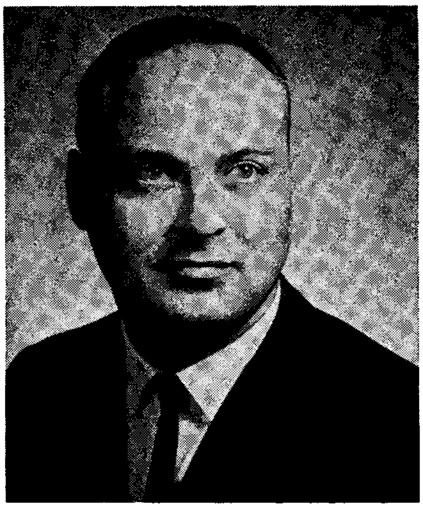
Reprinted from the JOURNAL OF FORESTRY, Vol. 68, No. 6, June 1970
Purchased by the Forest Service, U.S. Dep't. of Agriculture, for official use.



Water Regulation On Forest Land

Ralph A. Klawitter

ABSTRACT—One key objective of water regulation on wet forest land is to increase timber production. Other objectives are to improve wildlife habitat, range land, and flood control. Wetland forests vary widely in site conditions and in their responses to water and soil management. Each kind—swamps, bottomlands, bays, and wet flats—must receive a prescription suited to local peculiarities, because water regulation works best when properly applied to the task for which it is designed. Measures applied, however, must be well enough understood and sufficiently controlled to enable changes in design and shifts in productivity from one resource use to another as the future demands.

WATER REGULATION, water management, water control, or woodland drainage—whatever you choose to call it—is the manipulation of surface and soil water levels on wet forest land.

The unique value of wetland forests to the nation's resources was overlooked until recent years. These wetland forests, once viewed by the logger and road-builder as a curse, now are recognized as major wildlife, timber, water, forage, and recreational assets to the economy.

We have heard that, by the year 2000, every woodland acre in the South will have to produce its share of timber if growth is to keep up with cutting. One key objective of wet soil management, therefore, is to increase the production of timber.

As early as 1935, trials to improve pine production on the Apalachicola National Forest in northwestern Florida were conducted by the U. S. Forest Service. But it was not until after a 1947 water-regulation test in southern Georgia, that landowner interest was really awakened. In this test surface water was removed from a series of shallow depressions by a 2-foot deep ditch. Natural pine that seeded onto the pond margins demonstrated that excess water was a primary factor in preventing afforestation of wet soils with pine. Demonstrations of this kind encouraged lumber and pulp and paper companies to begin development of their wet soil holdings on an increasingly large scale, a practice which continues to the present.

THE AUTHOR is assistant director, Northeastern Forest Exp. Sta., Forest Serv., U.S.D.A., Upper Darby, Pa.

Benefits

The benefits which timber producers obtain from their investments in water regulation are manifold. In many fine stands of mature timber, previously inaccessible to loggers with conventional rubber-tired or tracked logging equipment, lowering of surface and ground water increased soil trafficability immediately. Spoil from the drainage ditches was shaped into hauling roads for logging trucks. These roads also served as access routes for crews involved in a host of management activities: site preparation, planting, fire, insect and disease control, etc. Consequently as unproductive soils were converted to productive soils, more acres could be put to work growing timber. Better survival, better stocking, and better growth all resulted (Fig. 1). Little wonder that the practice began to be applied in a widespread fashion throughout the southeastern Coastal Plain.

Timber producers were not the only ones to benefit. Wildlife managers soon discovered that water-management measures could be applied to wet forest soils to improve the habitat for certain species of wildlife. Range managers began to hold water levels high on range soils to increase forage production when rainfall was low. A small Florida community even withdrew ground water from otherwise unproductive swamp soils to meet water-supply needs.

