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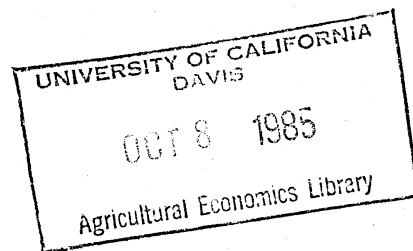
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Consideration of Offsite Impacts in  
Targeting Soil Conservation Programs

by  
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## Consideration of Offsite Impacts in Targeting Soil Conservation Programs

### Abstract

The offsite impacts of soil erosion should be considered in targeting regions for soil conservation programs. Regions where a reduction in erosion on agricultural land would improve water quality were identified, and compared to regions targeted using onsite criteria. Differences in the regions identified indicate that failure to consider both onsite and offsite impacts may result in inefficient targeting.

## Consideration of Offsite Impacts in Targeting Soil Conservation Programs

There has been a great deal of interest recently in directing soil conservation expenditures to those regions where the benefits from erosion reduction would be the greatest. Knowledge of areas where control of agricultural erosion is likely to generate sizable offsite benefits would help to identify regions where resources should be directed for reducing soil erosion.

The loss of soil and chemicals from agricultural land results in damages both on and off the field. Onsite damages consist primarily of impacts to productivity. There are a variety of offsite damages. Sediment fills reservoirs, blocks navigation channels, interferes with water conveyance systems, affects aquatic plant life, and degrades recreation resources. Pesticides affect aquatic plant and animal life, reducing recreation opportunities and possibly endangering human health. Nutrients from chemical fertilizer and manure promote the premature aging of lakes and estuaries, affecting recreation opportunities, municipal and industrial water supplies, and commercial fishing.

The emphasis of soil conservation programs has traditionally been on maintaining the soil resource base. Given this focus, it would not be unexpected for soil conservation programs to be targeted on the basis of onsite criteria, such as the erosion rate. If economic efficiency is an issue, this strategy may not be in the best interests of society. There is growing evidence that the offsite benefits from reducing agricultural nonpoint source pollution may be quite substantial, and may even surpass productivity benefits (Clark et. al. 1985). Clark estimated annual offsite damages from cropland (excluding range and pasture) to be 2.3 billion dollars (in 1980 dollars). This is a substantial figure. In a recent report to Congress, the GAO reported

that damages incurred both on and off the field are the true costs of erosion and should constitute the basic yardstick for USDA's allocation of conservation resources (GAO 1983).

If offsite and onsite impacts coincide geographically, then ignoring the offsite impacts would not be a problem. Addressing the worst onsite problems would address the worst offsite damages. However, there is no reason to believe that onsite damages coincide with offsite damages. The relationship between soil erosion and offsite damages is very complex. The delivery of agricultural pollutants to waterways from agricultural land depends on many factors, including the size of the watershed, average slope, amount of ground cover, and stream density. Water quality in the receiving waterway depends not only on the agricultural pollutants discharged, but also on pollutants from other sources, as well as on the physical, chemical, and biological characteristics of the waterway. The level of damages ultimately depends on the presence of water users. Without a demand for water, or for water quality, there can be no economic damages from poor water quality.<sup>1</sup> For these reasons, there is a great likelihood that the use of onsite criteria for targeting conservation program dollars will lead to an inefficient allocation of resources.

In this paper, regions will first be targeted on the basis of potential offsite benefits. Regions will then be targeted using onsite criteria, and the results compared. If there is a wide divergence in regions identified, then there would be reason to believe that both onsite and offsite impacts should be considered in the design of soil conservation programs.

<sup>1/</sup> This argument does not take into consideration preservation or option values. It is not known whether accounting for these demands for water quality, if possible, would have an impact on the results.

### Targeting of Regions

The procedure used for targeting regions on the basis of offsite impacts consisted of six steps. First, regions for study were identified. Second, average water quality levels were determined for each region. Third, the shares of pollutants entering waterways from agriculture were calculated. Fourth, a relationship between loadings and pollutant concentrations was developed. Fifth, a measure of surface water use intensity was developed. Finally, the use, quality, and pollutant share information were tied together to identify regions where a reduction in agricultural pollutants would result in the greatest offsite benefits.

