Chapter 3

THE IMPACTS OF FLOODPLAIN MANAGEMENT

In this chapter, we begin our exploration of the impacts of floodplain land use management by looking closely at development in the floodplains of each of the ten communities studied. We ask and answer four critical questions:

1) Has floodplain land use management steered potential development to non-hazardous locations?

2) Has floodplain land use management reduced the susceptibility of new development to flood damage?

3) To the extent that flood damage potential remains, have property owners ameliorated the potential adverse effects of catastrophic losses from flooding by purchasing flood insurance?

4) Are stronger floodplain land use management programs more successful than weaker programs in achieving various objectives, such as diverting new development to flood-free sites, reducing the susceptibility of new development to flood damage, minimizing the population exposed to injury and loss of life from flooding, and protecting the natural values (water quality protection, ground water recharge, open space preservation) of floodplains?

To answer those questions, we measured development in the floodplains of each community between 1976 and 1985. Using methods explained below, we compared actual floodplain development with projections of potential development without floodplain land use management programs. Differences between floodplain conditions (development, potential property losses, population at risk, open space) with the programs and counterfactual conditions without the programs provide a measure of program impacts.

Overall, we found that floodplain land use management programs diverted a substantial amount of potential development in flood-hazard areas to flood-free sites and reduced average annual flood losses by millions of dollars per year. Stronger programs had a marginally greater effect than weaker programs in diverting development from flood hazard areas; however, they had a substantially greater ability than weaker programs to reduce the susceptibility

of new development to flood damage. Even so, every program allowed some increase in flood damage potential, and the proportion of structures covered by flood insurance, after increasing every year to 1980, steadily decreased through 1985. Floodplain management is achieving some, but not all, of the objectives Congress set forth in redirecting national policy from sole reliance on structural flood control measures toward managing floodplain land use.

Measuring with Counterfactual Scenarios

Our previous research (Burby, French and Kaiser, 1980; Burby and French et al., 1985; Sheaffer and Roland, Inc., 1981) found that three types of program impacts are most important to local decision makers: 1) reducing property damage to structures located (or that might locate in the future) in flood-hazard areas; 2) protecting or enhancing human health and safety (minimizing population at risk); and 3) preserving environmental quality by maintaining open space land uses. The accurate measurement of those effects was one of the central concerns of this research.

The procedure we used involved eight steps:

1) Analysis of the socioeconomic and physical context.

2) Description of the floodplain land use management program and other public policies that may have affected the floodplain.

3) Measurement of actual floodplain development (states of development) over time, based on building permit records.

4) Analysis of community development trends (particularly the role of the floodplain in community development).

5) Construction of scenarios of development that would have occurred in the absence of a floodplain land use management program (the "no-program" alternative).

6) Estimation of average annual flood damages with and without the floodplain land use management program.

7) Estimation of program impacts from changers in development decisions (effects on population at risk and environmental quality).

8) Summary of program effects.

(See Sheaffer and Roland, Inc., 1977 and French, Miller, Burby and Moreau, 1980 for a detailed description of this methodology). Much of the baseline data required for steps 1 through 5 were assembled by Sheaffer and Roland, Inc. (1981) for an earlier study of 21 communities (including the ten communities studied here) conducted for the Federal Insurance Administration. Our research built on those baseline data.

Net program effects are defined as the incremental change in four program effect variables (property at risk and population at risk, open space acreage, and potential average annual flood losses) from 1976 through 1985 with the floodplain land use management program in effect in a community, less changes in the program effect variables that would have occurred without the floodplain land use management program (counterfactual conditions). Projections of "no program" scenarios for the period 1975-1990 prepared by Sheaffer and Roland, Inc. for the earlier Federal Insurance Administration study were adjusted to 1985, based on actual communitywide growth over the ten-year study period (rather than the projected rates used in the original Sheaffer and Roland study). Actual floodplain development, population at risk and loss of open space were estimated from building permits issued in each community during the ten years studied.

