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The effect on vegetation of inundation caused by the regulation and impoundment of water at six New England flood control reservoirs during the June-July 1973 flood was assessed from color infrared photography and corroborative ground surveys. A large amount of reservoir storage was utilized during the two-week inundation period, resulting in extensive damage to vegetation. Four degrees of apparent vegetative damage were differentiated from color infrared photography based on color differences ranging from bright red or magenta for healthy foliage to cyan for unhealthy, damaged or dying vegetation. Correlative ground truth data showed that the deciduous trees, particularly silver maple and red oak, were least affected and that coniferous trees, especially white pine, were most

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affected by siltation and inundation. Much of the understory vegetation, i.e. poplar, basswood and hornbeam, lost all leaves after inundation but new buds and shoots reappeared by late September 1973. Generally, trees inundated for less than 90 hours were not extensively damaged.

## PREFACE

This report was prepared by Dr. Harlan L. McKim, Research Soil Scientist, Lawrence W. Gatto, Geologist, and Carolyn J. Merry, Geologist, Earth Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory. The study was sponsored by the Water Control Branch, the Environmental Resources Branch and the Recreation-Resources Management Section of the U.S. Army Engineer Division, New England.

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# INUNDATION DAMAGE TO VEGETATION AT SELECTED NEW ENGLAND FLOOD CONTROL RESERVOIRS

by

Harlan L. McKim, Lawrence W. Gatto and Carolyn J. Merry

## INTRODUCTION

A cooperative program between the U.S. Army Engineer Division, New England, and the U.S. Army Cold Regions Research and Engineering Laboratory was initiated in September 1973 to determine the extent of vegetative damage in the New England Division reservoir system caused by the storage of floodwaters in late June and early July of 1973. Large areas were inundated for periods of one to two weeks at Union Village, North Hartland, North Springfield, Townshend and Ball Mountain reservoirs in Vermont and at Franklin Falls reservoir in New Hampshire. This flood was unusual because of its magnitude and the extremely high concentration of suspended sediment in the flood waters. Also, it occurred at the height of the growing season. Other significant floods have occurred during the winter and spring when vegetation was in a dormant stage and could withstand inundation for several weeks (Appendix C). Initial ground and aircraft observations in September 1973 indicated post-flood vegetation damage in the above-mentioned reservoirs. This vegetative damage was of immediate concern to the Corps of Engineers as the agency responsible for the operation and management of these reservoirs.

Several factors related to the flood were investigated: the areal extent of inundation, degree of siltation, bank slumping effects on the vegetation and the susceptibility of various tree species to inundation. The results of the investigation will be used in preproject planning studies to develop improved practices for forest management in reservoir areas susceptible to long periods of inundation and also in the preparation of environmental statements and assessments for future projects.

## JUNE-JULY FLOOD

During the last four days of June 1973, a strong, moist tropical airflow in conjunction with a stationary frontal system resulted in moderate to heavy rain over much of New England. Rainfall amounts varied from approximately 2 in. in coastal regions to 7 in. in the hills of western Connecticut and 8-10 in. in the mountains of Vermont and New Hampshire. At various times on the 29th and 30th, the rain was torrential and amounts of 4 in. in a six-hour period were reported. An isohyetal map for the storm period 27-30 June is shown in Figure 1. Rainfall totals for the three-day period ending at 0800 hours 1 July 1973 at six selected reservoirs were:

| Reservoir | Rainfall (in.) |
|---|---|
| Union Village | 5.0 |
| Ball Mountain | 7.8 |
| North Springfield | 5.7 |
| Townshend | 5.7 |
| Franklin Falls | 5.1 |
| North Hartland | 5.0 |

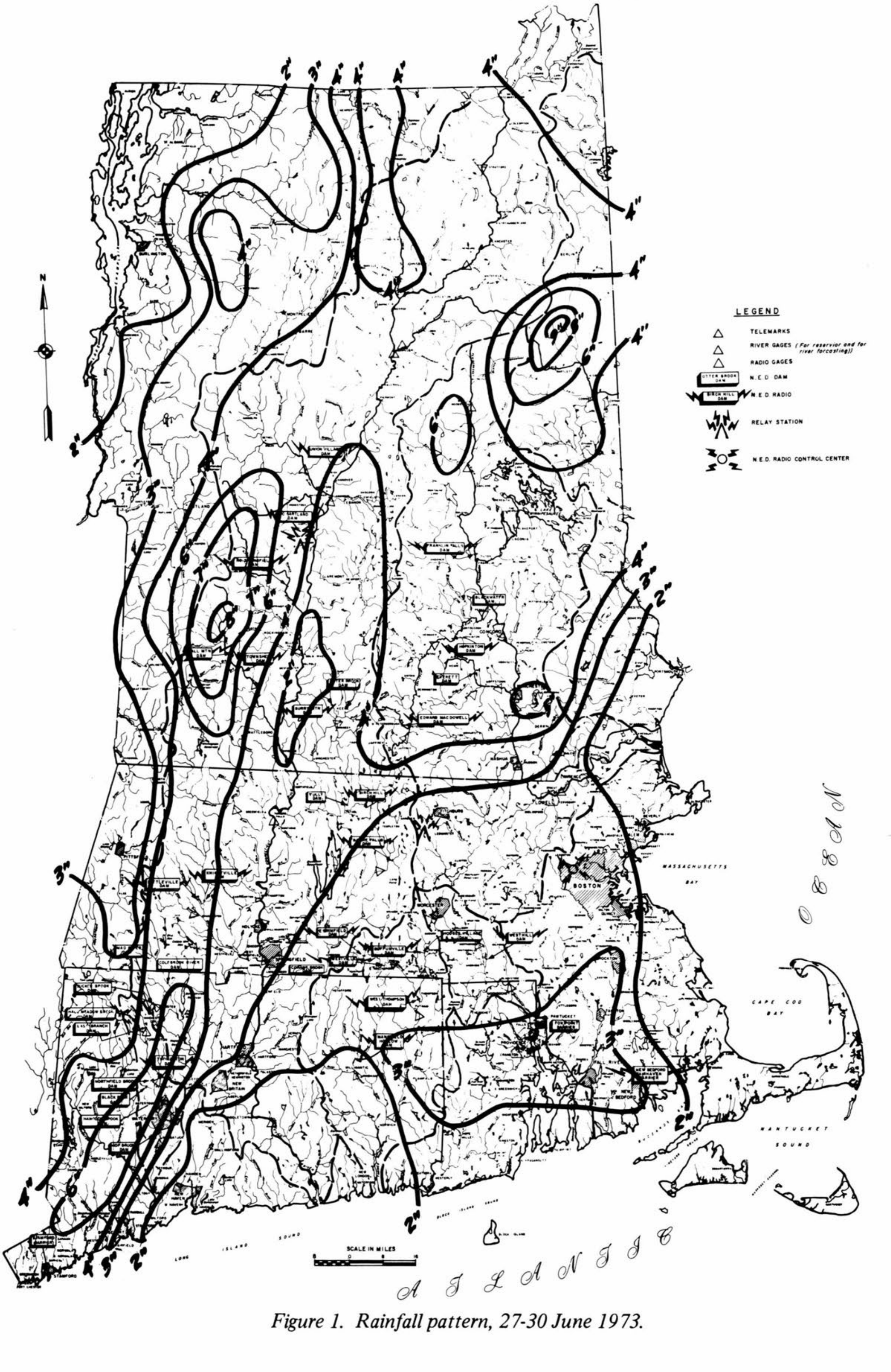


*Figure 1. Rainfall pattern, 27-30 June 1973.*

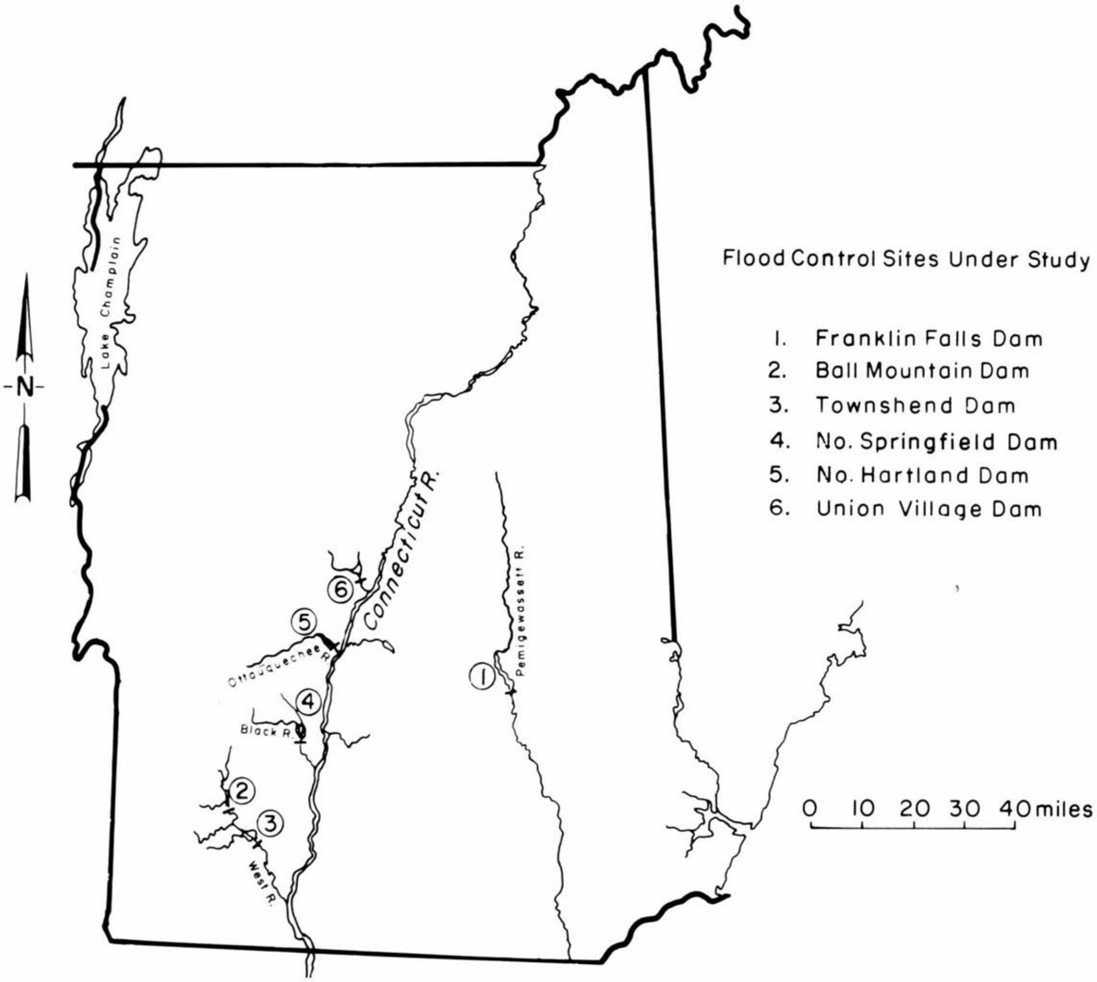


*Figure 2. Location of six New England flood control reservoirs.*

This heavy rain caused major flooding in many of the watersheds that drain the Green and White Mountains in Vermont and New Hampshire. In many of the tributaries of the Connecticut River in Vermont and northern New Hampshire, this was the largest recorded summer flood (June, July, August). Water discharges reached or exceeded the devastating floods of November 1927 and March 1936 in the Passumpsic, Ottauquechee, Black and Ammonoosuc Rivers. The Connecticut River from Wells River, Vermont, to Montague City, Massachusetts, reached its highest known summer levels. In the northern portions of the Merrimack River basin this storm caused the largest summer flood on record. A summary of flood peak discharges at selected U.S. Geological Survey gaging stations is shown in Table I.

All Corps of Engineers flood control reservoirs in the Connecticut River basin were utilized during the flood period. Near- record water heights and inundation periods were experienced at Union Village, North Hartland, North Springfield, Ball Mountain, Townshend and Franklin Falls reservoirs (Fig. 2). Maximum reservoir levels reached during the flood are shown in Table II. Water storages ranged from 33% of capacity at Union Village Dam to 66% at North Springfield Dam. In general, the Corps of Engineers reservoir system lowered Connecticut River flood levels by 4 to 5 ft between North Walpole, New Hampshire, and Montague City, Massachusetts; 3 to 4 ft from Montague City to Springfield, Massachusetts; and 2 to 3 ft from Springfield to Hartford, Connecticut.

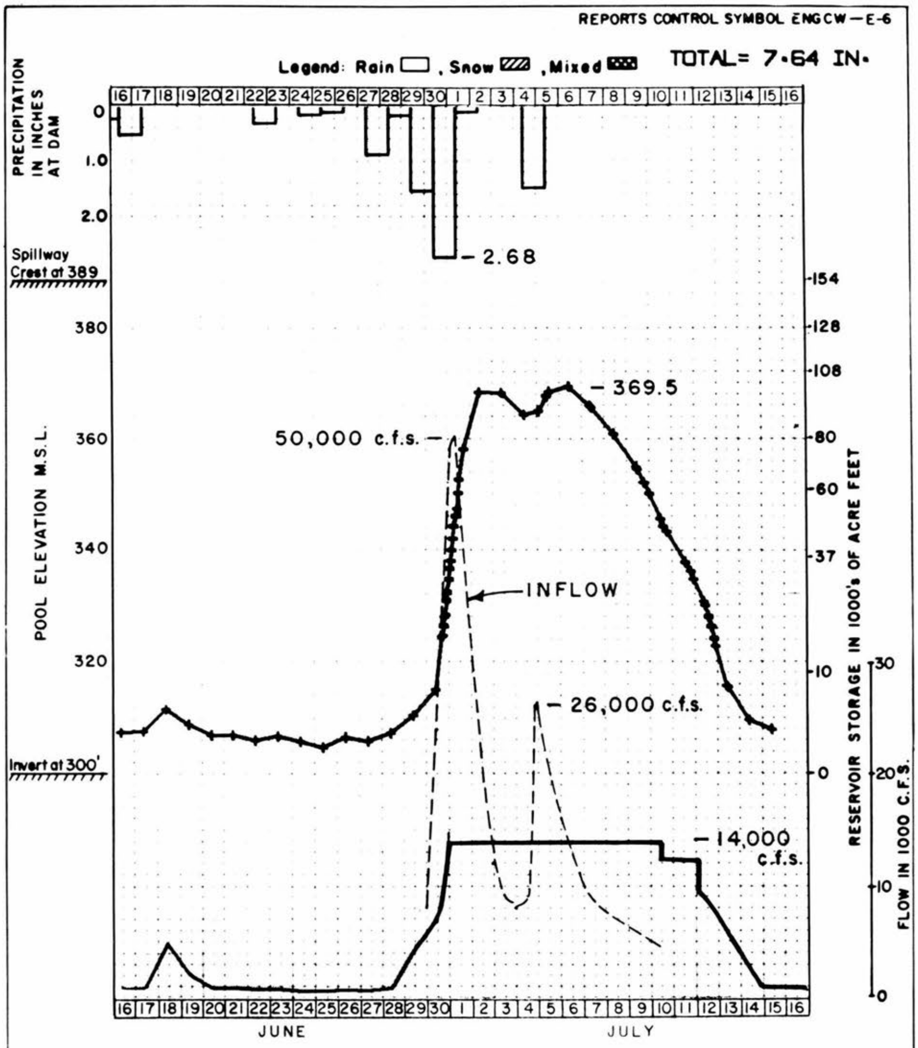
**Table I. Summary of peak discharges for significant floods in New England.**
Prepared by Water Control Branch, U.S. Army Engineer Division, New England.

| *Gaging station* | *Drainage area ($miles^2$)* | *Nov 1927 ($ft^3/sec$)* | *Mar 1936 ($ft^3/sec$)* | *Sept 1938 ($ft^3/sec$)* | *June-July 1973 ($ft^3/sec$)* |
|---|---|---|---|---|---|
| **Connecticut River Basin** | | | | | |
| Passumpsic River at Passumpsic, Vt. | 436 | 42,500 | 16,000 | 7,700 | 18,200 |
| Ammonoosuc River at Bath, N.H. | 395 | – | 27,900 | 26,800 | 37,000 |
| White River at West Hartford, Vt. | 690 | 120,000 | 45,400 | 47,600 | 42,300 |
| Ottauquechee River at North Hartland, Vt. | 221 | 30,400 | 19,200 | 24,400 | 31,000* |
| Black River at North Springfield, Vt. | 158 | – | 14,700 | 15,500 | 24,000* |
| West River at Newfane, Vt. | 308 | 45,000 | 39,000 | 52,300 | 35,000* |
| Connecticut River at White River Jct., Vt. | 4,092 | 136,000 | 120,000 | 82,400 | 86,000* |
| Connecticut River at Vernon, Vt. | 6,266 | 155,000 | 176,000 | 132,500 | 122,000* |
| Connecticut River at Montague City, Mass. | 7,865 | 179,000 | 236,000 | 195,000 | 124,000* |
| **Merrimack River Basin** | | | | | |
| Pemigewasset River at Woodstock, N.H. | 193 | (October 1959 – 47,000) | | | 29,900 |
| Baker River near Rumney, N.H. | 143 | 25,900 | 19,100 | 15,900 | 11,000 |
| Pemigewasset River at Plymouth, N.H. | 622 | 60,000 | 65,400 | 50,900 | 47,600 |
| Merrimack River at Franklin Jct., N.H. | 1,507 | 63,000 | 83,000 | 59,200 | 55,000* |
| **Other** | | | | | |
| Saco River near Conway, N.H. | 386 | – | 40,600 | 20,800 | 35,000 |

* Estimated natural discharge without Corps reservoirs.

