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Ground Penetrating Radar Investigations on Cranberry beds in Plymouth County, Massachusetts

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ABSTRACT

Ground-penetrating radar (GPR) and computer graphic techniques are being used by the U.S.D.A. Soil Conservation Service to collect subsurface information on areas which are used for the production of cranberries in southeastern Massachusetts. The radar is being used to aid in conservation management practices, engineering designs, pesticide and water quality research, soil and geologic mapping, and ground water mapping. Radar surveys have been conducted on over 30 cranberry beds, ranging in size from 0.5 to 100 acres. Computer graphic techniques are used to display radar data in a user friendly format.

INTRODUCTION

The Soil Conservation Service (SCS) has been using ground penetrating radar since the late 1970's. The GPR is used primarily for soil survey data collection, soil mapping, archaeological investigations, and water quality projects. The SCS currently owns and operates five GPR units throughout the United States, three units are located in Florida, one unit is located in Chester, PA., and the fifth unit is located in Plymouth County, Massachusetts.

The Massachusetts GPR program offers radar assistance to SCS offices throughout the New England area. In Massachusetts, two soil survey updates are currently underway in Franklin and Plymouth counties. During the winters of 1990 and 1991 the radar was used to determine its application for use on cranberry beds in Plymouth County. Results from the GPR investigations showed the radar to have a high potential for collecting subsurface information on cranberry beds.

GROUND PENETRATING RADAR

The ground-penetrating radar system used by the Massachusetts Soil Conservation Service is the Subsurface Interface Radar System 3. The System 3 consists of the Model PR8300 profiling recorder and a power distribution unit. The models 3207 (nominal center frequency 100 MHz) and 3110 (nominal center frequency 120 MHz) antennas are used for cranberry bed surveys.

LOCATION AND GENERAL GEOLOGY OF PLYMOUTH COUNTY, MASSACHUSETTS

Plymouth County is located in the southeastern part of Massachusetts (Fig. 1). Cape Cod and the Atlantic Ocean border to the south and east, the large urban and suburban areas of Boston and Providence, Rhode Island border to the north and west.

Cranberry farming is mainly concentrated in the southeast portion of Plymouth County. Figure 2 is a glacial geologic map of southeastern Massachusetts. The glacial sediments were deposited during the late Wisconsinan glaciation approximately 15,000 years before present. Most of the older cranberry beds are constructed on peat-filled kettle holes on the Wareham and Carver Outwash Plains in Plymouth County, and on the Mashpee Outwash Plain on Cape Cod (Fig. 2). The thickness of peat within the kettle holes ranges from less than 0.5 meters to greater than 12 meters (Deubert and Caruso, 1990). A cranberry bed located on an ice contact delta bordering glacial lake Taunton contains 18 meters of sapric and fibric material overlying sand (Hartshorn, 1960). Cranberry beds are also constructed in poorly and very poorly drained soils on glacial till, glacial fluvial, and glacial lacustrine deposits which have a thin (less than 40 cm) layer of peat and muck and are naturally wet enough for growing cranberries. Due to wetland regulations, new cranberry beds are being constructed in upland areas which lack peat. This can be done because cranberries do not require peat for growth. They will grow in sand if fertilized, and if an impervious layer is present to retain sufficient water for crop production.

