SCIPP

A NOAA RISA TEAM

Drought Communication Resources

DROUGHT COMMUNICATION RESOURCES

This document contains sample tweets, tip sheets, short explanations, references, and messages about topics related to drought. It is designed as a resource for communities to share as they are encouraging water conservation practices during drought. Each subject contains background information about the impacts of drought and some tips on how people can manage their homes and activities to reduce those impacts.

There are 6 topics covered:

- Drought and Your Yard
- Drought and Water Quality
- Drought and Wildfire
- Drought and Wildlife
- Surface and Groundwater
- Drought and Recent Rainfall

The first section contains sample tweets on each subject. We recommend that you share some of these tweets when your area shows up as Abnormally Dry (D0 – yellow) on the U.S. Drought Monitor: https://droughtmonitor.unl.edu/ and periodically while you are in various stages of drought. It would be good to share some from time-to-time even when you are not in drought, just to keep water awareness among the people who follow you.

The first page of each of the topics is designed as a 1-page “tip sheet” that you can share on a website, via social media, or as a handout. The tip sheet is a combination of background about the topics, how drought impacts that topic, and things that people can do to lessen impacts. The pages that follow provide a bit more background on the topic. This is geared toward a city manager, utility manager, water manager, emergency manager, or others who what to learn more details about the topic before posting information. The section also contains resources to other online guides that provide more in-depth background. Lastly, there is a script for a video. Our hope is to develop animated videos to accompany each topic; so far only one (surface and groundwater) has been completed. But the script can be useful for sharing as a Facebook post, for example.

We hope that you will find these useful. We would love to hear your suggestions for other topics and how you have used these resources.

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DROUGHT TWEETS

Drought and Your Yard

A brown lawn is not a dead lawn. Most lawns can go at least 3-4 weeks without water without significant damage.

“microclimates” in your yard – sandy soils, steep slopes, areas in direct sunlight, and areas near sidewalks and drives – may need more frequent watering. Hand-water these areas rather than the entire yard.

Frequent, light watering is actually harmful to grass. Infrequent, deep watering encourages plant root growth, which makes them more resilient to drought.

Irrigate your lawn only when necessary rather than on a fixed schedule. Just ¼ to ½ inch every 2-3 weeks will maintain roots and crowns.

Watering early in the morning rather than evening reduces chances for plant disease.

If you are planting a new lawn or garden, group plants by watering needs to you do not have to water the entire area frequently.

Increase mowing height – it helps root growth, shades soil, and inhibits weed growth. A sharp blade gives a clean cut that reduces the grass’ water use.

Drought and Wildlife

When it gets dry in areas surrounding the city, animals will come into neighborhoods looking for food. This includes your trash cans and food left out for pets.

As animals travel farther in search of food during drought, they will cross more roads. Be careful driving, especially near dawn and dusk.

Animals looking for food in neighborhoods, such as racoons, skunks, and opossums, may carry diseases. Be careful to keep your pets away from them.

Damage to habitats from drought is often temporary, but extreme drought can cause longer-lasting changes. This includes nesting and spread of disease.

If there are more wild animals around your neighborhood, store your trash cans securely and keep food inside. Cleaning trash cans and barbecues will reduce odors that may attract them.

Surface and Ground Water

Ground water and surface water are actually connected. Pumping from a well drains surface lakes, ponds, and streams.

Water moves through soil just as it does on the surface, although much more slowly. Intercepting it with wells prevents it from reaching streams and lakes

Gaining streams receive water from ground water movement, while water seeps from stream beds into ground water in losing streams.

The water table – the depth you have to dig to reach ground water – can change by season or in response to drought. A high water table contributes to surface water flow in rivers.

Everything must balance. Taking water out from one part of the system affects all parts. Pumping reduces surface water.

Over-pumping ground water can cause flow to reverse, causing water to move from streams, ponds, and lakes, toward the underground well.

Reversal of groundwater flow due to pumping can draw pollutants from surface water into underlying aquifers.

Drought and Water Quality

Blue-Green algae (cyanobacteria) may flourish during drought, affecting water quality in stagnant lakes and ponds

Runoff of chemicals from yard fertilizers and other sources provides nutrients that can cause algae blooms that can cause illness and kill fish.

When blue-green algae is present, additional treatment for water supplies is needed, which adds cost. Limiting yard fertilizers can reduce the likelihood of algal blooms.

Low water levels and warm water temperatures reduce dissolved oxygen in the water to dangerous levels for fish and other aquatic life.

Nitrogen and phosphorus from fertilizers reduce the amount of dissolved oxygen that fish need and can cause algae blooms that release toxins into lakes.

Runoff after an extended drought can carry excess sediment to rivers and lakes, increasing turbidity (how murky the water looks). Cleaning sediments creates more work and cost for water utilities.

Drought and Wildfire

Drought following a wet spring or summer increases wildfire risk, especially in grasslands. The wet growing season creates lots of vegetation that if dried out quickly can become fuel for fires.

Droughts during summertime heat or during winter dormant seasons for grasses creates fine fuels that can burn easily. Extra care is needed to not create any sparks.

Wildfires need heat, fuel, and oxygen. Any warm, windy day can supply two out of the three. Drought provides the fuel by drying out grasses which can catch fire easily under the right weather conditions.

In the Southern Plains, the frequency of shifts between wet and dry periods has been increasing. This creates vegetation build-up followed by drying that creates abundant fuels for wildfires.

La Niña, cooler waters in the tropical Pacific Ocean, favors droughts in the Southwest and Southern Plains, which may heighten the risk of wildfires.

Some of the largest wildfires in Texas, Oklahoma, and Kansas have occurred during drought following a very wet year. This allows buildup of vegetation that makes fires difficult to extinguish.

Drought and Recent Rainfall

It may be raining, but water restrictions are still in place. It takes a while for lakes and ground water to recover after a drought.

It may take several heavy rainfalls after a drought before lake levels begin rising. Dry soils and empty farm ponds will intercept a lot of the rainfall before it can run off to the lakes.

It may be raining here, but maybe not where our water comes from. Water may be pumped from many miles away. It may still be dry there.

DROUGHT AND YOUR YARD

1 HOW DROUGHT AFFECTS LAWNS AND PLANTS

- Lawns are more resilient than many people realize
- Newly seeded or sodded lawns need frequent irrigation until they become established
- Established lawns rarely need irrigation; grass can survive extended dormancy without significant damage
- Grass can survive 4-5 weeks in dormancy without damage to its roots or crowns (3-4 weeks if temperatures consistently above 80°F)
- “Microclimates” within the yard can affect water demands – sandy soils, slopes greater than 5%, slopes facing south or east, areas receiving more direct sunlight, and areas near cement drives and sidewalks may need more frequent watering.

2 ROOTS, SOIL, AND WATER

- Water use is dependent upon root depth, soil type, and vegetation height
- Most grasses have roots depth of more than 18 inches and can access deeper soil moisture, even if the top layer is dry (some cool-season grasses such as Kentucky bluegrass or perennial ryegrass have shallower root systems, only have 6-18 inches)
- Infrequent, deep watering encourages root growth and increases drought tolerance, compared to frequent but lighter watering
- Plants with small leaf area, light-colored leaves, and deep roots can survive longer without water
- Warm season grasses (such as bermuda or zoysia) generally require less irrigation
- Soil texture and compaction affect water retention; loam soil and aerated soils allow water infiltration and root growth

3 MANAGING TURF & PLANTS

- Irrigate only when necessary rather than on a schedule; only ¼- ½ inch every 2-3 weeks will maintain roots and crowns
- Check your irrigation system for leaks
- Water slowly to allow water penetration and prevent runoff; using drip or soaker hoses is recommended
- Wet soil to 4-6 inches depth, sufficient for most root systems
- Early morning watering reduces chances for disease as compared to evening watering
- Group plants by watering needs, so you do not have to water the entire yard frequently
- Increase mowing height to 2.5 to 3 inches – it helps root growth, shades soil, and inhibits weed growth
- 3 inches or more of mulch will insulate soil, reduce evaporation, and protect roots
- Reduce fertilizer use and aerate soil to improve water infiltration rate

HOW DROUGHT AFFECTS LAWNS AND PLANTS

When asked to describe drought, often people will mention brown lawns. But brown lawns are not necessarily damaged lawns. Being able to discern when a lawn is in trouble versus its normal defense mechanism to a dry period is important.

