Prof. William P. MacConnell*
Mr. Peter Stoll
University of Massachusetts
Amherst, Mass. 01003

Evaluating Recreational Resources of the Connecticut River

The study conclusively demonstrated the feasibility of analyzing the recreational potential of a large river from aerial photographs.

Abstract: *Aerial photogrammetric techniques were developed and tested for identifying and classifying river-based recreation sites. A classification system was designed to describe the nature of the land itself, the land use, or the vegetation on the landscape. The Connecticut, a large river running through four states, was examined and classified using the system. Analysis of two sets of aerial photographs taken with a time lapse of 10 to 13 years enabled determination of past use and development trends. A catalogue of maps classifying strips of land adjacent to the river was prepared to be reproduced for use by interested planning agencies. Statistics on land area by types for the river as it now is and as it was 10 to 13 years previously have been prepared by towns, counties, and states. The aerial photographs proved invaluable for analyzing the recreational potential of the Connecticut River.*

Introduction

Nation-wide studies indicate the need for greatly expanded recreational opportunities to satisfy both current and projected demands. The situation is especially acute in heavily populated regions such as the Northeast. The need for recreational developments associated with water is particularly critical. Recreation is not only a renewing experience for those who participate, but it can also have an important economic impact on areas where it is concentrated. The recreation business is a potential source of economic improvement in some rural portions of the Connecticut River Valley which are economically depressed. Recreational development of the Connecticut River would thus serve the dual purpose of providing much needed recreational opportunities for the many people of densely populated southern New England while at the same time bolstering the local economy in the more rural areas. It is significant that all four of the states through which it flows are becoming increasingly involved with problems of land use and resource development.

New programs are being developed to provide recreational opportunities, maintain open space, and preserve the amenity values of the landscape. The river is a major element in this complex. The problem is to develop its recreational potential without destroying its esthetic value. Many facets of the recreation problem have been studied and documented by the Outdoor Recreation Resource Review Commission (ORRRC) in a series of reports[1] issued during the past few years. Several of these ORRRC reports recommend the use of aerial photographs for classifying and locating recreation sites; but very little research has been done to determine the advantages and limitations of the technique for this purpose.[2,3] Further refinement of

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photogrammetric techniques for use in recreational planning would appear to be much needed.

A study to test the use of aerial photography for recreational planning requires a wide spectrum of conditions ranging from wilderness to metropolitan situations on or near water. The Connecticut River, arising in the forests of northern New England, passing through semirural central New England, and traversing urban and industrial sections of southern New England in its lower reaches, provides an ideal study area containing a variety of conditions for recreation. The Connecticut River is the largest river in New England, yet it is one of the least developed bodies of water for recreation. Heavy industrial and human pollution have precluded most kinds of water recreation, especially in the more densely populated areas through which it flows, where recreation pressures are greatest. Pollution abatement on the Connecticut River has moved ahead at a slow but steady pace, however, so that more of its waters are becoming suitable for recreational use. In the future this great river, relatively free of pollution, will face explosive recreational growth. City, county, and state government and planning commissions need knowledge about potential recreation sites on the river if they are to plan wisely and formulate proper zoning regulations for guiding future recreational development.

The purpose of this research was (*a*) to develop and test the use of aerial photogrammetric techniques as a tool for identifying and classifying river-based recreation sites; (*b*) to examine a large river system by this method, preparing maps, a catalogue of the suitable sites for recreational use, and recommendations concerning their development; and (*c*) to determine the changes in land use which have taken place along the river since it was last photographed.

The Study

The general procedure includes the following steps:

- Acquire new aerial photographs of the river at a scale of 1:12,000.
- Acquire earlier aerial photography of the river at a scale of 1:20,000.
- Evolve a photographic system for classifying the recreational potential of land and water.
- Interpret the aerial photographs of the Connecticut River and annotate them with the land use types, new buildings, potential scenic overlooks, secondary roads, shore line classification, and other features.
- Transfer this information to USGS maps.
- Reproduce the maps of the river in quantity for planning agencies.
- Prepare statistical summaries of this information by political units.
- Make recommendations for recreational development of the river.