Of increasing importance are the flood-control measures applied to wetland forests. Total yearly losses caused by floods in headwater areas exceed those caused by major rivers overflowing their banks farther downstream. Flood protection for upstream urban areas, industrial sites, and cropland is provided by opening and clearing bottomland channels of aquatic vegetation and debris, as well as by canalization.

The Wetlands

Wetland forests and their soils reflect the dominating influence of an abundant supply of water. But beyond this common feature they may vary widely from one

Fig. 1.—Water regulation made possible conversion of this pondcypress flat to slash pine forest.

locality to the next, each having its own peculiar combination of land form, parent material, vegetation, hydrology, and wildlife. Some are highly productive in a natural state, supplying large quantities of timber and other resources. Others may support only low-growing heaths and degenerate forests or open stretches of grass overtopped by an occasional slow-growing pine.

In many places, the various site attributes do not complement one another in the natural state to best serve man's needs. One or more of these attributes may then have to be altered by a scientific water- or soil-management measure to enhance the usefulness of the site as a resource area. For discussing these measures and their application, some grouping of wetlands is necessary. One scheme that has proved useful includes four general categories: swamps, bottomlands, bays, and wet flats.

Swamps

Swamps occupy the lowest locations along sluggish streams and rivers that wind through the coastal plain and the broad depressions at the heads of coastal plain streams. In some places, marine terraces or sand ridges that were formed by the sea block areas of low-lying land, and form large swamps. Two examples are the Dismal Swamp in the northern part of the Flatwoods and Okefenokee Swamp in the southern part. Many times the mouths of slow-moving streams are blocked by bars, which further tends to increase the size of some swamps.

Swamps are wetted by precipitation, filled by overflow from the streams they border, and replenished by seepage from adjacent uplands. Water frequently stands above the soil surface for long periods of time, and may be subject to considerable fluctuation in depth. Often water movement is so slow that it is almost imperceptible, but in wet cycles large volumes of water may pass through these sites.

Soil texture varies from coarse to fine, depending on the parent material and source of alluvium. Surface soils are frequently infiltrated with sufficient humus to be mucky; or, in other situations, thick accumulations of sedge and woody peat may develop.

Swamp vegetation is well adapted to a wet environment (Fig. 2). Consequently, drainage of ponds and swamps may be detrimental to these species and may even kill older trees if it permanently lowers the water table. Removal of surface and ground water in swamps also destroys waterfowl habitat, sanctuaries for deer pursued by dogs, and conditions suitable for reptiles, bears, and many other kinds of wildlife.

On the other hand, water regulation, rather than uncontrolled drainage, can increase the soil productivity of swamps for timber and wildlife, preserve their general character, and still enable them to be used as waterways for flood control of headwater urban and farm lands. Methods to achieve these ends include

Fig. 2.—A water tupelo stand along the Santee River in South Carolina.