Drought can impact plants through stunted growth, increased disease susceptibility, and increased susceptibility to winter injury, especially during abrupt temperature changes. Initially, growth stops and foliage wilts as plants become stressed. Signs of stress include wilting and curling of leaves and browning. Thresholds for mortality vary depending on the type of plant. Plants with small leaf area, such as grasses, lighter-colored leaves, and deep-rooted plants can survive longer without water than their counterparts. While flowers and shrubs may show signs of stress and be more subject to mortality, grasses are often much more resilient.

Lawns will turn brown after a brief dry spell, especially if temperatures are high, but will green up quickly as cooler, wetter weather returns. It is important not to confuse dormancy with damage. Most turfgrasses can survive in dormancy for 3-4 weeks without rainfall, longer if temperatures are below 80 degrees. Warm-season grasses are evolved to survive hot, dry summer months. These go dormant when soil moisture is depleted and come out of dormancy as moisture returns.

Initial signs of water stress to turfgrass is an off-color grayish-blue hue. Footprints may remain visible in the lawn instead of typically springing back after foot traffic. Although growth will slow or stop when stressed, grasses can go into dormancy and survive for several weeks without water, as long as the crowns (growing points) are protected. Plants with deep roots (such as tall fescue) can survive longer without water. Consequently, irrigation can be reduced without harming most turf. The exception is newly seeded or sodded turf, which needs more water until root systems can be firmly established.

You may also notice certain areas of the yard that show stress or go dormant more quickly than others. These “microclimates” are created by the soil, slope, and surroundings. Sandy soil will drain quickly. Compacted soils will not retain water well. Either of these are susceptible to stress. As soil conditions may vary greatly across a yard, you may see some brown patches amid other green areas. These should be hand-watered more frequently than the rest of the yard. Slopes greater than 5% also do not retain soil moisture well and may need more frequent watering. Slopes facing south and west or areas in full sunlight may dry more quickly, as they receive more direct sunlight and lost more water to evaporation and transpiration (or “ET” – evapotranspiration) than other areas. Areas near cement drives and sidewalks may also dry more quickly, as cement or asphalt heats quickly in the sun, warming the soil adjacent to it, and increasing evapotranspiration (ET). Other areas may need less water – places near buildings and hedgerows may lose less water as lower wind speeds reduces water loss.

ROOTS, SOIL, AND WATER

Soil texture affects water retention. There are three main types of soil: sand, silt, and clay. Sandy soil is made up of relatively large soil particles with large pore spaces. This provides good aeration but allows water and nutrients to drain rapidly. Clay soil with small particles and small pore spaces retains more water and nutrients, but can result in poor drainage and insufficient oxygen for plant roots. Silt retains moisture better than sandy soil, although it is easily compacted and may consequently have fewer pore spaces. Loam, a mixture of the three types, provides the benefits of all three – easy to cultivate and aerate, retains moisture, and drains well. The type of soil is going to have a large influence on the water needs of plants growing above.

Only a small percentage of water taken up by grasses is used for growth. Most is lost to the atmosphere through transpiration. Warm-season grasses are more efficient at carbohydrate production under water stress compared to cool-season grasses. Warm-season grasses can survive on only 20% of available ET compared to 40% for cool-season grasses. Consequently, cool-season grasses need to be watered more frequently during a drought, while warm-season grasses can survive several weeks without any watering at all. Grasses with deeper roots, such as Bermuda and Zoysia grasses in clay or loam soils, can survive much longer. In fact, infrequent, deep watering, encourages deeper root growth which increases drought tolerance.

It is also important to allow water to penetrate to the root zone. Thatch buildup (excessive roots, stemps, stolons, and rhizomes), more than ½-inch thick, slows water penetration to the soil and root zone, leading to shallow rooting. Excessive thatch should be removed during fall or spring when soil temperatures are cooler. Soil compaction can also reduce water infiltration and increase runoff. Soil aeration – breaking up soil to allow more pore spaces – improves shot and root growth, water infiltration rate, and water use efficiency.

MANAGING TURF & PLANTS

A lot of water can be saved by reducing irrigation, without harming the long-term health of your lawn. Irrigate only when necessary rather than on a fixed schedule. Most lawns only need ¼ - ½ inch of water every 2-3 weeks to maintain healthy root systems and crowns. Grass does not need to be green to be healthy; it can survive in dormancy for an extended period. Dormancy is a natural defense mechanism for grass – bringing it out of dormancy during a hot, dry period may actually make the grass more susceptible to impacts of heat and drought. Light, frequent watering is harmful because it encourages shallow rooting, making lawns more susceptible to drought and extreme heat.

When watering, water slowly to allow water to penetrate throughout the root zone in the soil. Soil should be moist to a depth of 4-6 inches. Irrigate to wet the roots and do not irrigate again until stress appears; this will increase rooting depth and decrease water losses to evapotranspiration. Areas that may need more frequent watering, such as “microclimates” where soil conditions or slope may drain water more quickly, should be addressed by hand watering rather than irrigating the entire lawn. When watering, wait for water to infiltrate before resuming watering; ponding and runoff are not helpful to the lawn.

Irrigation should be done in the early morning. This maximizes water availability, reduces evapotranspiration, and minimizes disease potential. Watering in the evening increases chances for disease and watering during the day increases water losses through evaporation. If using an irrigation schedule, adjust the schedule monthly to reflect seasonal changes in temperature, wind, humidity, and rainfall. Check your irrigation system for leaks, broken heads, faulty valves, and other malfunctions. Lastly, watch the forecast – there is no need to irrigate if rain is predicted in the near future (remember, a half-inch of rain can maintain healthy roots for 2-3 weeks).

When planting, select plants that are appropriate for the climate and soil type. Most new plantings need regular watering until they are established, but will require less water thereafter. If possible, group plants according to watering needs, placing those that need more frequent watering in the same area of the yard so that the entire yard does not have to watered frequently. Most trees, shrubs, and ground covers will not need watering at all, once established. Lightly pruning plants during winter dormant season or early in spring reduces water demands; heavy pruning requires more water as plant growth is increased.

Mowing can also reduce water demands. Increasing the mowing height to the maximum recommended height for the species reduces water use through improved root system development. Taller grasses also shade the soil, reducing the likelihood of sunburn injury and reducing weed seed germination. Sharpening the blade is also important. Sharp blades give a cleaner cut and cause less stress to the grass; a dull blade leaves jagged cuts that can increase water loss by 30-50 percent.

As grasses go dormant or slow growth, they will also need less nitrogen fertilizer. While abundant use of fertilizer may make a lawn look healthy, that is not necessarily the case. Excessive fertilization causes poor root growth and excessive topgrowth and increases water use. The rapid growth also causes grass to wilt faster during drought. Therefore, during drought, decrease fertilization to lowest recommended range and timing.

When grass is stressed or dormant, reduce turf traffic, if possible. This includes foot traffic, lawnmowers, and vehicles. Heavy traffic during drought can also compress the soil pores. During drought, the pores are filled with air instead of water, and have less resistance to collapse as pressure is applied to the soil above. This adds to soil compaction, which lessens the overall health of the lawn.

In gardens and flowerbeds, mulch insulates soil, reduces evaporation, maintains consistent soil temperature, and protects roots from heat and drying. Three inches or more of coarse mulch provides sufficient protection for most plants. Keep much several inches away from the trunks of trees or shrubs to reduce root and crown diseases and pathways for insects to damage the trees.

