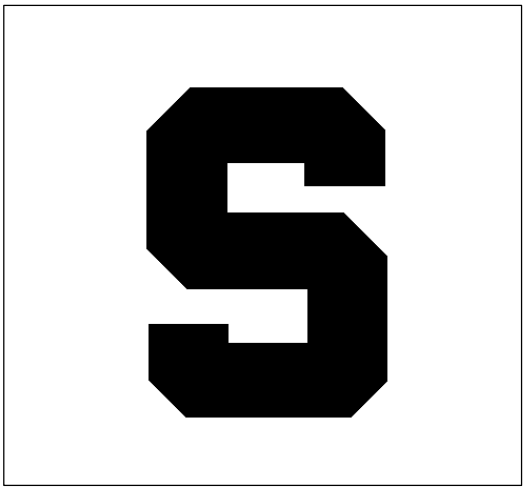
FORESTRY RESEARCH IN THE UPPER PENINSULA



A SUMMARY

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TABLE OF CONTENTS

INTRODUCTION **3**

BACKGROUND 3

FACILITIES AND INFRASTRUCTURE 5

CURRENT RESEARCH **6**

GENETICS OF WINDBREAK, CHRISTMAS TREE, AND ORNAMENTAL SPECIES 6

GENETICS OF TIMBER SPECIES 7

CONIFER SILVICULTURAL RESEARCH 8

HARDWOOD SILVICULTURAL RESEARCH 9

WHITE-CEDAR SILVICULTURAL AND ECOLOGICAL RESEARCH 11

OTHER PROJECTS 13

PAST RESEARCH **13**

INTRODUCTION

Forestry is a dominant force in Michigan's economy and is the principle industry in the Upper Peninsula. According to a report released in February of 1996 by the USDA Forest Service and the Michigan Department of Natural Resources, the forest products industry and forest-based recreation combine to contribute twelve billion dollars to the state economy annually. Forty-five percent of Michigan's forest land and growing stock are in the Upper Peninsula. Practicing sound forest and wildlife management assures the abundance, quality, and enjoyment of the resources upon which these industries are based. Michigan State University has been, and will continue to be, a leader in identifying resource management problems throughout the state and helping to solve them through research and education. This is especially true in Michigan's Upper Peninsula where forestry-based activities dominate the economy.

MSU's Department of Forestry has conducted forestry research and extension in the Upper Peninsula since the early 1920s. Research has been concentrated at the Dunbar Forest Experiment Station (near Sault Ste. Marie), the Jim Wells Forest (near Munising), the Upper Peninsula Experiment Station (in Chatham), and the Upper Peninsula Tree Improvement Center (in Escanaba). Research plots are also located throughout the Upper Peninsula on state, federal, and private lands and a close working relationship has been developed with these agencies and landowners. Coordination of the work done at these sites is provided by the Upper Peninsula Tree Improvement Center staff, whose mission is:

1. To anticipate and meet the research and educational needs of the University community (scientists, teachers, students, and extension specialists) and the community of forest resource managers in the northern Great Lakes region.
2. To provide long-term maintenance and observation of forest research projects and unique forested ecosystems, ensuring their availability to future generations of investigators and thereby contributing to increased knowledge of these ecosystems.
3. To demonstrate and apply the best principles of sound forest and wildlife management on University land and thereby increase the resource heritage.

Because of the long duration of most forest research, many early projects in the Upper Peninsula are still producing information. Others are only now beginning to yield data, although they were established five to ten years ago. Most projects require maintenance every five to twenty years to remain viable. Support of this long-term effort from the Agriculture Experiment Station has been vital to a successful and meaningful forest research program at Michigan State University. This document is a summary of the facilities available to MSU forest researchers and of the active research projects in the Upper Peninsula of Michigan. This now includes 8 projects at the Upper Peninsula Experiment Station in Chatham, one major project at the Jim Wells Forest, 14 projects at the Dunbar Forest, and 37 projects at UPTIC.

BACKGROUND

Michigan State University began conducting forestry research in the Upper Peninsula in 1925 on property near the mouth of the Charlotte River south of Sault Ste. Marie that became the Dunbar Forest. The Jim Wells Forest, between Marquette and Munising, became part of the University's forest research land-base in 1943 and the Upper Peninsula Tree Improvement Center in Escanaba was added in 1986. Today these properties are managed from Escanaba. A brief history of each property follows:

The **DUNBAR FOREST EXPERIMENT STATION** is a 5,700-acre tract near Sault St. Marie. It is the University's largest and second oldest off-campus facility. It has been a part of the Department of Forestry's research, education, and demonstration program since 1925. From 1940 through the 1970s, this forest was extremely active with planting, tending, and harvesting research programs, a forest seedling nursery, and a field program for forestry and civil engineering students from the main campus. Activity at this forest now capitalizes on the value of the long-term genetics and silvicultural studies at the site. Driving time to Dunbar Forest is about five hours from the main campus in East Lansing and about four hours from the Upper Peninsula Tree Improvement Center in Escanaba.
The last resident manager of Dunbar Forest retired in the fall of 1990 and a decision was made to manage the property from Escanaba. Most of the equipment was transferred to the Escanaba location and a caretaker was engaged to watch the buildings and take care of the grounds at Dunbar. The old office building has been converted into a bunk house that can house up to five visiting researchers. It is regularly used by faculty, staff, and graduate students from MSU and other institutions and agencies. Staff from the Upper Peninsula Tree Improvement Center use the lodging facility when they work at this forest.

Together with regional resource managers, the faculty and staff of the Department of Forestry set priorities, start new research, and revitalize existing studies at Dunbar Forest. The long-term research projects at Dunbar Forest, its diversity of forest stands, and its location on the Saint Mary's River are valuable assets. The University is working to capitalize on these assets as we enter the 21st century.

The **JIM WELLS FOREST** is a 440-acre tract near Au Train that has been part of the University since 1943. Tax delinquent land was given to the University by the State of Michigan so that sound forest management could be shown to be a profitable activity. This property is undeveloped except for a rudimentary truck-road system. The Jim Wells Forest is about 2 hours from Escanaba by car. Researchers working at this forest can obtain lodging at the University's Upper Peninsula Experiment Station at Chatham, which is only 20 minutes from the site.

