NDSU-North Dakota Forest Service

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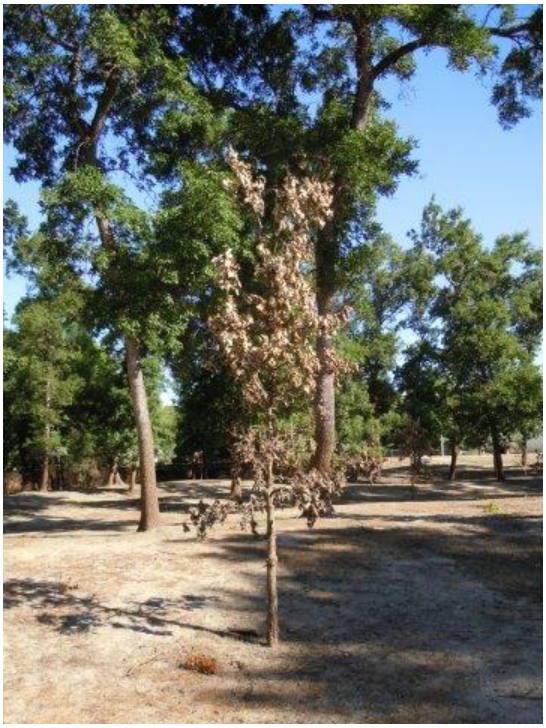
Flood Damage Tree and Shrub Assessment
Minot Park District, North Dakota

Executive Summary



Flood waters from the Mouse River overflowed the levees on June 22, 2011, inundating the valley area of Minot, North Dakota. The flood broke a more than 130-year-old record for high water. Everything that came into contact with the flood waters was damaged, including trees and shrubs. The Minot Park District requested assistance from the State Forester's office on June 25, 2011, to conduct an assessment of the trees and shrubs in the parks that were affected by the flooding, and an assessment of street trees planted within the past five years.

Trees and shrubs completely covered by the flood waters suffered mortality. Trees that had a significant portion of their canopy above the flood waters survived with little or no damage. However, flooding decreases available oxygen in the soil, which may damage root systems. The extent of the root damage is difficult to determine and depends on the species, soil type, and flood duration, as well as the age and prior health of the tree. Trees with the majority of their roots undamaged have a good chance to fully recover over the next few years.

A total of 2,017 trees and shrubs inundated by flood waters were killed or severely damaged. This includes 616 trees that will need to be removed due to safety concerns. The number of shrubs that were destroyed by the flooding totaled 1,401. Nine parks in Minot were affected by the flood waters. The most damage occurred in Oak Park, Roosevelt Park and the Zoo. Oak Park with its natural canopy of oak trees lost 160 trees, including a large number of smaller trees that had been planted in the last 5 to 10 years. Roosevelt Park and the Zoo lost 1,319 shrubs from its more formal gardens and developed recreational facilities. The estimated cost to remove all the dead or severely damaged trees and shrubs is $131,650.00. Based on a replanting cost of $430 per tree and $70 per shrub, the estimated cost to replace all the trees and shrubs is $362,950. The total tree and shrub removal and replanting costs are estimated to be $494,600.00.

Introduction

The purpose of the assessment is to assist the Minot Park District in determining the approximate number of trees and shrubs that were lost due to the flooding. The information will aid the park district in estimating the cost of removal and replacement of the plant material. The assessment documents the damage and can be used to apply for public assistance from state and federal agencies, including the North Dakota Department of Emergency Services and the Federal Emergency Management Agency.

The Minot Park District requested assistance from the State Forester's office on June 25, 2011, for evaluating trees and shrubs affected by Mouse River flooding. Joel Nichols, Community Forestry Specialist, and Brian Johnson, Minot City Forester, determined the North Dakota Forest Service would assess the condition of public trees in nine city parks, the Roosevelt Park Zoo and on Minot streets. Street trees planted within the last five years would be inventoried for flood damage. Joel Nichols arrived in Minot on July 27 and Sharon Bartels, Community Forestry Specialist, joined him on July 31 to conduct the field inventory. Fourteen person-days were devoted to the assessment for determining and documenting which trees and shrubs did not survive the flood or posed a significant risk to public safety. Trees posing a public safety risk were documented using GPS coordinates and the information was given to the City Forester to assist in the removal of those trees. Assessment data was entered into spread sheets.