Regions were defined as the 99 Water Resource Council Aggregated Sub-Areas (ASA) in the lower 48 states. The ASA's are watershed units, making them the desired unit for studying erosion's impact on water uses. The level of water quality in a particular stream in an ASA (except for major rivers which cross ASA boundaries) was assumed to be a function of activities taking place in that ASA.

Water quality data used in this analysis comes from the National Stream Quality Accounting Network (NASQUAN) water quality monitoring system, operated by USGS. Water quality data from 182 stations for 1982 and 1983 were used to characterize the ambient levels of total suspended solids (TSS), total phosphorus (TP), and nitrite-nitrate ( $\text{NO}_2\text{-NO}_3$ ) for each ASA. These pollutants are the major ones produced by agriculture.

The average ambient water quality levels were compared with levels at which important uses become impaired (Zison et. al. 1977). TSS levels above 80 mg/l have observable, negative impacts on aquatic life. High TSS levels also increase filtering costs of withdrawal users. TP levels greater than 0.1 mg/l increase potential for excessive eutrophication when phosphorus is a limiting

nutrient (as is generally the case in fresh water systems).  $\text{NO}_2\text{-NO}_3$  levels greater than 0.9 mg/l increase the potential for eutrophication when nitrogen is a limiting factor. Eutrophication affects both instream and withdrawal uses. Forty-eight of the 99 ASA's had average TSS readings greater than 80 mg/l, 28 had excessive  $\text{NO}_2\text{-NO}_3$  levels, and 60 had undesirable TP levels. A total of 68 ASA's had excessive readings of at least one of the pollutants (figure 1).

Several assumptions were made in calculating and interpreting the average water quality of the ASA's. It was assumed that data from the NASQUAN stations represented averages for an ASA, even though the quality of any one stream may vary considerably from the average, and all flow conditions may not be adequately represented. It was assumed that criteria could be chosen to assess the potential pollution from nutrients and sediment that would occur within a given ASA even though the degradation might occur at the extremes of flow conditions, rather than at an average. Finally, it was assumed that the water quality data was not influenced by point sources located close upstream from the monitoring stations.

Pollutants in waterways can originate from several sources. Agricultural land, including cropland, pastureland, and rangeland, is one source. Other potential nonpoint sources include forestland, mines, quarries, streambanks, and construction sites. For the 48 states, about 43% of all eroded soil was from land other than agricultural land (based on 1982 National Resource Inventory). Another source of pollutants, especially nutrients, is point sources, such as factories and sewage treatment plants. Identification of regions where a reduction in agricultural soil erosion would likely result in water quality improvements requires an accounting of pollution loads from each source.

Resource for the Future (RFF) has developed the National Water Discharge Inventory, which provides the basis for an accounting of pollutants entering waterways. This inventory includes the amounts and sources of various pollutants being discharged into the waters of each ASA. The amounts of pollutants from point sources are based on information contained in discharge permits for individual plants and factories. Information on nonpoint discharges comes from several sources. Urban nonpoint discharges are calculated using an urban runoff model. Discharges from cropland, pastureland, rangeland, and forestland are based on erosion estimates provided by the 1977 National Resources Inventory (NRI). For each ASA, a sediment delivery ratio was calculated and used to estimate the amount of eroded soil reaching waterways. The amounts of TSS, TP, and total nitrogen (TN) contained in the discharge were estimated using coefficients based on the characteristics of the major soil groups contained in each ASA. The assumption was made by RFF that the pollutants are carried in direct association with soil particles.

The RFF discharge inventory was incomplete, in that potential sources of erosion, such as federal forest and rangeland, pits, quarries, stream-banks, gullies, and construction are not included. Information on erosion from these other sources was obtained from the 1977 NRI and from other sources at the state level, and allocated to ASA's. The sediment delivery ratios and attached pollutant coefficients generated by RFF were then used to calculate TSS, TP, and TN discharges from these sources. A more complete accounting of total pollutant discharge for each ASA was therefore obtained. Agriculture's share of pollutants reaching waterways was calculated for each ASA. For the 48 states, agriculture contributed 59% of the TSS, 50% of TP, and 48% of TN entering waterways.