RESOURCES

Water Wise: Drought Effects on Turf in the Landscape
University of Nebraska-Lincoln Extension
https://extension.unl.edu/statewide/douglas-sarpy/pdfs/ce/resources/ce-g2191-water-wise-drought-effects-on-turf-in-the-landscape.pdf

Drought Damage – Lawn
Home and Garden Information Center
University of Maryland Extension
https://extension.umd.edu/hgic/topics/drought-damage-lawn

Drought Impacts on Landscape Plant Survival
eXtension.org
https://articles.extension.org/pages/62311/drought-impacts-on-landscape-plant-survival

Water Conservation Tips for the Home Lawn and Garden (publication 8036)
University of California-Davis Extension
https://anrcatalog.ucanr.edu/pdf/8036.pdf

Managing Turfgrass during Drought (publication 8395)
University of California-Davis Extension
https://anrcatalog.ucanr.edu/pdf/8395.pdf

DROUGHT AND YOUR YARD VIDEO

We often look at a brown lawn and think the grass is dying, but in reality, it is much tougher than many people expect. Just as lawns may turn brown in winter, they are not dead, they are just dormant. Many grasses can survive for more than a month in dormancy without water, even in the heat of summer.

The amount of water that plants need depends upon root depth, soil type, vegetation height, and of course, the plant's ability to withstand drought. Plants such as flowers and ornamentals usually need more frequent watering than grass, shrubs, or trees, once they are established. Most grasses can access deep soil moisture even if the top layer is dry.

When a lawn does need water, water slowly over a long time to let water sink in. This encourages deeper root growth, with improves drought tolerance, compared to frequent but less watering which causes shallow roots. Be sure to check your irrigation system for leaks to make sure you are not wasting water!

There may be spots in your yard that need a bit more water than others. Soil texture and compaction, areas that receive more direct sunlight, or areas near cement drives and sidewalks, can all use up water faster. If possible, group plants by watering needs so you do not have to water the entire yard as frequently. Increasing mowing height helps root growth, shades the soil, and inhibits weed growth – but be sure to use a sharp blade; jagged cuts actually increase the amount of water used by grass. You can also save water by using mulch in garden areas, aerating the soil, removing excess thatch, and reducing fertilizer use.

So, when you see your grass beginning to turn brown, don't panic. Just keep an eye on it and give it a nice drink every few weeks.

DROUGHT AND WATER QUALITY

1 BLUE-GREEN ALGAE (CYANOBACTERIA)

- When drought has been ongoing for a length of time, the soil becomes hardened and doesn't easily absorb rainfall
- Due to the hardened soil, the first several rainfalls after an extended dry period experience increased water runoff, especially into streams and lakes
- Increased runoff brings unwanted chemicals, especially yard fertilizers and other chemicals into nearby streams and lakes
- Additional chemicals into a stream or lake can cause an increase in bacteria growth, and coupled with warm daytime temperatures, can lead to algal blooms
- Blue-Green Algae, or Cyanobacteria, is one such algal bloom that can cause illness in humans, and cause fish kills
- Blue-Green Algae can also affect the drinking water supply, adding and costing more to the treatment process

2 DISSOLVED OXYGEN

- Fish and other aquatic life need dissolved oxygen in streams and lakes to survive
- When water levels are stable and relatively high, dissolved oxygen levels help maintain a healthy ecosystem
- When water levels get low, and have little to no flow, dissolved oxygen levels can decrease to levels dangerous for fish and other aquatic life
- Dissolved Oxygen decreases as Temperature increases
- Nitrogen and Phosphorus in the water can decrease the amount of Dissolved Oxygen
- Blue-Green Algae can also decrease the amount of Dissolved Oxygen in the water
- Drought conditions increase the risk of Dissolved Oxygen depletion in water bodies

3 TURBIDITY

- Turbidity is how clear the water is
- Turbidity can increase with water runoff due to increasing sediment and water flow
- Drought can cause increased runoff when it does rain, thereby increasing turbidity
- Drought is often made worse by high temperatures, which can decrease water levels (and also increase turbidity)
- Turbidity can cause issues for water treatment plants, as treatment plants have to monitor and report the amount of Total Suspended Solids and Total Dissolved Solids

BLUE-GREEN ALGAE

Blue-Green algae, or cyanobacteria, is present in almost all lakes, streams, and rivers, but typically at very low levels. During the summer months, as temperatures rise, the warm water can provide an environment favorable for the cyanobacteria to grow. Cyanobacteria also need nutrients to bloom, specifically phosphorus and nitrogen. Those nutrients are found in the soil, either naturally or added by fertilizer.

During drought conditions, the soil can become hardened and exacerbate runoff from any rainfall that does occur. This enhanced runoff can bring increased levels of these important nutrients, phosphorus and nitrogen, into nearby streams and lakes. With the increased nutrients and abundant sunshine and warmth, blue-green algae can rapidly reproduce. Prolonged drought conditions can create additional favorable environments for algae to grow, including shallow and slow-moving water.

Visually, it is easily recognizable by its bright green color, and its thick appearance. A common reference is that it looks like pea soup. Blue-Green algae itself is not harmful, but the algae can release toxins into the water that are both harmful to humans and aquatic life. In recent years, there have been several instances of fish kills that were linked to blue-green algae blooms. In 2011, several people became ill after swimming in an area lake that had blue-green algae blooms present.

Not only is Blue-Green algae a health concern, but it can also impact drinking water. Water where algal blooms are present can cost more to treat effectively. Likewise, many recreational lakes may face economic impacts when algal blooms are present. Many recreational lakes may reduce or close areas of the lake to protect humans and pets from coming in contact with the potential toxins.

DISSOLVED OXYGEN

Dissolved Oxygen is the measure of the amount of oxygen that is dissolved in the water. This is the amount that is available for fish and other aquatic life. Water that moves quickly, such as a high, full stream, contains high amounts of dissolved oxygen. Stagnant water, on the other hand, or water that does not flow very much, tends to have low amounts of dissolved oxygen.

During periods of drought, water levels in streams and lakes tend to decrease. Decreasing water levels, especially within streams, leads to more areas of stagnant water. Likewise, since many droughts are at their peak during the hottest times of the year, warm temperatures, and warm water temperatures, also decrease levels of dissolved oxygen. Dissolved oxygen is inversely proportional to water temperature (when one goes up, the other goes down).

Similar to Blue-Green Algae, Dissolved Oxygen can also be affected by nutrients being added to the stream or lake. Both nitrogen and phosphorus, which add to Blue-Green Algae growth, can reduce the amount of dissolved oxygen in the water. The presence of Blue-Green Algae can also reduce the amount of Dissolved Oxygen in a water body.

Dissolved Oxygen is a great reflection of the water quality in a stream or lake.

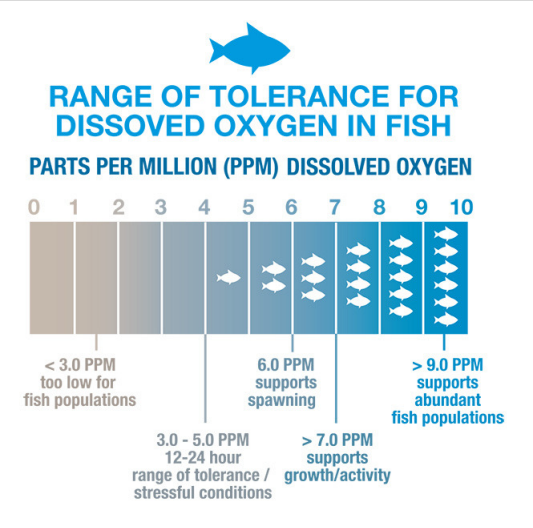

Image courtesy: https://www.water-research.net/index.php/dissovled-oxygen-in-water

TURBIDITY

Turbidity refers to a visual characteristic of water – how clear is the water? The physical measurement reflects the amount of light that is scattered by any material in the water. If the intensity of the scattered light is high, turbidity is high. Any material in the water can affect turbidity. That includes soil, sediment, algae, etc. If you can look at a stream, and the stream appears cloudy, then turbidity is high.