A management plan for this property was drafted by Maurice Day (Manager of Dunbar Forest) in 1946 and is still being followed today. Most of the forest was thinned under the supervision of Roy Skog (Extension forester in Marquette) in two phases throughout the 1950s and 1960s. A poor timber market prevented the completion of this task on the southernmost part of the tract. Detailed inventory, harvest, and cost records were kept for this operation and a final report was issued in May 1964. A second inventory and round of thinning were begun in 1991 and was completed in 1998. The 1964 report will be updated to include the costs and returns of this most recent management activity. Sixty-two CFI (Continuous Forest Inventory) plots were installed in 1998 at the site to provide better growth and yield projections for this stand.

The **UPPER PENINSULA TREE IMPROVEMENT CENTER** was established in 1986 when Michigan State University purchased an 840-acre beef farm in Escanaba, MI. This farm is located in an area where vast hardwood stands supplied charcoal to the region's pig iron furnaces in the mid-1800s. About 400 acres of these prime northern hardwoods were cleared around 1890 by one of the charcoal kiln supervisors and his brother. Together they established one of the first dairy farms in Delta County on the site that is now UPTIC.

Local farmers claim that UPTIC's farm fields are some of the best in the county, probably due to its fertile Onaway soils. The two brothers knew this because they were astute woodsmen. They chose the best forest in the area to clear for their farm. All of MSU's main forestry properties (Kellogg Forest, Russ Forest, Dunbar Forest, and UPTIC) were abandoned farms. UPTIC differs from the others in that it was not abandoned because it was on poor soils, but because of its remoteness from major agricultural markets. UPTIC is, however, located directly in the heart of Michigan's thriving forest industry.

UPTIC was expanded to its present size in 1987 when Mead Corporation donated an adjacent 880-acre tract of cedar swamp.

UPTIC became a fully functioning Experiment Station in 1988 with the arrival of a resident manager. The first project established at UPTIC was a forest genetics plantation of Douglas fir in 1986. Since then about 40 acres of genetics' plantations, comprising nine species and hybrids, have been installed. Tree improvement studies remain one of the principle functions of the Center but activities have expanded into a range of other areas over the last 14 years.

The staff at UPTIC has grown to include a Resident Forester, an Operations Forester, a Forest Technician, a secretary, and student interns. The Center also houses the office of the Extension Specialist for Forestry in the U.P.

This center is the focal point for Michigan State University's forestry research in the Upper Peninsula. It serves as the home base for the staff and equipment that are used to manage the Dunbar and Jim Wells Forests. Joint projects are frequently undertaken between staff at the Center and MSU's Department of Forestry, MSU's Department of Crop and Soil Science, MSU's Department of Fisheries and Wildlife, MSU's Department of Entomology, the Michigan State University Extension, the Michigan Department of Natural Resources, the Hiawatha National Forest, the Michigan Department of Agriculture, USDA Soil Conservation Service, and other groups (e.g., Society of American Foresters, USDA Resource Conservation and Development Forestry Committee, The Cedar Action Group, UP Whitetails Association, and local school groups) for demonstration, education, and research.

A unique working relationship has been established with Mead Corporation's Publishing Paper Division. They lease a small portion of UPTIC, where they conduct some of their research and establish genetic archives. The staff of UPTIC assist with research planning, establishment, maintenance, and data analysis when our research goals coincide. Mead reimburses the University for materials and time spent on these projects.

UPTIC can be reached in seven hours by car from the main campus in East Lansing. Air shuttle service is also available to the Lansing airport from a regional airport in Escanaba.

FACILITIES AND INFRASTRUCTURE

The **DUNBAR FOREST** is divided into two broad areas: the mainland units (about 2,600 acres) and the Neebish Island units (about 2,800 acres). 66% of the soils on the mainland units are fine sands with high water tables. The remainder of the soils are sandy or clay loams (28%) and organic mucks (6%). These soils support a variety of forest stands including: aspen (22%), lowland hardwoods (10%), upland hardwoods (7%), lowland conifers (13%), plantations (9%), alder brush (34%), and open land (5%).

Conditions on Neebish Island are similar although the soils have a finer texture (56% are loams and 44% are fine sands). Forest inventories have not been conducted on Neebish Island since 1946. At that time 63% of the area was covered by aspen, 25% by maple and birch, 8% by lowland conifers, and 4% was open. Since then, much of the aspen has been replaced by red maple and balsam fir and the number of understocked acres has increased. Neebish Island is accessible only by ferry so all operations on this part of the forest are restricted by transportation costs and scheduling. Timber harvesting on Neebish Island has been financially impossible.

Research plots have been established and maintained at Dunbar Forest for more than 70 years. This continuity offers a unique database and is a resource from which new research can arise. A program of pruning and thinning in conifer plantations as well as regeneration cuts in hardwood stands was recently begun to ensure healthy and vigorous stands for the next 20 years. The physical plant of Dunbar Forest is made up of several buildings including:

- A lodging facility that can house five people for short periods or 2-3 people for extended stays.
- An old barn (now empty).
- A pole barn with four main storage and work rooms. This structure has plumbing and electric heat.
- Two single-family residences (one is rented, one is used by the caretaker and his family).
- Equipment needed for light grounds maintenance is available at the Forest. Other equipment is available in Escanaba and can be transported to Dunbar Forest if necessary.

Arrangements to use Dunbar Forest must be made well in advance through the Escanaba office.

The **JIM WELLS FOREST** is a 440-acre tract located among rolling hills south of Lake Superior. The uplands make up about 68% of the area and are covered with a mixture of red maple, sugar maple, and American beech growing on sandy-loam soils. The lowlands make up about 32% of the area and are occupied by balsam fir, white pine, northern white cedar, and aspen growing on wet and mucky soils. These lowland areas are not suitable for forest operations because of their high water table and proximity to streams.

There are no buildings on the property but an improved logging road was recently completed. This road provides vehicular access to within 1/4 mile of all parts of the property. An extensive system of logging trails exists throughout the property.

A complete forest inventory was completed at the time of the first thinning (about 1950) and a second inventory thinning was completed in 1998. Data collected at this property provides insight into the financial viability of selection silviculture. It also allows us to quantify regeneration success using partial cutting systems in this part of Michigan. Sixty-two Continuous Forest Inventory plots were established in 1998 and will be monitored at 5 year intervals in perpetuity.

