Saltwater Flooding and Your Garden

Bulletin E349

Vitex looks dead after saltwater flooding, but scraped twigs (center) show green, living tissue.

Chloride burn on rhododendron leaves after flooding.

Cooperative Extension

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When storms roar onto the New Jersey coast, they may bring saltwater and unknown substances into our gardens. In the aftermath of coastal flooding, it can be difficult to know what to do in the landscape. Some of the effects are easily seen; some are more subtle. Should those scorched, dead-looking trees and shrubs be removed? Will the vegetable garden grow normally? Are the vegetables safe to eat? What are long-term health effects of those unknown substances?

Saltwater damage to plants comes mostly from the sodium chloride in ocean water. Chloride is actually an essential plant nutrient, and sodium is known to be necessary to some plants. They combine to form sodium chloride (NaCl), the table salt we put in saltshakers as well as the major salt in sea water. There are many other salts in ocean water, including other nutrients that are essential to plant growth. However, saltwater flooding may deposit more salt than plants can handle.

If there is excessive salt in the soil solution, the salt pulls water out of plant roots, leaving the roots dry and dead. If enough roots die, the entire plant will die. Even on surviving plants, root damage can make them less vigorous and less drought-tolerant in coming years. The plants simply have fewer living roots with which to take up water.

The chloride in saltwater gets taken into the plant and carried along with the transpiration stream. It tends to pile up at the edges of leaves and ends of twigs, resulting in edge and tip burn on leaves and dead tips on twigs.

Saltwater flooding raises the pH of the soil. The soil becomes less acid and more alkaline. Although the pH will decline over time, in the interim plants can experience nutritional deficiencies because of the alkaline conditions. The nutrients may be present in the soil, but the high pH prevents their uptake by plant roots.

Flood water may also deposit salt directly on the above-ground portions of plants. Leaves and branches covered by saltwater may die, while those above the flood remain green and alive. Winds bearing salt spray can also deposit salt on the aerial portion of the plant. This is especially damaging if the salt is not rinsed away by rain. The salt desiccates leaves and twigs and is particularly damaging to evergreens in winter storms.

If your garden has been flooded by saltwater, answer these questions before deciding on a course of action:

Was there enough rain to saturate the soil before the flood? If so, saltwater will float on top of the fresh water, slowing salt infiltration and minimizing damage to the soil and the plants.

How long did the flood last? Flooding that recurs through several tides, or that stands for more than a few hours, will cause more damage than a fast-draining flood.

What time of year was the flood? In fall and winter, dormant plants may sustain less damage than those flooded during the growing season.

What action to take depends on how soon after the flood action can be taken. The sooner you can begin to remove the salt from the plant environment, the less damage your plants may sustain.

Right After the Flood

The longer the salt stays in the soil around the roots, the more the roots will desiccate and the worse the damage is likely to be. In the first few days after the flood, the following are some actions that can help landscapes recover:

IRRIGATE: As soon as possible after the storm, hose down landscape plants to remove deposited salt and minimize leaf burn.

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Salt in the soil can be rinsed out (leached) by repeated irrigation with fresh water. Each time, irrigate as long as the water is soaking in, but stop when it starts to run off. The fresh water must pass through the soil to carry the salt with it. The purpose is to move the salt out of the top foot or so of the soil, because the surface soil is where most of the plant roots live.

The USDA Salinity Laboratory (Bernstein, 1955), reported the effectiveness of applied freshwater at leaching salt from each foot of soil depth:

- 6 inches of water leaches out about fifty percent of the salt.
- 12 inches of water leaches out about eighty percent of the salt.
- 24 inches of water leaches out about ninety percent of the salt.

There are obviously diminishing returns to continued irrigation. The first six inches takes out half of the salt in the top foot of soil, but it takes 24 inches of water to leach most of the salt. If possible, keep track of applied irrigation plus rainfall. A regularly-monitored rain gauge will give you an idea of the rainfall at your particular site. You can also check the precipitation in your area at the N.J. Weather and Climate Network website, http://climate.rutgers.edu/njwxnet.