Changes in flood losses (in constant 1975 dollars) were estimated using the same method employed in the earlier study (see Sheaffer and Roland, Inc. 1977). Again, losses for the "no program" scenario were calculated by scaling back Sheaffer and Roland's earlier 1990 projections to 1985 and adjusting them so that they are based on actual rather than projected overall communitywide growth rates between 1976 and 1985. Actual floodplain development over that ten-year period was used to estimate average annual flood losses with the floodplain management program employed in each community. We did not, however, adjust earlier estimates to take into account reduction in potential average annual flood losses due to new flood control works constructed in the communities studied. Thus, although our estimates of reduction in losses due to floodplain land use management are correct, total average annual loss figures overestimate potential losses to some extent.

Any policy research design which uses counterfactual scenarios to estimate "no program" conditions creates a number of opportunities for error. Because floodplain land use management is a "full coverage" program (the entire target population is covered by the program), it is not possible to use randomized, constructed, or statistical control groups to help identify program effect (see Rossi, Freeman and Wright, 1979 for a discussion of the problems involved in identifying impacts with full-coverage programs). Our use of reflexive controls

(before and after measurements) and counterfactuals (what Rossi, Freeman and Wright term shadow controls) provides a means of estimating program effects, but the construction of the no-program counterfactual scenarios is highly subjective and open to error. Because of that problem, our research design included the two other approaches to assessing program effects--analysis of target group decisions and analysis of land market data--presented in later chapters.

Limiting Further Development of the Floodplain

Over 120,000 dwelling units were built in the ten case study communities between 1976 and 1985--collectively, an increase in residential development of 23% over that ten-year period. There was a considerable amount of new residential construction in every community--even those whose populations were stagnant or declining, such as Omaha (9% increase), Savannah (10%), Toledo (6%) and Wayne (5%). Where population was increasing, there was explosive growth in dwellings: Scottsdale (up 78%), followed by Arvada (54%), Fargo (44%), Palatine (41%), Tulsa (34%) and Cape Girardeau (31%). The trend toward smaller household sizes, observed nationwide, led to the much higher rate of growth of residential units than population (23% vs. 4%) among the ten communities.

Diverting Residential Development to Flood-Free Locations

Each of the communities allowed additional development in the floodplain (see Table 3-1), but the communities' floodplains absorbed far less residential growth (2.1% of new residential development) than the floodplains' proportionate share (7%) of land available for development. In addition, floodplains absorbed proportionately less development than they had in previous years--in 1975, for example, 5% of all dwellings (26,588 of 555,574) were located in flood hazard areas. Thus, during the study period, floodplains became less attractive for residential use than they had been.

The five communities with stronger floodplain management programs had a higher proportion of their land area located in the floodplain than the five communities with weaker programs (9% vs. 6%), but they allowed a slightly lower proportion of new residential development to locate in flood hazard areas (2.0% versus 2.2%). That difference, of course, is too small to support the conclusion that program strength made much difference in the location of residential growth.

Where the floodplains offered attractive home sites, even strong programs such as the one Fargo put in place may not deter floodplain development, if the

TABLE 3-1

RESIDENTIAL BUILDING PERMITS ISSUED IN TEN CITIES, 1976-1985

City	Residential Building Permits Issued: 1976-85		Percent City in Flood-plain	Percent Permits in Flood-plain
	City	Flood-plain		
Stronger Floodplain Management				
Palatine	2,154	5	18	0.2
Scottsdale	23,962	430	3	1.8
Fargo	8,024	410	21	5.1
Arvada	7,761	14	7	0.2
Wayne	1,478	7	17	0.5
Total	43,379	866	9	2.0
Weaker Floodplain Management				
Omaha	17,298	3	7	0.2
Tulsa	39,472	873	4	2.2
Toledo	11,357	57	7	0.5
Cape Girardeau	2,541	35	27	1.4
Savannah	6,323	711	14	11.2
Total	76,991	1,679	6	2.2
Grand Total	120,370	2,545	7	2.1

community is growing rapidly. Where overall community growth is slower or floodplains are less attractive for development, as is the case in Omaha and Toledo, even a weaker program may deter residential use of the floodplain. That is not always the case, however, as witnessed by slow-growing Savannah where more than 10% of new residential units occupied flood hazard areas.