In order to determine how reductions in agricultural erosion affect ambient pollutant concentrations, a linear relationship between loadings and



concentrations was assumed. This assumes no additions to dissolved or suspended pollutants from deposits along the stream channel.

For each ASA, the percent reductions in loadings resulting from 100% and 50% reductions in agricultural erosion were calculated for each pollutant. It is realized that a 100% reduction in agricultural erosion is an unrealistic goal. It is used here for comparison purposes only.

These reductions were then applied to pollutant concentrations. If, for those regions which were identified as having water quality problems, all pollutant concentrations dropped below the threshold levels, then it was assumed that the potential for benefits existed. If any of the pollutants remained above the threshold, it was assumed that no benefits would be generated.

This procedure makes the assumption that benefits are generated only when the threshold levels are passed. When pollutant concentrations remain above the thresholds after erosion reductions (water quality remains poor), this assumption is probably a good one. Fish cannot survive above a certain concentration of suspended sediment, and nothing would be gained by leaving sediment concentrations in the lethal range.

There is evidence that benefits may result when improvements occur to water which was of already acceptable quality (concentrations below thresholds). For instance, a decrease in phosphorus concentrations will result in reduced algal growth rates, even when the initial concentration is already below the .1 mg/l threshold (McCabe et. al. 1982). This is likely to result in improved water clarity, and generate recreation benefits. It is most likely that the benefit from an improvement in water quality is greatest when the quality threshold is passed, rather than for changes which do not involve the threshold. For the purposes of targeting, ignoring non-threshold quality changes would not be a serious problem.

Twenty-two of the 68 ASA's which had excessive levels of at least one pollutant had concentrations of all pollutants reduced to below the threshold, assuming a 100% reduction in agricultural erosion (figure 2). A 50% reduction in erosion would reduce concentrations to below thresholds in only 10 ASAs (figure 3).

It should be noted that this procedure does not necessarily identify regions where agriculture's share of pollutant loadings are the greatest. A region may have poor water quality attributable mainly to point sources, but show improvements in water quality in relation to the threshold concentrations when only agricultural erosion is reduced. Conversely, there is no guarantee that a region with poor water quality attributable primarily to agriculture will show the desired improvements in water quality if the agricultural portion is controlled.

Assuming that benefits are proportional to use, the final step was to determine which of the ASA's identified above are heavy water users. There are two general categories of uses. Instream uses occur within the stream channel. Offstream uses occur outside the stream channel. In this analysis, recreation visits were used as an indicator of instream use intensity, and water withdrawals were used as an indicator of offstream use intensity. Information from the Water Resources Council was used to measure water usage for each ASA (Water Resources Council 1978). Regions having either recreation or withdrawal levels greater than the mean were designated intensive water use regions.

This procedure assumes that the per-unit value of withdrawal or recreation use is the same between regions. This may not be the case. A gallon of water withdrawn in one region may be more valuable than one withdrawn in another region, due to different mixes of industrial, municipal, and other users.

A targeted region was defined as an intensive use region which had an unacceptable level of at least one pollutant, and where control of agricultural erosion generates acceptable water quality. Of the 22 ASA's where a 100% reduction in erosion would reduce concentrations of all pollutants to below the thresholds, 11 were identified as intensive use regions (figure 4). Three lie in the Corn Belt, three are in California, two are in the Northeast, and one in each the Southern Plains, Lake States, and Mountain States.

Six of the 10 ASA's identified under the 50% reduction criterion were intensive use regions (figure 5). Two are in California, and one in each the Mountain States, Southern Plains, Lake States, and Northeast.