The **UPPER PENINSULA TREE IMPROVEMENT CENTER** is headquarters for work conducted at all three UP forestry properties. The 1700 acres at UPTIC are divided into several types of forests: 59% is northern white-cedar swamp, 15% is dominated by red maple-balsam fir-aspen stands, 2% is a beech-maple stand, and 24% is open agricultural fields in which plantations are established. About 100 acres of UPTIC are enclosed by electric deer exclosures, including 15 acres of a mature hardwood stand. The upland soils at UPTIC are highly productive Onaway fine sandy loams with some inclusions of other sandy loam soil types. The swamp land is predominantly Carbondale muck with some inclusions of other shallower muck soils.

A network of sites throughout the Upper Peninsula has been established cooperatively with the Department of Natural Resources, the Hiawatha National Forest, Mead Corporation, and others that are used for cooperative research projects by MSU staff and students.

A great deal of work has been accomplished in UPTIC's cedar swamps over the last four years to establish access and baseline hydrological data. UPTIC wetlands, together with other cooperators' sites throughout the central UP, form the only northern white-cedar research laboratory in the country.

The physical plant at UPTIC includes:

- A handicapped accessible headquarters building with four offices, wet lab, machine repair garage, wood shop, and equipment, records, and materials storage.
- Three machinery storage buildings.
- A lodging facility that can house four people for short stays or two people for extended stays.
- A residence for the on-site manager.

The Center has the equipment needed to:

- install and maintain forest plantations and research plots,
- irrigate small, remote test plots,
- clear and maintain land for forestry or agricultural experiments,
- construct and maintain forest roads,
- conduct small-scale timber harvests,
- conduct high-precision land surveys and produce maps,
- collect a range of field data,
- produce signs for marking research plots,
- provide transportation for researchers and their equipment on highways and trails during all seasons,
- maintain the range of equipment at the Center,
- construct and maintain electric and woven wire deer exclosure fences in fields, in upland forests, or in swamps,
- extinguish minor brush and grass fires.

UPTIC also possesses a range of analytical capabilities that include:

- real-time literature searching using on-line MSU library facilities including TreeCD and Agricola,
- computer storage and retrieval of an on-site collection of thousands of scientific reprints and journals,
- continuous, automated collection of basic climatological data,
- basic water chemistry analysis (temperature, conductivity, pH, and dissolved O2),
- a computer-based stem analysis (WinDendro system) based around a color scanner,
- soil, water, and plant sample preparation and storage,
- data entry and analysis using on-site computer network or by connection to the Internet and computer network services at Michigan State University's main campus.

The STAFF at UPTIC consists of:

- a resident manager (Raymond Miller) with experience in forest and site management and a background of forest research design, initiation, maintenance, and analysis,
- two full-time forest technicians (Brad Bender and Kile Zuidema) with experience in forest, grounds, and equipment maintenance as well as experience with forest surveying, data collection, and sample preparation,
- a secretary (Ingrid Klotz) assists with all of the clerical and financial records,
- two student interns work at the Center during the summer,
- UPTIC serves as the home office of the Michigan State University Extension Regional Forestry Specialist (Bill Cook),
- the Center also has access to resource scientists from the Hiawatha National Forest Headquarters in Escanaba and the Department of Natural Resources in this area.

CURRENT RESEARCH

Summaries of the ongoing and recently completed research and demonstration projects at or around UPTIC are given below. Summaries are also included for forest genetics and cultural tests that are measured and maintained by UPTIC staff at the Upper Peninsula Experiment Station in Chatham and on non-University land.

GENETICS OF WINDBREAK, CHRISTMAS TREE, AND ORNAMENTAL SPECIES

Hybrid Spruce Progeny Test: A 0.8-acre planting of 541 trees of full and ½-sib spruce progeny was established at the Upper Peninsula Experiment Station at Chatham in 1981 as part of a statewide test. The Spartan Spruce was developed from this type of testing. The planting remains as an archive of this genetic material.

Douglas-fir Progeny Test: A 5-acre plantation of 117 half-sib seedlots of Douglas-fir from interior sources was established at UPTIC in 1986 as part of a statewide assessment of this species for Christmas tree and pulp production. This plantation has been measured twice for height and other characteristics important to Christmas tree producers.

Spartan Spruce Progeny Viability Trial: A 4-acre plantation of 247 half-sib seedlots of Spartan Spruce (a patented white x blue spruce hybrid) and other spruces was established at UPTIC in 1988 to screen various crosses for cold tolerance in the UP. This plantation was scored for winter cold damage in 1990.

Blue Spruce Seedlot Uniformity Trial: A 1.5-acre plantation of 33 bulk seedlots of blue spruce from Colorado was established at UPTIC in 1988 to test and demonstrate the uniformity of seedlots collected using techniques similar to those of commercial seed distributors. The small planting stock used in this test responded badly to the harsh winters and survival was 38% by the fall of 1990. The planting was consolidated

by transplanting in the spring of 1991 and is now a 0.5 acre block of 350 trees, representing all of the original 33 seedlots.

Eastern Red Cedar Rangewide Progeny Test: This 2-acre plantation of 100 half-sib seedlots from throughout the eastern United States was established at UPTIC in 1989. The plantation is one of three established by MICHCOTIP and the USDA Soil Conservation Service to test the genetic variability of this species under a range of conditions. Of principle interest, is the species' adaptability for use in wind and snow breaks. Measurements of this and two other plantings were made in 1993 by MSU and SCS personnel.

Douglas-fir Elevation Transect Progeny Test: A 1.2-acre planting of 91 ½-sib Douglas-fir seedlots (collected along elevational transects within the Lincoln National Forest in New Mexico) was established at UPTIC in 1992. The test was designed to examine genetic differences and to screen the seedlots as candidate Christmas tree sources. Seedlings had poor root/shoot ratios when planted and mortality was high during the first year in the field. Subsequent losses to winter injury left so few survivors that the test has been abandoned. The surviving trees remain, however.

Scotch Pine and Jack Pine Christmas Tree Comparison Study: This small planting of 9 Jack pine families and 10 Scotch pine families was established in 1994 at UPTIC to compare within and between species variability in response to shearing. Each family is represented by a single 12-tree row plot.