**Table II. Maximum reservoir levels (July 1973) in selected New England reservoirs.**

| *Project* | *Drainage area ($miles^2$)* | *Level* | | *Full (%)* |
|---|---|---|---|---|
| | | *Elevation (msl)* | *Depth (ft)* | |
| **Connecticut River Basin** | | | | |
| Union Village, Vt. | 126 | 516.8 | 96.8 | 33 |
| North Hartland, Vt. | 220 | 503.9 | 113.9 | 50 |
| North Springfield, Vt. | 158 | 529.5 | 77.5 | 66 |
| Ball Mountain, Vt. | 172 | 923.3 | 177.8 | 59 |
| Townshend, Vt. | 106 (net) | 523.1 | 66.1 | 41 |
| Surry Mountain, N.H. | 100 | 516.6 | 31.6 | 21 |
| Otter Brook, N.H. | 47 | 723.4 | 40.4 | 14 |
| Birch Hill, Mass. | 175 | 830.0 | 15.0 | 14 |
| Tully, Mass. | 50 | 643.7 | 18.7 | 9 |
| Barre Falls, Mass. | 55 | 779.8 | 18.8 | 6 |
| Knightville, Mass. | 162 | 551.1 | 71.1 | 21 |
| Littleville, Mass. | 52 | 530.8 | – | 18 |
| Colebrook, Mass. | 118 | 716.7 | – | 13 |
| **Merrimack River Basin** | | | | |
| Franklin Falls, N.H. | 1000 | 369.5 | 69.5 | 66 |
| Blackwater, N.H. | 128 | 549.0 | 34.0 | 21 |
| MacDowell, N.H. | 44 | 923.8 | 19.8 | 25 |
| Hopkinton, N.H. | 382 (net) | 392.0 | 26.0 | 7 |
| Everett, N.H. | 44 | 354.3 | 29.3 | 7 |



## MONTHLY RESERVOIR OPERATION

FRANKLIN FALLS RESERVOIR
PEMIGEWASSET RIVER BASIN
D.A. = 1000 SQ. MILES
1" R.O. = 53,300 Ac - Ft
NEW ENGLAND DIVISION
WALTHAM, MASS.

+++++ Reservoir Stage and Storage

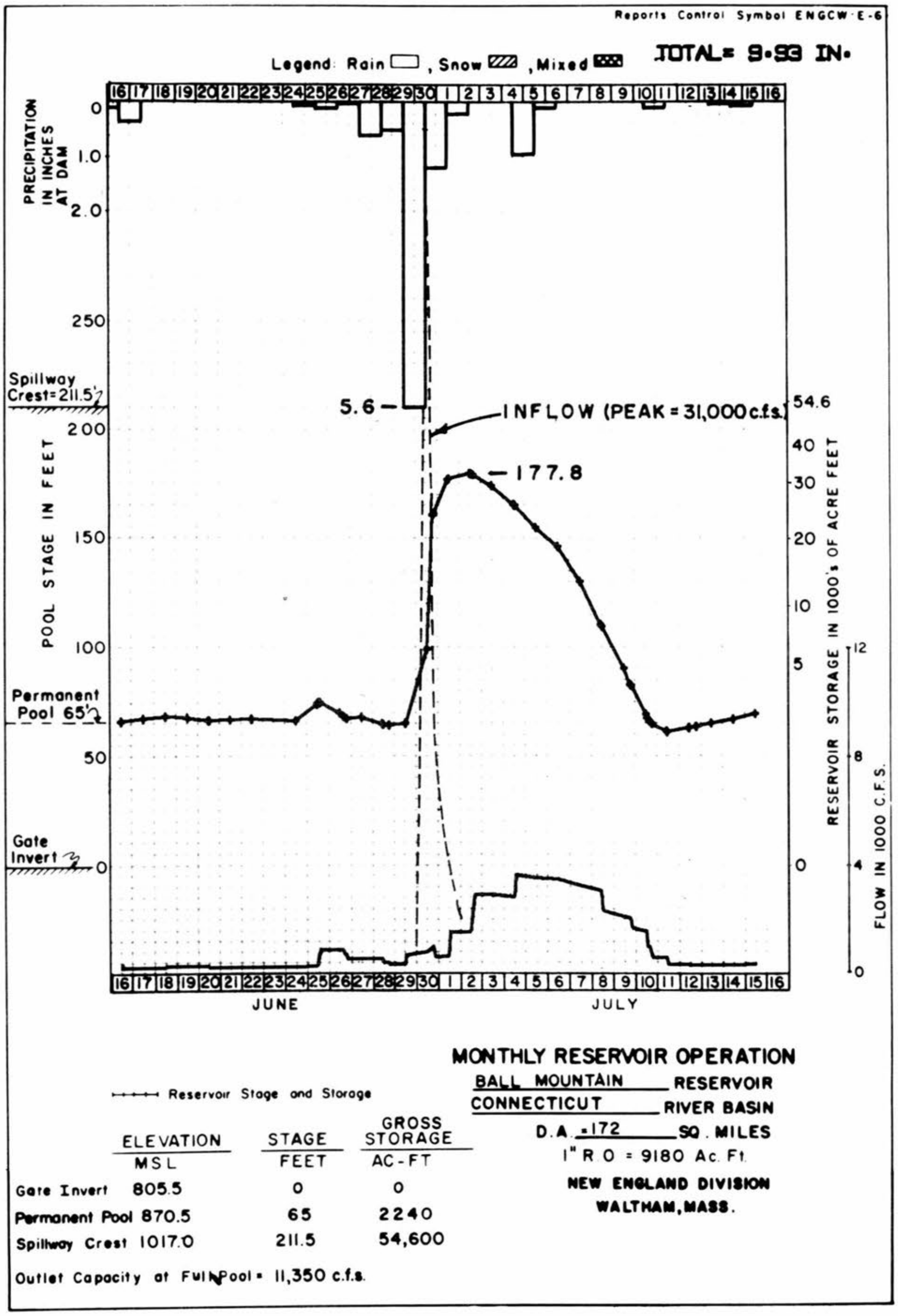
| | ELEVATION | GROSS STORAGE Ac. Ft. |
|---|---|---|
| Gate Invert | 300. | Ac. Ft. |
| Normal Pool | 307± | 3000 |
| Pool at Spillway Crest | 389.0 | 154000 |

Outlet Capacity with Pool at Spillway Crest = 42,000 c.f.s.

Maximum Regulated Outlet Discharge = 18,000 c.f.s.

*Figure 3. Reservoir storage, June-July 1973, Franklin Falls reservoir, Franklin, New Hampshire.*

Flooding in the Merrimack River basin was restricted to areas in the Pemigewasset watershed upstream of Franklin Falls Dam. Sixty-six percent of the storage capacity at Franklin Falls was utilized in controlling the flood waters. The reservoir system (principally Franklin Falls) lowered Merrimack River levels throughout the entire length, ranging from about a 13-ft reduction at Franklin Junction, New Hampshire, to about a 4-ft reduction at Lowell, Massachusetts.



| | ELEVATION MSL | STAGE FEET | GROSS STORAGE AC-FT |
|---|---|---|---|
| Gate Invert | 805.5 | 0 | 0 |
| Permanent Pool | 870.5 | 65 | 2240 |
| Spillway Crest | 1017.0 | 211.5 | 54,600 |

Outlet Capacity at Full Pool = 11,350 c.f.s.

*Figure 4. Reservoir storage, June-July 1973, Ball Mountain reservoir, Jamaica, Vermont.*

After a preliminary review of aerial photography by CRREL and NED personnel, vegetative damage appeared to be most extensive at Franklin Falls and Ball Mountain reservoirs. As a result these sites were selected for detailed analysis. Operation charts for these two reservoirs for the period 16 June – 16 July 1973 are shown in Figures 3 and 4. Table III lists the water depths that have occurred at each site.

**Table III. Maximum water depths in Franklin Falls and Ball Mountain reservoirs.**

| *Date* | *Maximum depth (ft)* | *Storage utilized* *Inches of runoff* | *Acre-ft* | *%* |
|---|---|---|---|---|
| | **Franklin Falls (1943-1974)** | | | |
| 1953 March | 75.7 | 2.2 | 116,800 | 76 |
| 1973 July | 69.5 | 1.9 | 101,700 | 66 |
| 1959 October | 55.7 | 1.3 | 70,100 | 44 |
| 1969 April | 49.1 | 1.1 | 56,200 | 35 |
| 1973 December | 47.9 | 0.9 | 50,800 | 33 |
| | **Ball Mountain (1961-1974)** | | | |
| 1969 April | 198.0 | 4.8 | 44,500 | 82 |
| 1973 July | 177.8 | 3.5 | 32,100 | 59 |
| 1968 March | 157.2 | 2.4 | 22,500 | 41 |
| 1972 May | 149.0 | 2.1 | 19,000 | 35 |
| 1962 April | 138.3 | 1.7 | 15,800 | 29 |

## APPROACH

In recent years, investigators in applied ecology, forestry and other disciplines concerned with the environment have frequently used false color aerial photography for crop and vegetation studies and surveys (Carneggie 1968, Ciesla et al. 1967, Heller 1968, Meyer and French 1967, Norman 1967). A color film sensitized to infrared radiation results in a "false color" photograph since the infrared record is combined with a visible light component. Visible color differences corresponding to variations of physiological differences in vegetation are more distinct to the human eye on this color infrared film than on black and white or color film (Applied Infrared Photography 1970).

Aerochrome infrared film, type 2443, was used to photograph the six reservoir impoundment areas in Vermont and New Hampshire on 10 September 1973, 66 days after the July high water levels had receded. Also, Franklin Falls and Ball Mountain reservoirs were reflown on 17 July 1974, approximately one year after inundation. The photography (scale 1 in. = 800 ft) was taken at an altitude of 4800 ft with a Zeiss RMK 15-23 camera.

Healthy vegetation has a high infrared reflectance and appears bright red on color infrared film. Disease, damage and physiological stress in the trees influence the extent of coloration on the color infrared photography and make possible the differentiation of various degrees of apparent kill. Areas of maximum apparent vegetative damage were to be delineated for the six reservoirs from the color infrared photography based on color changes from bright red or magenta for healthy foliage to cyan and brown for unhealthy, damaged or dying vegetation.

Damaged areas representative of the lower, middle and upper reaches in Franklin Falls and Ball Mountain reservoirs were determined from the color infrared photography. Field data collected during fall 1973 and summer 1974 documented the degree of vegetative damage in these areas (Appendix A). Detailed land surveys were conducted along line transects, a simple and useful way to analyze a tree community (Appendix B). These transects began at the edge of the river (at its normal level) and continued upslope through the inundated areas. Trees more than 4 in. in diameter and within 10 ft of the surveyed lines were inventoried. In addition, field notes and color photographs of the damaged areas were taken during boat surveys along the Pemigewasset and West Rivers upstream from the Franklin Falls and Ball Mountain Dams.

The following data were collected for approximately 400 trees along five transects at three sites at Franklin Falls, and 300 trees along seven transects at six sites at Ball Mountain: species, base elevation, diameter, height, extent of damage and degree of silting (Appendix A). A range finder was used to determine tree height and height of apparent vegetative damage. The transect lines were run from selected trees, labeled $T_1$, $T_2$, etc., using a Brunton compass for direction and a range finder for distance. Visual observations of slope characteristics, soil conditions and the local geomorphic setting at various locations along the transects were noted on black and white aerial photographs (CRREL files); color photographs were taken of stands with extensive apparent damage. The transect lines were resurveyed in the spring and summer of 1974 to observe the extent of vegetation damage one year after inundation.

## RESULTS

### Apparent vegetative damage in reservoirs

Four degrees of apparent vegetative damage were differentiated by visual analysis of the color infrared photography: 0-30%, 30-60%, 60-90% and 90-100%. Percentage of damaged trees was assessed on a pattern recognition and coloration basis. Patterns of similar tone and texture were first delineated, then the ratio of undamaged to damaged trees within the patterns was determined on a sample basis and the percentage of damaged trees calculated. The percentage of dead trees was based only on the number of trees and not the size of trees in a particular pattern, which could possibly bias the results. For instance, an area comprising many small damaged trees and only a few large live trees could show a predominantly red tone, but have 60-90% damaged trees by count. In addition, the percentage of damaged trees within an area is sometimes misleading. An area with a few highly damaged trees does not contribute to the total amount of vegetative damage as much as an area of dense growth with less damage.

Total acreage inundated during flooding and the percent acreage sustaining various degrees of apparent damage were determined with a planimetric color densitometer for each reservoir (Table IV). The damage to vegetation was more extensive in Franklin Falls than in the other reservoirs; approximately 216 acres showed apparent damage of more than 60% (Appendix E, Fig. E2). The trees in 960 acres of a total inundated area of 2400 acres were damaged to some degree by the flood.

Ball Mountain was second to Franklin Falls in degree of affected vegetation (Fig. E1). Of a total inundated area of 550 acres, 154 acres contained some degree of damage (Table IV). The remaining reservoirs, North Hartland, North Springfield, Townshend and Union Village (Fig. E3-E6), did not contain as much vegetative damage as Franklin Falls and Ball Mountain.

**Table IV. Areal extent in acres of vegetative damage in New England reservoirs.**

| | | | | *Areas with apparent tree damage* | | | |
|---|---|---|---|---|---|---|---|
| *Reservoir* | *Total land area* | *Total inundated area* | *Inundated area with trees* | *0-30%* | *30-60%* | *60-90%* | *90-100%* |
| **Franklin Falls** | 3144 | 2400 | 960 | 456 | 288 | 168 | 48 |
| **Ball Mountain** | 880 | 550 | 154 | 44 | 44 | 44 | 22 |
| **North Hartland** | 1190 | 590 | 100 | 23 | 18 | 47 | 12 |
| **North Springfield** | 1082 | 825 | 99 | 66 | 25 | 8 | 0 |
| **Townshend** | 910 | 283 | 29 | 20 | 3 | 6 | 0 |
| **Union Village** | 1292 | 385 | 104 | 15 | 50 | 23 | 16 |

## Franklin Falls reservoir

The dominant tree species identified along five transects at Franklin Falls were oak, pine, birch, hornbeam, aspen and maple (Table V). Generally, maple and oak trees were least affected by inundation and silt damage regardless of their geomorphic setting. Silver maples located on the floodplain and on islands in the upstream portions of the reservoir were least affected by inundation and appeared to have minimal silt damage as the tree canopy remained above the floodwaters. Revegetation of the lower branches on the maples and oaks occurred during the following spring. Field observations indicated that coniferous trees, especially the white pine, seemed to be more affected by silting than deciduous trees (Fig. 5).

Birch trees, primarily located on the lower part of the floodplain, usually retained a minimal amount of silt and were devoid of leaves at the time of the 1973 fall field surveys. Since these areas were inundated the longest, it is assumed that the tree damage was caused more by water than silting. The maturity and size of the birch trees were factors since the smaller and younger trees appeared to be most damaged.