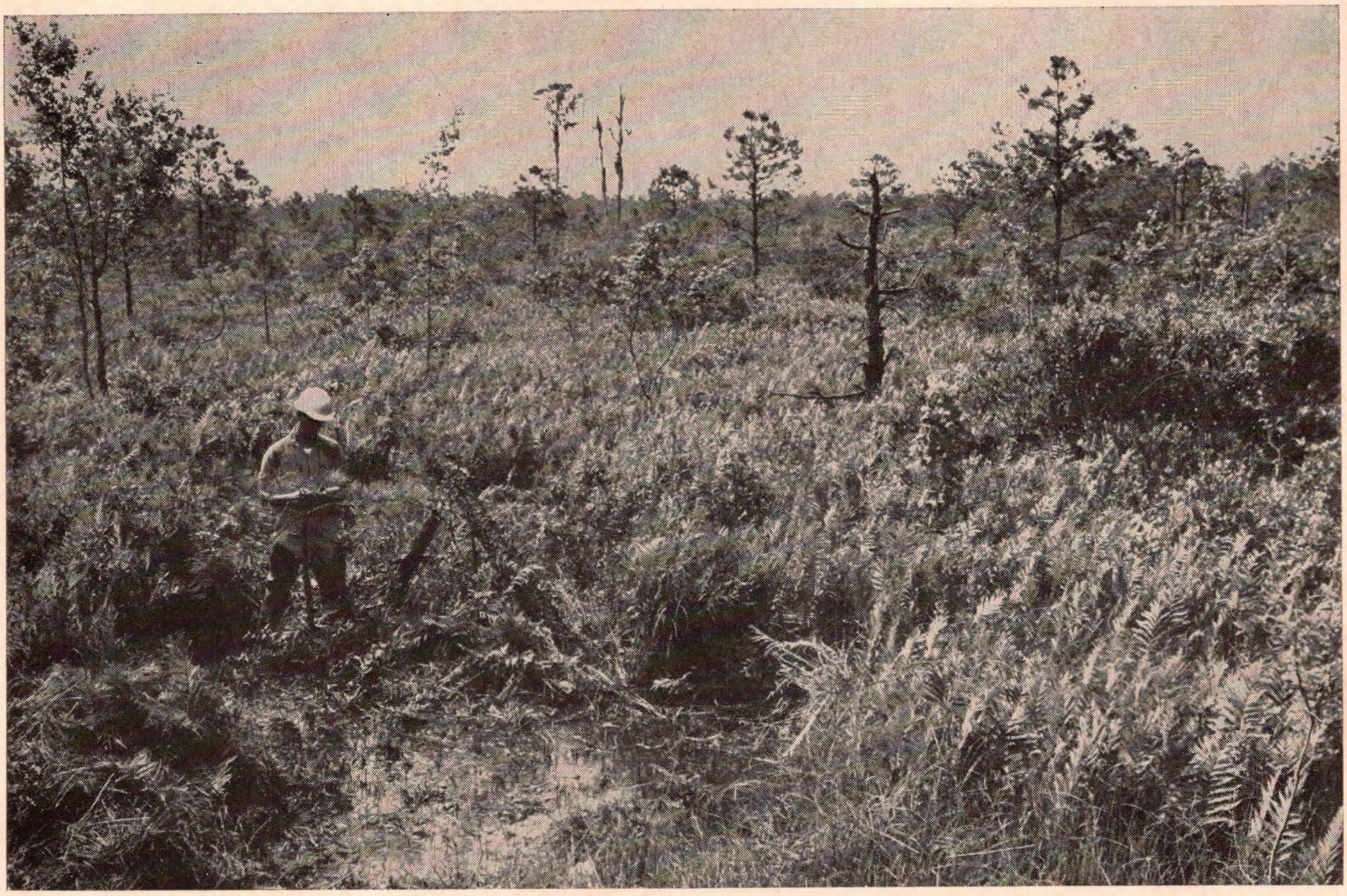


Fig. 3.—Water stands above the surface of this bay on the Francis Marion National Forest in South Carolina.

installation of dikes and control structures at well chosen locations, and water stage control to promote timber growth, improve the wildlife habitat, and achieve flood protection objectives.

Bottomlands

Bottomlands provide the extra channel capacity required to carry stormflow to the sea. Small streams seldom support bottomlands more than a few hundred feet wide, but major rivers are frequently separated from adjacent uplands by several miles of bottomlands. The land surfaces are characteristically flat, but have slight differences in elevation that produce large differences in drainage conditions, soils, and vegetation.

The bottomland forests are wetted by seepage, overflow, and precipitation; and although they are flooded for considerable periods during the year, water levels decline as the river drops, and soil surfaces remain dry for considerable lengths of time. Bottomlands are the repository of water-borne sand, silt, and clay, resulting in the typical indistinct soil profile associated with flooding.

Bottomlands are unexcelled for producing timber and wildlife because of the inherent soil fertility and the abundant supply of moisture.