Scotch pine and True Fir Variety Demonstration: A 3-acre planting of 38 commercial varieties of Scotch pine and four true fir species was established in 1994 and 1995 at UPTIC. Each variety is represented by two rows of 34 trees each and is being managed using commercial Christmas tree production techniques. The planting will demonstrate the performance potential of these varieties in this area and will be a focal point for workshops for local Christmas tree. Signs identify the varieties to the visitor and a tour of the planting is available on our web site.

GENETICS OF TIMBER SPECIES

Red Pine Progeny Test: A 2.3-acre plantation of 93 ½-sib families of red pine collected in Michigan was planted at the Upper Peninsula Experiment Station at Chatham in 1966 to help identify the best seed sources for use throughout the state. Height and diameter were measured in 1982.

White Pine Progeny Test and Seed Orchard: 44 Michigan ½-sib families were planted in the 3-acre plantation at the Upper Peninsula Experiment Station at Chatham in 1966 to find better families for reforestation of Michigan sites. The planting was pruned and measured in 1982 and a thinning to remove the poorest 22% of the families, based on these data, was done in 1983. This planting is now producing improved seed adapted to conditions in the central UP.

Tamarack Provenance Test: A 1.4-acre, rangewide provenance test of 25 ½-sib families of tamarack was established at the Upper Peninsula Experiment Station at Chatham in 1969. 1982 measurements from this plantation with data from other tamarack genetics plantings in Michigan were used to compile provenance recommendations for the state.

Norway Spruce Provenance Test: Two large plantings of 161 West German provenance's of Norway spruce were established in 1969. Two are in the UP: a 4-acre test at the Upper Peninsula Experiment Station at Chatham and a 9-acre test at Dunbar Forest. Another planting of this material is at Kellogg Forest. Although the geographic range of the provenances represented in this test is limited, it is the only genetic test of Norway spruce in Michigan.

Kellogg Hybrid Pine Full-sib Progeny Test: A 0.8-acre planting of 53 full-sib F2 families of a hybrid between Japanese red pine and Austrian pine was established at the Upper Peninsula Experiment Station at Chatham in 1982. This planting includes back crosses to the original parents. This promising fast-growing pine is being tested for cold tolerance.

Ontario White Spruce Seed Orchard Test: This 0.5-acre planting, established in 1983, is one of several designed to test 18 ½-sib families from Beachburg, Ontario, which is the best provenance for this species. This replicate is at the Upper Peninsula Experiment Station at Chatham and will eventually produce improved white spruce seed.

Larch Species and Genotype Trial: A 4-acre plantation of 162 seedlots of seven larch species was established in 1985 on a site owned by Mead Corp. approximately 20 miles from UPTIC. This planting is part of a statewide test conducted by MICHCOTIP in cooperation with the USDA Soil Conservation Service. Western larch proved to be unsuitable at all sites in the state. In the UP, tamarack, European, and Dunkeld hybrid larches all survived and grew at rates exceeding the average after three growing seasons. Measurements were taken after three, six, and twelve years to assess the growth of these species.

Larch Species Comparisons on Cooperators' Land: Four plantations of a subset of materials included in the larger test described above were distributed to the

Michigan Department of Natural Resources and Mead Corporation. These materials were planted in 1985 by these cooperators on their own land using a common design supplied by MICHCOTIP. Each planting contains 10 seedlots distributed among four exotic larch species. Each seedlot is represented by four replications of 25-tree row plots.

One of these plantings, near Marquette, was measured by a DNR crew in the summer of 1995. Survival was low for all species, but European larch had the best survival and growth. The whole set of plantings was measured in the summer of 1996.

Advanced-Generation White Spruce Progeny Test of Selected Sources: Hans Nienstadt of the Forest Service Forestry Sciences Lab in Rhinelander assembled and grew the "best" selections of white spruce from Minnesota, Wisconsin, Michigan, and Ontario tree improvement programs to create this fourth-generation progeny test. The 4-acre plantation of 170 half-sib seedlots was established at UPTIC in 1989 and is one of 5 plantings across the northern Lake States. After several years of mortality from white grub damage, the plantation was consolidated to half its original size. This planting will produce improved, locally adapted seed.

White Spruce Seed Orchard Progeny Test: Improved white spruce seed orchards exist throughout the Lake States. Part of the management of the orchards involves removing the poorer trees to increase the genetic potential of the collected seed. Progeny tests of seed orchards are conducted to establish genetic parameters for the population and to identify individuals and families that grow well. This 2.5-acre test plantation of 170 half-sib families was established in 1992 at UPTIC. It is testing a seed orchard at the Bergener Farm (part of the Kellogg Biological Station). Information from this planting will be used to rogue the Kellogg seed orchard to improve the quality of the seed produced there. The new plantation at UPTIC will eventually serve as a seed orchard after it has grown, been evaluated, and rogued.

Hybrid Poplars and Aspens Test: A 1-acre plantation of 50 full-sib families of hybrids between exotic poplars and native aspens was established at UPTIC in 1992. These crosses were made by Pat McGovern and are being tested for viability under cold conditions.

Jack Pine Seed Orchard Progeny Test: Jack pine is widely planted in northern Lower Michigan and is the only species that grows well on certain dry sites. This 3-acre planting of 124 ½-sib and full-sib seedlots was established at UPTIC in 1994 to provide genetic parameters for a Lake States-wide study that has been under way for many years. Full-sib crosses of superior performers in other Michigan tests will be compared with check seedlots. This planting will ultimately form a second generation seed orchard.

Hybrid Poplars and Aspens: A half-acre planting of 17 full-sib families of poplars and aspens was established at UPTIC in 1994 to supplement the earlier planting of poplar hybrids. This planting will also test the viability of these hybrids when grown in short growing seasons.

Norway Spruce Seed Production Plantation: This 1929 plantation of Norway spruce at Dunbar Forest has been thinned, leaving the largest and best individuals. Seed will be collected from this plantation and made available for reforestation in the Upper Peninsula. The origin of the trees in this plantation is unknown, but they have grown well and produce seed adapted to the short growing seasons of this region.

CONIFER SILVICULTURAL RESEARCH

Clearcut Reforestation Species Trial: This 5-acre plantation was established at the Upper Peninsula Experiment Station at Chatham in a sugar maple stand that had been clearcut following storm damage in 1982. Quarter-acre blocks of fives species were planted in 1982 to test adaptability and compare yields of red oak, red pine, Kellogg hybrid pine, Japanese larch, and European larch. A summary of growth in this plantation is available on our web site.