Turbidity increases when heavy rainfall and runoff brings sediment into streams and lakes. The increased flow, along with the soil, sediment, and other debris, will make the water cloudier and cause turbidity to increase. During periods of drought, the soil becomes hardened, allowing for more runoff when rain does occur. Runoff can bring both higher levels of sediment, and increase water flow. Likewise, drought conditions are made worse by high temperatures. High temperatures cause evapotranspiration, or evaporation off of water bodies. As the water levels decrease, turbidity can also increase as there is less area for the sediment to accumulate in.

Turbidity can also cause problems for drinking water treatment. Since turbidity can be increased with increasing sediment into a water body, that increased sediment has to be filtered out during the treatment process for drinking water. Total suspended solids (TSS) and total dissolved solids (TDS) are two measurable variables that water treatment plants have to analyze and report to EPA.

RESOURCES

Blue Green Algae Fact Sheet
Oklahoma Department of Environmental Quality
http://www.deq.state.ok.us/factsheets/general/bluegreealgae_web.pdf

Inhofe blames illness on lake algae
The Hill
https://thehill.com/blogs/blog-briefing-room/news/169511-inhofe-blames-illness-on-oklahoma-lake-algae

Harmful Algal Blooms
US Environmental Protection Agency
https://www.epa.gov/nutrientpollution/harmful-algal-blooms

Drought Stressor Monitoring Case Study: Dissolved Oxygen Monitoring in the San Joaquin and Stanislaus Rivers
California Department of Fish and Wildlife
https://www.wildlife.ca.gov/Drought/Projects/San-Joaquin

Dissolved Oxygen and Water
USGS
https://www.usgs.gov/special-topic/water-science-school/science/dissolved-oxygen-and-water?qt-science_center_objects=0#qt-science_center_objects

Dissolved Oxygen in Water
Water Research Center
https://www.water-research.net/index.php/dissovled-oxygen-in-water

Turbidity and Water
USGS
https://www.usgs.gov/special-topic/water-science-school/science/turbidity-and-water?qt-science_center_objects=0#qt-science_center_objects

Turbidity, Total Suspended Solids & Water Clarity
Fondriest Environmental Learning Center
https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

DROUGHT AND WATER QUALITY EDUCATIONAL VIDEO

Have you ever wondered why some water is cloudier than others? Or why your favorite swimming area at your local lake looks like pea soup? These are both visible reflections of the quality of the water.

During times of drought, when it does rain, the runoff can bring all sorts of unwanted things into nearby streams and lakes. Soil, sand, lawn chemicals (especially phosphorus and nitrogen), can all get washed into nearby streams and lakes after rain events. During the heat of summer, evapotranspiration off of streams and lakes can decrease the water level. When the water level is low, water can warm up more quickly. As water warms, any chemicals, such as nitrogen and phosphorus, as well as all other nutrients that have been added to the water, can cause algae to grow. One such algae that can form is Blue-Green Algae. Blue Green Algae itself is harmless, but when it releases toxins into the water, it can cause respiratory illness in humans and distress or death in fish and other aquatic life.

Similarly, as water levels decrease, the water can warm quickly. As it warms, the amount of Dissolved Oxygen decreases. Dissolved oxygen is very important for fish and other aquatic life. As Dissolved Oxygen decreases, it can cause distress and death for the aquatic life.

Turbidity can also cause water quality problems. A measure of water clarity, turbidity is how clear the water looks. If it's cloudy, turbidity is high. Both fast, moving water, and increased runoff of soil and other debris can increase turbidity. Turbidity can also increase as water levels decrease, as sediment is confined to a smaller area. Water treatment plants measure for turbidity, and have to treat the drinking water for the increase is sediment.

So, next time you look at a stream or lake, pay attention to how clear the water is, or if there appears to be any algae present. These are good indications of the quality of the water.

DROUGHT AND WILDFIRES

1 FIRE AFTER FLOOD

- Drought can occur even after a recent rainy period
- Rainfall during the winter and spring can enhance spring plant and vegetation growth
- Summertime heat, and lack of rainfall, can dry out the soil
- Excessive spring plant and vegetation growth can also dry out
- The excessive dry vegetation can provide plenty of tinder should a wildfire start
- New research is suggesting that wet years (pluvials) transitioning to extremely dry years are becoming more frequent in the Southern Plains
- Any warm, dry, windy day is able to produce large wildfires if dry vegetation is present.

2 WILDFIRE AND ENSO (EL NINO SOUTHERN OSCILLATION)

- ENSO, the El Niño Southern Oscillation, refers to the temperature of ocean waters in the central and eastern tropical Pacific Ocean, and how those temperatures affect global weather patterns
- El Niño reflects warmer than normal sea surface temperatures in the central and eastern tropical Pacific Ocean
- In the Southern Plains, El Niño conditions tend to produce wetter than normal conditions
- La Niña reflects colder than normal sea surface temperatures in the central and eastern Tropical Pacific Ocean
- ENSO neutral conditions reflect near average sea surface temperatures in the tropical Pacific Ocean
- In the Southern Plains, ENSO neutral conditions tend to produce warmer than normal conditions
- Drought associated with La Niña creates an increased wildfire danger in the southwest and Southern Plains

3 RECENT WILDFIRES

- The September - October 2011 fire in Bastrop County, Texas was the worst wildfire in Texas history
- The Bastrop fire was exacerbated by the extreme drought conditions in Texas in 2011, after a wet 2010 year
- April 2016 saw historic wildfires across NW Oklahoma and Southern Kansas burning more than 50,000 acres (350 Complex Fire), and 360,000 acres (Anderson Creek Fire), following an exceptionally wet 2015
- During a short-term drought following a very wet summer and fall the previous year, the April 2018 Rhea fire in NW Oklahoma and burned more than 280,000 acres

FIRE AFTER FLOOD

Fires need heat, fuel, and oxygen. Dry vegetation is the main source of fuel. Dry grasses will ignite easily, causing thicker fuels such as sticks, shrubs, and trees to burn if they are also dry. Heat and oxygen are supplied by daily weather conditions. Warm, windy days with dry fuels become ready to burn if there is an ignition source, such as sparks, lightning, or cigarettes. When these weather conditions are present, the National Weather Service may issue a Red Flag Warning, meaning there is an increased risk of fire danger. In some states, a burn ban may be in place, meaning no outdoor burning is allowed. Some of the biggest fires have been in spring, during dry winter through spring, and following a wet summer the previous year.

After a recent period of heavy rain, it may be hard to understand how drought conditions could be just around the corner. In some instances, rapid onset drought, or “flash drought”, can occur rapidly, even after heavy rain events. If heavy rains fall during the autumn or winter months, this can help enhance spring vegetation growth. Any additional rain in spring will add to that vegetation growth. When summer arrives with high temperatures and little or no rainfall, the vegetation that grew from the fall, winter, or spring rains can rapidly dry out. This dry vegetation can act as increased fuel for any wildfires that do develop.

Recent research has shown an increase in frequency of pluvial, or extremely wet years. In contrast, many of these pluvial years are followed by a period of dryness. Therefore, extremely wet years can enhance vegetation growth so when the dry period does occur, you have an increase in available fuel for wildfires, which increases the risk of uncontrollable burning.

Notable pluvial years in the Southern Plains in recent history include 2010, 2015 and 2017. All three of those years were followed by periods of dryness and enhanced wildfire conditions. Those years, 2011, 2016 and 2018, saw three of the top wildfire events in recent history, and the worst wildfire in Texas history.

WILDFIRE AND ENSO (EL NIÑO SOUTHERN OSCILLATION)

Are there certain weather patterns that enhance wildfire risk? Yes, there are. Generally, warm temperatures, low relative humidity, and gusty winds can enhance fire weather conditions. What about global patterns? For that answer, we turn toward ENSO – the El Niño Southern Oscillation. ENSO refers to the temperature of ocean waters in the central and eastern tropical Pacific Ocean, and how those temperatures affect global weather patterns. El Niño reflects warmer than normal sea surface temperatures in the central and eastern tropical Pacific Ocean. Likewise, La Niña reflects colder than normal sea surface temperatures in the same region.