What was Found

Flooding within the City of Minot began on June 22, 2011, and the water never receded until 21 days later on July 14. Trees and shrubs completely covered by flood waters were killed or severely damaged. Tree and shrub species that were killed by the flooding are as follows:

Trees

Acer negundo - boxelder
Acer saccharinum - silver maple
Acer tataricum ssp. ginnala - amur maple
Aesculus glabra - Ohio buckeye
Amelanchier hybrid - Juneberry
Betula - paper birch, white birch
Celtis occidentalis - hackberry
Crataegus - hawthorn
Gleditisia triacanthos var. inermis - thornless honeylocust
Eleagnus angustifolia - Russian olive
Fraxinus nigra - black ash
Juglan nigra - black walnut
Juniperus scopulorum - Rocky Mountain juniper
Malus - crab apple
Populus - poplar
Populus tremula 'erecta' - Swedish aspen
Picea pungens - Colorado (blue) spruce
Picea glauca ssp. densata - Black Hills spruce
Pinus ponderosa - ponderosa pine
Pinus sylvestris - Scotch pine
Prunus virginiana - chokecherry
Pyrus ussuriensis - Ussurian pear
Quercus macrocarpa - bur oak
Quercus ellipsoidalis - northern pin oak
Sorbus - mountain ash
Syringa reticulata - Japanese tree lilac
Syringa pekinensis - Pekin lilac
Thuja occidentalis - arborvitae
Tilia americana - American basswood
Ulmus - hybrid elm
Ulmus americana - American elm

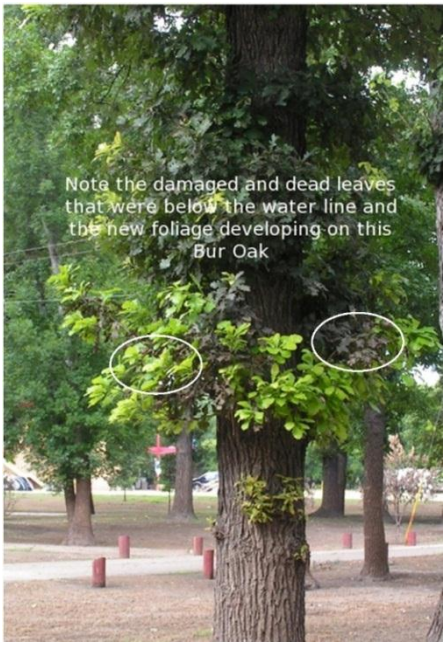
Shrubs

Berberis thunbergii - barberry
Caragana arborescens - common caragana
Caragana pygmaea - pygmy caragana
Cornus - dogwood
Cotoneaster lucidus - European cotoneaster
Juniperus horizontalis - creeping juniper
Juniperus x pfitzeriana - Pfitzer juniper
Juniperus sabina - Savin Juniper
Lonicera tatarica - Tatarian honeysuckle.
Lonicera xylosteum - dwarf honeysuckle
Physocarpus - ninebark
Pinus mugo - mugo pine
Potentilla fruticosa - potentilla
Spirea - spirea
Syringa meyeri 'Palibin' - dwarf Korean lilac
Rhus aromatic - fragrant sumac
Rhus glabra - common sumac

Rocky Mountain junipers that were covered by flood waters.

Young trees and shrubs, even the most flood tolerant species, were unable to survive being covered with water.

According to a July 1994 report by Dr. Kim Coder, University of Georgia, titled "Flood Damage to Trees," the tree does aerate as much of its tissues as possible during flooding. Transport modifications move oxygen more effectively from the air into lenticels and down into the roots, where some leaks out to oxidize materials (like iron and manganese ions), which are toxic. The oxygen availability is through lenticel and stomata openings, moving in both wood and bark.



Flooded trees produce larger, more open lenticels which are connected to intercellular spaces and can provide more oxygen transport.

Flooding also initiates adventitious roots on the submerged stem area. The more flood tolerant the species, the more likely the species will form adventitious roots.

Tree species that had foliage above the flood water and survived included:

Acer negundo - boxelder
Acer saccharinum - silver maple
Celtis occidentalis - hackberry
Gleditisia triacanthos var. inermis - thornless honeylocust
Fraxinus nigra - black ash
Juglans nigra - black walnut
Malus - crab apple
Populus - poplar
Picea pungens - Colorado (blue) spruce
Picea glauca ssp. densata - Black Hills spruce
Pinus ponderosa - ponderosa pine
Pinus sylvestris - Scotch pine
Quercus macrocarpa - bur oak
Quercus ellipsoidalis - northern pin oak,
Syringa reticulata - Japanese tree lilac
Thuja occidentalis - arborvitae
Tilia americana - American basswood
Ulmus americana - American elm

Shrub species that survived:

Cornus - dogwood
Viburnum lentago - nannyberry
Viburnum trilobum - American cranberrybush

This nannyberry was not fully submerged by the flood waters. This shrub could be cut back this fall to encourage new growth next spring.