For best results, irrigate immediately after the flood recedes. Remember that the water must soak in and pass down through the soil, carrying the salt with it. Stop when irrigation water starts to run off, and resume irrigation later. If immediate irrigation is impossible, irrigate as soon as feasible. Over time the plant damage is done and the need for irrigation diminishes as rainfall leaches the soil. However, be aware that areas protected from rainfall, such as under an overhang, won't benefit from rain. The salt will stay in the soil until it is flushed out with water.

APPLY GYPSUM: The sodium in saltwater damages the structure of aggregated soils such as loams, clay loams, and highly organic soil by dispersing soil aggregates. As the soil collapses into individual, tightly packed particles, the soil becomes muddy, compacted, and poorly drained. Add gypsum (calcium sulfate, $CaSO_4$) to replace the sodium with calcium and to improve soil structure. Very sandy soil doesn't have much structure to start with, so it is less affected by salt. Gypsum treatment does not improve the structure and function of very sandy soil. However, gypsum has another effect, even on sandy soil. Gypsum helps move salt out of the soil because the calcium replaces the sodium on soil particles, and then the salt can be more readily flushed away with rain and irrigation.

Gypsum works best if it is incorporated into the soil soon after flooding, followed by irrigation to help leach the sodium out of the soil. In sandy soil, use 50 pounds of gypsum per 1000 square feet; up to 100 pounds or more per 1000 square feet on heavier soils. If the gypsum is spread on the surface but not mixed with the soil, as on an existing lawn or shrub border, it should be applied in repeated smaller amounts, followed by watering-in to carry the gypsum into the soil and wash the salt away.

Do not spread lime (calcium carbonate, $CaCO_3$) unless recommended by a soil test. The saltwater flood has already raised the soil pH, and lime will increase the alkalinity even more. Gypsum adds calcium without making the soil more alkaline.
As time passes and more rain falls, adding gypsum is of less use in removing salt, because the rain leaches the salt from the soil.

RINSE THE FOLIAGE: Salt deposited on plants will worsen burned leaves and dead twigs. As soon as possible after the storm, spray fresh water on plants to rinse off salt. Evergreens are particularly susceptible to salt burn during winter storms.

REMOVE SAND AND DEBRIS: Sand may be washed in by the storm or pushed onto properties as streets are cleared. Sand piled around the base of trees and shrubs or spread over lawns and flowering perennials adds to the salt load in the soil and changes the oxygen levels in the root zone. A deep layer of sand also deprives small plants of light and air as they try to recover.
As soon as possible, remove as much sand as is feasible. Rinse mud and debris off the lawn and irrigate to flush the soil.

ADD ORGANIC MATTER: In areas to be replanted, till in organic matter such as leaf compost, along with gypsum. The organic matter will help restore soil structure and will act as additional storage for salts in the soil. It also provides food for microbes that help cleanse the soil. Leaf compost is often available from county recycling yards and from many municipal public works yards. See websites for your county or municipal solid waste department or municipal utility authority.

DO NOT FERTILIZE TOO SOON: Many fertilizers are salts, so they add to the salt load in the soil and may further damage plant roots. Be especially careful with chemical fertilizers containing potassium chloride. Wait to see how the plant grows, and fertilize as needed during the growing season. Organic fertilizers can be useful because most have a low salt index, and are therefore less likely to burn roots.

As Time Goes On

PRUNE AND IRRIGATE TO MINIMIZE STRESS: Plants may look hopelessly burned and dead after flooding and salt-bearing winds, but they may recover. Wait until the next growing season, when you can clearly tell what is dead, before deciding to remove trees and shrubs or prune out dead wood. If the plant survives, don't over-prune. The plant will need all the leaves it can grow to produce food for recovery from the damage.

New growth may look yellow and spindly on woody and perennial plants with damaged roots. As the summer turns hot and dry, pamper flood-damaged roots and minimize additional stress by watering during dry spells. One-half to ¾ of an inch of rain or irrigation twice a week should be enough. Avoid frequent, shallow watering, which only encourages shallow roots and increases susceptibility to drought damage.

