Long-Term Effectiveness of Vegetative Filter Strips

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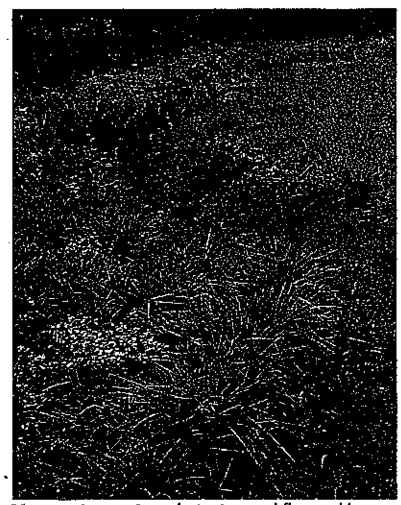
While progress has been made in the control of agricultural nonpoint source pollution, there is much work to be done to reduce sediment and nutrient loadings to the nation's waters. One method for removing sediment and nutrients from agricultural runoff, which is receiving considerable interest, is vegetative filter strips (VFS). Although VFS have not traditionally been part of state and federal cost-share programs, they are now being promoted through funding from the federal Conservation Reserve Program and state nonpoint source pollution control programs such as Virginia's Chesapeake Bay Program.

VFS are bands of planted or indigenous vegetation that are situated between pollutant source areas and receiving waters. They remove sediment, nutrients, and other potential pollutants from agricultural and urban runoff. VFS act by filtering particulates from surface runoff and decreasing sediment transport capacity, thereby inducing sediment deposition. VFS effectiveness is dependent on such factors as incoming sediment and nutrient load, flow velocity and depth, vegetation height and density, and VFS slope and width.

The design and effectiveness of VFS have been studied extensively under controlled experimental conditions. However, few studies have focused on their on-farm effectiveness or the maintenance procedures needed to sustain high nutrient and sediment removal rates. The following study investigated both effectiveness and maintenance by observing on-farm VFS to document appropriate and inappropriate management practices and site conditions affecting VFS performance, interviewing farmers and local conservation officials about existing installation and maintenance practices and operational problems, and developing a list of recommended installation and maintenance procedures.

RESEARCH METHODS

The study took place in rural Virginia. VFS of varying ages were selected for detailed inspection and evaluation. Two methods were used to evaluate perceived VFS effectiveness: site visits and a mail survey. The VFS were visited five times at 3-month intervals between March 1985 and April 1986. Some VFS were visited only once or twice because they were not serving their intended purpose, had never been planted, or no longer existed.



Vegetative strip with concentrated flow problems.

Each VFS was inspected for problems or characteristics that would enhance or reduce effectiveness. These observations were accompanied by measurements of width, slope, and vegetation; slope and land use of adjacent land; estimation of the percent of flow entering the VFS as concentrated flow; evaluation of cover; maintenance needs; owner attitudes; and other factors. After the last site was visited, questionnaires were mailed to owners of VFS to assess their opinions regarding VFS effectiveness and to obtain their recommendations for improving VFS.

STUDY RESULTS

Site visits. Of the 33 farms visited and evaluated, 18% had no VFS. Eighteen percent of the existing VFS were simply pastureland borders. All of the VFS had initially received cost-share funds, but at least two were known to have been withdrawn the first year; one because herbicides were mistakenly applied to the entire VFS, and another because the site was too wet for good vegetative growth.

Approximately 50% of the VFS had excellent vegetative cover for effective VFS performance under shallow sheet-flow conditions. Many of these VFS had fair to poor cover during the first two site visits because they had been planted during the previous 6-month drought period. By the end of the project, 50% of the VFS had good to excellent cover, 14% had fair cover, and 27% had poor cover.

Tall fescue was the dominant vegetation in all but two of the VFS, but orchard grass, clover, and lespedeza were also present. There was a wildlife habitat VFS which contained a mixture of millet, fescue, and cabbage. This VFS was thin at ground level, and, by the end of the project, had a sparse cover that was predominantly weeds. The fact that this VFS was never mowed undoubtedly contributed to its excessive weed growth and ineffectiveness. Indeed, most of the VFS investigated needed mowing; the most commonly used maintenance practice.

Approximately 20% of the VFS had severe erosion and gully problems in localized areas. Only one owner had repaired and reseeded eroded areas. In most cases, grass and weeds quickly became established in the gullies. However, the stabilized gullies allowed runoff to pass through the VFS as channel flow, reducing VFS effectiveness. Excessive weed growth was a significant problem in 29% of the VFS. The taller weeds shaded desirable grasses and reduced cover at ground level. Mowing, herbicides, and reseeding, or any combination, could have improved these VFS. Nineteen percent of the VFS had poor cover or severe damage, or both, because they were used as roads or turn rows. Deep tire tracks were found in some VFS, and those with heavy traffic were bare and compacted. Cattle had damaged two VFS. Grazing was not the problem, hoof damage was. Vehicular and cattle damage were usually most severe in lower areas close to streams and channels, where good cover was needed most.