What may be surprising to some was the failure of the procedure to identify more ASA's in regions of intensive agriculture with documented problems, such as the Corn Belt and Appalachian. There are several reasons for this result. Agriculture may not have contributed enough of a share of the pollutant loadings, such that a reduction in erosion would generate acceptable water quality. Also, the intensity of surface water use by instream and withdrawal users may not have been as great as for other regions. These results do not imply that no benefits would be generated in ASA's not targeted. Since this is a targeting exercise, only the more important regions are singled out.

#### Comparison with Other Criteria

The results of the targeting scheme outlined above were compared with results of targeting schemes based on onsite erosion criteria. Two such criteria were used; gross erosion and cropland erosion rate. The gross erosion criterion used total erosion from cropland, rangeland, and pastureland to rank the ASA's. The 11 ASA's with the greatest erosion were identified (figure 6). Most of these are located in the midwest. This criterion identified only 2 of the 11 ASA's identified using the offsite benefits criterion under the 100%

erosion reduction assumption. Of the six ASA's identified using the offsite benefits criterion under the 50% erosion reduction assumption, none were among the top six ASA's identified using the gross erosion criterion (figure 7).

If cropland erosion rate is used as the targeting criterion, the top 11 regions lie primarily in the midwest and southeast (figure 8). This criterion identifies only three of the ASA's identified using the offsite benefits criterion under the 100% erosion reduction assumption. None of the six ASA's identified using the offsite benefits criterion under the 50% erosion reduction assumption was identified using the erosion rate criterion (figure 9).

Based on these results, it is apparent that onsite targeting criteria will not satisfactorily identify regions where offsite impacts are significant. If the onsite productivity benefits from soil conservation programs greatly outweigh the offsite benefits, then the failure to account for the offsite impacts would not present much of a problem, as far as efficiency is concerned. However, if the offsite benefits are substantial, as recent findings suggest, then failure to consider them will result in inefficient targeting, if the goal is to maximize program benefits. Offsite impacts should be considered in targeting regions for soil conservation programs.

#### Summary

Regions where a reduction in erosion from agricultural land would have significant impacts on offsite water uses were identified. The sole use of onsite, erosion criteria for targeting will identify only a few of the regions which are important in terms of offsite benefits. Efficient targeting must consider both productivity and offsite benefits. The results are far from

certain, but it is felt that the approach taken provides a broad view of where offsite impacts are probably the greatest. The results could be greatly improved if better data were available. Improved information on nonpoint source pollution's impacts on water quality is needed, as well as information on the costs to water users from changes in water quality on a regional basis. Ideally, conservation efforts should be allocated on the basis of both on- and offsite benefits.

## References

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Figure 1 - Regions with excessive levels of at least one pollutant.