WITCHES' BROOM: After tips are killed on woody plants, multiple buds may sprout at the base of the dead tissue. The buds grow into dense clusters of twigs called witches' brooms. In later years, the tree or shrub starts to look as if many small shrubs were attached to its branches. There is no disease or

insect involved. If practicable, prune out the brushy clumps to restore the normal growth habit of the plant.

SOIL TESTING: Following saltwater flooding during the dormant season, irrigation and rainfall may bring soil salt levels down to normal before the next growing season. However, it is useful to know the salt level in the soil before planting, especially if there is a short interval between saltwater flooding and the growing season.

The Rutgers Soil Testing Laboratory can test soil for soluble salts. The forms for soil testing and directions for how to take a soil sample are available at the website, http://njaes.rutgers.edu/soiltestinglab. The basic "homeowner" soil collection kit is also available for purchase at the county offices of Rutgers NJAES Cooperative Extension. See http://njaes.rutgers.edu for a link to county offices. There is a fee for the basic soil test, which includes testing for nutrients and pH, and a further fee for a soluble salts test.

Saltwater flooding leaves the soil with a higher, more alkaline pH, which affects the growth of crops by affecting nutrient uptake. The pH of the soil may take a year or more to return to the level seen before the flood. Close to the next growing season, a pH test will show the current acidity/alkalinity balance and whether the soil needs adjustment to grow annual crops. Many of the county offices of Rutgers NJAES Cooperative Extension perform pH tests for a nominal fee. See the NJAES link above for contact information for your county office.

FERTILIZE CAREFULLY: Remember the damage to the root system, and try not to load the soil with excessive fertilizer salts. A soil test will tell you how much fertilizer is needed, if any. Apply slow-release fertilizers or use small, repeated applications of rapidly-available water-soluble fertilizer as recommended by the soil test.

Turfgrass and Salt

Cool-season turfgrasses vary in their tolerance of salt. Among lawn grasses, tall fescues are the most salt tolerant, followed by slender creeping red fescue. There are numerous varieties of tall fescue available and a few varieties of slender creeping red fescue ('Seabreeze GT', 'Sealink', 'Shoreline'). All will be more salt tolerant than other lawn grass species.

The other fine fescues such as hard fescue, strong creeping red fescue, and blue fescue crossed with hard fescue, rank next in salt tolerance, along with the perennial rye grasses. Kentucky bluegrass and Chewing's fescue are the least salt tolerant of the turfgrasses usually planted in New Jersey lawns. Within each species, varieties vary in their salt tolerance.

Grass varieties come and go in the trade, so the varieties mentioned here may no longer be available. However, research conducted at Rutgers University (Koch and Bonos, 2011) and the University of Minnesota (Friell et al. 2013) found 'Liberator', 'Eagleton', 'Diva', 'Rhythm', and 'Park' to be among the most salt tolerant Kentucky bluegrass varieties.

Alkaligrass, *Puccinellia distans*, is another very salt-tolerant grass that prefers high pH soil and that can tolerate wet soil. It will not thrive and compete in acid or neutral soil, but if you have a perennially flooded property with high pH soil, consider alkaligrass.

Neither alkaligrass nor slender creeping red fescue is likely to be found in commonly available grass seed mixes. Both are used in roadside seed mixes. Work with your landscaper or supplier to find seed mixes with salt-tolerant grasses.

To replant or overseed a salt-flooded lawn, consider a seed mixture emphasizing tall fescue, mixed with slender creeping red fine fescue, salt-tolerant bluegrasses, and salt-tolerant perennial ryegrass. Within the different species, include as many varieties as possible for maximum adaptability and insect and disease tolerance. This will become a lower-maintenance lawn, requiring less fertilizer and irrigation.

Cut grass high, at about 2 ½" to 3", to regenerate a strong root system as the lawn recovers after the flood. Mowing too low deprives turf of its food factory, the leaves. Follow the soil test recommendations for gypsum and other fertilization.

Zoysiagrass is a warm-season grass that is hardy in coastal New Jersey and is quite salt tolerant. Zoysia looks its best in the summer, so it might be a suitable lawn grass for

Witches' broom looks like small patches of brush in a tree.