In the total absence of floodplain management, we estimate that in contrast to the 2,545 new dwellings in flood hazard areas between 1976 and 1985, market forces would have led almost 12,000 dwellings to be placed in the floodplains of the ten cities (see Table 3-2). Again, the stronger programs, which diverted 83% (4,202 of 5,068 dwellings) of potential residential development from the floodplain, scored somewhat better than the weaker programs, which diverted 76% (5,242 of 6,911 dwellings) of potential development (Table 3-2).

In two of the communities with moderately strong programs--Wayne and Omaha--we projected that there would be no net additions to floodplain residential uses between 1976 and 1985. The projected zero increase in Omaha was predicated on an assumed continuation of land use changes underway in 1975 which were market driven and which were removing residences from flood hazard areas. Only three permits for residential construction in the floodplain were issued in Omaha during the study period, suggesting a respect for flood risks by the homebuilding industry and the city government.

In Wayne, a fundamental transition in floodplain development was taking place in 1975. Because of repeated flooding in the Passaic basin, the risks of residing in the floodplain were well known; consequently, residential uses were being retired and replaced by commercial and industrial uses. Our projections assumed that trend would continue and that there would be a net reduction in dwellings located in the floodplain. In fact, there was a transition to business uses (as we will discuss later in this chapter), but rather than replace existing flood-prone dwellings, new business uses occupied vacant sites. After disastrous flooding occurred in Wayne in 1984, the township targeted over 300 dwellings for relocation from the floodplain and received a commitment for federal financial assistance under Section 1362 of the National Flood Insurance Program; however, because the land involved belonged to a homeowners association rather than to individual property owners, all residents had to concur with the relocation plan before structures could be moved. That obstacle stalled the relocation effort.

Among the communities with stronger programs, Fargo and Scottsdale allowed a significant amount of floodplain development; and, although each diverted to flood-free sites a significant proportion of the dwellings that otherwise would have been built in the floodplain, their programs had less

TABLE 3-2

PROJECTED INCREASE IN FLOODPLAIN DWELLINGS WITHOUT FLOODPLAIN MANAGEMENT VS. DWELLINGS ACTUALLY BUILT, 1976-1985

City	Projected Increase w/o Floodplain Management		Actual Increase With Floodplain Management		Percent of Projected D/Us Diverted from Flood-Plain
	No.	% of City-wide Total	No.	% of City-wide Total	
Stronger Programs					
Palatine	473	22.0%	5	0.2%	99%
Scottsdale	1,774	7.4%	430	1.8%	76%
Fargo	1,842	23.0%	410	5.1%	78%
Arvada	1,149	14.8%	14	0.2%	99%
Wayne	-170	-11.5%	7	0.5%	0%
Total	5,068	11.7%	866	2.0%	83%
Weaker Programs					
Omaha	0	0.0%	3	0.2%	0%
Tulsa	1,596	4.0%	873	2.2%	45%
Toledo	2,873	25.3%	57	0.5%	98%
Cape Girardeau	119	4.7%	35	1.4%	71%
Savannah	2,333	36.9%	711	11.2%	69%
Total	6,921	9.0%	1,679	1.4%	76%
Total	11,989	10.0%	2,545	2.1%	79%

effect on the location of development than we expected. Among the ten cities, Fargo had the highest proportion of citywide development located in flood hazard areas in 1975. Part of that problem was resolved when flood control works eliminated much of the flood hazard in the County Drain No. 3 floodplain, which accounted for 160 of the 412 new dwellings built in flood hazard areas. The remaining 252 dwellings were constructed in the floodplain of the Red River of the North, whose proximity to the stream valley created an environmental amenity that contrasts sharply with the open plains that characterized hazard-free land in Fargo. Evidently, Fargo's program did not provide enough disincentives to persuade builders and homeowners to forego the amenities of the floodplain. In the case of Scottsdale, the parkland and golf courses developed in conjunction with the Indian Bend Wash project created residential amenities which stimulated development of the adjacent floodway fringe (also, the city gave builders density bonuses in exchange for contributions to flood control works and park development). As in Fargo, the attractiveness of greenspace was sufficiently strong to overcome added costs of development due to the floodplain land use management program.