The Connecticut River was photographed in 1965 by the James S. Sewell, Co. of Old Town, Maine to provide large scale modern photography for this study. The contract called for land coverage for a distance of at least 500 feet on each side of the river at a scale of 1:12,000. The pictures were taken on panchromatic film in the spring after the snow was gone from the ground and before the leaves had come out. The focal length of the camera was 8.25 inches.

Prior aerial photographs of the river at 1:20,000 scale were available from the U.S. Department of Agriculture (USDA). These were taken in the summer when vegetation was in leaf, using a camera with a 6-inch focal length and panchromatic film. Massachusetts was flown at this scale in 1951 and 1952. Connecticut was flown in 1952 and Vermont and New Hampshire were flown in 1952, 1953 and 1955.

This study classified the entire river from Long Island Sound in Connecticut to Lake St. Francis near the Canadian border, first on the 1:12,000-scale aerial photographs taken specifically for this purpose in 1965, and then on 1:20,000-scale photographs taken 10 to 13 years earlier by the USDA.

As a first step, all the land within 1,000 feet of the river's edge was classified on the aerial photographs on the basis of its current condition or use. The minimum-size land unit typed on the photographs was restricted to the map space required to display a map symbol. This size was one-half acre in Massachusetts and Connecticut, and one acre in Vermont and New Hampshire. Information annotated on the photographs was added to USGS maps which contain a wealth of other valuable information such as topography, location of roads, buildings, dams, bridges, and much more. The maps produced in this study show the USGS map features in blue, at a scale of one inch equals 2,000 feet. The land use types within 1,000 feet of the river are delineated in black on the blue map. The land-use classification system has seven categories which are described below.

The Classification System

The classification system was devised to describe the nature of the land itself, the vegetation on the landscape, and the land

use or other features which would be of value to those interested in the river and land near it. The system indicates those features that could be consistently and accurately interpreted on the photographs. New roads, buildings, and changes in the river location, as well as other map changes, were annotated on the pictures and added to the USGS maps along with the land-use types.

AGRICULTURAL OR OPEN LANDS—9 TYPES

One way to classify agricultural and open land is by the vegetation which it supports or is capable of supporting. To a degree, vegetative cover defines the land value and its potential for recreational use. Vegetative cover is the basis for agricultural land classification in this study. Soil types would be more valuable for this purpose but they are very difficult to determine on aerial photographs.

T—tilled or tillable crop land which is or has been intensively farmed. The boundaries on the ground are usually sharply defined and well maintained because the land is valuable. Most of this land is currently used to produce crops, but tillable land not in use here is usually mowed annually to keep it open and available for future farm use of other purposes. Government farm programs and other personal economic reasons may cause this land to be idle, but the annual mowing maintains its value and permits it to be recognizable on aerial photographs as tillable crop land. The land supporting farm buildings in included as part of this type.

P—pasture or wild-hay land which is not suitable for tillage due to steepness of slope, poor drainage, stoniness, or lack of fertility. This land has less sharply defined boundaries and often supports occasional scattered shade trees for the grazing animals. Livestock or the evidence of livestock use it often present.

AF—abandoned field which is reverting to wild land. Woody vegetation and grass are abundant but tree crown cover is less than 30 percent. If the crown cover were greater than 30 percent, the land would be classified as forest. This land may be grazed by domestic animals and it is highly productive of wildlife. Nearly all of this land was pasture or wild-hay land before abandonment.

O—productive fruit orchard or young orchards not yet in production.

AO—abandoned orchard. In addition to the decadent fruit trees, grass and woody vegetation are abundant in this type.

N—land supporting nurseries. This type would include greenhouses and land adjacent to them as well as lands supporting horticultural specialties, ornamentals and shrubs.

H—river bank or gullies to the river which are covered with miscellaneous herbaceous vegetation. Such gullied areas are unsuited for agriculture, and usually revert to forest in the long run.

S—sand area which may support scattered herbaceous vegetation.

PL—powerline or other maintained right-of-way for buried telephone lines, gas, or oil pipe lines.