Avoid low salt tolerant plants. Dead arbor-vitae littered streets after Superstorm Sandy.

Bradford pear shows sparse flowers the spring after salt water flooding.

Plants buried in sand left by ocean flooding. Sand should be removed.

a summer home. Because it is a warm-season grass, zoysia goes dormant and straw-colored in October and stays brown until warming weather in mid-May. It is planted by plugs or sprigs and can take two or three years to cover the ground, depending on spacing of the planting. Weed control may be needed as the lawn fills in. Because zoysiagrass spreads, it can slowly invade planting beds and borders as well as neighbors' lawns.

Rutgers publications about planting and maintaining lawns are included in the source list. Also useful is "Low Maintenance Landscaping for the Barnegat Bay Watershed."

Vegetables and Edibles

If the vegetable garden gets flooded during the growing season, do not eat leafy greens or any vegetables exposed directly to the floodwater. For soil you believe to be contaminated, one possibility is to avoid growing root crops like carrots, radishes, or potatoes in the first growing season after the flood. Test the soil, and adjust soil pH as recommended. Place mulch over the soil to keep aerial plant parts off the soil, and stick to above-ground crops like tomatoes, beans, and basil. Vegetables can also be grown in containers or raised beds filled with uncontaminated soil.

As you process the vegetables, peel root crops and wash produce in potable water to remove soil particles. Discard outer leaves of crops like lettuce, because the outer leaves are the most likely to have clinging soil particles.

Like other plants, vegetables and fruits vary in their tolerance for salt in the soil. If soil salt levels are high, treat the soil with gypsum and compost as discussed above. Germinating seeds and seedlings are generally more sensitive to salt than established plants. Start seeds in pots of commercial soilless growing mix and grow the seedlings into sizable transplants before planting out in the garden.

The box below shows the salt-tolerance rank of some fruits and vegetables, based on decreases in yield as soil salinity rises. (Maas, 1984) The rankings are only guidelines. Tolerance is not an absolute characteristic, and will vary with garden conditions.

Higher Salt Tolerance	Moderate Salt Tolerance	Sensitive To Salt
Beets	Turnip	Green bean
Squash, zucchini	Radish	Carrot
Wheatgrass	Lettuce	Strawberry
Asparagus	Grape	Onion
Kale	Pepper	Celery
	Sweet potato	Prune plum
	Broad (fava) bean	Apricot
	Corn	Peach
	White potato	Pear
	Cabbage	Blackberry
	Celery	
	Spinach	
	Cucumber	
	Tomato	

This Japanese black pine's needles were badly burned in Superstorm Sandy, but the buds are plump and alive and the tree will recover.

Junipers after Superstorm Sandy. Dead foliage shows how high flood water rose.

Plants vary in response to saltwater flooding. Here, two side-by-side flowering cherries; one thriving and one dead after Superstorm Sandy.

Plants may survive ocean surges better than houses do.

A moderate level of salt in the soil may not be a bad thing. In small quantities, sodium and chloride are plant nutrients. Field trials conducted at Rutgers University (Heckman, 2009) indicated that some people preferred the flavor of tomatoes produced by plants fertilized with sea salts. Researchers were careful to irrigate only the soil with saltwater, keeping it off the leaves. In addition, University of Pisa researchers (Sgherri et al., 2008) found higher levels of antioxidants in tomatoes irrigated with ocean water.

Soil Contamination

Aside from salt, should you worry about contamination of the soil? Contamination can occur as the result of disruption of nearby facilities such as septic systems, sewage treatment plants or outfall lines, industrial chemical sites, or sources of gasoline or oil. Is it likely that your soil is contaminated after flooding?

We can look for guidance to soil testing done after storms. For example, after the massive, prolonged flooding of Hurricanes Katrina and Rita in 2005, Louisiana State University soil scientists found normal levels of salt, lead, cadmium, nickel, zinc and mercury in tested soil samples (LSU 2005). They pointed out that whatever pollutants washed onto properties were very diluted by sea water, and therefore little pollution was actually deposited in the soil. These soil scientists recommended that they saw no need for special soil testing in flooded areas.