In the Southern Plains, El Niño conditions tend to produce wetter than normal conditions, whereas La Niña conditions tend to produce drier than normal conditions. ENSO neutral conditions reflect near average sea surface temperatures in the tropical Pacific Ocean. In the Southern Plains, ENSO neutral conditions tend to produce warmer than normal conditions.

The Southern Plains drought started in late 2010, and that August-September-October, and September-October-November were the 3rd strongest La Niña for that 3-month season. Therefore, there was an increased wildfire danger in the southwest and Southern Plains associated with La Niña conditions. Likewise, 2015-2016 was considered a very strong El Niño, partly contributing to the record rainfall seen throughout 2015 in the Southern Plains.

RECENT WILDFIRE EVENTS

Fueled by high temperatures, low relative humidity, and strong winds, drought conditions have exacerbated recent wildfire events in the Southern Plains. After a relatively wet year for most of 2010, the end of the year into 2011 started the beginning of the intense Southern Plains drought that lasted for several years. By September and October of 2011, drought conditions had reached exceptional levels for most of Texas and Oklahoma. On September 4, 2011, three separate fires began in and around Bastrop County in Texas. Winds in association with Tropical Storm Lee worsened the fire weather conditions, and the three separate fires merged into one. Now known as the worst fire in Texas history, the Bastrop County Complex fire burned over 1500 homes, with an estimated property damage around $325 million.

Record rainfall events in 2015 led to extensive vegetation growth across much of the Southern Plains. By March and April of 2016, dry conditions had overtaken portions of northwest Oklahoma and Southern Kansas, leading to several large wildfire complexes. In March 2016, the Anderson Creek Fire burned more than 360,000 acres across portions of northwest Oklahoma and Southern Kansas. Then in April, another wildfire, known as the 350 Complex Fire, burned another 50,000+ acres across the same region.

Another relatively wet year was 2017. By March and April of 2018, drought conditions in northwestern Oklahoma had deteriorated to extreme and exceptional. On April 12, a wildfire began near Rhea, Oklahoma, which quickly spread out of control. The Rhea fire was the largest of several wildfires, and it burned more than 280,000 acres. It was not 100% contained until two weeks later on April 25. Weather conditions during that period prompted the National Weather Service in Norman to use the word “historic” with regard to the wildfire conditions.

RESOURCES

Drought and Wildfires
North Carolina Climate Office
https://climate.ncsu.edu/edu/Wildfire

What is ENSO?
National Weather Service
https://www.weather.gov/mhx/ensowhat

El Niño Southern Oscillation (ENSO)
ESRL Physical Sciences Division
https://www.esrl.noaa.gov/psd/enso/climaterisks/years/top24enso.html

Changes in ENSO impacts in a warming world
NOAA Climate.gov
https://www.climate.gov/news-features/blogs/enso/changes-enso-impacts-warming-world

Future impacts of El Niño, La Niña likely to intensify, increasing wildfire, drought risk
National Science Foundation News Release 18-061
https://www.nsf.gov/news/news_summ.jsp?cntn_id=296344&org=NSF

Oklahoma Monthly Climate Summary May 2015
Oklahoma Climatological Survey
https://climate.ok.gov/summaries/monthly/2015/MCS_May_2015.pdf

Hundreds flee wind-whipped wildfires in Oklahoma, Kansas
USA Today
https://www.usatoday.com/story/weather/2016/04/06/oklahoma-wildfires/82698194/

The Worst Fire in Texas History
Fire Museum of Texas
http://www.firemuseumoftexas.org/the-worst-fire-in-texas-history/

OFS: Massive Rhea Fire now 100 percent contained
Fox25
https://okcfox.com/news/local/ofs-massive-rhea-fire-now-100-contained

DROUGHT AND WILDFIRES EDUCATIONAL VIDEO

It's pretty common to associate hot, dry conditions with droughts and even wildfires. But would you associate heavy rainfall events with wildfires? While there might not seem an obvious link between more water and wildfires, the connection is made by an increase in vegetation growth. Plants love it when it rains. Plants and other vegetation can grow when it rains. But when the rain stops, what happens to the vegetation? It doesn't grow smaller. It becomes dry, and brittle, and excellent material to burn. So while heavy rains, or above-normal rainfall, does not increase the risk for wildfires, it does provide the potential for wildfires to spread more easily once they do occur.

Now, this assumes that drought conditions follow the rain. And in recent history, the frequency of very wet years being followed by very dry years seems to be increasing. A prime example is 2015 into 2016. Oklahoma and Texas saw record rainfall amounts in the spring and summer of 2015. By spring of 2016, drought had established itself again in western Oklahoma. So when a large wildfire broke out (Anderson Creek Fire), excessive growth from the previous years' rains had dried out and provided extensive kindling for the wildfires. Another example happens to be the worst wildfire in Texas history. Following a relatively wet year in 2010, 2011 quickly deteriorated into extreme and exceptional drought by the fall of 2011. Three separate wildfires broke out around Bastrop County, TX, and aided by strong winds associated with Tropical Storm Lee, the separate fires merged into one large fire that burned for several weeks and destroyed more than 1500 homes.

While you can't forecast wildfires, you can forecast weather conditions that enhance the potential of wildfires, such as hot temperatures, low humidity, and strong winds. Another forecasting tool is understanding the ENSO – El Niño Southern Oscillation. El Niño, brought on by warmer than normal sea surface temperatures in the tropical Pacific, can bring increased chances of rainfall to the southern tier of the United States. The most recent strong El Niño was 2015 into 2016. As mentioned above, 2015 was an above-normal precipitation year for much of the Southern Plains. Similarly, La Niña reflects colder than normal sea surface temperatures in the Tropical Pacific Ocean, and tends to enhance dryness across the Southern Plains region. There can be some connections made to La Niña conditions enhancing the potential for both drought conditions to develop and potential wildfires. So knowing your local weather conditions, and understanding how global weather patterns can affect your local conditions, you can begin to forecast times when wildfires may be more likely.

DROUGHT AND WILDLIFE

1 SEARCHING FOR FOOD

- Drought causes food supply to shrink and can alter habitats
- Animals will expand their range – traveling farther than usual in search of food, water, and cover, including into neighborhoods and backyards
- Increases in interactions with people results in more accidents on roadways and potential disease transmission
- Drought can also affect migrations of butterflies and waterfowl that may change their migration routes to find food
- Amphibians and fish are also affected by diminished water supplies and warmer waters

2 CHANGES IN HABITAT

- Damage to habitats is often temporary, but extreme drought can cause longer-lasting changes
- Wildfires during droughts may burn longer and hotter, having a greater impact on food and shelter for wildlife
- Fewer suitable locations for nesting may affect over-wintering and breeding, creating a decline in populations that may last several years
- Trees and shrubs produce fewer flower buds, meaning fewer fruits and nuts the next year, and become more susceptible to insects

3 INCREASED VULNERABILITY

- Animals have fewer places to hide which makes them more vulnerable to predators
- Ground nesting birds such as turkeys and pheasants and ground dwelling mammals such as ground squirrels are most impacted
- Disease may spread more easily as animals cluster around limited water and food supplies
- Predators may actually benefit from drought, as it is easier for them to spot and catch prey
- The process affects both predators and prey, with weaker members dying and strengthening the genetic pool

4 REDUCING CONTACT WITH WILDLIFE

- Store trash and food inside and clean trash cans and barbecues to reduce odors
- Clean underneath bird feeders and fallen or rotting fruit and vegetables
- Drive more slowly, especially at dawn and dusk on rural roads, to lessen chances of accidents as animals expand their ranges

Drought affects wildlife, just as it does plants and people. Wildlife have to forage for food. As food supplies diminish, animals expand their range, coming into more frequent contact with people and residential areas. In addition to reducing food supplies, drought also creates temporary, and in some cases permanent, changes in habitats that can affect survival rates for a species. If this were not enough, migrating animals and loss of ground cover make them easier prey and congregating around water sources increases disease transmission.