Herbicide Effects on Spruce Survival Under Drought Conditions: A plantation of spruce transplants was established at UPTIC in the spring of 1988. A severe drought followed planting. The inadvertent lack of weed control in two rows of this plantation provided data that shows the profound effect of weed control under stress conditions. Average survival with good weed control was 98% but only 24% where no weed control was applied. A report of these results is available on our web site.

Norway Spruce & Red Pine Comparative Yield, Grub Control, and Wind Sensitivity Study: Red pine is widely planted for fiber production because of its high yields. Norway spruce may match or exceed red pine's yields on better sites, but has not been properly tested. This investigation is designed to compare the two species at UPTIC. Two grub control pesticide treatments were also tested (together with a control group) during planting of this project in the spring of 1992.

Both species in this plantation suffered extensive damage from deer browsing during the first few years but have outgrown that problem. Many were replanted in the spring of 1995 to bring the plots back to full stocking. The plantation is being monitored for browsing and is

sprayed with animal repellants as necessary. Red pine stocking is below optimal levels in several plots.

Red Pine Thinning Studies: Some of the first red pine plantation management trials in the country were established at Dunbar Forest. During the fall of 1991, two of these red pine thinning studies (one begun in 1951 the other in 1961) were remeasured. Several publications have been based on these studies. Mead Corporation and the USDA Forest Service are both keenly interested in the information from this test. The Forest Service is providing labor assistance for this project.

Red Pine Spacing Study: An area on MDNR land near Dunbar Forest at Pickford was selected in 1968 to test the effects of initial plantation spacing on red pine yields on sandy soils. Two areas were established: 1) 20, 1/10th-acre plots were set out randomly in an existing young plantation of red pine and thinned to one of 5 densities. The thinnings were done in the 6th growing season after the trees had been planted. 2) in 1971 an adjacent area was planted with red pine to test six similar densities. This second plantation uses a randomized block design with four blocks and 1/10th-acre plots each surrounded by adequate border rows. Measurements were taken in the summer of 1996 and a report was prepared and presented to the Michigan Society of American Foresters. A copy is available on our web site.

Red Pine and European Larch Growth and Yield: A mixed planting of European larch and red pine was established in 1950 at Dunbar Forest. Recent measurements have shown that the European larch grew about 20% faster than the red pine in height, diameter, and volume on this site at age 43 years.

Soil Calcium Levels under Pine and Deciduous Forests: This study was conducted by University of Minnesota researchers at Dunbar Forest in 1993. It examined the sustainability of intensive harvesting from the standpoint of Ca depletion.

White Pine Planting Density Study: White pine was once a major forest cover type in Michigan, but now covers only a fraction of its original area. Pest problems have historically limited success and interest in white pine regeneration. A recent increase in interest among resource managers to re-establish white pine led to a multi-faceted research project involving MSU's Department of Forestry, Michigan Department of Natural Resources, and the US Forest Service.

One aspect of this research involved studying the long-term effects of plantation density on white pine weevil and white pine blister rust incidence and on the trees' response to these pests. A 20-acre plantation of white pine was established at UPTIC in the spring of 1998 to help answer these questions. The large plots of various densities will be monitored for many decades to come.

HARDWOOD SILVICULTURAL RESEARCH

Red Oak Tree Shelter/Weed Control Study: Red oak is a valuable species for both timber and wildlife. Its presence in UP hardwood stands has diminished with harvesting. Overcoming regeneration problems of this valuable species is important for the region. A test was established at UPTIC to determine the effects of tree shelters on red oak. No differences in survival were seen during the first growing season, but trees in shelters grew 60% taller than those without shelters. 2nd, 4th, and 6th-year growing season data were summarized. One clear conclusion has been that Tubex tubes, when installed according to 1990 manufacturer's recommendations, caused excessive winter injury to red oak after the first growing season. Also clear is that the netting installed to prevent blue bird death, as recommended by the manufacturer, caused severe terminal deformity. A summary of results from the test appears on our web site.

Aspen Herbicide Sensitivity Study: Regenerating genetically improved aspen is a difficult task that involves extensive site preparation and tending. A study was initiated in 1990 to test the sensitivity of 570 triploid, hybrid aspen seedlings planted into areas treated with common site preparation herbicides (Arsenol, Oust, and Accord plus Oust). There were three planting sites in the Upper Peninsula, two on Mead Corp. land and one at UPTIC. Each planting was a split-plot randomized block design with two main plot treatments (mechanical scarification and no scarification) and four split-plot treatments (three herbicide treatments and one control). The herbicides were reapplied in 1991 and final survival and growth was measured at the end of that growing season. First-year data, summarized in Paul Schultz's thesis, showed triploid aspen to be severely damaged by Arsenol but benefited by Oust plus Accord.

Upland Hardwood Regeneration in Pastured Woodlots: Many woodlots around UPTIC have been pastured or are in areas with extremely high deer populations. Regeneration of hardwoods on these sites has been difficult, and sometimes impossible due to the intense competition from pasture vegetation and over browsing.

A study was initiated in 1992 in a 25-acre upland hardwood woodlot at UPTIC to quantify the impacts of deer browsing and sod competition on hardwood regeneration after a cutting. Following a thinning to a residual basal area of 60 sq. ft, the stand was subdivided into three sod control treatments (herbicide, mechanical, and control). Half the area was fenced with electric deer exclosures. The result was a split-plot randomized block

design with three blocks. Seedling establishment and growth will be monitored over time.

Upland Hardwood Management by Selection Silviculture: The upland hardwoods at the Jim Wells Forest have been thinned for the second time since the University obtained the property in 1943. The woods operations were completed in 1998. This thinning will: 1) continue the process of improving the quality and size of the residual trees on the site, 2) encourage regeneration of desirable hardwood species and thus broaden the age class structure of the stand, and 3) generate a set of cost and yield figures similar to those obtained in the 1960s by Roy Skog. Sixty-two Continuous Forest Inventory plots were established in 1998 to provide growth data for the forest.

Deer Exclosure Design Trials: Deer browsing of regenerating woody plants is one of the most significant impediments to their survival in the forests around UPTIC. In some cases, browsing is causing a shift in species composition and a reduction in diversity. One management tool to reduce this problem is to exclude deer from regenerating trees.