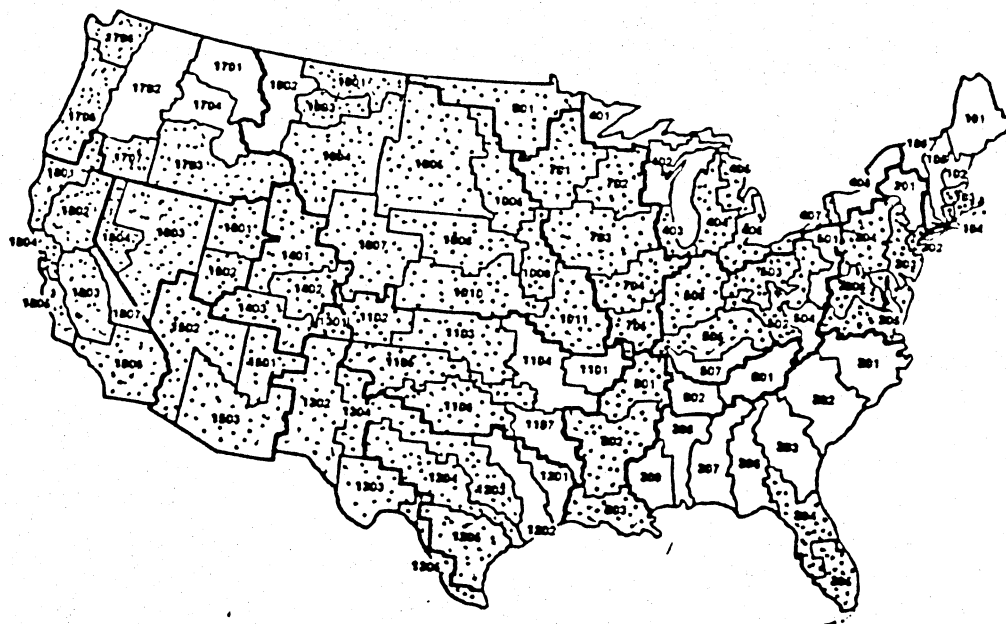


Figure 2 - Regions where 100% reduction in agricultural erosion reduces pollutant concentrations below threshold levels.

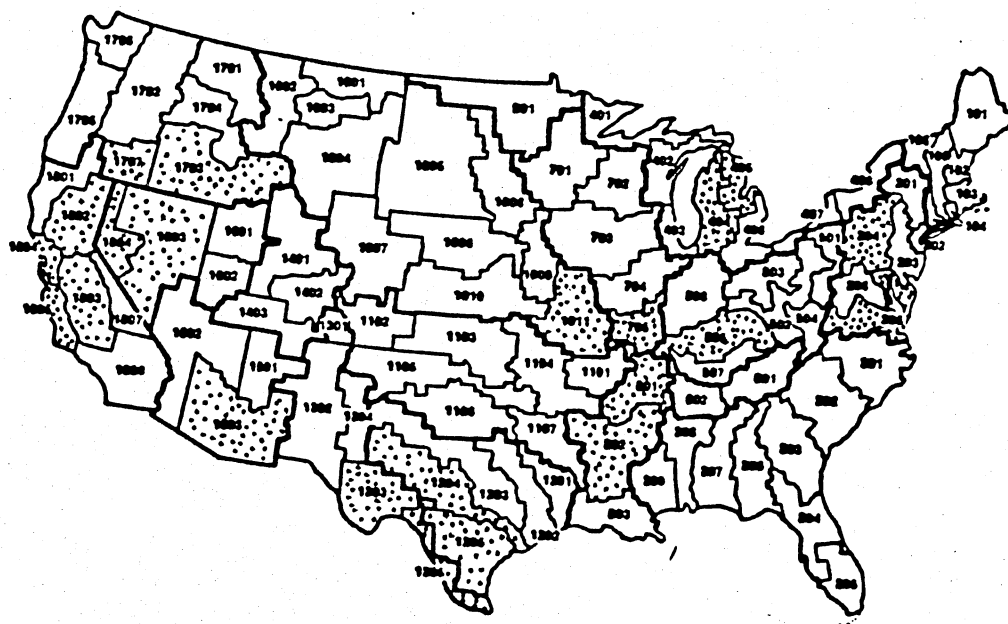


Figure 3 - Regions where 50% reduction in agricultural erosion reduces pollutant concentrations below threshold levels.