**Table V. Tree species sampled in Franklin Falls reservoir.**

| | *Kill site†* | | | | | *Total* | *Genus* | *Percent* |
|---|---|---|---|---|---|---|---|---|
| *Species** | *1A* | *1B* | *1C* | *2A* | *3A* | *no. trees* | *total* | *of total* |
| Northern red oak | 1 | 5 | 20 | 12 | 6 | 44 | | |
| White oak | 3 | 1 | | | | 4 | | |
| Chinkapin oak | | | | 1 | | 1 | 49 | 22.1 |
| Eastern white pine | 1 | 3 | 20 | 2 | 19 | 45 | 45 | 20.4 |
| Grey birch | 6 | 5 | 8 | 2 | 4 | 25 | | |
| White birch | | | | | 3 | 3 | 28 | 12.7 |
| Hop hornbeam | 3 | 1 | | 15 | 2 | 21 | | |
| American hornbeam | | | | 3 | 2 | 5 | 26 | 11.8 |
| Quaking aspen | 4 | 1 | | 13 | 4 | 22 | | |
| Big tooth aspen | | | | | 3 | 3 | 25 | 11.3 |
| Silver maple | 5 | | 1 | 3 | | 9 | | |
| Red maple | | 2 | 4 | | | 6 | | |
| Sugar maple | | 3 | | 1 | | 4 | 19 | 8.6 |
| American basswood | | | 3 | 7 | | 10 | 10 | 4.5 |
| White ash | 1 | | | 5 | | 6 | 6 | 2.7 |
| American elm | | | 1 | 3 | | 4 | 4 | 1.8 |
| Black willow | | 4 | | | | 4 | 4 | 1.8 |
| Wild black cherry | | | | | 1 | 1 | 1 | 0.5 |
| Unknown | | | | 4 | | 4 | | |
| Total | 24 | 25 | 57 | 71 | 44 | 221 | 221 | 100.0 |

* See Appendix D for scientific name.
† See Appendix B for transect location.

The inundated understory vegetation, such as hornbeams less than 30 ft in height, was defoliated; however, new growth was observed on many of the lower branches in October (Fig. 6). The understory on the lower floodplain was extensively damaged by ice during the December 1973 flood. The tops of many trees less than 5 in. in diameter were cracked or completely broken in transects 1A, 1B and 1C (Fig. 7).

Alders and willows grow in wet, low-lying locations. The alders were more severely damaged by inundation than the willows, but both were extensively damaged by the ice conditions present during the December 1973 floods. Elm trees observed primarily in the abandoned portion of the town of Hill had previously been killed by Dutch elm disease or floods.

Shrub vegetation in the meander scar located approximately four miles upstream from the dam appeared dead in fall 1973 (Fig. 8). However, revegetation had occurred by the summer of 1974 (Fig. 9). Slumping along stream banks occurred in the steep side slopes composed of unconsolidated loamy sands deposited

Figure 5. Damaged white pines along transect 3A, Franklin Falls reservoir.

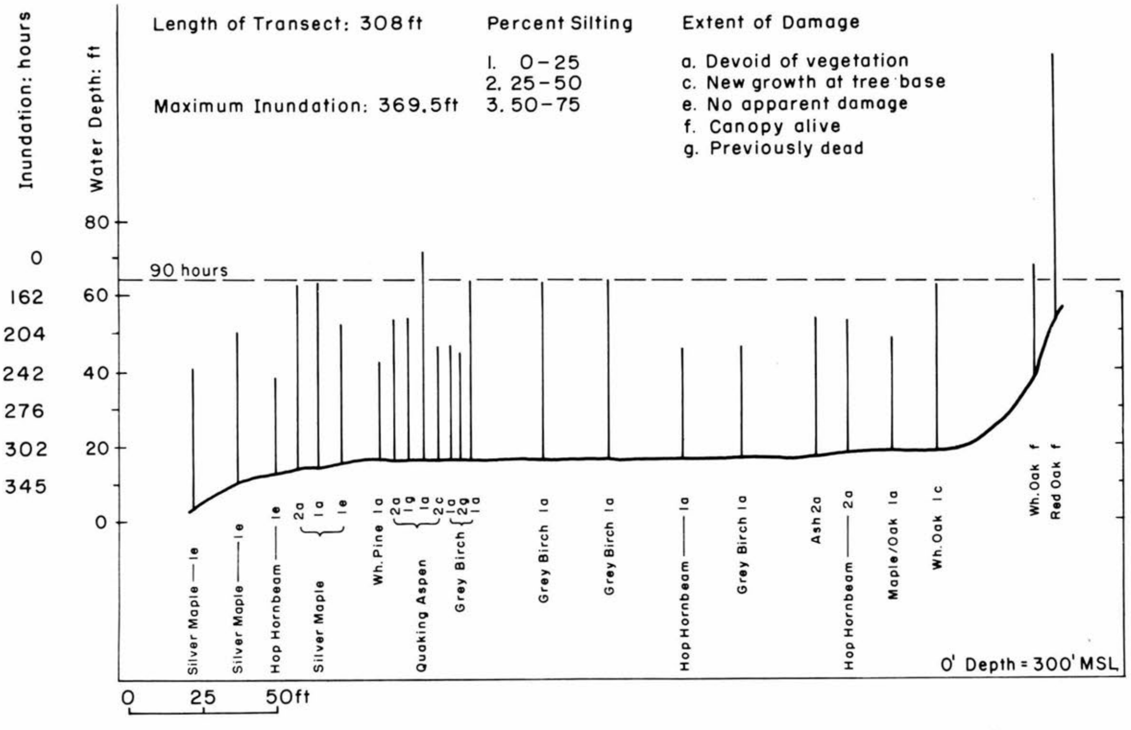
Figure 6. New growth on lower branches along transect 1B, Franklin Falls reservoir.

*Figure 7. Ice-damaged alders and willows on floodplain near transect 1B, Franklin Falls reservoir.*

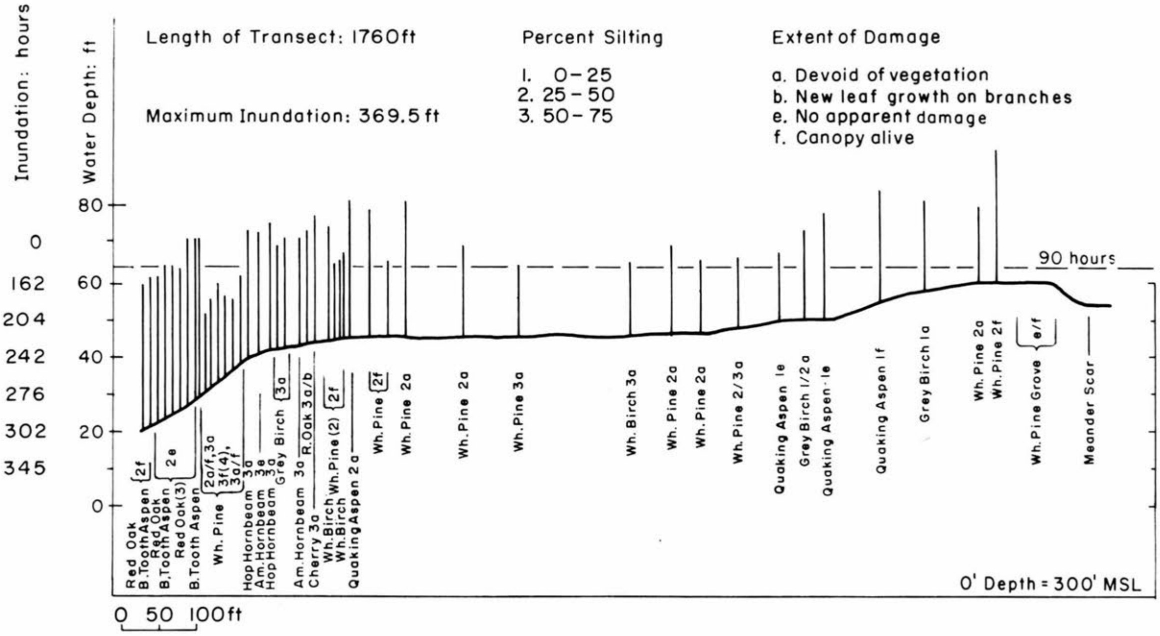
*Figure 8. Meander scar at end of transect 3A, Franklin Falls reservoir.*

*Figure 9. View across meander scar (see Fig. 8).*

*Figure 10. Slumping in the loamy sand deposits along the east bank of the Pemigewasset River near transect 1A, Franklin Falls reservoir.*



*a. Transect 1A.*



*b. Transect 3A.*

*Figure 11. Relationship of duration and depth of inundation, topographic position, tree height, vegetative damage and siltation at Franklin Falls reservoir.*

by glacial meltwater streams (glaciofluvial terraces) located on the northeast side of the Pemigewasset River (Fig. 10). At least five such areas were identified on the September 1973 photography and during fall field surveys. The primary effects of slumping were the uprooting of trees, the removal of shrubs and grasses and the undercutting of the bank.

Figure 11 shows profiles of two transects, 1A and 3A, representative of the damage at Franklin Falls reservoir. Illustrated are tree heights and species, water depth in feet, inundation time in hours, topographic setting, percent silting and extent of damage. Percent silting is a visual estimate of the degree to which the tree was silt-covered and was recorded as follows: 1) 0-25%, 2) 25-50%, 3) 50-75%, and 4) > 75%. The extent of tree damage was categorized according to the following criteria: a: completely devoid of leaves, b: new leaf growth on branches, c: new growth at base, d: ice damage, e: no damage, f: canopy alive, and g: previously dead. On the diagram a number and letter following the tree species name indicate the percent of silting and the extent of damage. For example, the first tree on transect 3A (Fig. 11b) is designated red oak 2f. The percent of silting, 2, was 25-50% and the designation f indicates that the damage was restricted to the lower branches while the canopy remained alive.

A critical relationship was determined from these transect profiles between species susceptibility and inundation time: trees completely covered by water for more than 90 hours during the flood showed the most apparent damage. This damage is attributed to the duration of inundation and the degree of silting.

### Ball Mountain reservoir

The dominant tree species identified along the seven transects in the Ball Mountain reservoir were maple, pine, birch, spruce, beech and hemlock (Table VI). Spruce, hemlock, pine and birch were generally located close to the river bank, whereas the maple and beech trees were found further upslope. Maple trees were more abundant than oak trees at Ball Mountain. However, silver maples, found at Franklin Falls to be more tolerant of inundation and/or siltation than many of the coniferous trees, were virtually absent at Ball Mountain.

**Table VI. Tree species sampled in Ball Mountain reservoir.**

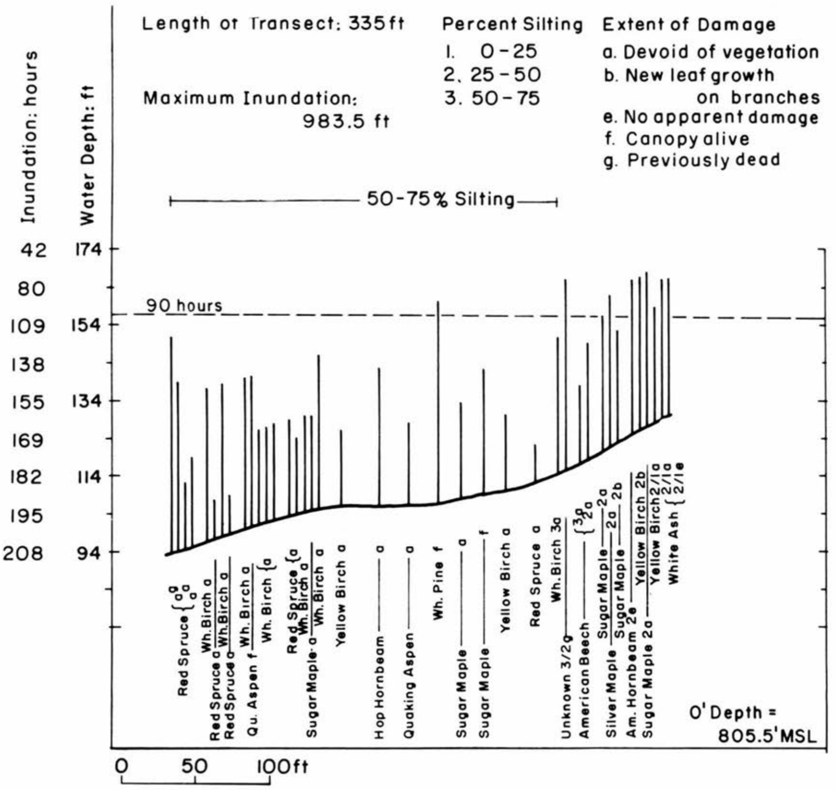
| *Species** | *Kill site†*<br>*1A* | *2A* | *3A* | *4A* | *4B* | *5A* | *5B* | *Total no. trees* | *Genus total* | *Percent of total* |
|---|---|---|---|---|---|---|---|---|---|---|
| Sugar maple | | 3 | 6 | 6 | 4 | 2 | 4 | 25 | | |
| Red maple | | 2 | 4 | | 7 | 6 | 1 | 20 | | |
| Silver maple | 1 | 1 | | 1 | | | | 3 | 48 | 20.6 |
| Eastern white pine | | 8 | | 1 | 35 | | 4 | 48 | 48 | 20.6 |
| Yellow birch | 6 | | 8 | 4 | 4 | 8 | | 30 | | |
| White birch | | 1 | 2 | 9 | 4 | | | 16 | | |
| Grey birch | 1 | | | | | | | 1 | 47 | 20.0 |
| Red spruce | 6 | | 8 | 9 | | 6 | 1 | 30 | 30 | 12.8 |
| American beech | | 6 | 8 | 2 | | | 1 | 17 | 17 | 7.3 |
| Hemlock | 3 | | 8 | | | | 6 | 17 | 17 | 7.3 |
| Northern red oak | | 7 | 1 | | 1 | | | 9 | 9 | 3.8 |
| Quaking aspen | 2 | | | 2 | 3 | | | 7 | 7 | 2.9 |
| Hop hornbeam | | 4 | | 1 | | | | 5 | | |
| American hornbeam | | | | 1 | | | | 1 | 6 | 2.6 |
| White ash | | | | 2 | 1 | 1 | | 4 | 4 | 1.7 |
| Unknown | | | | 1 | | | | 1 | 1 | 0.4 |
| Total | 19 | 32 | 45 | 39 | 59 | 23 | 17 | 234 | 234 | 100.0 |

* See Appendix D for scientific name.

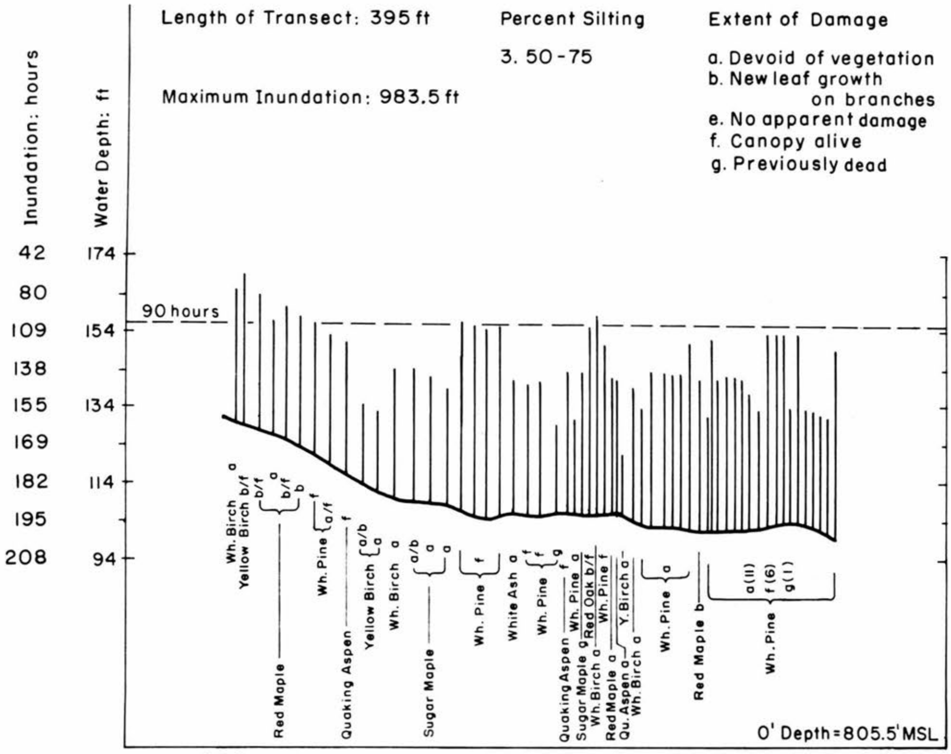
† See Appendix B for transect location.

