000 | |
| Golf club costs | — | | | — | | | 300 | | | 300 | |
| Tree losses | — | | | — | | | — | | | — | |
| Subtotal | — | | | — | | | 45,300 | 100 (10.6) | 100 (20.0) | 45,300 | 72.0 (2.5) |
| | | Percentage of GT | | | Percentage of GT | | | Percentage of GT | | Grand Total | |
| Town totals | 8,600 | 13.7 (0.5) | | 9,000 | 14.3 (0.5) | | 45,300 | 72.0 (2.5) | | 62,900 | (3.5) |

[a] See note to Table 23.

2. Within the increase-supply table, municipal emergency supply costs are the single most important item, followed by industrial investments and domestic wells. The three together account for 78.5 percent of the total attributable to measures to increase supply.

3. The costs and losses from measures to restrict use (Table 24) are, as mentioned above, dominated by business investments and lost revenue. These two items account for 62 percent of the costs and losses recorded in this table. Even within the set of losses from restrictions, sprinkling losses still show up as relatively unimportant (4.2 percent of the reduced total).

It is, however, necessary to consider certain important adjustments to these raw cost data. First, we look at the investment aspect of certain of the reported costs. Then, corrections are made for considerations of accounting stance and assumptions about the extent of deferral or transferral of "lost" production. Finally, because this study focuses on the municipal system, we eliminate from the final accounts losses and gains accruing to self-supplied water users. These matters are taken up in Chapter 10.