Before Superstorm Sandy in 2012, the US Environmental Protection Agency (EPA) secured Superfund sites in New York and New Jersey. Inspection of the sites after the storm found little impact on the sites and no expected threat to human health. Pollutants did not seem to move off site.

People living near wastewater treatment outfall lines may be particularly concerned about enteric bacteria in floodwater. EPA testing of the ocean water after Superstorm Sandy in areas of waste treatment outfalls found elevated levels of fecal coliform bacteria (EPA 2012). Therefore, direct exposure to the floodwater posed some risk of contracting a gastrointestinal disease.

It makes sense to avoid floodwaters, and to stay away from standing water, saturated soil, and flood debris in the immediate aftermath of the flood. Frequent hand washing and wearing gloves, masks, and safety glasses are commonsense protections against bacteria and other contaminants in floodwater. Read more about it at the websites and factsheet links listed below.

The Centers for Disease Control and Prevention (CDC) points out that there are many variables that affect how much microbial contamination from sewage treatment plants gets deposited in soil, including how much contamination was originally released and the level of treatment received by wastewater before it was released. The breakdown of microbes in the soil is also variable, depending not only on the type of microbe but also on environmental factors. Sunlight, drying of soil, air temperature, and soil pH all help inactivate bacteria and viruses. Although there are exceptions, the CDC says that it takes about two or three months for most enteric bacteria to break down in the soil (CDC, 2011).

There are some commonsense signs of chemical contamination. For example, gasoline has a strong smell. Gasoline and other light hydrocarbons, such as benzene, volatilize and leave the soil rather quickly. Oil, on the other hand, leaves a black residue that may have a sheen, and water will bead up on oil-soaked ground. If you find oil on your property, there is a DEP hotline to report it, at 1-877-WARNDEP. The EPA publishes factsheets on dealing with the aftermath of flooding, including one on oil contamination (EPA, 2012). It recommends steps such as incorporating compost into soil to encourage growth of microorganisms that break down oil. The fact sheet also recommends cutting oil-coated shrubs and herbaceous plants to the ground and composting or disposing of the material in the trash.

Private laboratories can test for chemicals such as heavy metals and hydrocarbons, but testing for unknowns can become expensive because there are so many possible chemical contaminants. If you want to pursue it, you can call the NJ Department of Environmental Protection Office of Quality Assurance at 609-292-3950 to find a laboratory. You can also search their website, http://www.nj.gov/dep/oqa by clicking on the "certified laboratories" box and select "solid hazardous waste labs" from the list. Many of the listed laboratories are private, but some will accept soil samples from the public.

But what about later on? What about children playing outside? What about growing vegetables in the soil? What about the dust coming in the window? The CDC (2011) published guidance for public health authorities, but some of the recommendations can be applied to individuals and home properties. They recommend, for example, that sand in sandboxes and soil, mulch, and wood chips around outdoor play equipment may need to be removed, and that outdoor equipment exposed to floodwater should be cleaned before use.

Further recommendations about cleaning up sediments after a flood can be found in publications (Vermont, 2011; EPA, 2012) included in the reading list, but the following are some of the recommendations for dealing with contaminated soil:

- Cover contaminated soil with clean soil, mulch, or other materials, especially around play equipment.
- Plant new grass or other vegetation as needed to keep plants growing to cover the surface and hold soil in place.
- Keep soil outdoors by using doormats, leaving shoes at the door, cleaning tools and boots outside, and damp-mopping floors.
- Frequently replace filters on heating and air conditioning systems.
- Wash pets, and wash hands after handling pets that go outside.
- Wear gloves when handling soil and change dirty gloves frequently.

If the next storm that roars onto the New Jersey coast brings saltwater into your garden, remember that the flood water itself is the most likely cause of illness. Avoid contact with the flood, and then start thinking about how to bring back your landscape. The sources listed here contain further insights about recovering from saltwater flooding.

Sources, Further Reading, and Useful Websites

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