*Figure 12. Silt deposition (5-7 in.) on bank of West River at beginning of transect 3A, Ball Mountain reservoir.*

*Figure 13. Trees killed by previous floods at beginning of transect 3A, Ball Mountain reservoir.*



*a. Transect 4A.*



*b. Transect 4B.*

*Figure 14. Relationship of duration and depth of inundation, topographic position, tree height, vegetative damage and siltation at Ball Mountain reservoir.*

The coniferous trees, especially the red spruce, appeared to be most affected by siltation. Also, the red spruce did not appear as tolerant of high moisture conditions as the white pine and hemlock. Greater siltation occurred at Ball Mountain than at Franklin Falls. Many of the yellow birch at Ball Mountain were coated with large amounts of silt as compared to the birch trees in Franklin Falls. Many low-lying areas were covered with 5 to 7 in. of silt which by September has partially dried to form a mud-cracked surface (Fig. 12). This extensive siltation may have been the primary cause of vegetative damage.

Observations made during the October 1973 field survey at Ball Mountain indicated that many of the trees that appear dead on the aerial photography were killed by earlier floods (Fig. 13). This was especially true along transect 3A where 29 out of 45 trees (64%) had been killed by prior floods (Appendix B). However, birch, quaking aspen, red spruce and hemlock had lost most of their original foliage due to the June-July flood; revegetation of the lower branches had not occurred by summer 1974.

The Pemigewasset River valley at Franklin Falls was bordered by steep-sided hills with extensive flat to gently sloped bottomlands, whereas the West River valley at Ball Mountain had steep slopes with a very limited floodplain. Extensive slumping did not occur at Ball Mountain since the glaciofluvial deposits present at Franklin Falls were absent.

Figure 14 shows profiles of two representative transects, 4A and 4B, at Ball Mountain. As at Franklin Falls, trees completely covered by water for more than 90 hours during the June-July flood showed the most apparent damage.

## CONCLUSIONS

This study has shown that color infrared photography is very useful in differentiating vegetative damage in reservoirs. Four distinct degrees of vegetative damage were mapped, based on the infrared reflectance differences between healthy and unhealthy vegetation apparent on the color infrared photography: 0-30%, 30-60%, 60-90% and 90-100%. Damage was assessed on a tree pattern and coloration basis; trees were considered damaged if they exhibited blue, brown, green or pink tones on the color infrared photography. Observations from the 1973 fall field surveys indicated that the lower branches of some trees were defoliated whereas the crowns were quite vigorous.

In the six sampled reservoirs, smaller (less than 5 in. in diameter) and younger trees were more affected by inundation than larger, mature trees. However, all trees that were inundated for more than 90 hours were affected to some degree.

The most extensive vegetative damage occurred in the Franklin Falls reservoir as a result of inundation, siltation and slumping. Slumping occurred primarily in a highly erodable glaciofluvial terrace at five sites on the northeast side of the Pemigewasset River. While damage was confined to narrow bands on either side of the river, it extended nearly the entire length of the reservoir. In the Ball Mountain area the steep-sided, V-shaped valley confined the vegetation damage to the very narrow floodplain and lower slopes adjacent to the West River. At Franklin Falls, the ice conditions associated with the December 1973 flood, added to the effects of the summer inundation, caused extensive damage to trees on the floodplain. Tree damage was less at the remaining reservoirs with the least damage occurring at North Springfield and Townshend reservoirs.

Generally, the maple and oak trees were the least affected by inundation and silt damage regardless of their location within the reservoir areas. Specifically, silver maple trees, located primarily at Franklin Falls, were most tolerant of the inundation and appeared to have minimal silt damage. Birch and quaking aspen usually retained a minimal amount of silt and were devoid of leaves when observed during the fall field surveys. Generally these species had not revegetated by summer 1974. Since these trees were primarily located on the floodplain and were inundated for the longest time, it is assumed that they were damaged more by water than by silting.

Previous studies in other parts of the country (Hunt 1951, Ahlgren and Hansen 1957) have indicated that many species of coniferous trees can tolerate long-time inundation. However, ground surveys during this study have shown that the species most susceptible to inundation was white pine, followed by red spruce and hemlock. If these trees were located upslope from the river bank, survival was more likely. Alder, willow, hornbeam, and other understory vegetation were initially damaged by inundation and silting; however, these species began to revegetate by September 1973 as indicated by ground surveys and aerial photography.

## RECOMMENDATIONS

The following recommendations are based on the results of a one-year investigation:

1. Methods should be considered to stabilize the slopes within the Franklin Falls reservoir. Floods have increased bank slumping at this project, resulting in accelerated vegetative damage. Research during the next two years should be directed toward the development of revegetation and landscape technique to maintain or improve slope stability.

2. Mature silver maple and red oak trees appear to be the most tolerant of prolonged inundation and are suggested for replanting anywhere within the inundated area. Research during the next two years will identify the tree type and tree size most appropriate for revegetation at specific landscape locations.

3. Birch, aspen, white pine, red spruce and hemlock on floodplains are especially susceptible to water damage and are not recommended for replanting in these areas. Field observations from the 1974 summer surveys indicated that birch and aspen were not revegetating at locations above the floodplain, whereas white pine had begun to revegetate. Additional research will provide data on the relationships between inundation time, degree of silting, landscape location and winter kill for these less tolerant tree species.

## FUTURE RESEARCH PLANS

Cooperative efforts of NED and CRREL personnel during the next three years will include research in the following areas:

1. Long-term effect of "flood pruning" on forest composition.
2. Susceptibility of partially killed trees to disease, insect infestation and siltation.
3. Multiregressional statistical analysis to determine the significance of each of the measured ground truth factors.
4. Revegetation of various grasses at slumping sites to reduce erosion.

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# APPENDIX A: FIELD DATA AND OBSERVATIONS FROM FRANKLIN FALLS AND BALL MOUNTAIN RESERVOIRS

## Legend

Degree of *Silting* as determined by subjective visual analysis

| | |
|---|---|
| 1 | 0-25% |
| 2 | 25-50% |
| 3 | 50-75% |
| 4 | >75% |

Extent of tree *Damage*

| | |
|---|---|
| a | Completely devoid of leaves |
| b | New leaf growth on branches |
| c | New growth at base |
| d | Ice damaged |
| e | No damage |
| f | Canopy alive |
| g | Previously dead |

DBH Diameter at breast height

Photographs mentioned in the Remarks section are available for viewing at USA CRREL, Hanover, New Hampshire.

## Table AI. Franklin Falls Reservoir, Transect 1A.

| *Tree* | *Species* | *Base elev (ft)* | *DBH (in.)* | *Ht (ft)* | *Silting* | *Damage* | *Remarks* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | *4 October 1973* | *23 April 1974* |
| T1 | Silver maple | 305 | Clump-8 | 37 | 1 | e | Photograph 1: water level along treeline (E to W view) 4-ft distance from previous tree. | Most of trees on lower slope of transect are ice damaged (d); average height of ice damage is 325 ft. |
| 1 | Silver maple | | 6.1 | | 1 | e | | |
| 2 | Hop hornbeam | | 3.0 | 25 | 1 | e | | |
| 3 | Silver maple | | Clump-8 | 49 | 2 | a | | |
| 4 | Silver maple | | Clump-5 | 49 | 1 | a | | |
| 5 | Silver maple | | Clump-2 | 37 | 1 | e | | |
| T2 | White pine | 316 | 13.5 | 26 | 1 | a | | |
| 6 | Quaking aspen | | 4.8 | 37 | 2 | a | | |
| 7 | Quaking aspen | | 4.8 | 37 | 1 | g | Appears to have been dead for long period; leaves on upper branches absent. | Break in slope; water height at 314 ft. |
| 8 | Quaking aspen | | 13.6 | 55 | 1 | a | | |
| 9 | Quaking aspen | | 6.4 | | 2 | c | | |
| 10 | Grey birch | | 5.7 | | 1 | a | Top broken. | |
| 11 | Grey birch | | 4.2 | | 2 | g | Appears to have been dead for long period. | |
| T3 | Grey birch | 316 | 10.2 | 47 | 1 | a | Entire tree killed. | |
| 12 | Grey birch | | 6.5 | 47 | 1 | a | | |
| 13 | Grey birch | | 4.1 | 29 | 1 | a | | |
| 14 | Hop hornbeam | | 5.0 | 29 | 1 | a | | |
| 15 | Grey birch | | 7.5 | 29 | 1 | g | Appears to have been dead for long period; entire tree killed. | |
| T4 | Ash | 318 | 10.8 | | 2 | a | Start upslope from floodplain. | |
| 16 | Hop hornbeam | | 9.3 | | 2 | a | Rough, channeled, lenticular bark. | |
| 17 | Maple/Oak | | 4.2 | | 1 | a | Local area has many (about 16) 2-4 in. diameter maples, oaks, hornbeams with new base growth. | |
| 18 | White oak | 320 | 9.0 | 44 | 1 | c | 1st tree starting upslope; about 18 maples and oaks are dead. | |
| 19 | White oak | 340 | 5.8 | 29 | – | f | Height to kill - 10 ft. | |
| T5 | Red oak | 356 | 17.6 | 69 | – | f | Height to kill - 10 ft; transect end; photo 2 of transect; photo 3 of slump. | Slump is now more extensive in area due to December flood. Mostly pine trees along higher terrace levels. See photographs 1-6 showing ice damage and increased slumping. |

## Table AII. Franklin Falls Reservoir, Transect, 1B.

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 4 October 1973 | 23 April 1974 |
| T1 | Red oak | | 17.2 | 36 | 1 | a | Near river bank on flood plain. | Tree bases (1-8) are submerged at this time. Extensive ice damage (d) along lower part of flood plain. |
| 1 | White pine | | 15.3 | | 1 | f | | |
| 2 | Unknown | | 10.0 | | 2 | a | | |
| 3 | Red oak | | 19.2 | | 2 | f | | |
| 4 | Grey birch | | 6.1 | | 1 | c | | |
| 5 | Hop hornbeam | | 4.5 | 15 | 1 | b | Swampy. | |
| T2 | Grey birch | | 4.5 | 35 | 1 | a | | |
| T3 | Black willow | | 8.4 | | 1 | e | Swampy, alders. | |
| 6 | Black willow | | 9.4 | | 1 | e | | |
| 7 | Black willow | | 9.9 | | 1 | e | Swampy; 3-4 in. diameter alders; location le on aerial photograph. | |
| 8 | Black willow | 316 | 10.0 | 44 | 1 | e | | Break in slope, water elevation |
| T4 | Grey birch | | 4.5 | 20 | 1 | a | | |
| T5 | Grey birch | | 8.9 | 35 | 1 | a | | |
| 9 | Grey birch | 323 | 5.8 | 25 | 1 | a | Area just begins to slope. | Top broken. |
| 10 | Red oak | 325 | 4.2 | 40 | 1 | c | | |
| 11 | Quaking aspen | | 4.0 | 34 | 1 | a | | |
| 12 | Red maple | | 7.1 | 63 | 2 | b | Sloping ground. | |
| 13 | Red maple | | 9.4 | 50 | 2 | b | | |
| 14 | Red oak | | 10.0 | 44 | 1 | f | | |
| T6 | Sugar maple | 330 | 19.6 | 44 | 2 | f | Sloping ground. | |
| 15 | Sugar maple | 330 | 8.8 | 44 | 2 | f | | |
| 16 | Sugar maple | | 11.3 | 56 | 2 | e | | |
| 17 | White pine | 345 | 15.7 | 59 | 0 | e | | Break in slope; top broken. |
| 18 | White pine | | 8.2 | 38 | 1 | g | | |
| 19 | Red oak | 347 | 6.1 | 50 | 1 | e | Top of hill. | |
| T7 | White oak | 347 | 5.8 | 50 | 1 | e | Height of kill - 10 ft; photo 5 – backsight onto transect. | See photographs 7-8 showing ice damage. |

## Table AIII. Franklin Falls Reservoir, Transect 1C.

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | 4 October 1973 | 23 April 1974 |
| T1 | Red oak | 319 | 12.3 | 47 | 1 | e | River bank; dry, flat. | The average ice damage height is 330-340 ft. See photos. |
| 1 | Red oak |  | 7.2 | 35 | 1 | e |  |  |
| 2 | Grey birch | 319 | 6.1 | 44 | 1 | b |  |  |
| 3 | Basswood | 326 | 9.9 | 62 | 1 | e |  |  |
| 4 | Basswood |  | 4.3 | 35 | 1 | e |  |  |
| 5 | White pine | 326 | 5.4 | 32 | 1 | a |  |  |
| 6 | Red oak | 327 | 18.1 | 62 | 1 | e | Dry, flat. |  |
| 7 | White pine | 327 | 7.8 | 31 | 1 | a |  |  |
| 8 | White pine | 327 | 8.2 | 31 | 2 | a |  |  |
| 9 | White pine | 327 | 5.6 | 28 | 2 | a |  |  |
| 10 | White pine | 327 | 7.2 | 28 | 2 | a |  |  |
| 11 | Red oak | 327 | 21.2 | 62 | 2 | f |  |  |
| 12 | Red oak | 327 | 14.2 | 59 | 2 | e |  |  |
| 13 | White pine | 327 | 5.2 | 28 | 2 | a |  |  |
| 14 | White pine | 327 | 5.8 | 59 | 2 | a |  |  |
| 15 | Red oak | 327 | 19.4 |  | 2 | f |  | Lower branches – ice damaged. |
| 16 | White pine | 327 | 10.4 | 40 | 1 | a |  | Tree top freshly broken – 13 ft. |
| 17 | White pine | 327 | 7.7 |  | 1 | f |  |  |
| T2 | Red oak |  | 19.9 | 42 | 1 | f | See location 1f on aerial photo; small stand of aspen north of line. |  |
| 18 | Red oak | 325 | 13.0 | 62 | 1 | f |  |  |
| 19 | White pine | 325 | 6.8 | 25 | 1 | a |  | Roots exposed, heavily silted at base. |
| 20 | White pine | 325 | 5.8 | 19 | 1 | a |  |  |
| 21 | Red oak |  | 7.4 | 50 | 2 | a |  |  |
| 22 | Red oak |  | 13.1 | 44 | 1 | a |  |  |
| 23 | Red oak |  | 21.0 |  | 2 | g |  |  |
| 24 | White pine | 330 | 13.3 | 44 | 2 | a/f |  |  |
| 25 | Red oak |  | 16.9 |  | 1 | e |  | Top broken at 25 ft. |
| 26 | Red oak |  | 19.8 |  | 2 | g |  |  |
| 27 | Grey birch |  | 4.6 |  | 2 | a |  | Top broken. |
| T3 | Red oak |  | 14.6 | 29 | 2 | a |  |  |
| 28 | Basswood |  | 4.7 |  | 2 | c |  | Top broken. |
| 29 | Red oak |  | 18.8 | 62 | 1 | f |  | Branches broken. |
| 30 | Elm |  | 16.7 |  | 1 | g |  |  |
| 31 | White pine |  | 15.8 |  | 1 | a/f |  |  |
| 32 | Red oak |  | 7.7 |  | 1 | a |  |  |
| 33 | Grey birch | 335 | 5.1 |  | 1 | a |  | Birch tops broken 10-15 ft. |
| 34 | White pine | 335 | 5.8 |  | 2 | a | Clump. | Pine tops broken 20 ft. |
| 35 | White pine | 335 | 6.4 | 31 | 2 | a |  |  |
| 36 | Grey birch | 335 | 6.0 |  | 2 | a |  |  |
| 37 | Grey birch | 335 | 7.7 |  | 2 | a/f | Clump. |  |
| 38 | Grey birch | 335 | 5.1 | 38 | 2 | a/f |  |  |
| 39 | Grey birch |  | 5.2 |  | 2 | g |  |  |
| 40 | Grey birch |  | 6.1 |  | 2 | a/f |  |  |
| 41 | Red oak |  | 5.8 |  | 2 | f |  |  |
| 42 | White pine |  | 7.8 |  | 2 | a |  |  |
| 43 | Red oak |  | 14.4 |  | 2 | f |  |  |
| 44 | Red oak |  | 19.8 | 50 | 2 | f |  | Branches broken off. |
| T4 | Red oak |  | 8.8 | 41 | 2 | a | Start of slope. | Top broken off; ice damage height – 12 ft. |
| T5 | Red maple |  | 21.2 | 33 | – | e |  |  |
| T6 | White pine | 335 | 11.3 | 62 | 1 | e | Slope. |  |
| 45 | Red maple | 335 | 15.8 | 50 | 1 | f |  |  |
| 46 | Silver maple | 340 | 8.4 | 50 | 1 | e |  |  |
| 47 | Red maple | 350 | 12.5 | 106 | 1 | f |  |  |
| 48 | White pine | 355 | 7.0 | 38 | 1 | f |  | Ice damage to lower branches. |
| 49 | Red maple | 359 | 11.6 | 50 | 1 | f |  |  |
| T7 | White pine | 366 | 11.3 | 56 | 1 | e |  |  |
| 50 | White pine | 355 | 5.9 | 38 | 1 | e |  | Ice damage to lower branches; see photos 9-11 showing ice damage. |