Soil and water changes resulting from uncontrolled drainage effect profound changes on stand composition, tree growth, and regenerative potential. On this point our knowledge of cause and effect is limited. Consequently, recommended water-regulation measures are limited to those that are likely to increase the amount of soil water available for plant growth.

Seasonal flooding of bottomlands can produce benefits to timber. Shallow water impoundments created by constructing low dikes and dams in flats and shallow drainageways can increase the amount of water that is stored by the soil. The extra moisture benefits tree growth, mast production, and reproduction. Water is supplied by precipitation or headwater streamflow, or is pumped in, depending upon local circumstances. It should be drained out promptly each spring because the growth of many trees is reduced and others are killed if water stands on the area all year. If the irrigation system is properly handled, timber growth can be increased by about 50 percent.

Shallow water impoundments in bottomlands are also used by wildlife managers to attract waterfowl. The main requirements are mast-producing forest trees, suitable terrain and soils, and, of course, water. Flooding is begun when the leaves have started to change their color in the fall and ends in the spring when tree buds swell and dormancy ends. The usual depth of flooding to facilitate waterfowl feeding is 1 to 18 inches.

Bays

Bays, or upland bogs, cover approximately 3 million acres of wet forest soils in the Coastal Plain. Although they can be found throughout the Southeast, they occur most frequently in eastern North Carolina in the northern part of the Flatwoods section. Their physiography is variable, ranging from the elliptical-shaped "Carolina Bays", which are enclosed by a full or partial sandy rim, to irregularly shaped bays with alternating ridges and depressions that lie parallel to one another.

In both kinds of bays, natural drainage is very slow because of the long elevated ridges through them or along their margins, and the lack of fall toward outlets, which slows the natural process of stream dissection (Fig. 3). In addition, depressed and slowly permeable subsoils impede downward drainage, and outlets are blocked by accumulations of plant debris and the growth of mosses, grasses, and shrubs. These sites are wetted primarily by rainfall, and consequently they vary in wetness with seasonal and long-term precipitation cycles.

Because natural drainage is poor to very poor, mineral soils usually contain a well-defined humus-infiltrated layer, which may be overtopped by peat accumulations many feet deep. These peat layers generally are well decomposed and have poor structure and low rates of permeability, although exceptions occur where the type of peat differs.

Primary source of peat in the upper layers is sphagnum mosses. Inclusions of woody peat and sedge peats occur within large bays and also as basal layers, indicating that significant changes in vegetation have taken place. Particularly striking are the numerous stumps of swamp forests uncovered during road and ditch construction. Possibly the early vegetation was composed of sedges and reeds in marshy communities and scattered swamp forest that spread out over time. Sphagnum mosses later may have increased and contributed to an expansion of the bays through obstructed drainage, rising water tables, and site deterioration in the typical process of paludification.

Coastal Plain bays typically are relatively poor producers of timber, water, forage, and wildlife at best. Where mineral soils or subsoils lie within 2 feet of the surface, adequate drainage—in combination with chopping, prescribed burning, bedding, and planting—produces considerable improvement in timber productivity. Part of the response probably results because the peaty material subsides after drainage, is further reduced by burning, and finally is combined with mineral soil during the bedding process. Best site indexes are usually found where subsoils contain a significant amount of clay.

Deep and relatively infertile peat soils yielded by sphagnum mosses are more of a problem. Bays with this type of soil seldom display the responsiveness to water and soil management shown by the shallow peat soils or mineral soils. Early survival of planted trees may be good, which indicates initially at least that high water levels may be a limiting factor. As time passes, survival sometimes declines and growth is slow, which indicates that drainage and soil-preparation measures by themselves are not enough to cure the problem. Fertilization has been suggested as an additional measure required to bring such soils into production. However, not enough is known at this time about the hydrochemical processes in infertile bay soils to recommend suitable amelioration measures.