Three of the weaker floodplain land use management programs--those in Cape Girardeau, Savannah, and Tulsa--resulted in the diversion to flood-free sites of lower-than-average proportions of new development. That was not unexpected. Given the lack of locational elements in their floodplain management programs (see Figure 2-1 in Chapter 2), the diversion of expected development would result only from the added publicity given to the flood hazard by the programs and by added development costs associated with requirements to elevate new construction.

A year-by-year tabulation of residential construction in Tulsa (shown below) suggests that while more stringent floodplain management regulations were in place, floodplain development was diverted to flood-free sites. When development pressures mounted and the city relaxed those standards during the period 1978-1984, however, a considerable amount of floodplain development took place.

	Building Permits Issued City-wide	Building Permits in Flood Plain	
		Number	Percent
1976	3,286	4	0.1
1977	3,775	13	0.3
1978	3,862	42	1.1
1979	3,625	55	1.5
1980	3,478	205	5.9
1981	2,484	18	0.7

1982	6,285	47	0.7
1983	7,741	448	6.3
1984	3,390	0	0.0
1985	1,546	1	0.1

The weaker Toldeo Program, however, is an anomaly. Continued development of the floodplain in Toledo almost ceased (57 dwellings were built in flood hazard areas compared to a projection of 2,873 without a floodplain management program), even though it had one of the weaker programs we studied and city officials were not seeking to steer development to flood-free sites. There are three possible explanations. First, if the more desirable portions of the floodplains had been occupied before 1976 (by which time over half of Toledo's floodplains were in urban use), floodplain building sites may have been less desirable for new development than we anticipated in projecting floodplain development without a program. Second, given the slow rate of growth in Toledo, developers may have become more selective in choosing building sites. Third, with slow growth, the primary market for new construction in Toledo would be residents moving within the metropolitan area rather than people moving to Toledo from other places; thus, the market may have been more knowledgeable about and sensitive to the flood hazard than in previous years.

Diverting Commercial Development from the Floodplain

Of the building permits issued for nonresidential structures during the ten-year study period, 379 of a total of 9,164 permits were for locations within flood hazard areas (see Table 3-3). That represents just 4% of all permits for nonresidential construction issued, but it is twice the proportion of permits issued for residential construction in the floodplain. Those data reinforce a perception reported by many of the floodplain land use management staffs with whom we talked: communities are more concerned with the potential for loss to residential property and deaths than they are with losses to business property. Furthermore, the data suggest that the strength of the floodplain land use management program has relatively little systematic effect on business location decisions. The proportion of nonresidential development in the communities in flood hazard areas was higher, rather than lower, in the five communities with the stronger programs.

Even though commercial and industrial development was taking place at a greater rate than we expected and was not influenced by the strength of floodplain management programs, there was much less nonresidential development in flood hazard areas than would have been the case in the

TABLE 3-3

NONRESIDENTIAL BUILDING PERMITS ISSUED IN TEN CITIES, 1976-1985

City	Nonresidential Building Permits Issued: 1976-85		Percent City in Flood-plain	Percent Permits in Flood-plain
	City	Flood-plain		
Stronger Programs				
Palatine	66	0	18	0.0
Scottsdale	NA	NA	3	NA
Fargo	401	24	21	6.0
Arvada	234	7	7	3.0
Wayne	121	24	17	19.8
Total	822	55	9	6.7
Weaker Programs				
Omaha	1,689	85	7	0.2
Tulsa	3,374	115	4	3.4
Toledo	744	5	7	0.7
Cape Girardeau	1,268	104	27	8.2
Savannah	1,267	15	14	1.2
Total	8,342	324	6	3.9
Grand Total	9,164	379	7	4.1

absence of those programs (see Table 3-4). Across all ten communities, we estimate that floodplain management programs diverted 1,590 acres of commercial and industrial development that otherwise would have located in flood hazard areas. A higher proportion of nonresidential development, however, was diverted to nonhazardous areas in the communities with weaker programs than in those where floodplain management was more robust. Thus, commercial and industrial use of the floodplain seem to have more to do with local circumstances--particularly the attractiveness of flood hazard areas for business use--than the application of floodplain management policy.