At the time of the assessment, American elms, bur oak, green ash and hackberry had new foliage emerging from limbs that were covered by the flood waters.

Genetics, health and tree vigor seem to have played a role in survival as seen in the images below. For example, the pictures below of bur oaks and American lindens growing side by side depict one tree recovering with healthy foliage, while the other was severely damaged or killed by flood waters.

The foliage and branches of conifers that were submerged by flood waters were killed. In some cases, this has disfigured the trees to the point where they need to be removed.

These spruce trees have lost at least 2/3rds of the canopy, which decreases potential food production and loss of their aesthetic value, and should be removed.

The spruce trees in the image above have lost a couple layers of their canopy. The dead layers should be removed; the remaining canopy will provide adequate food production and aesthetically pleasing trees.

The smaller Scotch pine in the image above were covered by flood waters and killed. The larger pine had at least half of the crown destroyed. The future health and the aesthetic appeal of the trees are questionable. Trees should be replaced with a species that would be more tolerant to flooding.

The Scotch pines to the right have lost less than half of the canopy. The remaining canopy should be able to produce enough food to keep the trees healthy, but the aesthetic value of the trees has decreased. To help mask the damage, shrubs could be planted in front of the trees improving the overall appearance of the area.

The willow trees that were planted at this location came through the flood with very little damage.

The Siberian larches to the left were not submerged by the flood waters. However, the foliage has turned yellow and most of it has fallen off the tree. There is still green cambium present on the branches. These trees should be monitored to see if they produce new foliage yet this year. If the branch cambium remains green, the trees should be left until next spring to see if they send out new foliage.

The junipers to left, as well as the arborvitae below, have dead branches and foliage where the flood water covered them. These branches should be removed and, if necessary, shrubs or perennials could be planted at the base to improve their aesthetic appearance.

Similar problems as those above have occurred in the planting to the left. The deciduous shrubs could be cut back to 4-6 inches from the ground this fall; they will sprout new growth next spring.

The greatest immediate threat to the larger trees within the water-saturated soils of the flooded area is from strong winds. Even without strong winds, some tree roots have not been able to keep the trees upright.

The green ash to the left had a significant natural lean. The root system is failing, causing cracks in the soil at the base of the tree. This tree was removed due to safety concerns.

Several trees have fallen, primarily in Oak Park.

The street trees that were killed by the flood were those that were submerged. There were some instances where no trees were found due to the accumulation of debris on the boulevard from houses that had been stripped to the frame. Trees that had made it through the flood did have some mechanical damage from debris. Additional loss of trees can be expected on the boulevards due to the removal of debris and during the reconstruction of houses in the previously flooded areas of Minot.

Numbers

The following spread sheet shows the number of trees and shrubs on publically owned or controlled property that are dead or not salvageable, broken down by location. There are additional trees on private property that were not surveyed by this assessment that have not or will not survive the recent flooding in the Minot area.

Tree and Shrub Replanting Costs

Street Trees			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	102	$30,600.00	$13,260.00	$43,860.00
	Shrubs	0			

Oak Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	160	$48,000.00	$20,800.00	$68,800.00
	Shrubs	0			

Roosevelt Zoo			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	19	$5,700.00	$2,470.00	$8,170.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	524	$23,580.00	$13,100.00	$36,680.00
					$44,850.00

Roosevelt Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	77	$23,100.00	$10,010.00	$33,110.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	795	$35,775.00	$19,875.00	$55,650.00
					$88,760.00

Jack Hoeven Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	96	$28,800.00	$12,480.00	$41,280.00
	Shrubs	0			

First Links			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	92	$27,600.00	$11,960.00	$39,560.00
	Shrubs	0			

Leach Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	5	$1,500.00	$650.00	$2,150.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	29	$1,305.00	$725.00	$2,030.00
					$4,180.00

Nubbin Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	35	$10,500.00	$4,550.00	$15,050.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	12	$540.00	$300.00	$840.00
					$15,890.00