FOREST LANDS—40 TYPES

Forested land is classified by a system which describes the forest by species, height and density. Species differentiation is necessary because some species have a greater resistance to recreational impact than do others.[5] Heavy recreational use of forest land, like heavy grazing, results in soil compaction and tree damage. Height indicates tree size, while density determines light conditions under the stand and the likelihood of brushy conditions occurring there. This code system permits 105 one-story types and many more two-story types. For simplicity in presenting statistics, we limited the number used to 40. The spruce and fir types were used in the two northern states but these species did not occur in the southernmost states. Species and species groups are designated by letters as follows:

P—species of pine constitute at least 80 percent of the stand. Pine is moderately resistant to heavy recreational use.

HK—hemlock constitutes at least 80 percent of the stand. Hemlock is resistant to recreational use.

S—spruce and/or fir constitute at least 80 percent of the stand. Spruce is susceptible to damage from recreational use.

H—species of hardwood constituting at least 80 percent of the stand. Most hardwoods are fairly resistant to recreational use, but oaks are susceptible.

PH—a mixture of pine and hardwood with neither the pine nor the hardwood making up 80 percent of the stand. *PH* is moderately resistant to recreational use.

HH—a mixture of hemlock and hardwood with neither the hemlock nor the hardwood making up 80 percent of the stand. *HH* is resistant to recreational use.

SH—a mixture of spruce and/or fir with hardwoods, none making up 80 percent of the stand. *SH* is susceptible to damage from heavy recreation.

Five height classes are designated by numbers as follows:

1—1 ft. to 20 ft. Sight distance is less than 50 feet and travel through the stand is difficult.

2—21 ft. to 40 ft. Sight distance is more than 50 feet in hardwood stands of high density and travel is fairly easy. Sight distance usually is less than 50 feet in softwood stands of this size and travel is difficult because of the persistent branches.

3—41 ft. to 60 ft. Sight distance is up to 100 feet in high density stands and travel is easy.

4—61 ft. to 80 ft. Sight distance is up to 200 feet in high density stands and travel is very easy.

5—81 ft. to 100 ft. Sight distances are long and travel is easy.

Three density classes are indicated by letters:

A—high density, 81 to 100 percent crown closure. Sight distances usually are good in *A* density stands of *3* height or taller. Sight distance improves with increased tree size in dense stands. The tree crowns are shorter and tree stems are clear of live branches in high density stands. Spruce and hemlock maintain live branches longer than pine in dense stands so sight distances are shorter with these species.

B—low density, 51 to 80 percent crown closure. Sight distances are apt to be poor depending on the abundance of lesser vegetation or brush piles if the stand has been recently logged. Low density stands maintain long tree crowns, reducing sight distances, and are highly productive of wildlife.

C—open forest, 30 to 50 percent crown closure. Sight distances and other characteristics are similar to "B" density stands but the stands are more open and lesser vegetation and grass are apt to be more abundant.

This code method of classifying or describing forest stands lists species, height and density as in the following examples:

P2A—a pine stand 21 to 40 feet in height with high density.

HH4A—a mixture of hemlock and hardwoods 61 to 80 feet in height with high density. No two story types were recognized in this study.

WET LANDS—9 TYPES

The wet-land classification is a modification of that used by the Office of River Basins of the U.S. Fish and Wildlife Service.[4] Wet lands are highly productive of wildlife.

SFF—seasonally flooded basins or flats. The soil is waterlogged or covered with water during the spring of the year, but well-drained during the growing season. Grasses and herbaceous plants are the cover.

B—bog. The acid soil is waterlogged and contains both woody and herbaceous plants of of the heath family as well as sedges and sphagnum mosses.

SS—shrub swamp which has water up to six inches in depth. Common woody species are alder, buttonbush, dogwood and willows.

M—meadow with waterlogged soil through most of the growing season. Vegetation is usually grasses and sedges. A reed (Juncus spp.), which grows in the wetter parts of the meadows, photographs very darkly, making meadows easy to identify.

SM—shallow marsh which is wetter than meadows. The soil is completely waterlogged or covered with water up to a depth of six inches. There is little open water in this type, which borders the river or deep marshes. The predominant vegetation usually is cattails, sedges and grasses.

DM—deep marsh which is wetter than the SM and has open water interspersed with patches of vegetation. The water ranges from six inches to three feet in depth and the vegetation is primarily pondweeds and cattails.