## Table AIV. Franklin Falls Reservoir, Transect 2A.

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 4 October 1973 | 23 April 1974 |
| T1 | Red oak | | 13.7 | 40 | 3 | a | Roots exposed by river erosion. | Ice damage along lower branches. |
| 2 | White pine | | 15.8 | 38 | 3 | f | | |
| 3 | Red oak | | 4.0 | 13 | 3 | a | Dry. | Minor ice damage. |
| 4 | White pine | | 17.0 | 44 | 2 | f | | |
| 5 | Grey birch | | 25.5 | 44 | 2 | f | | Branches broken off. |
| 6 | Red oak | 330 | 26.0 | 50 | 2 | f | | |
| 7 | Red oak | | 23.0 | 50 | 2 | f | | |
| 8 | Silver maple | 327 | 9.0 | 44 | 2 | f | | |
| 9 | Silver maple | | 11.0 | 40 | 2 | f | A log in tree. | |
| 10 | Ash | | 11.0 | 46 | 2 | a | | |
| 11 | Ash | | 10.5 | 50 | 2 | a | | |
| 12 | Basswood | | 14.2 | 63 | 2 | f | | |
| 13 | Sugar maple | 338 | 21.2 | 63 | 2 | f | Dry. | |
| 14 | Hop hornbeam | | 5.1 | | 2 | f | | Broken off at 8 ft. |
| 15 | Basswood | | 4.5 | 25 | 2 | f | | Broken top. |
| 16 | Unknown | 343 | 5.3 | | 2 | g | | Broken at 35 ft. |
| 17 | Grey birch | 344 | 8.0 | | 2 | f | | |
| 18 | Basswood | 344 | 4.8 | 56 | 2 | e | | |
| 19 | Basswood | 345 | 11.0 | 56 | 2 | e | Clump of four. | |
| 20 | Ash | | 11.8 | 56 | 2 | e | | |
| 21 | Ash | | 12.1 | 56 | 2 | e | | |
| 22 | Red oak | 355 | 7.5 | 44 | 2 | f | | |
| 23 | Ash | 355 | 10.5 | 50 | 2 | a | | |
| 24 | Silver maple | 355 | 3.5 | 25 | 2 | a | Clump. | |
| 25 | Red oak | 355 | 23.0 | 31 | – | f | | |
| 26 | Chinkapin oak | 355 | 3.9 | 19 | – | f | Rain began; degree of silting estimates difficult to make. | |
| 27 | Quaking aspen | 355 | 8.5 | 50 | – | f | | |
| 28 | Red oak | 355 | 18.3 | 50 | 2 | f | | |
| 29 | Red oak | 355 | 11.7 | 56 | 2 | f | | |
| 30 | Quaking aspen | 355 | 7.5 | 50 | 2 | f | | Branches broken. |
| 31 | Quaking aspen | 355 | 9.3 | 56 | – | – | | |
| 32 | Red oak | 355 | 3.7 | 31 | – | a/f | | |
| 33 | Quaking aspen | 355 | 5.1 | 38 | – | f | | |
| 34 | Quaking aspen | 355 | 8.7 | 56 | – | f | | Branches broken. |
| 35 | Hop hornbeam | 355 | 5.7 | 25 | – | g | Scaly, rough bark. | |
| 36 | Hop hornbeam | 355 | 5.5 | 50 | – | a | | |
| 37 | Unknown | 355 | 9.2 | 50 | – | f | Clump. | |
| 38 | Unknown | 355 | 8.6 | 50 | 2 | e | | Branches broken. |
| 39 | Red oak | 355 | 4.4 | 38 | 2 | f | | |
| 40 | Basswood | 355 | 5.8 | 50 | – | e | | |
| 41 | American hornbeam | 355 | 6.9 | | – | f | Two trees. | |
| 42 | Unknown | 355 | 4.3 | 31 | – | a | | Branches broken. |
| 43 | Elm | 355 | 19.1 | 56 | – | g | Clump-2. | |
| 44 | Hop hornbeam | 355 | 5.4 | 44 | – | – | | |
| 45 | Red oak | 355 | – | 44 | – | f | | |
| 46 | Hop hornbeam | 355 | 6.2 | 46 | – | f | | |
| 47 | Basswood | 355 | 7.0 | 38 | – | f | | |
| 48 | Elm | 355 | 10.2 | 62 | – | e | | |
| 49 | American hornbeam | 355 | 5.0 | 38 | – | a | Clump. | |
| 50 | Hop hornbeam | 355 | 6.5 | 38 | – | a | 6 - from base. | 1 trunk broken. |
| 51 | Quaking aspen | 355 | 8.8 | 50 | – | e | 7 in a row. | |
| 52 | Hop hornbeam | 355 | 8.2 | 46 | – | a | 5 - from base. | |
| 53 | Hop hornbeam | 355 | 5.6 | 40 | – | a | 3 - from base. | Branches broken. |
| 54 | Quaking aspen | 355 | 8.2 | 40 | – | f | | |
| 55 | Quaking aspen | 355 | 7.7 | 40 | – | g | | |
| 56 | Hop hornbeam | 355 | 6.2 | 40 | – | a | | |
| 57 | Hop hornbeam | 355 | 6.8 | 40 | – | a | | |
| 58 | Quaking aspen | 355 | 9.2 | 40 | – | f | | |
| 59 | Red oak | 355 | 8.7 | 40 | – | f | 2 - from base. | |
| 60 | American hornbeam | 355 | 7.1 | 40 | – | a | | |
| 61 | Quaking aspen | 355 | 5.2 | 40 | 1 | f | | |
| 62 | Hop hornbeam | 355 | 8.7 | 40 | – | a | | |
| 63 | Quaking aspen | 355 | 6.1 | 40 | – | f | 4 in area. | |
| 64 | Hop hornbeam | 355 | 7.9 | 40 | – | a | | |
| 65 | Quaking aspen | 355 | 6.3 | 40 | – | f | | |
| 66 | Basswood | 355 | 9.8 | 40 | – | e | Clump. | |
| 67 | Hop hornbeam | 355 | 5.4 | 40 | – | a | Clump-2. | |
| 68 | Quaking aspen | 355 | 6.6 | 40 | – | f | 5 in a row. | |
| 69 | Hop hornbeam | 355 | 5.4 | 40 | – | a | | |
| 70 | Elm | 355 | 12.0 | 40 | – | g | 4 - from base; nearby is 70 ft white birch, 6 from base. | |
| 71 | Hop hornbeam | 355 | 8.2 | 40 | – | a | | |
| | | | | | | | 117 white pines in north row; lower portion damaged.<br>Photographs:<br>6. The field group.<br>7. Across Pemigewasset River from west bank - NE view.<br>8. Across Pemigewasset River from west bank - SE view.<br>9. Canopy seen on maple trees.<br>10. Water line on trees. | See photographs 12-16 showing ice damage. |

## Table AV. Franklin Falls Reservoir, Transect 3A.

| *Tree* | *Species* | *Base elev (ft)* | *DBH (in.)* | *Ht (ft)* | *Silting* | *Damage* | *Remarks* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | *4 October 1973* | *23 April 1974* |
| T1 | Red oak | 320 | 5.3 | 40 | 2 | f | | Red oaks – leaves on crown and along trunk. |
| 1 | Big Tooth aspen | | 5.2 | | 2 | f | | Quaking aspen appear more damaged as leaves sparse. |
| 2 | Red oak | | 5.0 | | 2 | e | | New growth along lower branches. |
| 3 | Big Tooth aspen | | 7.3 | | 2 | e | | Scattered ice damage on lower parts. |
| 4 | Red oak | | 5.3 | | 2 | e | | |
| 5 | Red oak | | 4.2 | | 2 | e | | |
| 6 | Red oak | | 4.2 | | 2 | e | Clump. | |
| 7 | Big Tooth aspen | | 10.3 | | 2 | e | | |
| 8 | White pine | | 25.3 | | 2 | a/f | Location 3a on aerial photo-line of large white pines. | Height of damage is 20 ft. |
| T2 | White pine | 330 | 5.9 | 22 | 3 | a | | |
| 9 | White pine | | 7.2 | | 3 | a/f | Pines predominate in this area. | |
| 10 | White pine | | 10.5 | | 3 | f | Dry, flat. | |
| 11 | White pine | | 8.0 | | 3 | f | | |
| 12 | White pine | | 5.3 | | 3 | f | | |
| 13 | White pine | | 8.3 | | 3 | a/f | | |
| T3 | Hop hornbeam | 340 | 5.8 | 34 | 3 | a | Dry, flat. | Damage, same. |
| 14 | American hornbeam | | 5.0 | | 3 | e | Dry, flat. | |
| 15 | Hop hornbeam | | 5.5 | | 3 | a | | |
| 16 | Grey birch | | 4.0 | | 3 | a | Small birch trees dead. | |
| 17 | Grey birch | | 4.0 | | 3 | a | | |
| 18 | American hornbeam | | 4.2 | | 3 | a | | |
| 19 | Red oak | | 4.0 | | 3 | a/b | | |
| 20 | Cherry | | 7.2 | | 3 | a | | |
| T4 | White birch | 340 | 4.8 | 30 | 2 | f | Knoll. | Damage, same. New growth along lower trunk; scattered ice damage on trees. |
| 21 | White pine | | 5.5 | | 2 | f | | |
| 22 | White pine | | 6.5 | | 2 | f | | |
| 23 | White birch | | 7.6 | | 2 | f | | |
| T5 | Quaking aspen | 345 | 11.5 | 36 | 2 | a | | Revegetated; 15 ft to unrevegetated. |
| 24 | White pine | | 20.0 | | 2 | f | 2-Clump. | |
| 25 | White pine | | 4.7 | | 2 | f | | |
| T6 | White pine | 345 | 18.9 | 36 | 2 | a | 130 ft from T6, photo 11 shows clump of white pines. | |
| 26 | White pine | | 12.0 | | 2 | a | Dry, flat. | |
| 27 | White pine | | 4.2 | | 3 | a | | |
| T7 | White birch | 345 | 4.0 | 20 | 3 | a | Photograph 12 - west view of flat, grassy plain. | Damage, same. |
| 28 | White pine | | 11.0 | | 2 | a | | |
| 29 | White pine | | 9.8 | | 2 | a | | |
| 30 | White pine | | 6.0 | | 2/3 | a | Flat, grassy plain. | Extensive ice damage on pines in plain. Outside grove of white pines, many of lower branches with new needle growth. |
| T8 | Quaking aspen | 350 | 6.2 | | 1 | e | | Completely vegetated but lower leaves appear generally unhealthy. |
| 31 | Grey birch | | 4.2&4.5 | | 1/2 | a | Clump-2, just 25 ft north of white pines area "a". | |
| T9 | Quaking aspen | 350 | 8.6 | 29 | 1 | e | 20-50 ft east are 7 white pines. | Damage, same. |
| T10 | Quaking aspen | 355 | 6.8 | 29 | 1 | f | 20-40 ft east are 5 white pines (9 ft high) and 1-4 clump of grey birch. | |
| 32 | Grey birch | | 4.2 | | 1 | a | Clump-5. | |
| T11 | White pine | 360 | 8.5 | 20 | 2 | a | Three white pines about 11 ft high. Photo 13 shows 40 ft high white pine. | |
| 33 | White pine | | 15.9 | | 2 | f | Minor damage on lower portion. | |
| | | | | | | | Approximate transect through grove of white pines to oxbow; all were "e" to "f". | Ice damage extensive in oxbow; See photos 17-25. |

Photographs:

14. View NE direction across oxbow.
15. View SE direction across oxbow.
16. View southerly direction across oxbow.
17. View NW direction across oxbow.
18. View of oxbow.

**Table AVI. Ball Mountain Reservoir, 1A.**

| *Tree* | *Species* | *Base elev (ft)* | *DBH (in.)* | *Ht (ft)* | *Silting* | *Damage* | *Remarks* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | *11 October 1973* | *3 July 1974* |
| T1 | Red spruce | 870 | 6.7 | 32 | 2-3 | a | | Completely devoid of vegetation |
| 1 | Red spruce | | 5.1 | 27 | 2 | a | Dry, slope | |
| 2 | Red spruce | | 27.0 | 45 | 2-3 | a | Dry, slope | |
| 3 | Red spruce | | 8.0 | 27 | 2-3 | a | Dry, slope; clump-2 | |
| 4 | Hemlock | | 11.7 | 40 | 2-3 | f | Dry, slope | |
| 5 | Hemlock | | 6.2 | 35 | 2-3 | f | | |
| 6 | Hemlock | | 7.1 | 40 | 3 | f | | |
| 7 | Grey birch | | 9.7 | 40 | 3 | a | | |
| 8 | Red spruce | | 16.9 | 30 | 3 | a | Near creek | |
| 9 | Red spruce | | 11.1 | 35 | 3 | g | Near creek, slump along bank; 2 trees (pine) nearby; dead previously | |
| T2 | Silver maple | 920 | 7.5 | 30 | 2 | a | Clump-2 | |
| 10 | Yellow birch | | 4.9 | 25 | 2 | a | Clump-3 | Not leafed out |
| 11 | Quaking aspen | | 5.4 | 40 | 2 | e | Slope | Has leafed out |
| 12 | Quaking aspen | | 6.3 | 40 | 2 | e | | |
| 13 | Yellow birch | | 5.4 | 25 | 2 | a | | Not leafed out |
| 14 | Yellow birch | | 21.3 | 60 | 2 | a/b | 3 hemlocks-clump, at base | Leafed out, above or at edge of water line |
| 15 | Yellow birch | | 32.3 | 60 | 2 | a/b | Between tree 15 and 16 are small sugar maples alive; slope near creek | All are alive |
| 16 | Yellow birch | | 20.9 | 60 | 1-2 | a | Slope near creek | |
| T3 | Yellow birch | 950 | 18.8 | 60 | 1 | a/b | | |

Photographs:
1. West side of dam
2 & 3. South side of permanent pool, about 1000′ west of dam
4. Transect line (N); many white pine, oak and white birch damaged by silt/water along Transect A
5, 6, & 7. Panorama of north side of pool (5 near dam)
8. South shore between dam, photo location on map

## Table AVII. Ball Mountain Reservoir, Transect 2A.*

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 11 October 1973 | 3 July 1974 |
| T1 | White pine | 875 | 15.0 | 57 | 1 | a/f | Slope, dry | |
| 1 | White pine | | 11.8 | 57 | 1 | a/f | | |
| 2 | White pine | | 8.0 | 57 | 1 | a/f | | |
| 3 | White pine | | 9.7 | 57 | 1 | a/f | | |
| 4 | Red oak | | 12.1 | 57 | 1 | a | | |
| 5 | White pine | | 13.8 | 57 | 1 | a | | |
| 6 | White pine | | 9.0 | | 1 | g | Slope, dry; nearby dead maple, clump-4 | |
| 7 | White pine | | 7.4 | 43 | 1 | a | Slope, dry | |
| 8 | White pine | | 8.5 | 43 | 1 | a | | |
| 9 | Red oak | | 7.4 | 50 | 1 | a | | |
| 10 | Red oak | | 4.9 | 40 | 1 | a/b | | |
| 11 | American beech | | 4.8 | 25 | 2 | a | Small valley | |
| T2 | Sugar maple | 885 | 18.3 | 60 | 2 | f | Dry | |
| 12 | American beech | | 6.5 | 30 | 1 | f | | |
| 13 | American beech | | 8.9 | 55 | 1/2 | a/b | Tops dead, center alive | |
| 14 | American beech | | 7.6 | 55 | 1 | a/b | | |
| 15 | Red oak | | 7.0 | 50 | 1 | a/b | | |
| 16 | Red maple | | 14.8 | 50 | 1 | f | Clump-3 | |
| 17 | Sugar maple | | 7.0 | 50 | 1 | a/b | | |
| 18 | Sugar maple | | 6.9 | 45 | 1 | f/b | Clump-2 | |
| T3 | White birch | 895 | 10.3 | 50 | 1 | g | In area to east, trees are completely devoid of vegetation | |
| 19 | Hop hornbeam | | 6.8 | 40 | 1 | a | | |
| 20 | Hop hornbeam | | 9.1 | 40 | 1 | a | Clump-5 | |
| 21 | Red oak | | 6.0 | 50 | 1/2 | a | Dry, slope | |
| 22 | Silver maple | | 4.8 | 30 | 1/2 | a | | |
| 23 | Hop hornbeam | | 5.7 | 35 | 1/2 | a | Ledge; dry | |
| 24 | Hop hornbeam | | 6.0 | 35 | 1/2 | a | | |
| 25 | Red maple | | 5.5 | 40 | 1/2 | e | | |
| 26 | American beech | | 8.1 | 40 | 1/2 | a | | |
| 27 | American beech | | 8.2 | 40 | 1/2 | a | | |
| 28 | Red oak | | 23.9 | 60 | 1 | e | | |
| T4 | Red oak | 900 | 15.3 | 60 | 1 | e | | |
| | | | | | | | Many trees at start of $T_A^2$ are dead, from previous kill. South side of river in area 2 is revegetated shrubs since 1961 when dam was built – the inundation killed shrubs.<br>Photographs:<br>9. Beginning of Transect $T_A^2$ | |

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* Along stone wall.