We are constantly testing various exclosure techniques at UPTIC. Methods used have included individual tree shelters (tubes, nets, and cages), permanent 8' woven wire fences, permanent electric high-tensile wire fences up to 8' tall, and temporary electric ribbon and rope fences.

The latter exclosure system is designed to be used around new plantations for a few critical years to get them established, and then moved to a new plantation to repeat the job. We are experimenting with several variants and this type of fence to determine how practical this will be in forestry applications. A document describing these fencing options and comparing their cost is available on our web site.

Regenerating Upland Hardwoods Using Group Selection Cuttings: Maintaining and increasing species diversity in northern hardwood stands has become a top priority for many forest managers. Seedlings of native species have differing light requirements for successful regeneration and recruitment. This study will determine the appropriate size canopy opening to encourage regeneration of several of these native species. Species of particular interest include sugar maple, red oak, yellow birch, white pine, and eastern hemlock.

Preparations for the project began at Dunbar Forest in 1999. Plot harvesting will take place in 2000. Monitoring of regeneration and growth will continue for at least 15 years.

Herbicide Sensitivity Trial for Fiber Farm Species: Controlling weed competition in Fiber Farming systems is both critical for success and difficult. The crop species grown in these plantations tend to be sensitive to most commercial herbicides and often require repeated, expensive mechanical cultivation to exclude weeds. Six herbicides were tested on poplars, aspen, and larch in 1998 at UPTIC. Crop tolerance to these chemicals was determined at various application rates and at different growth stages. This test established that:

1. Clopyralid, imazaquin, sethoxydim, and fluazifop can all be safely applied to newly planted, actively growing poplars, aspens, and larches in Upper Michigan. None of these herbicides had adverse effects on the survival or the growth of the crop trees at the end of the first growing season in the field.
2. Prodiamine is not suitable for use as a pre-emergence herbicide in first-year hybrid poplar plantations. Three quarters of all poplar cuttings treated with this chemical died and those that survived grew poorly in relation to mechanically weeded control cuttings.
3. Unrooted cuttings of hybrid poplar treated with oxyfluorfen survived and grew as well as mechanically weeded trees in Upper Michigan.

A complete report is available on our web site.

Herbicide Effectiveness Trial for Hybrid Poplar: An integral part of any short rotation woody crop production system is the exclusion of weeds from the developing trees. A two-year test of imazaquin and pendimethalin was established in the spring of 1999 in a plantation of two hybrid poplar clones. The study will determine the effects of these two herbicides when applied at various rates on tree growth and weed control. Results from this test will be directly applied to our Fiber Farming demonstration area. This work is partially supported by American Cyanamid. A second, identical, study was established in East Lansing in 1999 to compliment this test.

Short Rotation Fiber Farming Demonstration: Aspen fiber is the leading agricultural crop in the UP and ranks 6th statewide. Methods for producing aspen and poplar fiber on short (<20 year) rotations using intensive silvicultural methods are being investigated and demonstrated at UPTIC. An eight-acre plantation containing four clones of hybrid poplars, a seed source of hybrid aspen, and a seed source of hybrid larch was established at UPTIC in the spring of 1998. Soil amendments, fertilizers, and weed control systems are being tested in this plantation.

The goal of this project is to determine an optimal combination of clones and cultural methods for producing aspen-like fiber in a third of the time that

natural stands require. The work is being done with the close cooperation of Mead Corporation, who hope to use the information to provide private landowners with another forest management option.

WHITE-CEDAR SILVICULTURAL AND ECOLOGICAL RESEARCH

Enhancing Cedar Regeneration By pH Adjustment: Germination of northern white-cedar has been shown to improve as pH increases from 5.0 to 8.0 under laboratory conditions. In 1987 the DNR in Escanaba applied lime to some test plots in a harvested cedar stand to determine the effects on regeneration. Lime was applied at 0, 1, 1.5, and 2 tons per acre. Seed germination data from these plots was analyzed by UPTIC personnel. Initially, seedlings were more abundant in heavily limed plots than the unlimed control plots, but the reverse was true after only three years.

A second liming study was begun by UPTIC personnel in 1989 on a scarified swamp site to repeat the DNR experiment under more controlled conditions. Lime was applied at 0, 1, 2, and 4 tons-per-acre in a randomized block design. pH measurements were taken on the site in the spring (just before lime was applied) and again in the fall (3 months after liming). Liming did not increase the pH in any plot and in fact, the pH decreased for all treatments during the year.

A third liming investigation was begun on these same plots in 1990, to better understand what was happening on this site. This time lime was applied at rates of 0, 3, 6, and 9 tons-per-acre. pH levels were determined before lime application in the spring and at three additional times throughout the growing season. Similar pH series were also measured at four other swamp sites in the area. Liming did not affect pH in the first growing season although it was applied at exceptionally high rates. pH also varied over the growing season at all sites.

We have concluded from this work that the buffering capacity of these organic soils prevents us from economically changing their pH with lime. We also learned that pH varies within a site and throughout the growing season. This means that many soil samples must be taken to describe surface pH accurately on these sites.

Fencing Effects on Regenerating Northern White-Cedar Stands: Animal damage to young northern white-cedar is believed to be one principle deterrent to the successful regeneration of the species. Guidelines were developed for erecting deer exclosure fences for research plots under the auspices of the CEDAR Action Group. The CEDAR Action Group is a committee of 40 resource managers, land owners, and sportsmen formed to coordinate cedar management, information, and research. This group is coordinated through UPTIC. Fences that conform to these guidelines are being built by members of the committee in several Delta County locations and in northern Lower Michigan. A network of exclosures over a wide range of sites will eventually exist, in which the effects of deer browsing on wetland forest regeneration can be quantified.

One design involves enclosing an area of at least 3,800 sq. ft. with a woven wire fence that is 8’ tall. This design is statistically acceptable for monitoring the development of sapling size trees. Three sites in Delta County were fenced and are monitored by UPTIC staff using this design.

Another design was developed for monitoring seedling regeneration only. Because seedling studies can be done in small plots, these fences are small, cheap, and easily built. The seedling plot fence design includes a 10’ circle of 5’ tall woven wire held in place by “t” posts. The DNR has been installing fences like this for several years. UPTIC personnel installed 33 of these fences during the summer of 1995 in small clearcuts in cedar stands throughout the central UP (see Cedar Stand Origin Study below).