TSM—tidal salt marsh which is flooded twice daily. Vegetation is primarily saltmarsh cordgrass.

ISM—irregularly flooded salt marsh, flooded at monthly high tides and during severe storms. Vegetation is primarily saltmeadow cordgrass and saltgrass.

BP—beaver pond.

W—open water.

Vegetation in wooded swamps is designated by forest type symbols and the swamp situation is shown by swamp symbols on the USGS map.

MINING, EXPOSED ROCK OR WASTE DISPOSAL AREAS—6 TYPES

Mining in the Connecticut River Valley is mainly for sand, gravel or stone. Waste disposal occupies much space and has many characteristics unfavorable to recreation.

SG—sand and gravel. This area is used for the extraction of sand or gravel.

OM—other mining. This area is used for the extraction of stone and materials other than sand or gravel. Mining sites, though ugly to most, are fascinating to rock collectors.

SB—spoil bank. This is land from which sand, gravel or other soil materials have been extracted, or land on which surplus soil material has been deposited. When these areas are clothed with vegetation they are typed by the vegetation covering them.

D—dump. This land is used for dumping waste and refuse materials such as tin cans.

DA—automobile dumps. Autombobile graveyards or active automobile junk yards.

FB—filter bed. This is land and associated buildings used for treating liquids containing organic or chemical matter.

R—rock outcrop.

URBAN—12 TYPES

Land classified as urban is an area encompassing a large number of people living and working in closely ordered structures in a confined land space. Its limits are at the border of the block street pattern or just beyond it.[6]

UI—industrial land containing facilities for the manufacture and assembly of raw or partially processed products such as machinery, chemicals, electronics, appliances, etc. Warehouses and transportation facilities for bulk products and an open or interrupted street pattern characterize this type. Few people live here.

UC—commercial land predominantly used for distribution, or merchandising goods and services. Stores, hotels, offices, and smaller warehouses are usually set near streets having a close pattern. The buildings in the central commercial district are the tallest and most closely spaced, forming the "core" of the city or town. Most of the city people not living in residential areas live here.

UT—transportation land used for air, water or land transportation structures and facilities. Airports, docks, rail yards, and terminal

freight and storage facilities are characteristic of this land use. Transportation facilities which are part of an industrial complex are included as part of the industry and classified UI.

UP—public or quasi-public land containing facilities to serve large numbers of people. Examples are: schools, hospitals, prisons, etc.

UR—urban residential land used for homes and apartments which are spaced closely, arranged in orderly curved or rectangular patterns and set back from the street. Isolated large structures such as churches are part of the landscape. Most of the people live here.

UO—open undeveloped land which is lying idle in the midst of urban areas or adjacent to them.

UCR—clustered residential land with clusters of three or more domestic dwellings in farming or forested areas. This type includes homes and related structures such as garages, barns and sheds in a more scattered pattern than on residential land. The vegetation here would be trees, gardens, lawns and dirt yards associated with the dwellings.

UE—estates with extensive lawns, gardens, shrubs and other *grounds*.

HW—highways with 200 feet or more of right-of-way width.

HC—highway in construction with 200 feet or more of right-of-way width.

†-Cemeteries. The cross symbols for older cemeteries are already on the USGS base map. New cemeteries are added to the map.

L—dike or levee. Older dikes are already recorded on the base USGS maps; new ones will be added.

□—buildings. Older buildings are shown on the map; new buildings will be added.

OUTDOOR RECREATIONAL FACILITIES—14 TYPES

Public beaches or boat launching sites would be desirable in this classification but none were found on the river.

RM—marinas

BY—boatyards which have facilities for boat building, sale or repair, but little access to the river or direct water recreation services like marinas have.

RCG—campgrounds

RYC—organized youth camps

RG—gold courses

RD—driving ranges

RT—race tracks

RS—swimming pools

RC—tennis courts

RP—parks

RA—athletic fields and stadiums

RPG—playgrounds which have a conglomeration of many types of playground facilities.