## Table AVIII. Ball Mountain Reservoir, Transect 3A.

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 11 October 1973 | 3 July 1974 |
| T1 | Red spruce | 900 | 13.0 | 43 | 3 | a | Near river bank; about 6-7 in. of silt, mud cracks | Top vegetated brown |
| 1 | Red spruce | | 7.6 | 35 | 3 | a | Many previously dead trees in this area | |
| 2 | Red spruce | | 10.9 | 50 | 3 | a | | |
| 3 | Red spruce | | – | | 3 | g | Upslope; silt | |
| 4 | Red spruce | | – | | 3 | g | | |
| 5 | Red spruce | | – | | 3 | g | | |
| 6 | Red spruce | | – | | 3 | g | | |
| 7 | Hemlock | | – | | 3 | g | | |
| 8 | Yellow birch | | – | | 3 | g | | |
| 9 | Sugar maple | | 10.8 | 60 | 3 | g | | |
| 10 | Hemlock | | – | | 3 | g | Upslope | |
| 11 | Yellow birch | | – | | 3 | g | | |
| 12 | Yellow birch | | – | | 3 | g | | |
| 13 | White birch | | 7.2 | 55 | 3 | g | | |
| 14 | Red spruce | | – | 30 | 3 | g | | |
| 15 | American beech | | – | 45 | 3 | g | | |
| T2 | Yellow birch | 910 | 5.6 | 20 | 3 | a | Gentle slope; not as much silt on ground as between tree 1-15 | |
| 16 | Yellow birch | | 8.4 | 35 | 3 | a | | |
| 17 | Hemlock | | – | 25 | 3 | g | | |
| 18 | Sugar maple | | 10.5 | 45 | 3 | g | | |
| 19 | Hemlock | | – | | 3 | g | | |
| 20 | Hemlock | | – | | 3 | g | Gentle slope | |
| 21 | Yellow birch | | 6.4 | 30 | 3 | g | | |
| 22 | Hemlock | | 7.0 | | 3 | g | | |
| 23 | Sugar maple | | 8.8 | 60 | 3 | a | | Still "a" |
| 24 | Sugar maple | | 17.8 | 55 | 3 | f | | Still "f" |
| 25 | Sugar maple | | 10.6 | 40 | 3 | g | | |
| 26 | American beech | | 5.8 | 60 | 3 | a | | |
| 27 | Sugar maple | | 10.2 | 60 | 3 | a | | |
| 28 | Red maple | | 7.2 | 50 | 3 | a | | |
| 29 | American beech | | – | | – | g | | |
| 30 | Red maple | | 4.8 | 35 | – | g | | |
| 31 | American beech | | 4.9 | 20 | 3 | g | | |
| 32 | American beech | | – | | – | g | | |
| 33 | Red maple | | 4.5 | 50 | 3 | a | | |
| 34 | American beech | | 18.3 | 50 | 3 | e | | |
| 34A | American beech | | – | | – | g | | |
| T3 | Oak | 920 | – | | – | g | | |
| 35 | Yellow birch | | 10.9 | 50 | 2 | a | | Still "a" |
| 36 | Hemlock | | – | | 2 | g | | |
| 37 | Red maple | | 13.1 | | 1 | g | | |
| 38 | Hemlock | | – | | 1 | g | | |
| 39 | Yellow birch | | 10.0 | 40 | 1 | a | | |
| T4 | White birch | 945 | 12.6 | 55 | 1 | e | | |
| 40 | American beech | | 10.0 | 50 | 1 | e | | |

Photographs:
10. SE direction from $T^3_A$
11 & 12. Shoreline of Site 3 area
13. Area "f" on east side of West River
14. Upstream, area "g" -similar to Site 3
15. East side of West River opposite location "g" on aerial photograph
16. Ball Mountain Dam
17. Sign and Ball Mountain Dam
18. Mink on Winhall River
19. Island in West River above bridge

## Table AIX. Ball Mountain Reservoir, Transect 4A.*

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silt-ing | Dam-age | Remarks<br>12 October 1973 | <br>3 July 1974 |
|---|---|---|---|---|---|---|---|---|
| T1 | Red spruce | 900 | 9.6 | 57 | 3 | g | Thick layer of silt with mud cracks as at Site 3. Directly across river, high silt coat, mud cracks, many previously dead trees. | |
| 1 | Red spruce | | 5.8 | 45 | 3 | a | | |
| 2 | Red spruce | | 7.4 | 17 | 3 | a | | |
| 3 | Red spruce | | 7.3 | 33 | 3 | a | | |
| 4 | White birch | | 8.8 | 40 | 3 | a | | |
| 5 | Red spruce | | 6.4 | 12 | 3 | a | | |
| 6 | White birch | | 9.3 | 40 | 3 | a | | |
| 7 | Red spruce | | 5.5 | 10 | 3 | a | | |
| 8 | White birch | | 7.0 | 40 | 3 | a | Clump-2 | |
| 9 | Quaking aspen | | 8.2 | 40 | 3 | f | | |
| 10 | White birch | | 5.4 | 25 | 3 | a | | |
| 11 | White birch | | 7.9 | 25 | 3 | a | | |
| 12 | White birch | | 5.8 | 25 | 3 | a | Clump-2 | |
| 13 | Red spruce | | 10.4 | 30 | 3 | a | | |
| 14 | Red spruce | | 5.6 | 20 | 3 | a | | |
| 15 | White birch | | 6.2 | 30 | 3 | a | | |
| 16 | Sugar maple | | 6.1 | 30 | 3 | a | | |
| T2 | White birch | 924 | 8.7 | 40 | 3 | a | Clump-2; ferns on level ground | |
| 17 | Yellow birch | | 10.0 | 20 | 3 | a | | |
| 18 | Hop hornbeam | | 14.4 | 35 | 3 | a | | |
| 19 | Quaking aspen | | 4.3 | 20 | 3 | a | 5 quaking aspens of same size still alive | |
| 20 | White pine | | 20.3 | 52 | 3 | f | Small trail 30 ft space E; area of alders | |
| 21 | Sugar maple | | 11.8 | 33 | 3 | a | Clump-2 | |
| 22 | Sugar maple | | 12.4 | 33 | 3 | f | | |
| 23 | Yellow birch | | 8.4 | 20 | 3 | a | Flat, low area<br>Ferns returning | Not leafed out; yellow birch nearby, not leafed out |
| 24 | Red spruce | | 6.5 | 10 | 3 | a | | |
| T3 | White birch | 942 | 11.1 | 35 | 3 | a | Slope | |
| 25 | – | | – | 50 | 3/2 | g | Upslope; near end of inundation | |
| 26 | American beech | | 8.1 | 20 | 3 | a | | |
| 27 | American beech | | 6.5 | 30 | 2 | a | | Below this elevation, no birch is leafed out |
| 28 | Sugar maple | | 8.2 | 35 | 2 | a | | |
| 29 | Silver maple | | 7.8 | 40 | 2 | a | | |
| 30 | Sugar maple | | 6.2 | 25 | 2 | b | | |
| 31 | American hornbeam | | 15.4 | 40 | 2 | e | | |
| 32 | Yellow birch | | 7.6 | 40 | 2 | b | | |
| 33 | Sugar maple | | 6.8 | 40 | 2 | a | Slope; clump-3 | |
| 34 | Yellow birch | | 6.4 | 30 | 2/1 | a | | |
| 35 | White ash | | 10.2 | 35 | 2/1 | a | | |
| T4 | White ash | 975 | 5.8 | 35 | 2/1 | e | Clump-3<br>Photographs:<br>20. Across West River to east side of Site 4, north of bridge | |

* Near bridge on east side of river.

## Table AX. Ball Mountain Reservoir, Transect 4B.

| *Tree* | *Species* | *Base elev (ft)* | *DBH (in.)* | *Ht (ft)* | *Silt-ing* | *Dam-age* | *Remarks* 12 October 1973 | *Remarks* 3 July 1974 |
|---|---|---|---|---|---|---|---|---|
| T1 | White pine | 905 | 15.0 | 50 | 3 | a | Dry, flat area through tree 21 | Trees T1-9 are now "a" |
| 1 | White pine | | 5.9 | 30 | 3 | a | | |
| 2 | White pine | | 5.4 | 30 | 3 | a | | |
| 3 | White pine | | 8.2 | 30 | 3 | a | | |
| 4 | White pine | | 5.7 | 30 | 3 | a | | |
| 5 | White pine | | 18.0 | 50 | 3 | f | | |
| 6 | White pine | | 7.3 | 30 | 3 | a | | |
| 7 | White pine | | 9.7 | 50 | 3 | f | | |
| 8 | White pine | | 11.7 | 50 | 3 | a | | |
| 9 | White pine | | 14.2 | 50 | 3 | f | | |
| 10 | White pine | | 5.5 | 30 | 3 | a | | |
| 11 | White pine | | 7.8 | 35 | 3 | f | | |
| 12 | White pine | | 8.7 | 40 | 3 | f | | Canopy browning |
| 13 | White pine | | 8.5 | 40 | 3 | a | | |
| 14 | White pine | | 11.6 | 40 | 3 | a | | |
| 15 | White pine | | 12.6 | 40 | 3 | a | | |
| 16 | White pine | | 15.0 | 50 | 3 | f | | |
| 17 | White pine | | 6.5 | 30 | – | g | | |
| 18 | Red maple | | 12.5 | 40 | 3 | b | | Devoid of vegetation |
| 19 | White pine | | 10.8 | 50 | 3 | a | | |
| 20 | White pine | | 13.4 | 40 | 3 | a | | |
| 21 | White pine | | 12.2 | 40 | 3 | a | | |
| 22 | White pine | | 10.0 | 40 | 3 | a | Dry, flat; silt, mudcracks in area through tree 27 | |
| 23 | White pine | | 8.9 | 40 | 3 | a | | |
| 24 | White pine | | 4.9 | 30 | 3 | a | | |
| 25 | White pine | | 6.1 | 35 | 3 | a | | |
| 26 | Yellow birch | | 5.5 | 15 | 3 | a | | Not leafed out |
| 27 | Quaking aspen | | 6.4 | 35 | 3 | a | | |
| 28 | Red maple | | 6.9 | 35 | 3 | a | Silt, mudcracks found through tree 32 | Still "a" |
| 29 | White pine | | 14.8 | 45 | 3 | f | | |
| T2 | White birch | 915 | 7.0 | 52 | 3 | a | | Still "a" |
| 30 | Red oak | | 14.3 | 50 | 3 | b/f | | |
| 31 | Sugar maple | | 8.0 | 37 | 3 | g | | |
| 32 | White pine | | 5.2 | 25 | 3 | a | | |
| 33 | Quaking aspen | | 8.1 | 37 | 3 | f | Dry, gentle slope through tree 38 | |
| 34 | White pine | | – | 22 | – | g | | |
| 35 | White pine | | 9.5 | 35 | 3 | f | | |
| 36 | White pine | | 11.5 | 35 | 3 | f | | |
| 37 | White ash | | 7.9 | 35 | 3 | a | | |
| 38 | White pine | | 17.3 | 50 | 3 | f | | |
| 39 | White pine | | 10.1 | 50 | 3 | f | Dry, gentle slope, mudcracks through tree 43 | |
| 40 | White pine | | 11.0 | 50 | 3 | f | | |
| 41 | White pine | | 11.8 | 50 | 3 | f | | |
| 42 | Sugar maple | | 9.5 | 30 | 3 | a | | |
| 43 | Sugar maple | | 5.9 | 33 | 3 | a | | |
| 44 | Sugar maple | | 7.1 | 35 | 3 | a/b | Dry, gentle slope through tree 53 | |
| T3 | White birch | 920 | 7.6 | 33 | 3 | a | | Not budded |
| 45 | Yellow birch | | 9.7 | 20 | 3 | a | | |
| 46 | Yellow birch | | 7.6 | 20 | 3 | a/b | | |
| 47 | Quaking aspen | | 6.5 | 35 | 3 | f | | |
| 48 | White pine | | 11.0 | 35 | 3 | a/f | | |
| 49 | White pine | | 10.8 | 35 | 3 | f | | |
| 50 | Red maple | | 6.1 | 35 | 3 | b | | |
| 51 | Red maple | | 7.4 | 35 | 3 | b | Clump-4 | |
| 52 | Red maple | | 6.3 | 30 | 3 | b/f | Clump-3 | |
| 53 | Red maple | | 8.8 | 35 | 3 | a | Slope | |
| 54 | Red maple | | 5.5 | 30 | 3 | b/f | | |
| 55 | Yellow birch | | 6.4 | 40 | 3 | b/f | | |
| T4 | White birch | 940 | 7.0 | 35 | 3 | a | Water level 20 ft higher than base of T4 | Still alive |

## Table AXI. Ball Mountain Reservoir, Transect 5A.

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 12 October 1973 | 3 July 1974 |
| T1 | Yellow birch | 900 | 13.3 | 35 | 3 | a | River bank, ice damage on tree; gentle slope through tree 4 | |
| 1 | Red spruce | | 14.0 | 40 | 3 | a | | |
| 2 | Red spruce | | 19.2 | 45 | 3 | a | Clump-2 | |
| 3 | Red spruce | | 3.9 | 20 | 3 | a | | |
| 4 | Red maple | | 14.8 | 30 | 3 | g | | |
| 5 | Red maple | | 9.8 | 30 | 3 | a | | |
| 6 | Red spruce | | 13.5 | 40 | 3 | a | Level ground | |
| 7 | Yellow birch | | 5.1 | 20 | 3 | a | Dry, flat area through tree 12 | |
| 8 | Yellow birch | | 8.0 | 25 | 3 | a | | |
| 9 | Yellow birch | | 16.2 | 30 | 3 | a | | |
| 10 | White ash | | 9.4 | 40 | 3 | a | | |
| 11 | Red spruce | | 9.3 | 25 | 3 | a | | |
| 12 | Red maple | | 7.6 | 35 | 3 | a | | |
| 13 | Red maple | | 12.1 | 35 | 3 | e | Slope through tree 17; many small Hop Hornbeams | |
| 14 | Red spruce | | 9.8 | 30 | 3 | a | | |
| T2 | Red maple | 925 | 13.6 | 40 | 3 | f | | |
| 15 | Yellow birch | | 9.9 | 30 | 3 | a | | |
| 16 | Sugar maple | | 14.2 | 45 | 3 | e | | |
| 17 | Sugar maple | | 16.4 | 50 | 3 | e | | |
| 18 | Yellow birch | | 11.2 | 35 | 3 | a | Much silt on ground, mudcracks along transect, all small trees less than 20 ft coated with silt | |
| 19 | Yellow birch | | 14.6 | 40 | 3 | b | | |
| T3 | Red maple | 950 | 16.9 | 50 | 3 | b | | |
| 20 | Yellow birch | | 14.5 | 50 | 3 | a/minor b | Grasses returning on small peninsula of Site 5; mudcracks and silt-covered ground<br>Photographs:<br>21. Upstream on West River from center of Site 5. | |