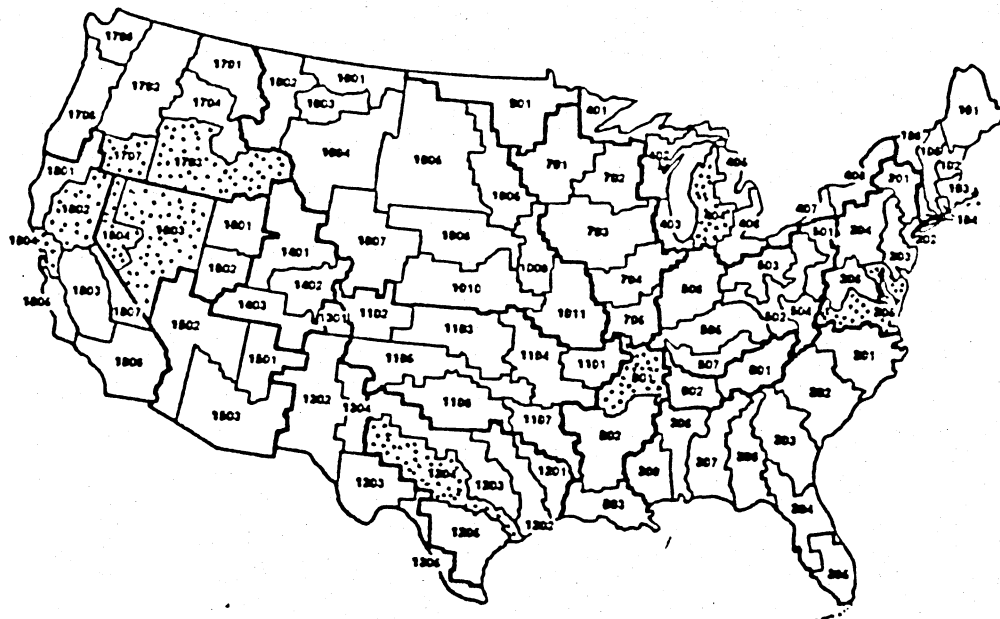


Figure 4 - Regions targeted for offsite damage reduction under the 100% agricultural erosion reduction assumption.

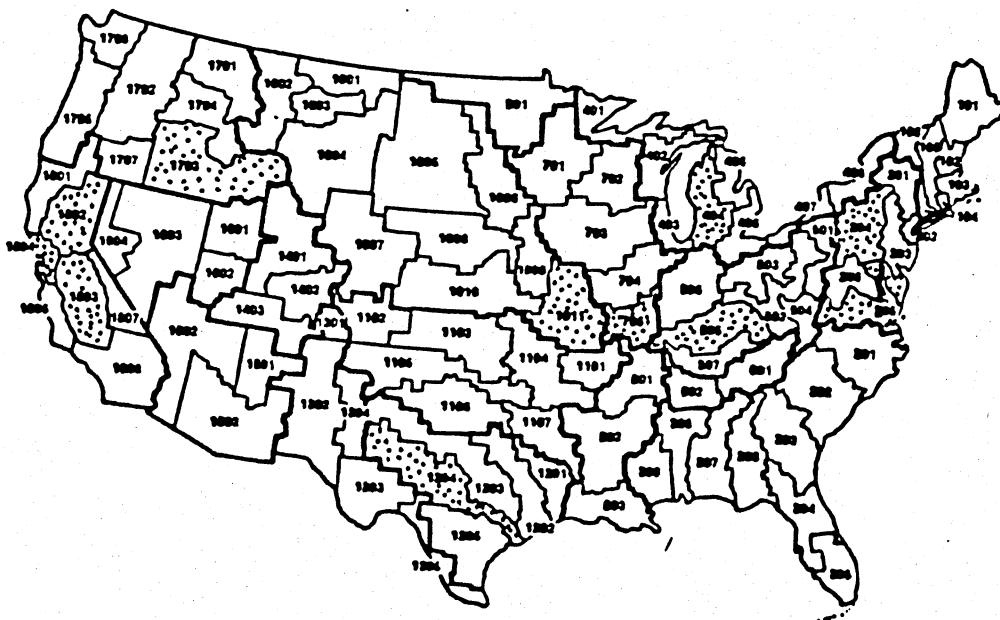




Figure 5 - Regions targeted for offsite damage reduction under the 50% agricultural erosion reduction assumption.