The majority of the VFS were ineffective for water quality improvement because most flow was concentrated. Runoff entering the VFS as concentrated flow averaged 60%. Larger fields in hilly areas generally had well-developed drainageways and the highest proportion of concentrated flow. Flatter, more uniform fields has less concentrated flow, but, as field size increased, so did internal field drainageways and concentrated flow. Filter strips appeared to be most effective in smaller fields where runoff could not concentrate before reaching the VFS. Strips adjacent to grassed waterways and other drainage ways would have helped by removing sediment and nutrients from the runoff before it concentrated.

Fifteen percent of the VFS were higher than adjacent cropland, so only extreme runoff could run through them. Another 23% had significant portions that were higher than adjacent cropland. Such problems were most pronounced along larger streams where natural levees had built up in the flood plain. These filter strips were effective only for stream bank and localized erosion protection.

Individual VFS ranged from 3 to 9 m (10 to 30 ft) wide and averaged approximately 5.8 m (19 ft) long. Most new VFS were approximately 6 m (20 ft) wide, but width tended to decrease each time the fields were tilled. Some VFS lost as much as 3 m (10 ft), but 1-m (3-ft) width reductions were more common. Filter strip widths tended to be much narrower where valleys, woods, and natural drainageways projected into fields. These areas are where VFS should be the widest because flows naturally concentrate in these areas.

Tillage caused problems on several flatter fields where mold-board plowing was practiced. If the soil was plowed parallel to and away from the VFS, a deep gully formed next to the strip. If this furrow was not removed by disking, surface runoff would collect and flow along the VFS until it crossed the VFS as concentrated flow when it reached a low point. One way to alleviate this problem would be to plow perpendicular to the VFS to minimize concentrated flow and distribute flow uniformly, but this method would require using the VFS as a turn row which might cause more damage. Another alternative would be to stop plowing 0.5 m (2 ft) from the VFS or to plow the soil toward the filter, and then follow with disking. In this way, a furrow would not be formed, and subsequent disking would be easier and more effective.

The Federal Vegetative Filter Strip Program

VFS use in the U.S. is expected to increase significantly in the next few years because it is an approved U.S. Department of Agriculture cost-share practice under the Conservation Reserve Program (CRP) of the Food Security Act of 1985. The CRP was established to encourage farmers to convert highly erodible cropland into permanent (10 years) cover. This program was designed to reduce soil erosion, improve water quality and wildlife habitat, and eliminate production of excess commodities. Participating farmers receive an annual rental payment of \$75 to \$200/ha•a for land enrolled in the program. Originally, only highly erodible land was eligible for the CRP. In 1988 the CRP was modified to include VFS because of their potential environmental benefits, but only if they met certain requirements.

- The land must be adjacent and parallel to a stream, river, lake, estuary, or wetland that is larger than 2 ha (5 acres)
- The land must have been used for agriculture for at least 2 years between 1981 and 1985
- The land must still be suitable for crop production
- The land with VFS must be capable of reducing sediment delivery to adjacent water bodies
- The land must be planted with permanent grasses, trees, or shrubs
- The VFS must be a minimum of 20 m (66 ft) wide and no more than 30 m (99 ft) wide
- The VFS may not be grazed or harvested during the 10-year contract period

THE QUESTIONNAIRE

Twenty-seven different reasons were given for installing VFS, 21 of which were related to the VFS program goals of erosion control and water quality improvement. Other reasons included the funds received from the state cost-share program, wildlife habitat enhancement, need for field borders, and extra hay production. Fifty-six percent of the respondents were satisfied with recommended seed mixes and planting practices. Dissatisfied farmers recommended higher fescue seeding rates and using switch grass, fungus-free fescue, tall grasses, and more wildlife habitat mixes. Vegetative filter strip widths varied from 3 to 90 m (10 to 300 ft). Most of the respondents believed that a 6 m (20 ft) wide VFS was satisfactory. Eighty-eight percent of the landowners reported having cropland adjacent to the VFS, and 12% had adjacent pasture land.

Most of the respondents said that mowing and proper fertilization were the principal management practices needed to maintain VFS. Annual reseeding, avoiding the use of VFS as roadways, and careful herbicide application on adjacent fields were also recommended. Thirty-one percent of the respondents said their VFS performed satisfactorily. However, 63% reported problems such as poor cover establishment from drought, weed and Johnson grass invasion, reduced width from careless plowing, sediment build-up, narrow widths, formation of gullies from concentrated flow, drift or misapplication of herbicides on adjacent cropland, and excessive weed growth.

All respondents reported that VFS were effective for erosion control and water quality improvement, and that they would maintain their VFS after the state cost-sharing program ended. When asked if they would install new VFS without cost-sharing, 33% said yes, 40% said no, and 27% were not sure.

RECOMMENDATIONS

Despite the apparent problems with using VFS, they can be effective. To increase the cost-effectiveness of VFS with respect to water quality, the following specifications and recommendations should be incorporated into VFS cost-sharing programs. Most of these recommendations have been incorporated in Virginia's VFS program. These recommendations should be used as guides, and final decision to install VFS at specific sites should be made by local conservation or pollution control officials.