In five of the communities--Palatine, Scottsdale, Arvada, Toledo, and Savannah--there was little nonresidential development of flood hazard areas between 1976 and 1985. Palatine allowed no nonresidential development of the floodplain; Toledo allowed only five nonresidential structures in the floodplain, and the staff there estimated that an equal number of older commercial buildings in the floodplain had been demolished (although demolition records were not filed separately by floodplain and non-floodplain location). Thus, we estimated no net increase in business acreage in Toledo's floodplains.

Records of building permits for nonresidential uses could not be obtained for Scottsdale. Visual inspection of the Indian Bend Wash floodplain, however, revealed few nonresidential structures, either old or new. Professional staff in Scottsdale reported to us that virtually all new development near the wash was residential because if developers deepened the floodway and managed it as recreational open space, they were allowed to increase the density of their projects from four to six or eight dwellings per acre. That density bonus increased the profitability of the floodplain for residential use and reduced pressure for nonresidential uses. In Arvada (seven commercial structures) and Savannah (fifteen commercial structures), most business development was also diverted to nonhazardous areas.

In Wayne Township, and to a lesser extent Fargo, Omaha, Tulsa, and Cape Girardeau, there was a considerable amount--fifteen or more structures--of nonresidential development in floodplains between 1976 and 1985. Nearly one of every five business structures built in Wayne during that period was in a flood hazard area, and in Cape Girardeau the proportion was nearly one in ten. In 1975, the floodplain played an important role in accommodating commercial development in those communities, and that role continued over the study period. In fact, in Wayne the program encouraged nonresidential uses of flood hazard areas, which was also true of the program in Omaha. When Cape Girardeau joined the regular phase of the National Flood Insurance Program in 1980, residential development in the floodplain all but ceased. Commercial and industrial development, however, continued un-

TABLE 3-4

COMPARISON OF PROJECTED INCREASE IN FLOODPLAIN NONRESIDENTIAL ACREAGE WITHOUT FLOODPLAIN MANAGEMENT WITH ACTUAL NEW NONRESIDENTIAL ACREAGE, 1976-1985

City	Projected Increase w/o Floodplain Management		Actual Increase With Floodplain Management		Percent of Projected Acreage Diverted from Flood-Plain
	No.	% of City-wide Total	No.	% of City-wide Total	
Stronger Programs					
Palatine	0	0.0%	0	0.0%	0%
Scottsdale	0	0.0%	NA	NA	NA
Fargo	57	28.2%	12	5.6%	79%
Arvada	9	7.6%	4	3.4%	56%
Wayne	34	60.5%	12	19.7%	65%
Total	100	24.3%	28	6.8%	72%
Weaker Programs					
Omaha	106	12.5%	43	5.1%	59%
Tulsa	1,017	60.3%	58	3.4%	94%
Toledo	0	0.0%	0	0.0%	0%
Cape Girardeau	444	70.1%	52	8.2%	88%
Savannah	112	17.6%	8	1.3%	93%
Total	1,679	40.2%	161	3.9%	90%
Total	1,779	25.7%	189	4.1%	89%

abated. Finally, there was considerable nonresidential as well as residential development in Tulsa's flood hazard areas, although as shown in Table 3-4, much less than there would have been had no regulations at all been in place.

Reducing Susceptibility to Flood Damage

A primary goal of the National Flood Insurance Program is to reduce future flood loss potential in the nation by requiring safe land use management and construction practices in flood hazard areas. Congress viewed the requirement of minimum building standards for floodplains as a preventive measure. As shown above, land use management measures encouraged but not required by the NFIP have reduced encroachment of new development on flood hazard areas from what there would have been without those measures, but in each of the ten communities, there was additional floodplain development. When there is encroachment, building regulations that require elevation and/or floodproofing of new structures to or above the 100-year base flood are designed to reduce the susceptibility of that development to flood damage from all but very rare flood events.

Compliance with Building Regulations

Building regulations will have their intended effect only if builders comply with the requirements. Since none of the communities operated systematic surveillance programs to detect violations of building standards, we were concerned that the standards could be ignored and the violations not detected. Our previous research (Burby and Kaiser, 1987) suggested that noncompliance with floodplain management regulations is widely perceived by local government officials. To determine whether noncompliance also characterized the ten cities that are the focus of this research, we measured the elevations of 110 new buildings in seven of those communities.