Therefore selection of the site for improvement still is the key to success in rehabilitation of bays. Where the peat layers are shallow or the peat is rich in nutrients, response to water regulation is likely to be most favorable.

Wet Flats

Wet flats are upland sites located on the very broad and level to nearly level interstream areas of the lower Coastal Plain and Flatwoods section. Primary source of water for these wetlands is precipitation, which lingers on and in the soil for long periods. Occasional surface rises of a few inches retard surface flow over large areas, except in the immediate vicinity of shallow streams where most land slope occurs. Water moves slowly through the soil because of slowly permeable subsoil layers, lack of soil profile development, insufficient hydraulic head between the soil surface and stream flowline, or some combination of these factors. Although wet flats are somewhat poorly to poorly drained, their wetness is seasonal and they frequently alternate in moisture conditions between excessively wet and dry.

Present Efforts

Most efforts in water regulation are now concentrated on the 4 million acres of wet pine soils. A procedure commonly practiced is to remove surface water and lower the soil water enough by means of surface ditches to increase soil trafficability for heavy equipment, and thereby facilitate road construction and timber harvest. Thereafter the site is cleared, bedded, and replanted with one of the southern pine species.

After planting, additional collection ditches are installed as needed to reduce the growing season water table to an average of about 2 feet below the surface in sandy soils. This average water level has produced survival rates of more than 85 percent and height growth rates of 2 feet per year with slash pine in northwestern Florida.

Internal water movement is often much slower in clay soils than in sandy soils, particularly where profile development is lacking and structure is poor. Most of the lowering of the water table will result from removal of surface water and a consequent decrease in the amount of recharge. In either case, the physical properties of the soils improve, and an increase in soil fauna is encouraged.

The tree response to water management in many wet pine flats has been good. In North Carolina both basal area and height growth of pond pine was nearly doubled by drainage. One scientist attributed site improvement for pond pine to lowered water levels and subsequent improved soil properties. Other researchers determined that the yield from slash pine stands on excessively wet soils in Florida can be doubled with water management and estimated the same for loblolly pine on wet pond pine sites in North Carolina. In addition, with proper water regulation, totally nonproductive wet soils could often be converted into high-yielding pine soils.