Site eligibility. VFS are effective for water quality improvement only under shallow, sheet-flow conditions; therefore, they are inappropriate for fields with significant concentrated flow. VFS site suitability should be determined through inspection by a conservation or pollution control official trained in VFS site selection and evaluation. Large fields with significant internal drainageways are acceptable only if VFS are installed on both sides of internal drainage ways. These VFS remove pollutants from runoff before they can enter the drainage ways and be transported by concentrated flow. VFS are inappropriate for pastures because they are already protected from excessive sediment and nutrient loss.

Vegetative filter strip establishment. Vegetation and seeding rates should be appropriate for local soil and climatic conditions, and approved for use in the designated area. Grasses and legumes, or combinations thereof, are most effective for erosion control and water quality improvement because of their dense growth, resistance to overland flow, and filtering ability. Shrub and wildlife strips should not be permitted because they are relatively ineffective for water quality improvement.

Lime and fertilizer should be applied according to soil-test recommendations and incorporated in the top 7 to 15 cm (3 to 6 in.) of soil as part of seedbed preparation. Vegetation should be planted during optimum seeding times on firm, moist seedbeds. No-till planting is preferable. If site conditions are unfavorable at planting, mulch should be applied immediately after seeding. Mulching is recommended for all VFS establishment to minimize rill development during cover establishment.

Some VFS sites may require limited grading to correct topographic problems such as gullies or high areas within or immediately down slope of the filter. Such grading is not economically feasible for sites with severe topographic limitations. At sites with significant flow parallel to the VFS, shallow berms or terraces should be constructed perpendicular to the VFS at 15- to 30-m (50- to 100-ft) intervals to intercept runoff and force it through the VFS before it can concentrate further.

VFS should be minimum of 6 m (20 ft) wide at the time of establishment. In steeper areas, with poorly drained soils, minimum VFS width should be determined according to approved local specifications.

Maintenance practices. To promote good vegetative growth, nutrient removal, and filtering ability, VFS should be mowed and the residue harvested a minimum of 2 to 3 times a year. Harvesting will increase the vegetation density at ground level, remove nutrients from the system, and minimize nutrient release when vegetation decomposes. Caution should be used when applying herbicides to VFS or adjacent fields. If herbicides are applied to fields, sprayers should be turned off before VFS are crossed or used for turn rows.

VFS should not be used as roadways because traffic will cause damage that may cause concentrated flow problems. If a VFS must be used as a roadway, it should be 2 to 3 m (7 to 10 ft) wider than normal, and the roadway should be located on the down-slope side of the filter so that runoff will be filtered before it can concentrate. Cattle should be prohibited from VFS at all times, but especially during rainy, muddy periods.

VFS should be inspected after planting, and, if stand is adequate, the area should be re-fertilized and overseeded. VFS should be inspected regularly thereafter for damage caused by tillage operations, misapplication of herbicides, gully erosion, sediment inundation, and so on, and should be repaired as soon as possible. VFS that have accumulated so much sediment that they are higher than adjacent fields should be plowed, disked, and graded if necessary, and reseeded to reestablish shallow sheet-flow conditions.

Cost-share eligibility. VFS should be inspected by a conservation or pollution control official after establishment, before payment of cost-sharing funds is approved, and once a year thereafter to ensure that the VFS meets minimum standards. The official should notify the operator if the VFS does not meet standards and allow for a reasonable period of time to correct deficiencies. All cost-share funds should be withheld or returned if the deficiencies are not corrected. VFS that are less than 75% of their original width, 1 or more years after establishment, should be removed from the cost-share program.

Overall, the Virginia VFS program has been beneficial. Even in areas where VFS are ineffective for filtering sediment and nutrients from runoff, they have provided localized erosion protection along stream banks where erosion is often most critical. Farmers interviewed believed that VFS were effective for water quality improvement, and almost all indicated that they would continue to maintain existing VFS after cost-sharing ended. However, most farmers said that they would not install new VFS without cost-sharing. Hopefully, this attitude will change and more farmers will accept their responsibilities toward our air, land, and water.■

Virginia's Vegetative Filter Strip Program

The Virginia VFS cost-share program was initiated in 1983 as a part of the state's Chesapeake Bay Program to encourage farmers to install permanent VFS along stream banks to filter runoff, stabilize soil, and protect stream banks against scour and erosion. The program is administered by the Soil and Water Conservation Districts for the Virginia Division of Soil and Water Conservation. Participating farmers receive $0.33/m ($0.10/ft) of VFS at the time of installation, but are required to refund this amount if the VFS are not maintained. State specifications have changed considerably since 1983 to correct problems associated with VFS.

- VFS must be installed within 30 m (100 ft) of a live or intermittent waterway
- VFS must average 6 m (20 ft) in width with a minimum width of 3 m (10 ft)
- VFS 3 m (10 ft) wide are acceptable if land slope is less than 2%
- VFS must be planted in a permanent vegetative cover according to approved seeding specifications and maintained for a minimum of 5 years
- State cost-sharing funds will be provided only once per VFS while the land is under the same ownership
- VFS will be designed and installed so that they filter sheet flow

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