Individual Tree Shelter Effects on Cedar Growth: Several tree species have been shown to exhibit greater survival and early growth when planted in plastic tube tree shelters (see Red Oak Tree Shelter Study above). A preliminary study was conducted during the summer of 1989 that led to the establishment, in 1990, of a tree shelter test for northern white-cedar on three sites. One hundred trees were planted on each of two sites: one at UPTIC and the other on state land. Each site has 50 trees in 4’ Tubex shelters and 50 unsheltered trees. Another group of 25 trees were planted nearby inside an 8’-tall woven wire fence.

At UPTIC, seedlings in tubes grew 30% taller than those outside the tubes during the first growing season but survival was unaffected. Since then, the unprotected trees have been browsed and those in the tubes have had winter injury. The result is that the trees in nearby fences are now nearly 40% taller than those in the tubes. All trees on the UPTIC site, except those in the fence, have not increased in height since the first growing season.

Strip Clearcut Regeneration Study: Many cedar stands fail to regenerate following standard prescriptions for strip cutting. Three successfully regenerated strip cuts were examined during the summer of 1994 to determine the sequence of their regeneration. Each strip was sampled across and along its axis with nine plots. Ages of all stems greater than 1 foot tall were determined. Height growth of all stems greater than 6.5 foot tall was also studied.

Each strip had individual trees that had regenerated at the time of the cutting and so were as old as the cutting itself (approx. 30 years). However, most of the individuals regenerated after the cutting so the young stands are all-aged. The oldest individuals in the stands are dominant in height.

This work shows that strip cuts in cedar stands require extended periods to become fully stocked. It also shows the futility of one-time direct-seedlings in cedar cuts as an artificial regeneration technique. A summary of this work appears in Forest Ecology and Management.

Cedar Ecology and Hydrology Research Area: An 1,100 acre area at UPTIC has been identified as a wetland watershed. The site is bounded by uplands and drains through an identifiable stream channel. This site offers a particularly unique opportunity to monitor, study, and describe the dynamics of these cedar swamps over a long period. A great deal of time has been spent in providing access and defining this area. Nearly 3 miles of old logging trails have been reopened for winter access. Twenty monitor wells have been established throughout the site including a stream monitoring station on Portage Creek. A baseline survey has been conducted to establish horizontal and vertical reference points throughout the site

Snowpack Monitoring in an UPTIC Swamp: The depth and water equivalent of the snowpack in the cedar research area described above was monitored throughout the winter of 1992-1993. Four samples at each of 20 monitoring points were sampled with an 8" snow corer designed at UPTIC. Snow depths and densities varied wildly even among closely spaced sites with similar overstory conditions. Recommendations for future sampling in this swamp have been drawn from the experience of this preliminary study.

Cedar Stand Origin Study: As current management of cedar fails to reliably regenerate cutover stands, our most recent research approach to the problem focuses on describing how mature cedar forests in the U.P. became established in the first place. By discovering how these older forests got started (e.g., by fire or windstorm), and by examining their development over time, we can better "imitate" nature when we try to create our own new cedar forests. Our study involved a detailed examination of tree rings from over one thousand trees from swamps in the region. By examining these rings and trees we can piece together the age of the stand and how it developed and grew over the last 300 years or so. A summary of this work appears in the Canadian Journal of Forest Research.

Patch-clearcut Regeneration Study: The cedar stand origin study (above) has provided a set of thirty-three 1/40th-acre clearcut patches (37’ diameter) in 11 different cedar swamps throughout the central UP. With the DNR and USFS we have constructed small (10’ diameter x 5’ tall) wire deer exclosures and installed a groundwater monitor well in each of these plots. This network of plots is the most extensive sample of cedar sites in Michigan. It will be monitored over the next ten years to determine the effects of various factors on the regeneration of cedar at these sites.

Seed Shelter Study: Scattering cedar seed into cut-over areas has long been done to increase the number of cedar seedlings. Some recent evidence shows that regeneration of clearcut strips can take from four to 30 consecutive seed years. This means that most of the tens of thousands of seeds that fall on the ground each year in cedar stands must fail to germinate or must dry out and perish. If managers are going to spend money sowing seed, it makes sense to give these seeds a better chance at survival than their "wild" counterparts.

Small seed shelters are commercially available and used for other species like spruces and pines in Canada. We successfully tested three shelters recently using cedar seeds on bucket-mounded sites. Nearly twice as many cedar seeds germinated and grew in the least expensive of these shelters than in unsheltered control plots. These shelters are compressed peat pots, like those used in gardening, with their bottoms removed. They only cost two cents each and may be well worth the cost.

Cedar Microsite Hydrology Study: We often think about cedar as a swamp species that prefers wet soils, but this study shows that cedar seedlings can only survive when they are growing above the high water level. Other species like balsam fir and tag alder occupy sites where the water is too high for cedar.

A 30-year-old strip cut in a cedar swamp at UPTIC was studied. Cedar regeneration was abundant at one end of this 600-foot-long strip and absent at the other. This disparity in regeneration could not be explained by differential animal pressure or other gross site features. Cedar seedlings were found only on mounds (or hummocks) that protruded above the seasonal high water table at the site. The number of cedar seedlings was strongly correlated with the number of mounds.

It is postulated that drainage changes at this site (due to road and railroad grade building) changed the water table enough to submerge the suitable mounds at one end of this strip. This effect has wide-spread implications for cedar stands in the UP. Surveying the number of available "micro-sites" before making any regeneration cuts in cedar stands is advisable. A summary of this work appears in the Canadian Journal of Forest Research.

Swamp Scarification Study: Two cut-over cedar swamps in Delta County were treated with a roto-tiller-

like machine called the "American Ranger" in 1988. These sites have regenerated almost completely to sedges and cat tails following this scarification. We now know that these former cedar stands can no longer support cedar seedlings because they are too wet. The treatment eliminated all the high spots so that the whole area was submerged in the spring. This work and the study mentioned above lead us to conclude that successful cedar regeneration will depend on increasing the number of dry microsites using a technique like "bucket mounding" or by lowering the water table.