The response to a specific water-regulation measure

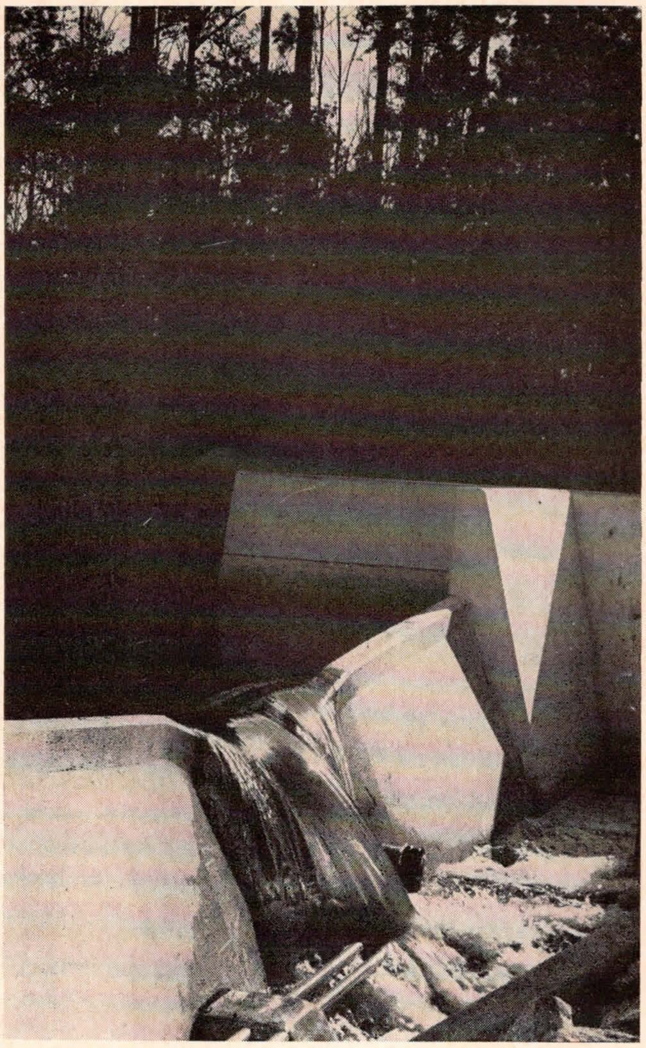


Fig. 4.—A stream-gauging station in a wetland forest on the Coastal Plain of South Carolina.

can vary depending on the soil conditions. It has been suggested that fine-textured soils responded more to drainage, and that loblolly pine on them tolerated higher water levels and grew faster than the same species on coarse-textured soils. Early soils research has indicated that, for all the southern pines, the productivity of poorly drained soils increased with increasing fineness in texture and depth of the subsoil. Generally, more fine-textured soils are found in the northern part of the Coastal Plain than in the southern part. In any case, it seems likely that water regulation will continue to be applied throughout the Coastal Plain—north and south—to increase productivity of wet pine soils as long as projected timber and pulpwood demands are expected to exceed supplies.

System Design

The primary objective in the design of a wetland forest water-management system is to hold sufficient water on wetland soils to fulfill the productivity objectives of timber, wildlife, forage, and water, and to remove the rest of the water in an orderly manner without damage to soil, channels, downstream improvements, or estuarine environments. Mature pine forests use considerable amounts of water—approximately 38 inches according to one estimate. As a result, clearcutting has an appreciable effect upon water levels, causing them to rise enough to endanger regeneration or seriously hamper logging operations. Thus the design should consider the effect that later manipulation of vegetation will have on the amount of water that will have to be removed.

A water-management system for slash pine on wet flats should be similar in many respects to the systems used on farm lands. Disposal ditches should be installed across the slope or in natural low wet locations at intervals of about 1/4-mile to remove subsurface water. Collection ditches should be installed at 660-foot (10-chain) intervals across the slope or at random where slopes are broken to remove surface water. Beds should be constructed up and down the prevailing slope to raise seedlings above any surface water and to use the furrows to conduct water to collection ditches. This design is based upon the experience gained on wet, sandy, pine soils on the Gulf flatwoods, where a less intensive system has not functioned as effectively as first expected.

Several tests have shown that bedding alone can produce significant increases in survival, as well as growth rates two or three times more than that experienced on unbedded soils. The question also arises as to whether or not bedding was beneficial to soils drained—with deep ditches and shallow collection ditches—to an average growing-season water table depth of 2 feet. A study in northwestern Florida indicated that growth could be improved significantly even if survival was not.

Even in the level flatwoods, small wet depressions, which are impractical to drain individually, hold enough water to adversely affect tree growth. Slight changes in soil conductivity can create wet spots that do not become apparent until after planting. Most of these problems can be alleviated by the use of bedding to elevate seedlings above the wet spots, increase their effective rooting zone, and provide other benefits.

Water regulation is a tool that can be used to improve the productivity of millions of acres of wet forest soils in the southeastern United States for wildlife, timber, forage, and water. But like any tool, it works best when properly applied to the task for which it is designed (Fig. 4). Consequently, it must be tailored to fit particular kinds of wet soils to achieve maximum productivity and fulfill the landowner's needs at minimum cost. In some cases, the landowner's immediate objective may be aimed toward maximum production of timber or wildlife; in another, his primary concern may be forage or water, or some combination of these resources.

However, the needs of man are ever-changing, and it is difficult to predict which resources wetland soils will have to produce in greatest abundance in the future. Thus the water-regulation measures we apply today should be well enough understood and sufficiently controlled to enable changes in design and shifts in productivity from one resource to another as the future demands. □