The method, developed by Sheaffer and Roland, Inc. (1984), involved the following seven steps:

1) Determine the ground elevation at or near the structure from existing benchmarks, such as manholes, fire hydrants, curbs, and plot plan references.

2) Determine the elevation of the first habitable floor required by the regulations from the building/development permit or subdivision plat.

3) Determine the base flood elevation (BFE) at or near the structure from the permit, plat, or Flood Insurance Rate Map (FIRM).

4) Predetermine a height for a hand level--usually by marking a car window at three or four feet.

5) In the field, park the car at (or near) the benchmark, use the hand level to determine how much above or below the predetermined level height the first floor is.

6) Calculate the field-determined first floor elevation estimate (by adding or subtracting the instrument height and field reading).

7) Compare the field elevation estimate with the BFE and required first floor compliance.

Compliance data were not obtained in three communities. In Scottsdale, elevation of all building sites on fill was required at the subdivision permitting stage of the development process; no specific elevation was noted on building permits. Visual inspection showed that subdivisions adjacent to the Indian Bend Wash were built on fill to or above the wash's 100-year flood elevation. In Palatine, three buildings were visually checked to see if they were located outside of the floodplain (set back) and that no fill encroached on the floodplain, as specified in the special use permits granted for their development. In all three instances compliance appeared to be satisfactory. In Savannah, field benchmarks were difficult to obtain, and a visual check was made to observe fill relative to street level. Compliance with Savannah's building regulations appeared to be satisfactory.

Of 52 residential structures checked, four (8%) had been elevated below the base flood elevation required by city regulations. Three of those four cases were in Wayne Township, however, where benchmarks taken from the city's detailed (one-foot contour) topographic maps may not have been accurate enough relative to localized variations in ground level to provide reliable results.* Of 58 nonresidential structures we checked, four were below the

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*As evidence of that, it is noteworthy that we found as many structures elevated above the required minimum base flood elevations in Wayne Township as were elevated below the minimum. Since extra elevation is costly, that fact suggests our methods may not have provided reliable results in Wayne.

required base flood elevation; however, three of those four cases were in were Wayne Township. Thus, outside of Wayne Township, where we had difficulty in obtaining reliable estimates of building elevations, only 2 of 87 structures (2.3%) we checked were inadequately elevated. Even without a systematic effort on the cities' part to detect violations, compliance with floodplain management regulations appears to be exceptionally high.

Potential Average Annual Flood Damages

Over the ten-year study period, we estimate that average annual flood damages (in 1975 dollars) increased by 4% from $18.047 million to $18.846 million (see Table 3-5). In the absence of the floodplain land use management programs in place in the ten communities, we estimate average annual damages would have increased by 65% to $29.840 million (see Table 3-6). Thus, floodplain land use management produced a net savings of almost $11 million per year in potential average annual flood losses; those savings ranged from a low of $35,000 per year in Cape Girardeau to a high of almost $3.5 million per near in Tulsa. The overall 4% actual increase in potential damages was 36.8 percent below our estimate of what losses would have been if the communities had not adopted floodplain management programs.

Our estimates of average annual flood damages are based on estimated average annual flood damages per acre of residential, commercial, and public development calculated in 1975. Figures for 1985 were developed by multiplying the 1975 per acre flood loss figures by projected and actual acreage of development that occurred in the communities between 1976 and 1985. Thus, our damage figures do not take into account flood control structures completed in Fargo, Omaha, Palatine, Scottsdale, Toledo and Tulsa during the study period that could have reduced the flood damage potential. We also do not include added damage potential contributed by floodplain development, built prior to 1975, that was annexed by the communities over the study period. Since the focus of this research is on damages averted by floodplain management, rather than by flood control investments, we believe the damage data reported here are adequate for our purposes.

The effects of more stringent building elevation requirements in the communities with stronger floodplain management programs are reflected by the data summarized in Tables 3-5 and 3-6. Between 1976 and 1985, potential average annual flood losses increased an average of 1.3% in the communities with stronger programs, versus an average of 5.5% in the communities with weaker programs (see Table 3-5). Percentage reductions in potential losses in comparison with our estimates of losses without floodplain land use management averaged 43.8% in the communities with stronger programs