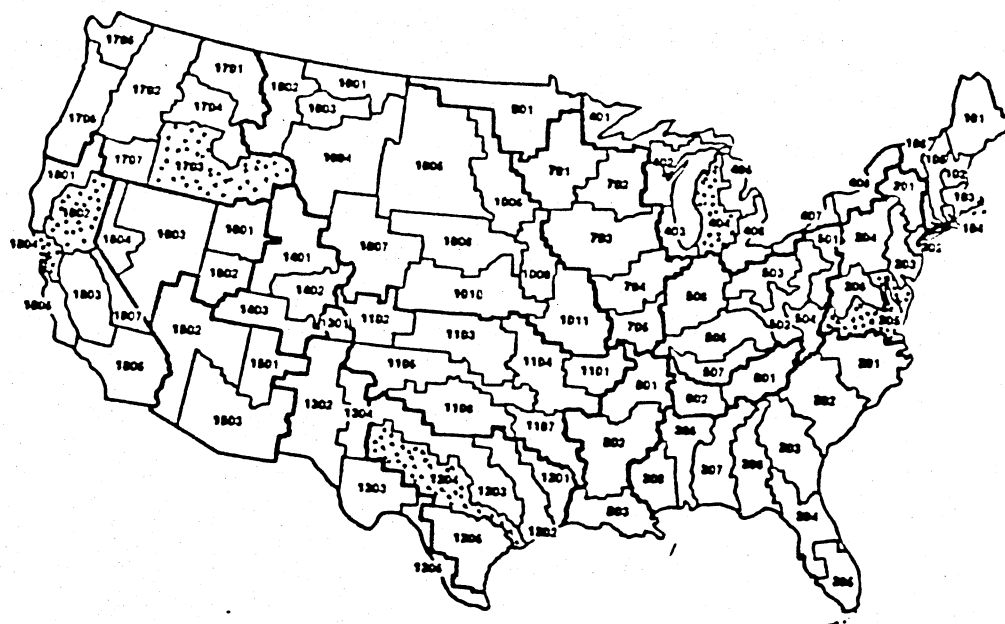


Figure 6 - Regions targeted using gross erosion criterion (for comparison with figure 4).

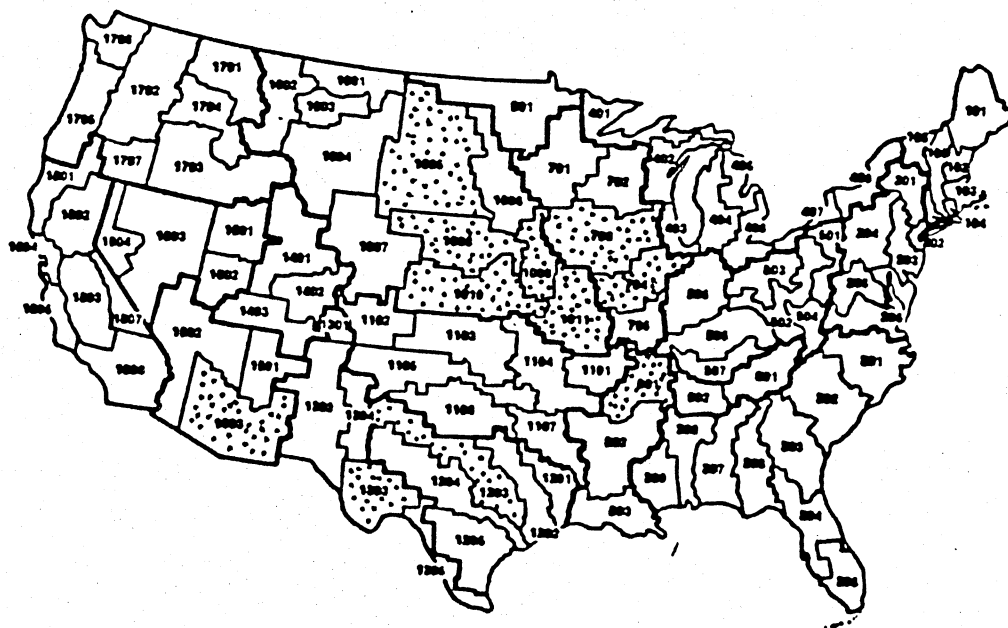


Figure 7 - Regions targeted using gross erosion criterion  
(for comparison with figure 5).