## Table AXII. Ball Mountain Reservoir, Transect 5B.

| Tree | Species | Base elev (ft) | DBH (in.) | Ht (ft) | Silting | Damage | Remarks | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 12 October 1973 | 3 July 1974 |
| T1 | Hemlock | 925 | 20.0 | 51 | 3 | a | River bank; level area; next to dirt road | |
| 1 | Red maple | | 11.2 | 50 | 3 | b | | |
| 2 | American beech | | 4.9 | 40 | 3 | e | | |
| 3 | White pine | | 13.3 | 40 | 3 | a | | |
| 4 | White pine | | 11.4 | 40 | 3 | f | | |
| 5 | White pine | | 8.3 | 40 | 3 | f | Gentle slope through tree 10 | |
| 6 | White pine | | 6.0 | 40 | 3 | f | | |
| 7 | Hemlock | | 7.7 | 30 | 3 | a | | |
| T2 | Sugar maple | 940 | 19.8 | 60 | 3 | f/b | | |
| 8 | Red spruce | | 5.7 | 30 | 3 | a | | |
| 9 | Hemlock | | 5.9 | 25 | 3 | a | | |
| 10 | Hemlock | | 6.8 | 30 | 3 | a/b | | |
| 11 | Sugar maple | | 19.3 | 50 | 3 | a/b | Slope; silt and mudcracks through tree T3 | Height to inundation (road level) is 25 ft |
| 12 | Hemlock | | 6.0 | 20 | 3 | f | | |
| 13 | Sugar maple | | 6.9 | 50 | 3 | e | | |
| 14 | Sugar maple | | 5.4 | 50 | 3/2 | e | | |
| T3 | Hemlock | 960 | 11.8 | 30 | 2 | e | | |

### Table AXIII. Ball Mountain Reservoir, Kill Site 6.
Sampling date 12 October 1973.

Mainly grasses on river meander

Road is lined dominantly with maple trees

Photographs:

22. SW direction, 5 Red oaks about 45 ft high
23. W direction, 3 Quaking aspens and 3 White pines
24. NW direction, Quaking aspens

# APPENDIX B. TRANSECT LOCATIONS FOR FRANKLIN FALLS AND BALL MOUNTAIN RESERVOIRS

*a. Transects 1A, 1B and 1C.*

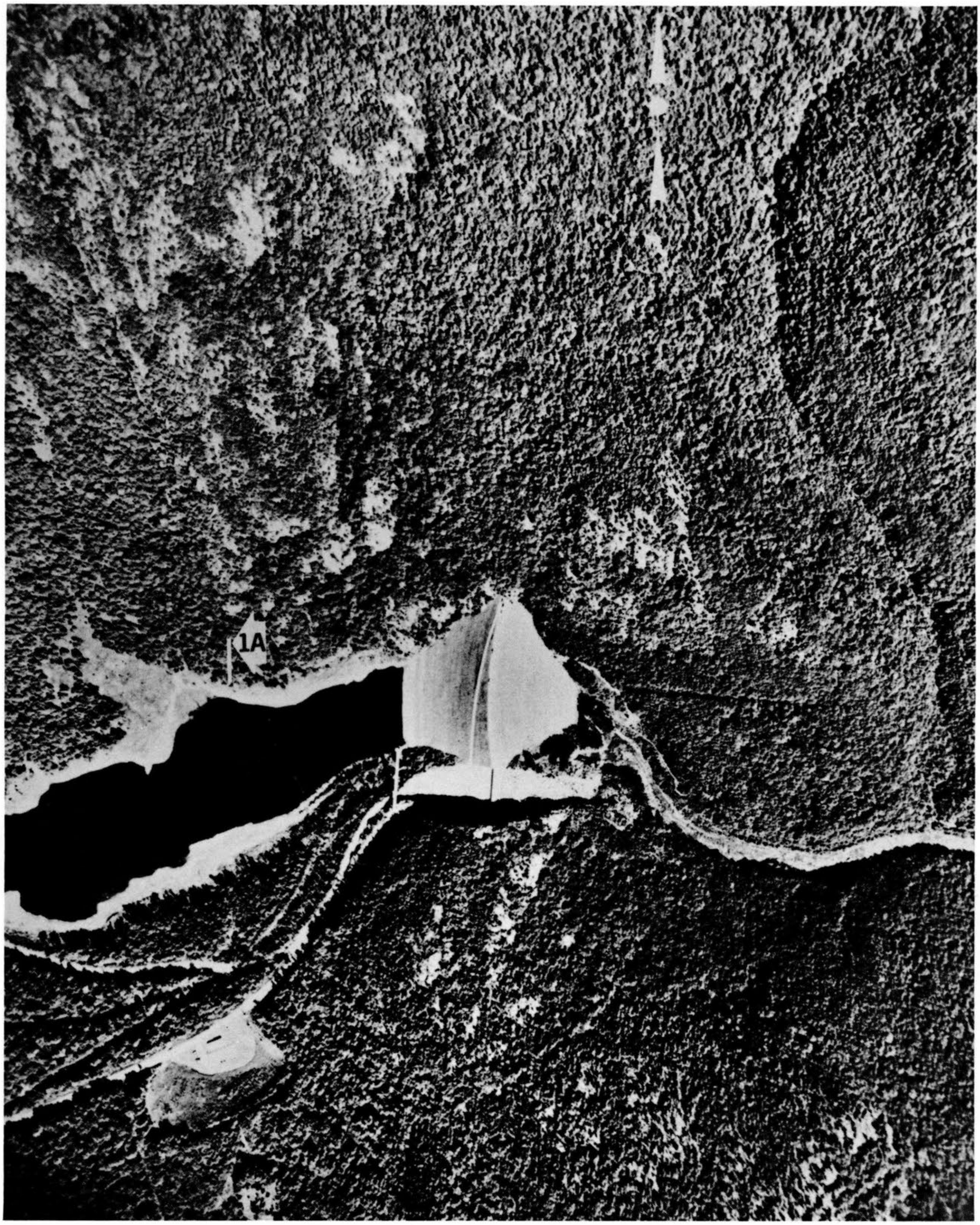
*Figure B1. Franklin Falls reservoir, Franklin, New Hampshire.*

*b. Transect 2A.*

*Figure B1 (cont'd). Franklin Falls reservoir, Franklin, New Hampshire.*

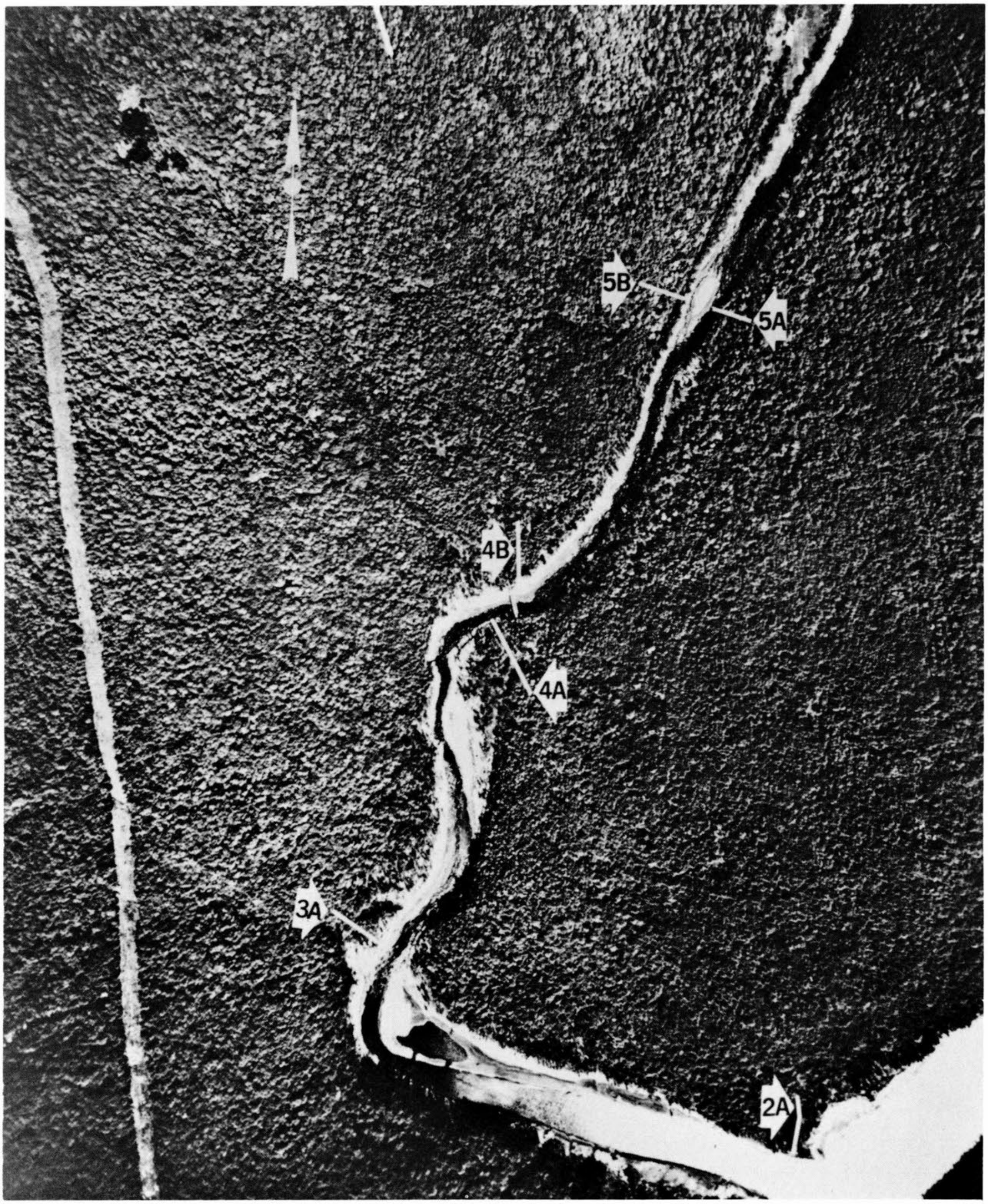
*c. Transect 3A.*

*Figure B1 (cont'd).*



*a. Transect 1A.*

*Figure B2. Ball Mountain reservoir, Jamaica, Vermont.*



*b. Transects 2A, 3A, 4A, 4B, 5A, 5B.*

*Figure B2 (cont'd).*

## APPENDIX C. EFFECT OF INUNDATION ON VEGETATION

### Literature Review

The effect of long-term inundation on tree mortality has been investigated in many areas throughout the United States. Results of a study of vegetation conducted on the upper Mississippi River to assess the effect of 26 locks and dams constructed by the Corps of Engineers showed that generally no species survived four years of constant flooding; however, even when trees were permanently flooded, impoundment had little effect the first year (Green 1947). In most instances river birch (*Betula nigra*) and silver maple(*Acer saccharinum*) were the first to show loss of vigor, while pin oak (*Quercus palustris*) appeared more tolerant. In addition, analysis of increment borings showed that increased water levels had little effect on the growth of trees standing on high ground where they were flooded for short, intermittent periods during extremely high flood stages (Green 1947).

Many investigators (Hall and Smith 1955, Lentz 1928, Yeager 1949, Green 1947) found that when flood water completely covered the tree for any considerable length of time, death resulted. However, trees whose crowns remained above water showed little indication of damage. Other experiments have been conducted to determine the effects of different degrees and methods of flooding on various species of pine seedlings (Hunt 1951, Ahlgren and Hansen 1957). The results showed that flooding the roots for three months in the spring does not permanently injure pine root systems.

The causes of plant injuries that result from flooding of the soil are very complex. Kramer (1951) found that the large reduction in the water absorbing capacity of the root systems which follows flooding might be adequate to explain the injury to the shoots. Parker (1950) states that the roots of some species are more susceptible to injury from the lack of oxygen and excess of carbon dioxide found in flooded soils, and injury to the roots usually results in decreased absorption of water and minerals and in damage to the shoots.

Recent flooding experiments in the southeastern United States, conducted in a growth chamber and greenhouse, showed that height, growth and root adaptations of yellow poplar, sycamore, green ash, sweet gum and water tupelo were correlated with flood tolerance. All except yellow poplar could be spatially separated along a relative flood tolerance scale by the presence or absence of one or more root adaptations (Hook and Brown 1973). Furthermore, Hosner and Boyce (1962) suggest that adaptations in the root systems are necessary for seedlings to survive under flooding. It is generally accepted that flood tolerance in tree species is largely dependent upon a combination of root adaptations.

## APPENDIX D: SCIENTIFIC NAMES OF TREE SPECIES

| *Common name* | *Scientific name* |
|---|---|
| Northern Red Oak | *Quercus rubra* |
| White Oak | *Quercus alba* |
| Chinkapin Oak | *Quercus muehlenbergii* |
| Eastern White Pine | *Pinus strobus* |
| Grey Birch | *Betula populifolia* |
| White Birch | *Betula papyrifera* |
| Yellow Birch | *Betula alleghaniensis* |
| Hop Hornbeam | *Ostrya virginiana* |
| American Hornbeam | *Carpinus caroliniana* |
| Quaking Aspen | *Populus tremuloides* |
| Big Tooth Aspen | *Populus grandidentata* |
| Silver Maple | *Acer saccharinum* |
| Red Maple | *Acer rubrum* |
| Sugar Maple | *Acer saccharum* |
| American Basswood | *Tilia americana* |
| White Ash | *Fraxinus americana* |
| American Elm | *Ulmus americana* |
| Black Willow | *Salix nigra* |
| Wild Black Cherry | *Prunus serotina* |
| Red Spruce | *Picea rubens* |
| American Beech | *Fagus grandifolia* |
| Hemlock | *Tsuga canadensis* |
| Speckled Alder | *Alnus rugosa* |