SEARCHING FOR FOOD

The first thing people may notice about wildlife is a change in animal behavior. Animals depend on water and plants, just like people. As drought impacts grasses, berries, nuts, and other food sources, animals will expand their range, seeking new supplies to meet their dietary needs. In some cases, animals can migrate great distances as local food supplies and water sources diminish.

Because animals are traveling further, they are more likely to come into contact with people. Deer, that often appear "shy" and tend to stay away from human development, may venture out of the fringes of woodlands into pastures and open fields in search of food. This may mean crossing roadways, which can increase the number of accidents with vehicles. Other animals, such as raccoons, skunks, and opossums, will show up more frequently in backyards and around garbage cans, forage among backyard gardens, and try to eat from bird feeders and outdoor pet food dishes. These interactions may make pets more susceptible to transmission of rabies and other diseases. Black bears are highly adaptive and mobile, with more frequent sightings of bears in suburban areas.

Less water may mean fewer insects as well. Many people may consider this a good thing, but insects are an important source of food for many animals at the bottom of the food chain. Bats and birds rely upon insects; consequently, fewer insects leads to fewer bats and birds, which escalates up the food chain. Furthermore, bats may not be able to build up the fat reserves they need for migration and hibernation, leading to a decline in populations. This means there may be fewer bats the next year eating the more abundant insects.

Drought can also affect natural migrations. Monarch butterflies and waterfowl are some of the species that have an annual migration. If there are insufficient food sources along their migratory paths, they will experience higher mortality or alter their paths. The extra effort or longer travel routes may make them more vulnerable to predators or accidents. Birds may look for alternate locations where they land, affecting breeding habits. For other animals that go into hibernation in the winter, they may not be able to build up sufficient fat reserves, increasing their risk during winter hibernation or causing them to come out of hibernation earlier the next year, before normal food sources are growing.

Even smaller animals such as amphibians and reptiles are affected as "micro-habitats" dry up. Frogs, salamanders, and newts usually do not travel far. As water sources dry up, they become more susceptible to starvation and disease. Newts may go into hibernation early and remain there longer. Aquatic animals such as fish are also affected by drought. Warmer waters reduce mixing in lakes, which reduces oxygen in deeper parts of the lakes. Warm streams also stress cool-water fish species, such as trout. Low water levels can also affect fish that migrate to spawning grounds, such as salmon.

CHANGES IN HABITAT

Habitat also provides shelter. As grasses thin, trees lose their leaves, or brush thins, and the camouflage upon which animals rely may disappear. This makes them more vulnerable to predators, but can also affect nesting habits. Animals may seek alternative habitat locations to raise young, seek shelter, and provide water sources. Increased mortality of perennial vegetation leaves less cover for over-wintering animals, which subsequently affects breeding, shelter, and predation. Damage is often only temporary, but extreme drought can cause longer-lasting changes to habitats, sometimes permanently.

During drought, dry vegetation becomes more at risk for wildfires. Wildfires may burn longer and hotter, affecting habitats for a longer period after a fire. Wildfires displace animals, sometimes pushing them into human populations in search of food and shelter. Soil erosion and sedimentation in ponds, lakes, and streams can also affect the ability of animals to re-establish themselves after a fire.

Trees and shrubs will produce fewer flower buds during drought. These buds become the fruit and nuts that the trees will produce the next year. Consequently, food supplies may be limited the year after a drought. Trees also become stressed and less able to repel invading larvae from bark beetles and wood boring insects. Populations of such insects may flourish following a drought. Other insects, such as gypsy moths, may also increase populations following a drought because fungi that typically control such populations are reduced. Insects will defoliate shrubs and trees, competing for food with other animals.

INCREASED VULNERABILITY

Grass not only provides a food source, but it also provides hiding cover. As grasses are thinned and go dormant, some animals become easier to spot. Predators benefit. Ground nesting birds such as turkeys and pheasants and ground dwelling mammals such as ground squirrels are most impacted. Higher predation rates also mean that there will be fewer young of that species the following year. This can be especially harmful for threatened and endangered species, which are already relatively few in number.

It is important to remember, however, that droughts are a natural and important part of developing ecosystem balance over millennia. Without droughts, some species would over-produce, which in turn would alter the habitat. Droughts, in this sense, reset the ecosystem. Droughts put predators at an advantage and prey at a disadvantage. Not only is it easier for predators to spot prey, but the prey tend to be weaker and congregate in greater numbers around fewer water and food sources. Consequently, predators may thrive during drought. However, this too has natural limits. As the number of prey diminishes, the weaker and diseased predator will die, actually strengthening the genetic pool.

Predators are one concern, but disease may be a far greater concern. As animals crowd among diminished water sources and areas of food, they are in closer contact which allows easier spread of disease. Deer populations have declined precipitously during some droughts, such as in Tennessee in 2007, due to diseases spread by ticks. Higher temperatures can also activate dormant bacteria in the soil, such as clostridium botulism or avian botulism. Maggots eat the bacteria and birds then eat the maggots, concentrating toxins in the birds.

REDUCING CONTACT WITH WILDLIFE

Although little can be done to compensate for the natural impacts of drought, there are some things that we can do to lessen contact with wildlife. Storing trash and food inside houses or sheds will keep it out of reach of small mammals and bears coming into urban areas in search of food. Washing out trash cans and cleaning barbecues after use will reduce odors that attract bears. Regularly cleaning underneath bird feeders will reduce a source of spilled food that attracts other animals. Cleaning up fallen or rotting fruit and vegetables from gardens and yards will also keep animals away. This not only has the advantage of fewer unwanted animals around your home, but also reduces the possibility of interaction between these animals and your pets.

In the wild, conservationists may increase monitoring of threatened and endangered species and if necessary take precautions to protect populations at risk. Fish hatcheries can maintain stocks of fish that can be re-introduced to streams and lakes after the conclusion of a drought. Driving more slowly, especially at dawn and dusk on rural roads, lessens the chances of accidents that may harm or kill wildlife.

RESOURCES

How Does Drought Affect our Lives?
https://drought.unl.edu/Education/DroughtforKids/DroughtEffects.aspx

Drought impacts on wildlife
Wisconsin Department of Natural Resources
https://dnr.wi.gov/topic/wildlifehabitat/drought.html

Drought and wildlife: Explore the connection
Michigan State University Extension
https://www.canr.msu.edu/news/drought_and_wildlife_explore_the_connection

Coexisting with Wildlife During Drought
National Environmental Education Foundation
https://www.neefusa.org/weather-and-climate/coexisting-wildlife-during-drought

Drought Hurting Animals, Plants
California Academy of Sciences
https://www.calacademy.org/explore-science/drought-hurting-animals-plants

Why lions can feast during a drought
https://www.pri.org/stories/2016-03-13/impact-drought-has-wildlife

DROUGHT AND WILDLIFE EDUCATIONAL VIDEO

Have you sometimes noticed more animals, like raccoons, skunks, and opossums, around your neighborhood at times? It may be because of drought. Animals like these, as well as bears, bobcats, and birds, have to look harder to find food during drought. As they stretch out their normal habitats, they come into neighborhoods, where they may find a good meal of garbage or something from your garden.

The reason that they have to look farther is that natural growth of grasses, berries, nuts, and other nutritious food sources, are less plentiful during drought. These animals, along with ducks, turkeys, pheasants, and ground squirrels, also have fewer places to shelter or make nests. Drought is hard on such animals, especially as they may need to put on weight to survive the winter. Even smaller animals like amphibians – frogs, toads, and salamanders – face difficulties as their local water sources dry up. There are also fewer insects. While we may think of that as a good thing, those insects are food sources for bats and birds, who are then food sources for larger animals.

Not all animals may think drought is a bad thing. With a loss of ground cover and fewer water sources, animals are easier for predators to spot and catch. Predators such as large cats, and in places like Africa, lions, may thrive for a time, as large herds cluster around a watering hole. However, it won't last. As their prey succumb to the effects of drought, there will be fewer that they can catch, causing a thinning of their ranks too. This is all Mother Nature's way of improving the genetic pool, as the stronger ones will survive. Predators are not the only risk for animals during drought – disease can spread easily as a lot of animals congregate closer together.