RI—drive-in theaters

RSK—ski areas

RIVER BANK AND EDGE OF RIVER BED—26 TYPES

The river bank and the edge of the river bed in Massachusetts are classified by a code system which describes the river bank by its steepness and elevation, by the soil or artificial material of which it is constructed, and the depth of the water near the edge of the river bed. The bottom material at the edge of the river bed is generally the same as the material of which the bank is composed. The river bank classification proved the most difficult of all classifications to apply. It was therefore done only on the Massachusetts section of the river where it was easier to interpret and somewhat more important because of denser populations there. The river bank was classified only on the 1:12,000 scale photography because it could not be accurately accomplished on the 1:20,000 scale photography and there is little change in these types over short periods of time. This code system of classification permits 40 types; to maintain simplicity only twenty-six types were permitted.

The steepness and elevation of the bank are classified by numbers as follows:

1—a beach-like situation with no abrupt drop to the water

2—an abrupt drop to the water which is less than 10 feet

3—an abrupt drop to the water of 10 to 20 feet

4—an abrupt drop to the water which is more than 20 feet

The composition of the bank is classified as follows:

S—sand or gravel

M—mud, clay, or soil other than sand or gravel

R—rock

RR—rip-rap or rock material used to stabilize the bank

RW—retaining wall of wood, concrete or other material

The depth of water within 20 feet of the shore at high water level is classified as follows:

1—a gradual increase to a water depth of less than five feet, 20 feet from shore.

2—an abrupt drop to a water depth of more than five feet, 20 feet from shore.

This code method of classifying or describing the river's edge lists bank elevation, soil composition, and water depth as in the following example:

2S2—a river bank with an abrupt drop to the water of less than 10 feet, composed of either sand or gravel, while the river bed has an abrupt drop to a water depth of more than five feet, 20 feet from the shore.

INTERPRETATION PROBLEMS

The 1:12,000-scale photographs were interpreted first so that the interpreters could gain experience with the classification system on the less difficult, larger-scale photography. The agricultural, mining, urban and recreational types were all relatively easy to inter-

pret. The wet lands, forest lands, and river bank were much more difficult. The river bank classification proved so difficult and required so much ground checking to verify accuracy that it was limited to the Massachusetts section of the river and was done on the larger-scale photography only.

Photo scale and season of photography offered some problems. The 1:12,000 scale photography, taken when hardwood trees were without leaf, was easier to interpret because photo images were larger. The absence of leaves on photographs of this scale permitted better interpretation of ground detail, which otherwise would have been masked by the trees. Buildings, roads, wooded cemeteries and many other features were easily located under hardwood trees on this spring photography. Hardwood tree height and density were hard to estimate because the leafless trees were not well resolved at the 1:12,000 scale, but with considerable ground checking the interpreters trained themselves to consistently classify hardwood forests without leaves. In general, vegetation was harder to identify on the spring photography in spite of its larger scale because of the lack of leaves on deciduous plants. The interpreters found that they could consistently and accurately apply the system on the 1:20,000 pictures. Some ground detail like buildings and roads was lost under evergreen tree species on both sets of photographs and the same loss occurred under hardwood forest on the photographs with the leaves on.

The river bank classification was difficult to apply even on the large-scale photography because it required the estimation of water depth in water which was usually opaque because it was carrying a heavy load of silt. Trees on the river bank prevented accurate measurement or estimation of the steepness and elevation of the bank above the water on the summer photography and made it difficult on the spring photography. The Massachusetts and Connecticut sections of the river have few trees on the river banks and these are hardwoods, so it is possible to apply the bank classification on the large scale leafless spring photography in these states. The river bank classification was difficult to apply on the 1:12,000 scale spring photography and impossible on the 1:20,000 summer photography.

The classification system evolved in the study was rigorously and successfully tested by four interpreters on both sets of aerial photographs. Good interpreters, using similar photography, could successfully apply a similar classification to any river. Application of the river bank classification requires large scale photographs taken in open country or in country which is mostly open when the trees are without leaves.