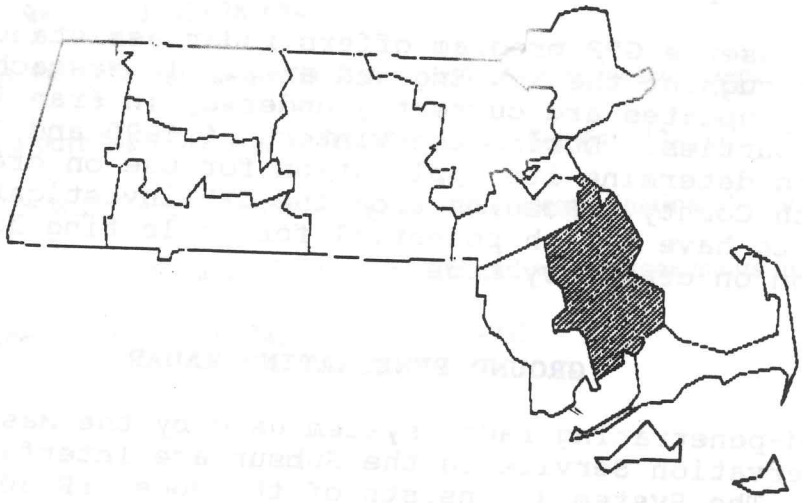

Figure 1. Location of Plymouth County, Massachusetts

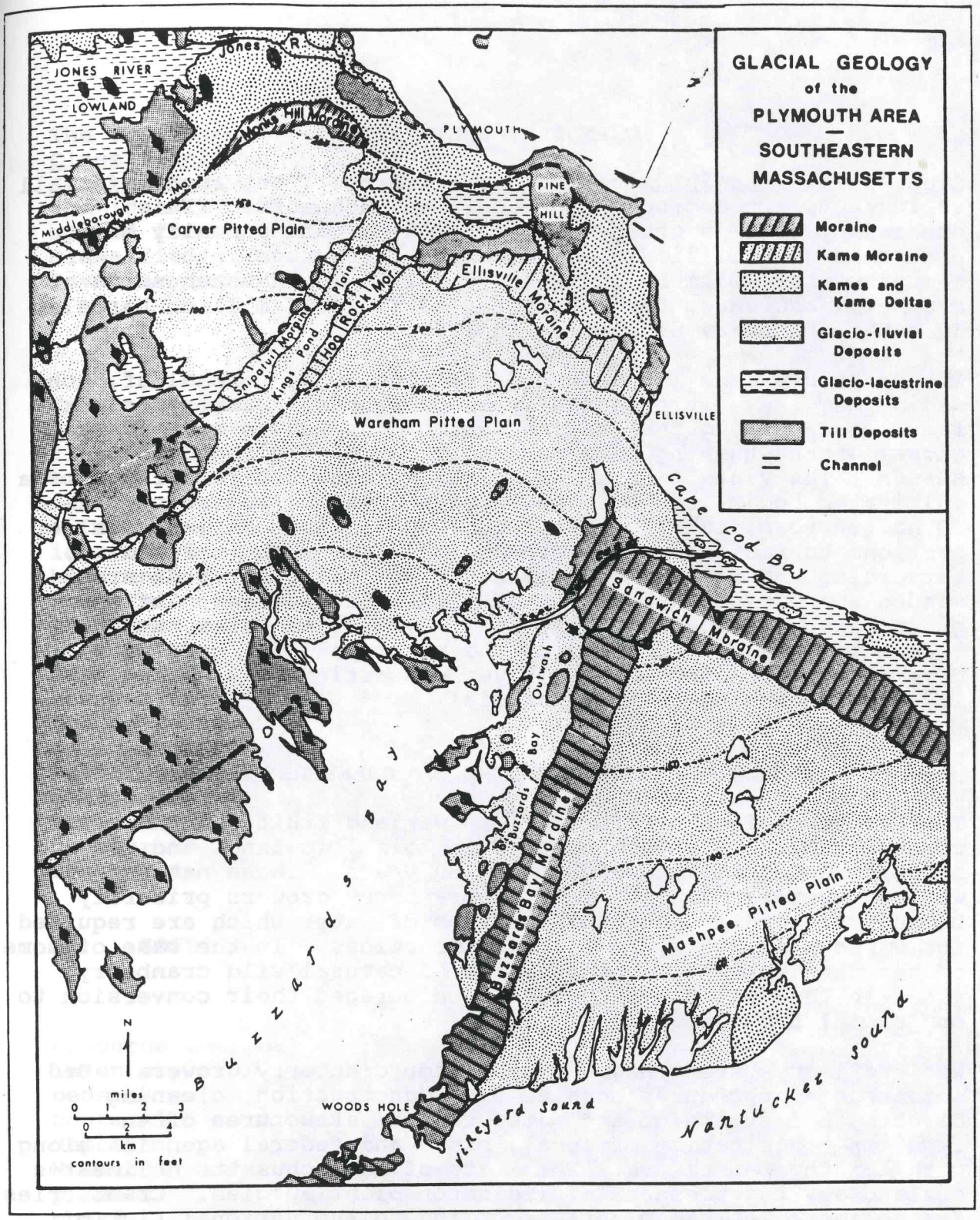

Figure 2. Glacial Geology Map of Southeastern Massachusetts (from Grahame Larson, 1980)