There may not be much we can do for wildlife, but there are things we can do to keep them away from our homes. Storing trash and food inside buildings, washing out trash cans and cleaning barbecues, and cleaning up fallen food from bird feeders and fallen or rotting fruits and vegetables from gardens or yards, fewer animals will be attracted to your neighborhood. While it might be nice to leave them a meal, the more animals get accustomed to searching for food around our houses, the less likely they will be to go back to the wild once the drought is over. Animals can also pose a threat to your pets and spread diseases, like rabies and ticks, so it is best to keep them in their natural habitats. But you can do them a favor – slow down on rural roads just in case some of them are crossing.

DROUGHT SURFACE AND GROUND WATER

1 HYDROLOGY - IT'S ALL CONNECTED

- When rain falls or snow melts, some of the water infiltrates into the soil; excess water runs off across the land into streams, rivers and lakes while the rest is lost back to the atmosphere through evaporation and transpiration by plants
- The water in the soil actually moves like it does on the surface, eventually returning through streams and lakes
- We can measure surface flow and lake elevation, but it is difficult to do likewise for ground water
- Small-scale geologic features in the beds of surface water bodies affect seepage into ground water
- Time lags between seeping into the soil and emerging again in surface water may make ground water seem disconnected

2 GROUND WATER

- The soil consists of an unsaturated zone near the surface, a saturated zone below, and an impermeable layer (such as rock)
- The saturated zone, also called an aquifer, can vary from zero to thousands of feet deep
- The top of the saturated zone is called the water table, which is the depth to which a well must be dug in order to pump ground water
- The water table depth can change seasonally (such as in summer when water demand is higher) or in response to drought
- Water in the saturated zone creates pressure, which allows water to move and to be pumped
- When the water table reaches the land surface, it contributes water to rivers as base flow, ranging on average from 14% to 90% of total stream flow
- Gaining streams receive water from ground water movement, while water seeps from the stream to the ground water in losing streams; as the water table drops, gaining streams can become losing streams
- Water movement is very slow, taking from days in localized areas to years across larger and deeper reaches

3 THE EFFECTS OF PUMPING

- Inflow to ground water is balanced by outflow to streams and withdrawal from wells
- Increasing withdrawal from wells (pumping) reduces outflow to streams
- During drought, recharge (inflow) is less or even non-existent, causing a decline in the water table
- To balance, withdrawals from wells must be replaced by water from nearby surface water sources
- Over-pumping can cause ground water flow to reverse; pulling water through the soil from a stream or lake toward a well
- Water bodies will fill more slowly or begin losing water to the surrounding land and will continue to do so for some time, even after rain returns
- Reversal of ground water flow can also draw pollutants from surface water into underlying aquifers

HYDROLOGY - IT'S ALL CONNECTED

Precipitation – rainfall and snowfall – is the source of virtually all fresh water. When precipitation falls, some of it infiltrates into the soil, while excess runs off across the land into streams, rivers, and lakes. Some is lost back to the atmosphere as it is taken up by plants through transpiration or evaporated directly from the soil or surface water. While the part that soaks into the soil may seem disconnected, that is far from the case. Ground water and surface water interact through many different landscapes, affecting the flow of rivers and levels in lakes.

Thinking of water as a system – where precipitation moves through the subsurface before entering stream channels – can improve management of precious water resources. However, a big challenge is that it is difficult to observe ground water movement. We can see and measure surface flow, using stream gauges to measure the volume of flow in a river or elevation to measure how much water is stored in a lake or reservoir. Doing the same for groundwater is difficult because we cannot see it and it may not be confined to narrow channels like a river.

Small-scale geologic features in the beds of surface water bodies affect seepage patterns. For example, a section of a stream with a sand bed allows more rapid infiltration of water from the stream into the sub-surface than another section of the same stream that may flow over a rocky surface. The size, shape, and orientation of sediment grains are all important factors determining loss from streams to ground water, and similarly the ability of ground water to supply a source for streams. Surface water can also seep into stream banks, causing loss of water and delays in travel time. Such losses depend not only on the characteristics of the soil, but prior ground water and streamflow conditions such as how recently and how much rain has fallen, vegetation along the banks of rivers or lakes, and the condition of the channel.

Because of these complex interactions, the balance of water between the surface and sub-surface is difficult to know, but essential to proper management. Managing only one component of the hydrologic system – the surface water that we can see and measure – is only partly effective because depletion of subsurface water will affect depletion of surface waters; similarly, excess ground water can sustain surface water supplies even when there is a precipitation deficit.

ROOTS, SOIL, AND WATER

A soil profile consists of three main components: an unsaturated zone, a saturated zone, and an impermeable layer. The unsaturated zone near the top has voids – spaces between grains of gravel, sand, silt, clay, and cracks in rocks. These voids contain both air and water. It is also sometimes called the soil water zone, as the area is crossed by plant roots and tunnels from burrowing animals and insects.

Below this is the saturated zone. In the saturated zone, the voids are completely filled with water (ground water). The top of the saturated zone is called the water table. The depth from the land surface to the water table can vary from zero to hundreds or thousands of feet. This depth can vary seasonally due to accretion of water from recharge and losses from withdrawals. Water can be extracted from areas with large pore systems, such as sand or gravel; these areas are called aquifers. Other areas may exist in the saturated zone where soil is saturated but cannot be extracted due to closely-packed small pores, such as clay soils.

Unlike the unsaturated zone, the water in the saturated zone creates pressure, allowing water to be pumped and causing water to move laterally, downward, and in some cases, upward. Water moves through the soil and these voids slowly, over a matter of days in localized areas near the surface to years – even thousands of years – across larger and deeper reaches.

Some of this flow may reach the surface at points where the water table intersects the land. This becomes base flow for streams, or the proportion of stream water that is derived from ground water inflow (as opposed the portion supplied by runoff from precipitation). Base flow contributions vary across the U.S., ranging from 14% to 90% of total stream flow.

Streams, or portions of streams, that receive such ground water are termed gaining streams, meaning that they gain water from the subsurface. This may be visible such as seeps or springs where water bubbles from the ground or cracks in a hill, but much of such flow is invisible, feeding into the bottom of a river channel that is carrying water from elsewhere. Other parts of streams where the water table lies lower than the streambed are termed losing streams, meaning that the streams lose water from the stream channel to underlying ground water. Streams may be gaining in some reaches and losing in others, depending upon the slope of the channel, depth to the water table, and soil characteristics. Streams may also change from gaining to losing throughout the year; for example, a dry season may cause the water table to lower turning a stream from a gaining to a losing stream.

The energy of the ground water system is measured by hydraulic head, a sum of the pressure due to elevation (gravitational potential energy) and pressure of the water. Water flows from high to low hydraulic heads. This causes water to flow (slowly) through the sub-surface. If the water table is below the surface water body, the potential energy in the surface water body is higher, so it will cause water to flow downward through the bottom of the water body toward the lower water table. If the water table is high, the hydraulic head may cause water to move upward toward the surface, eventually emerging as springs, seeps, or feeding into existing streams. The rate of flow is dependent upon the permeability of the aquifer; for example sand has larger pore spaces allowing water to pass through more easily and quickly.

Water flow may be reduced if the water table drops, either through a dry season or drought or from extraction (pumping). In such a case, the gravitational potential energy increases as the water table drops, causing more water to seep downward toward lower hydraulic head. This can turn a gaining stream into a losing stream or change the location of the start of base flow (for example, not gaining water until further downstream).

EFFECTS OF PUMPING

Inflow to the ground water system from recharge (precipitation) is balanced by outflow to streams and withdrawal from wells. Increasing withdrawal therefore reduces outflow to streams. During drought, recharge is less, or even non-existent, causing a net decrease to the system, exhibited by a decline in the water table. If inflow is zero or minimal, then water from withdrawals must be replaced by water from nearby surface water sources.