Bob's Lake Study: An in-depth review of Thomas Nelson's 1939 work in a cedar swamp near Bob's Lake (Marquette County) was conducted and summarized by Rod Chimner, Mike Zuidema, and Ray Miller. We reviewed the conclusions Nelson made in 1951 (inadequate cedar regeneration was taking place on the site and cedar that did regenerate was being removed entirely by browsing deer) and found the same situation now. Stem analysis of the stand showed that cedar had been regenerating on this site from 1761 through about 1925 but that no cedar had regenerated during the last 70 years. We were surprised to find cedar of many ages on this site. This means that the trees regenerated over a long time (200 years or more) rather than all at once after a large disturbance. Cedar stopped regenerating at Bob's Lake soon after the adjacent upland areas were logged. The remaining trees in the swamp began to grow faster after upland logging.

Jamestown Slough Case Study: This minor study was conducted to provide information and materials about a cedar stand in Manistique for use in an outdoor education facility being developed for school children. A set of basal disks was removed from all trees in a transect through the stand. These disks were sanded and their ages were determined at UPTIC. A summary of the stand's species and age structure was prepared and returned with the disks to the Manistique facility for use by the school children. This project provides an additional data point to the study of cedar stand age structures described earlier. Cedar here ranged in age from 130 years-old to 55 years-old.

OTHER PROJECTS

Papermill Sludge as a Soil Amendment for Agricultural Crops: Mead Corporation disposes of all its papermill sludge in a landfill. Other papermills in the UP incur similar expenses and are anxious for a solution. Material like this is routinely applied to agricultural land in Wisconsin and it is hoped that similar land applications can be made in Michigan. This sludge is primarily composed of cellulose and clay. When applied to the land it tends to increase soil moisture holding capability and may contribute to the nitrogen levels in the soil. A study was conducted at UPTIC in 1998 to document the effects of applying the sludge to corn and barley crops. The work was funded by Mead Corporation and conducted by a private research company.

Balsam Shading Effects on Fir and Sugar Maple Seedling Growth: Balsam fir and sugar maple seedlings easily regenerate in the shade of mature forests. This basic ecological study is being done to determine if the evergreen species can take advantage of the early and late parts of the growing season when the deciduous species do not have their leaves. If so, this may give them a growth advantage and effect species composition in forests like ours if the global climate changes.

The project combines the resources of Michigan State University's Department of Forestry and Princeton University. It began in the spring of 1999 and will continue for at least two years. A set of 166 fir and maple seedlings are part of the study. Shade structures were placed over half of the individuals in early spring and late fall to prevent them from photosynthesizing on mild days during those times. The unshaded trees are free to grow if they can. Growth and photosynthesis activity are being monitored for all trees.

PAST RESEARCH

Western White Pine Progeny Test: A 1/10-acre planting of 56 trees of 10, ½-sib families from Idaho were established at the Upper Peninsula Experiment Station at Chatham in 1970 to test this exotic species for cold tolerance. These trees usually turn red each winter, and could be used for Christmas trees if this color became popular.

Grand fir Progeny Test: A 3.5-acre plantation of 103 half-sib seedlots of Grand fir from Idaho, Montana, and Washington sources was established at UPTIC in 1986. This was one of two such plantings (the other was at the Albion facility), designed to screen this species for its adaptability as a Michigan Christmas tree. Mortality was high due to the drought conditions following planting and to the severity of winter cold damage in this plantation, so the test has been discontinued

Scotch Pine Shearing Uniformity Trial: The uniformity of seedlings in growth, color, and response to shearing is important to Christmas tree growers. This 1-acre test of 57 seedlots was established at UPTIC in 1989 to measure and demonstrate variation among closely related seedlings. All seed came from a single plantation or seed orchard. Half this planting has been sheared annually and the other half has been allowed to grow freely. A preliminary assessment of the tree response to

shearing was recorded in the fall of 1995. This project has revealed some differences in bud development that have not been reported by other investigators.

Black Locust Progeny Test: A half-acre test of 40 half-sib families of black locust, selected from a rangewide progeny test in Lower Michigan, was established at UPTIC in 1989. Previous work with black locust showed that it could be adapted and grow well in extremely cold areas of Michigan. Placing these trees in the Upper Peninsula was intended to subject them to cold stresses that occur infrequently in Lower Michigan, thus reducing the time required to screen them for their responses. Winter damage to these trees was severe the first year and continued for several years after that. The test was abandoned in 1992.

Black Locust Progeny Test: Following the failure of the 1989 black locust progeny test (89.06), a larger 2-acre test of 160 half-sib families of black locust selected from the same rangewide progeny test in Lower Michigan was established at UPTIC in 1992. It was hoped that the families in this new test would show cold tolerance. Winter damage to these trees was severe the first several years and this test was abandoned in 1995.

Red Pine Seedling Type/Planting Time Trial: Questions remain about which type of seedling (bare root or container grown) is the best to use, and whether spring or fall planting produces better survival. A test was begun at UPTIC in cooperation with the Michigan DNR and Mead Corporation in 1990 to examine these questions.

The original plan called for five types of red pine seedlings to be planted during both the spring and fall of each of three successive years, beginning in 1990. By the fall of 1991, after half the test had been planted, the white grub population on the test site had increased and killed more than 80% of the trees. Mead Corp. and the MDNR both experienced similar problems. An insect census of this site during the spring of 1992 found an excess of 1.3 grubs per cubic foot of soil (0.5 is considered high). The project was abandoned as a result.

Windbreak Species Effectiveness Trial: A study was established at UPTIC in the spring of 1991, in cooperation with the USDA Soil Conservation Service, to test various windbreak shrub species for adaptability to Upper Peninsula weather conditions. The open land at UPTIC mandates some type of windbreaks to reduce snow accumulations, and this project offered benefits to both the research and demonstration mission of UPTIC and to the physical plant needs.

Thirteen species of shrubs and four species of trees were selected based on their efficacy in windbreaks in other regions. Five replications of 5-tree row plots were planted in 1991. Deer browsing became a severe problem during the first growing season. Protective netting was placed over all seedlings but most species never recovered from the initial browsing. The browse damaged was compounded by a high white grub population in the area. Together both reduced the vigor of the test trees to the extent that the project had to be abandoned.

Agroforestry Forage Trial: Forage plots were established at UPTIC in 1989 by Mr. Robert Barret (graduate student, Department of Forestry) and Dr. Richard Leep (Crop and Soil Science Department). These plots included standard forage crops and a nitrogen-fixing tree species, black locust. Yield comparisons were planned both in the UP and in Lower Michigan to determine the viability of woody crops as forage. After two attempts at planting, low survival forced the abandonment of these plots. This work was continued in East Lansing.