CRANBERRY CULTIVATION

Cranberries (Vaccinium macrocarpon) are the front runner for all agricultural food crops produced in Massachusetts. This speciality crop is grown on over 4,800 ha. and annually bring more than $390 million dollars worth of revenues into Massachusetts (Gilmore and Rinta, 1988). The Massachusetts cranberry accounted for 47% of the total (4.17 million barrels) domestic cranberry production in 1991.

The cranberry is a low growing, trailing, woody broadleaf, non-deciduous vine. It produces stems or runners from one to six feet long. During the growing season, the leaves are a dark glossy green, turning to a reddish brown during the dormant season. The vines form a thick mat over the entire surface of a cultivated bed. Cranberry beds range in size from about 0.2 to 80 ha (Burrows, 1976). Dikes subdivide large beds into smaller sections to facilitate management practises such as flooding, harvesting and fertilizer applications. Cranberry beds are sanded every 2 to 4 years. Sand facilitates aeration of the ground, penetration and horizontal movement of water, and it stimulates the productivity of the plants. Older beds usually have a 10 to 20 inch surface layer consisting of alternating layers of sand and organic material.

WETLAND CLASSIFICATION OF CRANBERRY BEDS

The Cranberry is a native American wetland fruit. Commercial cranberry beds have been created in moist, lowlands and scrub/forested wetlands for over 150 years. These natural wetland systems were utilized by cranberry growers primarily because of readily available sources of water which are required for various cranberry cultivation practices. In the case of some of the earliest beds, the presence of natural wild cranberry vines in the vegetative community encouraged their conversion to commercial beds.

Wetland issues are a major concern for cranberry growers. Bed maintenance procedures such as dike construction, cleaning ditches, bed expansion and water control structures often requires notification of local, state and federal agencies along with lengthy paper work. The State of Massachusetts delineates wetlands by the presence of indicator plant species. Cranberries are obligate wetland plants according to the National List of Plant Species that Occur in Wetlands. The Federal Government delineates wetlands according to the quidelines set forth in the 1987 Federal Manual for Identifying and Delineating Jurisdictional Wetlands. This system utilizes a three parameter approach to delineating wetlands based on plant species, soils, and hydrology. All three criterion are present in cranberry beds and they are considered wetlands.

The U.S. Fish and Wildlife Service has adopted and use the Classification of Wetlands and Deep-Water Habitats of the United States, December 1979, by L. M. Cowardin, et al., to delineate and identify wetlands. The Fish and Wildlife Service uses this system for the National Wetland Inventory. Cranberry beds are classified palustrine farmed (Ps), on the National Wetland Inventory maps.

GPR SURVEY PROCEDURE ON CRANBERRY BEDS

Cranberry beds are surveyed with the radar by first establishing a grid on the bog. During the winter season when the beds are flooded and covered with ice is the quickest and most cost effective time to conduct radar surveys. Ice allows grids to be easily established and traversing cranberry beds with the radar is more rapid and causes no harm to the vines. When there is no ice, traversing the beds with the radar can be made on the dry beds until mid to late spring without damaging the vines. Traversing cranberry beds during the growing season can damage the vines and lower yields.

Once a grid is established across a bed, the radar control unit, antenna, and power source are mounted on a carrying device and the unit is dragged manually across the cranberry bed. Coring, using steel rods and peat sampling equipment is then conducted in selected locations to confirm the radar profiles, classify the peat, and to establish radar signal propagation velocities. The radar data is then entered into a computer program which produces contour maps showing the thickness and distribution of peat for the surveyed bed.