Riverside Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	1	$300.00	$130.00	$430.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	9	$405.00	$225.00	$630.00
					$1,060.00

Moose Park			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	25	$7,500.00	$3,250.00	$10,750.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	18	$810.00	$450.00	$1,260.00
					$12,010.00

Green Valley			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	4	$1,200.00	$520.00	$1,720.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	14	$630.00	$350.00	$980.00
					$2,700.00

Totals			$300 Avg. Cost Per Tree 2" Caliper B&B	Planting and staking costs per tree $130	
	Trees	616	$184,800.00	$80,080.00	$264,880.00
			$45.00 per shrub 5 gal container	$25 planting charge per shrub	
	Shrubs	1401	$63,045.00	$35,025.00	$98,070.00
				TOTAL COST	**$362,950.00**

Tree and Shrub Removal Costs

Tree Removal	Average of $100 per tree	$ 61,600.00
616 Trees		
Shrub Removal	Average of $50 per shrub	$ 70,050.00
1,401 Shrubs		
	TOTAL COST	**$131,650.00**

Tree and Shrub Recommendations

Remove sediment that has been deposited where possible, especially within 4 – 5 feet around the base of the trees.

Remove trees that have been identified for removal on the assessment sheets because of public safety risks (locations provided to Minot city forester).

Remove shrubs and small dead trees.

Prune off dead and broken limbs.
Inspect trees periodically for unseen damage at the time of the assessment. This is especially true of root damage. The amount of root damage will vary between tree genus and individual trees. Refer to Dr. Kim Coder's "Flood Damage to Trees" – July 1994, University of Georgia – Generally under flooded conditions, the woody roots survive and non-woody roots die. Loss of root mass through attack (from fungal pathogens) and decay leave the tree prone to drought damage the following growing period and to windthrow.

Water the trees if the roots that remain are not able to absorb enough moisture to maintain the health of the trees.

Replanting Trees and Shrubs

Minot's parks still have many mature large trees. Tree and shrub replanting can begin once the soil dries out, the dead plant material is removed, and any soil grading or construction has been completed.

Street trees on boulevards should not be replanted until after the residential housing reconstruction activity has been completed. Construction activity may cause compaction of the soil, physical damage to the trees, or complete destruction of trees by construction equipment.

References

The following article, written by Dr. John Ball of South Dakota State University, describes flooding's effects on trees, and how to help trees recover after flooding.

SDSU Extension Extra
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Horticulture
South Dakota State University / College of Agriculture & Biological Sciences / USDA

Flood-damaged Trees

Dr. John Ball, South Dakota State University Extension Forestry Specialist and South Dakota Department of Agriculture Forest Health Specialist

Flooding's Effects on Trees

Tree health is adversely affected when the surrounding soil is temporarily flooded by the overflow of streams and rivers, or when the soil is saturated by persistent rains. The primary effect of flooding is the reduction in soil oxygen. The upper six inches of a typical soil has an abundance of oxygen, and is where the roots responsible for the absorption of water and nutrients reside.

Most people are aware of photosynthesis, the process where trees "take in the bad air" (CO_2) and "give back the good air (O_2)," but many are unaware that living tree tissue is also respiring, taking in the good O_2 and giving off the bad CO_2; this applies to all the living tissue in a tree, including the roots. When flooding occurs, the soil has less oxygen for root respiration and the roots begin to die. As the roots die, the tree's ability to absorb water decreases and the foliage begins to wilt. Paradoxically, the tree dies from the lack of water because it is standing in water, a phenomenon referred to as "physiological drought."

Symptoms of Flood Injury

The most common symptoms associated with flooding:

- leaf discoloration, usually yellowing
- leaf scorching and wilting
- premature fall color
- premature defoliation
- sprouting along the trunk
- twig and branch dieback
- with severe or persistent flooding, death

The above symptoms may occur during or after flooding. It may take several years for a tree to decline after a flood, and many more years before the tree begins to recover.

Tree Species and Flooding

Tree species do not respond the same to flooding. Some tree species, typically those found growing naturally along rivers and streams, can tolerant and adapt to flooded conditions. Species that are tolerant to flooding may be able to withstand more than a month of flooding, depending on other conditions. Species that are intolerant of flooding may begin to die with as little as a week's exposure to flooding. An individual tree's tolerance to flooding is also dependent upon its age and health. Over mature trees generally cannot withstand as long a period of flooding as younger trees, though seedlings and saplings are also killed. The trees most likely to survive are usually 4 to 16 inches in diameter (measured at 4.5 feet above the ground). Trees that are in good health are more likely to survive the stress of flooding, regardless of age.