Cartography

Base maps were prepared from the standard USGS maps by butting and cropping them to form a new map of USGS size with the river running down the middle of the map. Connecticut and Massachusetts USGS maps are at a scale of 1:24,000. The base sheets assembled from as many as four USGS maps were made the same size and scale as the standard USGS maps. New Hampshire and Vermont USGS maps are at a scale of 1:62,500. These maps were cut in quarters so that they covered the same land surface as the maps described above. One or two portions of these quartered USGS maps formed the base sheet when enlarged. These maps were enlarged 2.6042 diameters to a scale of 1:24,000. Through this procedure all the base maps were made at the 1:24,000 scale and all had the Connecticut River centered on the base map sheet.

Information annotated on the 1965 aerial photographs was transferred to transparencies over the base maps with a vertical sketchmaster using India ink fountain pens. By putting the typed information on transparent overlays it was possible to have the final maps printed in two colors. The base maps are printed in blue with the typing information overprinted in black to give a strong contrast.

The principal points of the aerial photographs were transferred to the base maps and marked by circles with the photo number written inside each. The flight strip numbers were written adjacent to the principal point circles at the beginning and end of each flight line. These principal points provide a handy photo index permitting quick retrieval of any photo of the river. This information on the maps will permit any map user to use the maps as a photo index for ordering aerial photography of the river.

Maps were not made from the early photography since the information was outdated and such maps would have little utility value with more modern maps, like those described above, readily available. Area statistics were extracted directly from the annotated pictures and comparisons of historical or planning value could be easily made without going through the laborious map-making process.

Area and Shore Front Statistics

Areas of the vegetative and land-use types on the prepared maps were determined by dot grid and expressed in acres by towns, counties, and states. On the dot grid used each dot represented 0.824 acres on the 1:24,000-scale maps. Areas were measured directly on the 1:20,000-scale photographs using a dot grid where each dot represented 0.638 acres. Much of the land adjacent to the river was flat and the photograph scale was very uniform. The area statistics determined on the photographs were compared with those measured on the prepared maps for accuracy, and the photo area statistics were adjusted by towns using the map acreage as a base.

River frontage types were measured with a map measure and expressed in front feet for the Massachusetts section of the river. This part of the classification was applied only on the modern 1:12,000-scale photographs because, as previously indicated, it was not possible to apply this classification on the 1:20,000-scale photographs.

Conclusions

Four photo-interpreters developed the skills necessary to consistently and accurately apply the vegetation and land use classifications developed and described here using 1:12,000- and 1:20,000-scale panchromatic aerial photographs. The river bank classification could be applied only on the large scale photographs taken when the trees were without leaves in the southern states where the land was mostly open and nearly all the tree species were hardwoods. The 1:12,000-scale photographs was preferred because of the larger scale and because the trees in this leafless spring photography did not mask the ground, permitting easy identification of roads, buildings, shore lines and other features. On the other hand, the 1:20,000 scale photography taken in the summer with the leaves on, enjoyed some advantages in vegetation typing, making some parts of the forest, farm and wet land classifications easier to apply.

The time lapse aerial photo analysis covering a time span of 10 to 13 years proved that not much change has occurred on the river in the recent past. The river is still severely polluted and its polluted state continues to prevent recreational development, use, and enjoyment. The photo study permitted accurate determination of past land use as well as changes on the river landscape. The prepared maps, showing both USGS map features as well as the land classification within 1,000 feet of the river, indicate nearly everything of interest to planners in the study area. They should be valuable to the many federal and state agencies studying the river and making all kinds of plans for it.

In this study, aerial photographs proved useful for many purposes besides the application of the classification system described here. The land bordering the river was evaluated on air photos with respect to access, parking areas, picnic and camping areas, scenic overlooks, and other picturesque sites and vegetation. Analyses to evaluate the shore line for beach sites, docking sites, shoreline fishing and hiking all could be made. Evaluation of the river itself for conditions affecting boating, fishing, and swimming, including such matters as water depth, currents, nature of the river bottom, aquatic vegetation, physical obstacles in the river, and navigational landmarks were sometimes possible, but identification of water conditions was rendered more difficult because of the heavy load of silt in the water, which is characteristic of the lower reaches of the Connecticut River.

This study conclusively demonstrated the feasibility of analyzing the recreational potential of a large river from aerial photographs and illustrated the scope, variety and invaluable nature of information which can be derived from such analysis over any time period for which aerial photographs exist.

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