SOIL CONSERVATION SERVICE USE OF GPR ON CRANBERRY BEDS

Soil/Geologic Mapping

Resource maps such as surficial geologic maps, National Wetland Inventory maps and soil survey reports often delineate cranberry beds as a noncommittal map unit regardless as to whether the bed contains peat or is located on till or glacial fluvial/lacustrine deposits. In the Soil Survey Report for Plymouth County, Massachusetts (Upham, 1969), all areas developed for cranberry production were mapped as an undifferentiated map unit, "Sanded muck". This provided soil survey users with no information concerning the nature and thickness of peat within the map unit. As a result of GPR studies on cranberry beds, the update of the Plymouth County soil survey will delineate cranberry beds based on the pedologic and geologic classification of the bed. There are 10 map units for cranberry beds in the current soil survey legend. Each map unit has a significant difference based on land use interpretations, geologic and pedologic classification, and

hydrologic properties. Morphological properties of cranberry beds play an important role in the functioning and use of the bed as a medium to grow crops. Peat has an influence on soil temperature, pH, nutrient availability, moisture content, and chemical movement and retention within the bed.

Conservation Management Practises

The Soil Conservation Service is the technical branch of the USDA. Technical assistance is provided to growers for improving and protecting the soil, water and related resources. The GPR is used to collect subsurface information during the initial planning process of a project. The following are some examples of the projects the SCS has used GPR to assist in conservation management planning.

DIKE CONSTRUCTION

Cranberry management practices require beds to be flooded periodically for harvesting, sanding, pest control and frost protection. Water levels are maintained in a bed through a system of dikes and ditches. Constructing dikes on low strength materials such as peat is often difficult and costly. Dikes built on deep deposits of peat are continuously subsiding and require constant maintenance. Most dikes are built without any design consideration taken for the material the dike will be constructed on. When the SCS is involved in designing a dike, a radar survey is conducted to map out the areas where the peat is deep, so design modifications can be used such as the use of geotextile fabrics and constructing low flow dikes which are smaller and lighter.

BED LEVELING

Due to long term subsidence, some cranberry beds develop irregular surfaces and are difficult to flood and harvest. Unleveled beds also require more water to flood, one study showed that 45 percent more water was needed to flood a bed that had an irregular surface. Leveling the bed surface can be done by use of heavy equipment and lazar leveling equipment. The bed is stripped of the vines, leveled, re-sanded, and replanted. It usually takes 3 to 4 years before the bed is up to full productivity. Radar surveys are made to determine if the bed should be leveled by cutting or filling the bed and to determine if heavy equipment can be used to level the bed.

BED EXPANSION AND CONSTRUCTION

Due to wetland regulations, new cranberry beds are being constructed in upland areas. Water levels are maintained by either excavating the area to the watertable and then establishing a cranberry bed or perching the water on a

restrictive layer such as basal till, lacustrine silts and clays, or impervious fill material. The GPR is used to locate and map restrictive layers and determine the depth to watertable, which is easily identified on the graphic profiles in most areas of southeastern Massachusetts.

PESTICIDE AND WATER QUALITY RESEARCH

The radar has been used to assist research groups who are studying the environmental impacts of cranberry farming. The radar has been used to characterize the soil and geologic deposits at study sites, determine the optimal location for monitoring wells, determine direction of groundwater flow, and locate sampling sites information.

INVESTIGATING PROBLEM AREAS

The radar has been used to investigate problem areas of a bed such as sink holes, unproductive areas, and leaking dikes. The GPR is also used to locate objects within a bed such as buried tree stumps, irrigation lines, boulders, and man-made objects.

SUMMARY

Ground penetrating radar is an effective tool for collecting subsurface information on areas which are used for the production of cranberries. Radar surveys have been conducted on over thirty cranberry beds in Southeastern Massachusetts. Computer graphics are used to display GPR data in a user friendly format. The radar is used to map soil and geologic deposits within cranberry beds and to assist the Soil Conservation Service with conservation planning programs.

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