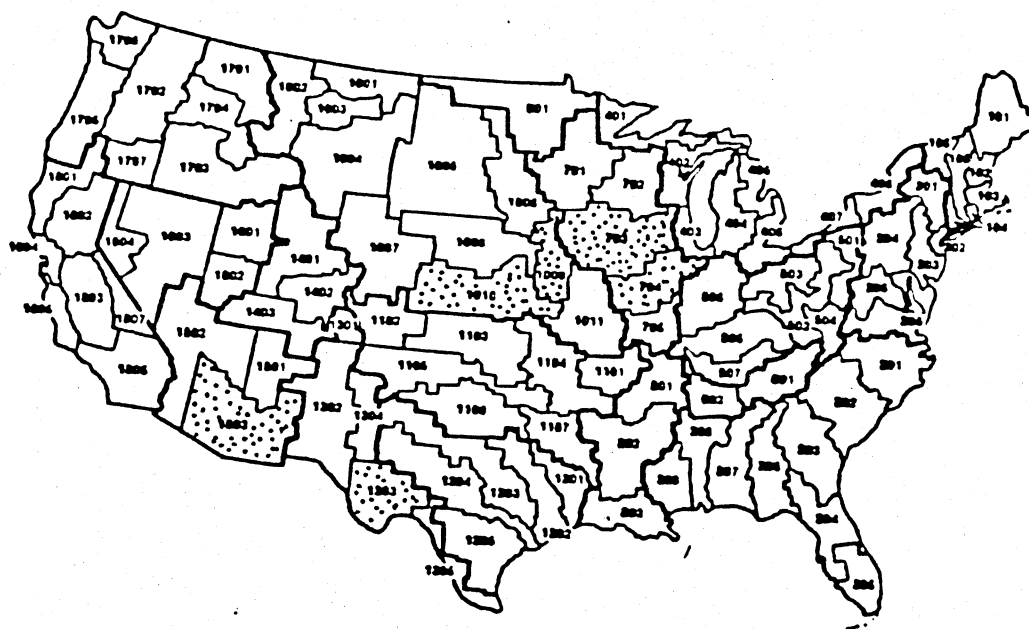


Figure 8 - Regions targeted using erosion rate criterion  
(for comparison with figure 4).

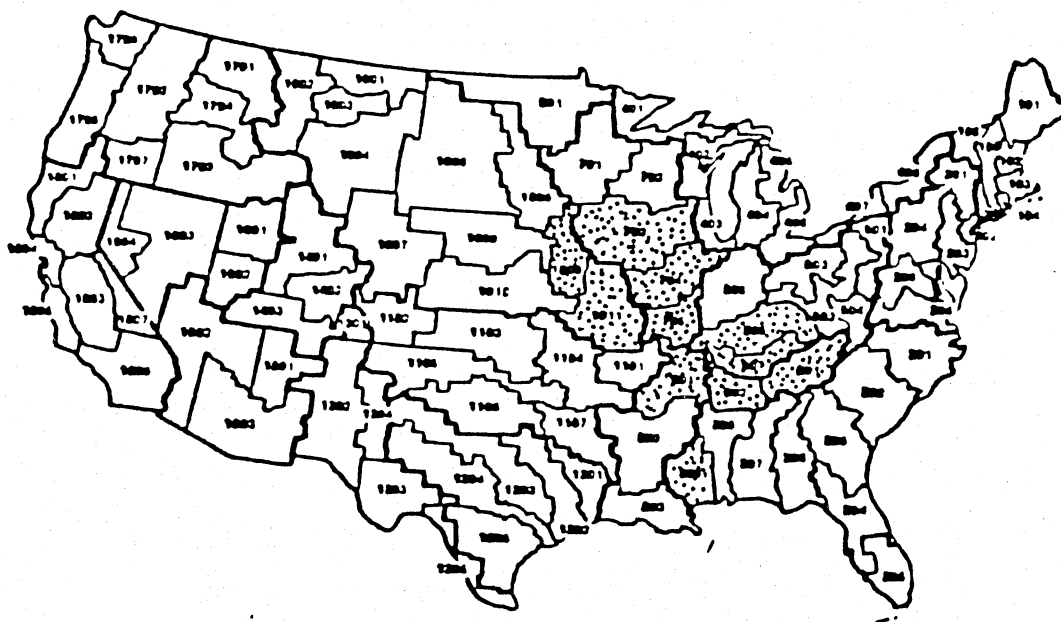


Figure 9 - Regions targeted using erosion rate criterion (for comparison with figure 5).