The commonly planted species with the highest tolerance to flooding (these trees may be able to withstand more than a month of flooding):

Acer negundo - boxelder
Acer rubrum - red maple
Fraxinus pennsylvanica - green ash
Fraxinus nigra - black ash
Salix nigra - black willow

The commonly planted species with an intermediate tolerance to flooding (these trees may be able to withstand several weeks to a month of flooding during the growing season):

Acer x *freeman* - Freeman maples (common cultivars, including 'Autumn Blaze')
Acer saccharinum - silver maple
Betula nigra - river birch (foliage may yellow)
Celtis occidentalis - hackberry
Fraxinus americana - white ash
Gleditsia triacanthos - honeylocust
Platanus occidentalis - sycamore
Populus - cottonwood and poplars
Quercus - bur oak, swamp white oak
Ulmus americana - American elm

The commonly planted species with the lowest tolerance to flooding (these trees may decline after only weeks of flooding during the growing season):

Acer platanoides - Norway maple
Acer saccharum - sugar maple
Aesculus glabra - Ohio buckeye
Betula - birch (except river birch)
Crataegus - most hawthorns
Elaeagnus angustifolia - Russian-olive
Gymnocladus dioicus - Kentucky coffeetree
Juglans nigra - black walnut
Malus - crabapples and apples
Prunus - all cherries (including black cherry) and stone fruits such as peaches and plums
Pinus - pines
Picea - spruce
Quercus rubra - northern red oak
Sorbus - mountainash
Tilia - lindens
Ulmus - many of the hybrid elms, including 'Discovery' and 'Accolade'
Ulmus pumila - Siberian elm

Conditions of Flooding

Season of Flooding

Late spring and early summer flooding is the most harmful to trees, as they are the times when roots are actively growing. Standing in water, or even saturated soils, is harmful to all trees at this time of year. Flooding in late winter while the tree is dormant is the least harmful.

Duration, Depth, Water Temperature and Movement

Duration, depth, and water temperature and movement are all key factors in determining the impact of flooding on trees. The longer the water remains during the growing season, the greater the impact. If the flood water recedes within a week, most trees will recover. If the waters remain for a month or two, many trees will begin to decline and may die. The depth is also an important factor. Water on the trunks is considerably more harmful than water just covering the roots, so a good rule of thumb is the higher the water the greater the injury. Lastly, the water temperature and movement have an influence on the amount of oxygen carried in the water. The warmer the water and the less movement, the lower the oxygen level and the more potential for injury.

Simply put, if the floodwaters become stagnant and remain for several weeks or more, covering the lower 2 or 3 feet of the tree's trunks, most likely the tree will decline and die, though this may take a year or more to occur.

Helping Trees after Flooding

After the floodwaters have receded, inspect the tree to determine whether the root collar, the base of the tree where the roots flare out and enter the soil, has been covered by sediment. If the flood has deposited sediment around the tree, carefully remove this material and restore the original grade as far out from the trunk as possible.
Ideally, all the deposited soils can be removed, but at the least, an area within 4- to 5-feet of the trunk should be restored to the pre-flooding grade, even an additional 3-inches of soil deposited around the base of a tree can have detrimental effects.

Also inspect the lower trunks for any torn bark. Use a sharp knife to cut away any torn bark, but do not attempt to carve the wound into an elliptical pat tern or apply any wound dressing or paint. Any broken branches should be pruned off the tree.

It may take several years for a mature tree to recover from a single summer of flooding. During this recovery time, the tree is very vulnerable to attack by a number of insects and pathogens. Inspect your trees several times during the growing season and identify and manage any pest outbreak.

Do not fertilize your trees. Generally they will not benefit from any additional nutrients applied as a fertilizer. However, once the soils have dried, you may need to water the tree as the root system may have declined enough that it cannot absorb sufficient water to maintain the canopy. Also, expect some dieback in the canopy; remove these branches as they die. Do not prune any living branches unless they are broken.

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EXEX6025 Access at http://pubstorage.sdstate.edu/AgBio_Publications/articles/ExEx6025.pdf

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Disclaimer

The assessment was limited to visual inspection of accessible subject trees within the defined areas as noted for the purpose of evaluating and estimating losses, costs of removals, and costs of replanting.

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