# APPENDIX E: PERCENTAGE OF TREES DAMAGED

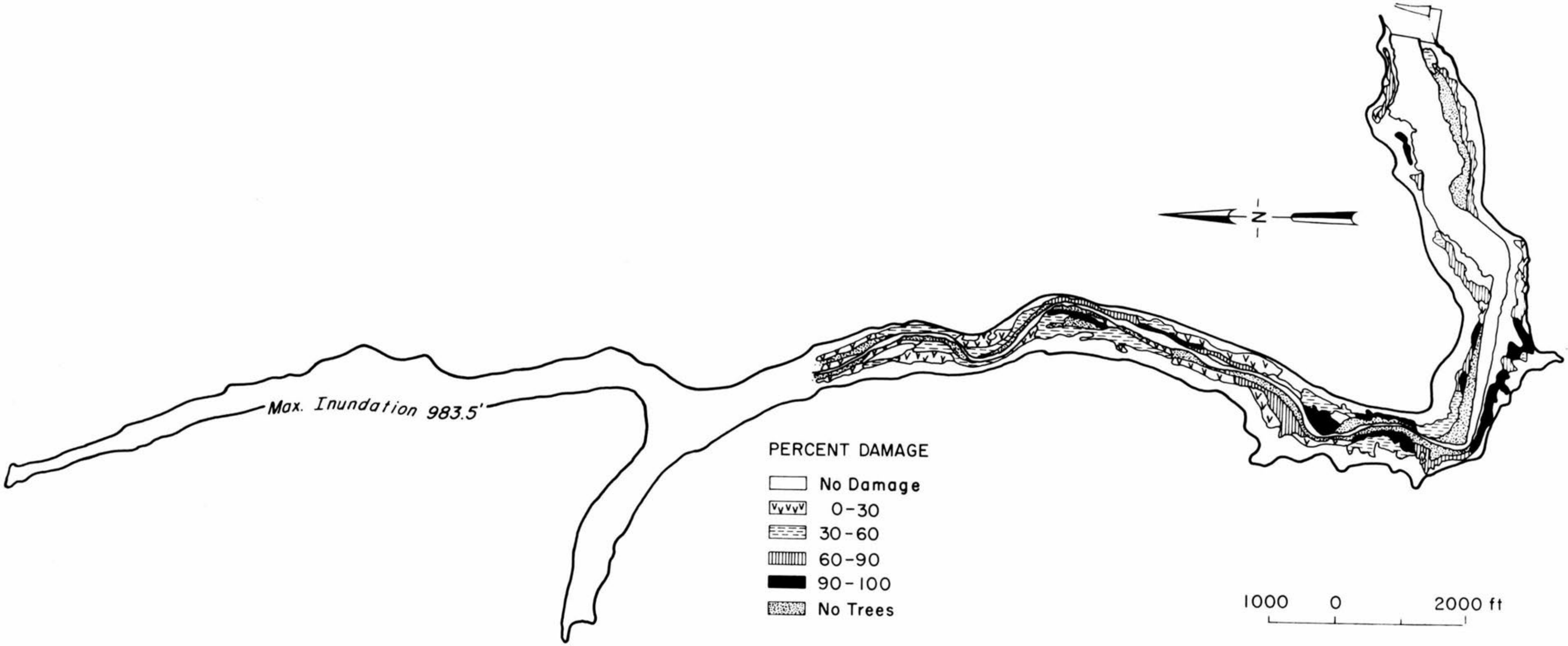


*Figure E1. Percentage of trees damaged at Ball Mountain reservoir, Jamaica, Vt.*

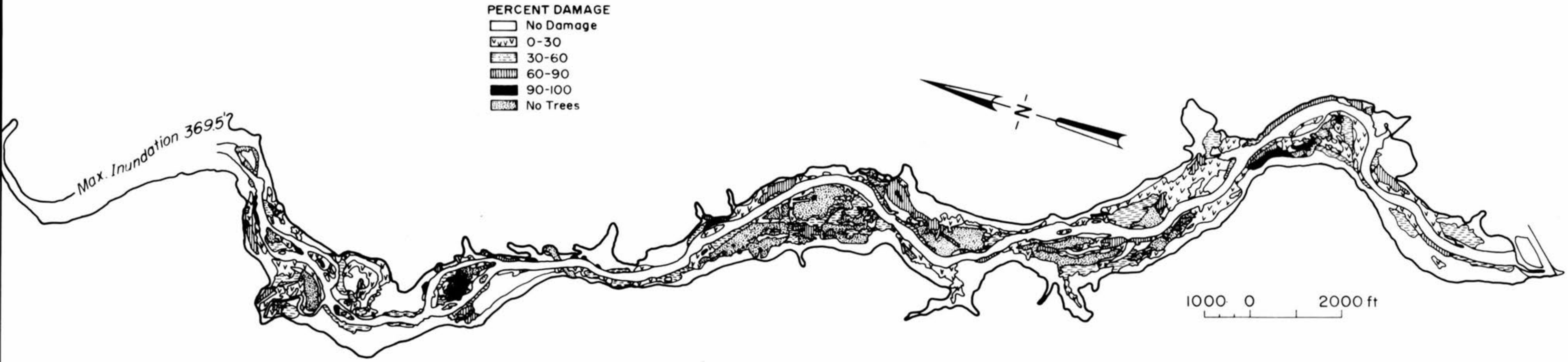


*Figure E2. Percentage of trees damaged at Franklin Falls reservoir, Franklin, N.H.*

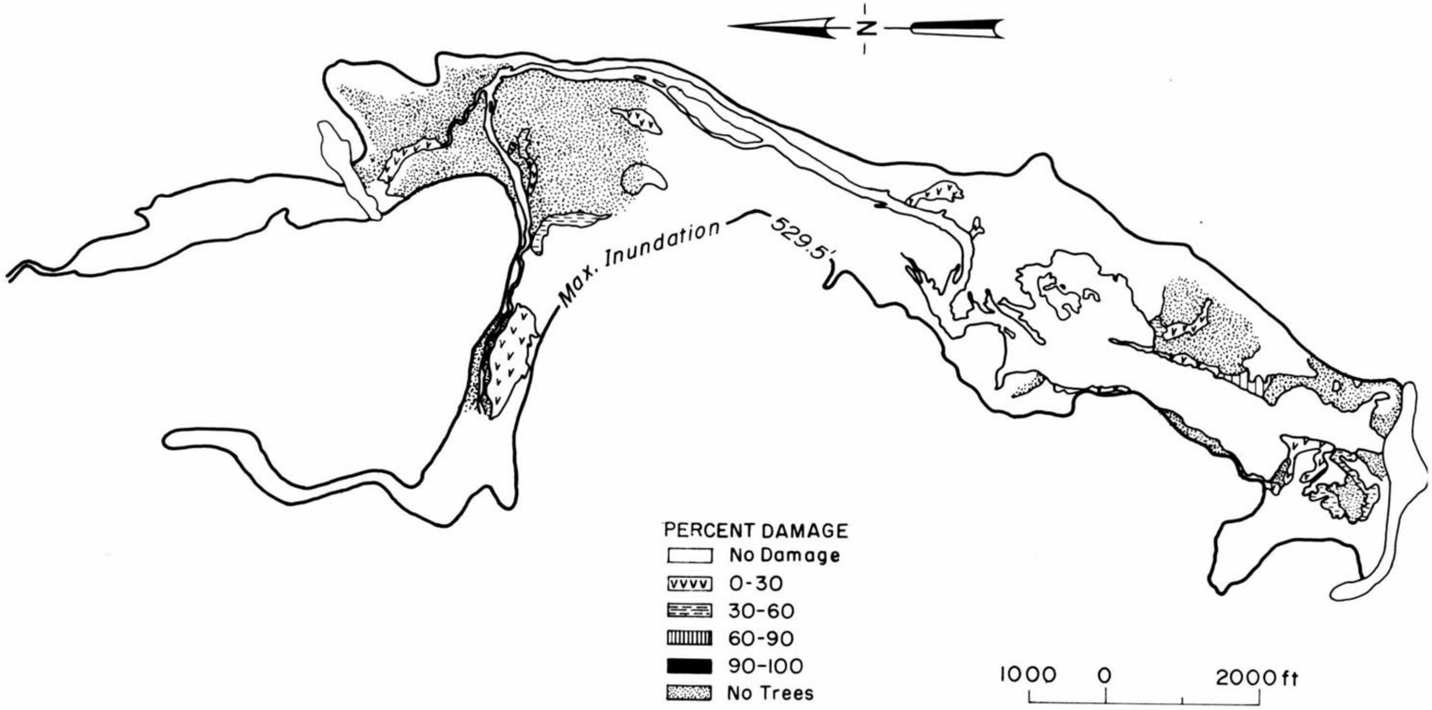


*Figure E3. Percentage of trees damaged at North Springfield reservoir, Springfield, Vt.*

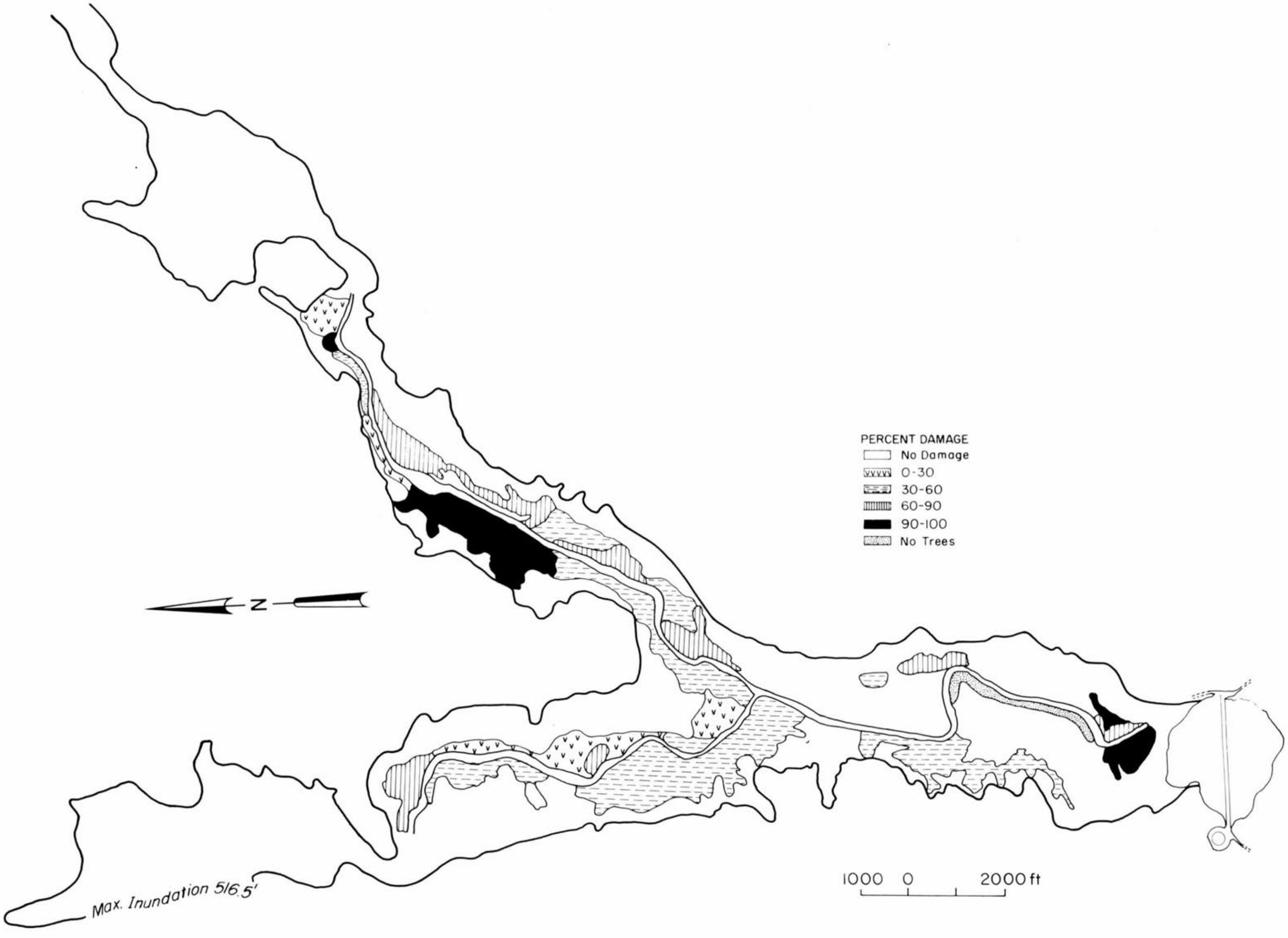


*Figure E4. Percentage of trees damaged at Union Village Dam, Union Village, Vt.*

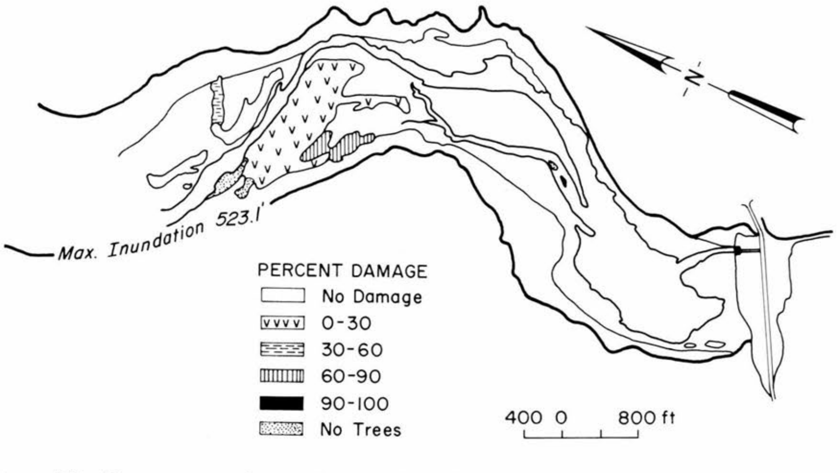


*Figure E5. Percentage of trees damaged at Townshend reservoir, Townshend, Vt.*

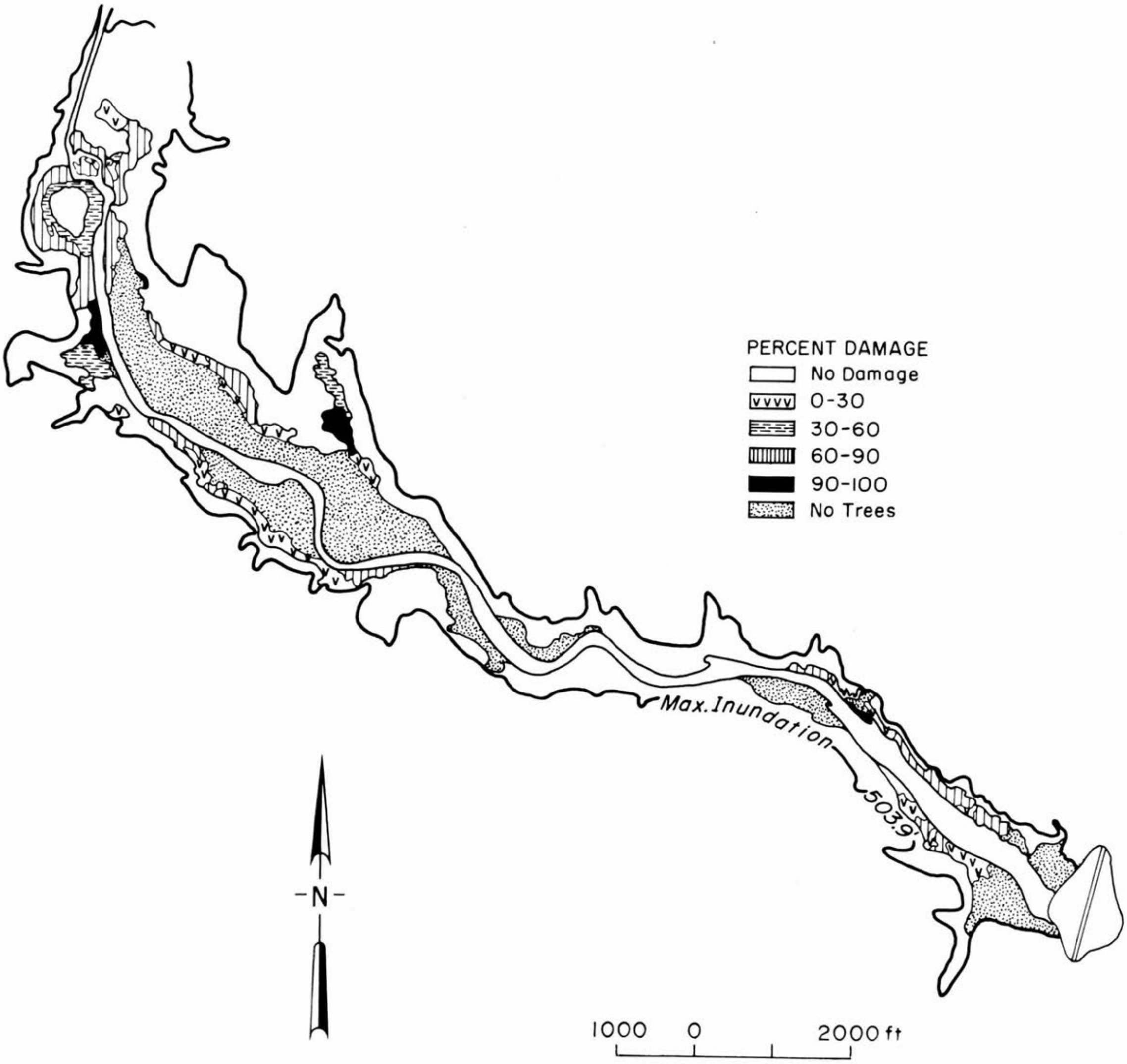


*Figure E6. Percentage of trees damaged at North Hartland reservoir, North Hartland, Vt.*