Withdrawal of ground water from a well lowers the pressure at that point, which reduces hydraulic head and causes nearby water to move toward it. This is visualized as a “cone of depression” near the well, where the water table lowers in the immediate vicinity and pulling water toward the well from all directions. If this is near a stream or lake, it can reverse the direction of flow, causing water to flow from the surface water body toward the well. It can also intercept ground water moving from inland areas toward the stream or lake. Consequently, water bodies will fill more slowly or begin losing water to the surrounding land.

Withdrawing water from a single well or a small group of wells has local impact, but may be enough to cause streams, ponds, and nearby lakes to go dry. Withdrawal from many wells over large areas may have regional effects. Furthermore, when rain does return, the flow patterns may linger while the water table recovers. As a result, if aquifers have been substantially depleted, it may be difficult to retain surface water as surface water levels will continue to decline between rain events.

In the long term, many rivers depend on base flow from ground water. For example, the Gunnison River in Colorado receives, on average, 58% of its' annual flow from ground water, with the other 42% coming from snowpack and precipitation. The Gunnison is a major tributary of the Colorado River system, which has been in long-term decline. Experts estimate that if all groundwater pumping were stopped in the Colorado River basin, it would take 40 years for the aquifers to regain their balance. In the meantime, many of these aquifers draw from the Colorado River and associated lakes to replenish these long-term deficits.

An additional concern from over-pumping is that if the hydraulic head reverses direction and surface water bodies become losing, rather than gaining, then pollutants that are in the surface water may be more easily pulled into ground water systems. Shallow aquifers that are directly connected to surface water is most at risk. Changing the ratio of ground water (base flow) to overland flow (runoff, precipitation) can also affect acidity, temperature, and dissolved oxygen content in the surface water bodies, which in turn can affect aquatic species.

RESOURCES

Groundwater and Surface-Water: A Single Resource
U.S. Geological Survey Circular 1139
https://water.usgs.gov/ogw/gwsw.html

Surface Water-Groundwater Interaction
InTeGrate, Penn State University
https://www.e-education.psu.edu/earth111/node/938

Interconnected Surface-Water Depletion
U.S. Geological Survey California Water Science Center
https://ca.water.usgs.gov/sustainable-groundwater-management/interconnected-surface-water-depletion.html

Droughts, Climate Change, and Ground-Water Sustainability
U.S. Geological Survey Circular 1186
https://pubs.usgs.gov/circ/circ1186/html/boxb.html

Less Than Zero
Abrahm Lustgarten, ProPublica
https://projects.propublica.org/killing-the-colorado/story/groundwater-drought-california-arizona-miscounting-water

VIDEO: Groundwater and Surface Water Interactions Under Water Shortage
University of California – Davis
https://www.uctv.tv/shows/Groundwater-and-Surface-Water-Interactions-Under-Water-Shortage-33721

DROUGHT SURFACE AND GROUND WATER EDUCATIONAL VIDEO

Have you ever seen a sign during a drought saying “private well” with a nice green lawn? Even though water is being pumped up from underground, it still affects surface waters. How is this possible?

Underground water is stored in aquifers – gaps in rocks and pores in soil, that fill with water, acting as an underground lake. Water can be pumped from aquifers to the surface for things like drinking, industry, livestock, and yes, even green lawns.

As water is pulled from the aquifer, water levels drop, just like it does for a surface lake. And as these levels drop, nearby wells that are not as deep may go dry. Not only that, but water from the surface will begin moving downward, to fill the spaces and pores, causing water levels to drop in lakes and ponds, even if water conservation is being practiced on the surface.

So, next time you turn on that well-water sprinkler, think about how it affects your neighbors and your community. If they are under water restrictions for surface water, it would be a good idea to practice conservation for underground supplies too.

Link to Video (1:58)
https://www.youtube.com/watch?v=9j5aoD8WDb8

WHY ARE THERE WATER RESTRICTIONS WHEN IT HAS JUST RAINED?

1 BEFORE THE RAIN

- During a drought, the ground becomes dry
- Lake levels decrease and ponds can dry up, possibility completely
- Green grass and other plants can dry out, become brown and, in the case of grass, go dormant
- As lake levels decrease and ponds begin to dry, water restrictions may be put in place

2 HOW RAIN REPLENISHES LAKES

- The first rain after a prolonged dry period will create runoff that will be intercepted by area ponds
- Ponds and streams will dry quickly as water seeps out to come groundwater underneath
- Any water restrictions currently in place should continue
- The second rain after a prolonged dry period will continue to create runoff into area ponds
- Groundwater will continue to replenish through seepage from ponds and lakes
- Ponds may begin to hold water
- Lake levels will still not increase much
- After the third rain, ponds will be more full
- More runoff will reach area lakes

3 AFTER THE RAIN

- Depending on severity of drought, amount and intensity of rainfall, it may take several rains before ponds and lakes respond
- Some places may begin to reduce or lift the water restrictions
- Some restrictions may remain, in order to prepare for additional drought

4 WATER SOURCES WHERE IT IS STILL DRY

- The third rain after a prolonged dry period will continue to help grass and plants
- Groundwater is replenishing
- Ponds will fill
- Lakes will finally start to refill
- Any water restrictions in place may be lifted or reduced

BEFORE THE RAIN

During a drought, dry and hot conditions will make the soil dry out. High temperatures and abundant sunshine will promote evapotranspiration, or loss of water through evaporation, from the surface of area lakes. This will allow lake levels to decrease, and without any appreciable rainfall, levels will decrease further. Area pond levels will also decrease, as evapotranspiration will act faster on a smaller water body. Since many area lakes may be a source of potable water (drinking water) for communities, as levels decrease, water restrictions, mostly on outdoor water uses, may be implemented.

HOW RAIN REPLENISHES LAKES

The first rain after a prolonged dry period may help grass and plants continue to grow. Dry ground from the drought conditions will encourage the first rainfall to be strictly runoff into area ponds and lakes. The rain will begin moistening the top layer of the soil, allowing subsequent rains to be absorbed more effectively. These dry ponds and lakes, however, will absorb the runoff first and therefore not increase any water levels. This runoff may first aid groundwater replenishment first, albeit slowly. Since lake and pond levels will not have increased with this first rainfall, any water restrictions in place will mostly likely continue.

The second rain after a prolonged dry period will continue to help grass and plants. After the first rain, soils will be more ready to absorb and make use of the next rainfall. This will encourage water saturation, which will help rainwater seep into the soil and start replenishing ground water. Likewise, area ponds may start to retain water, slowly increasing their water levels. Lake levels, however, may not increase much. Most likely, any water restrictions on outdoor watering will continue.

The third rain after a prolonged dry period will continue to help grass and plants. After the first several rainfalls, soils will be absorbing the water. This will continue to encourage water saturation, which will help rainwater seep into the soil and start replenishing ground water. Likewise, area ponds may be increasing their water levels at a more rapid pace. Lake levels will also begin to rise. At this point, water restrictions may be reduced or ended, depending the amount of rainfall.

AFTER THE RAIN

What this shows, is that it takes several rainfalls before groundwater and surface water begin to respond to the rainfall. This means that just because it rained, we shouldn't immediately lift our water restrictions. In many instances, the drought has been ongoing for awhile, and it would take more than several rainfalls for things to start to improve. Of course, this is dependent upon how long and severe the drought has been, types of soil, and intensity of rainfall.

Several communities have seen a huge improvement in area ponds and lakes, some being completely refilled after depletion, but will continue water restrictions in order to make sure there is water available for later in the year. One prime example includes California. After multiple years of extreme to exceptional drought, a very wet period from 2016 into 2017 almost eliminated drought in many regions of California. Los Angeles, however, maintained their water restrictions, hoping to help maintain enough water to make it through another three years of drought.

WATER SOURCES WHERE IT IS STILL DRY

The source of drinking water for some cities may be quite a distance from the city itself. Large cities may have rights to water stored in distant reservoirs which can be accessed via channels or pipes. In such cases, rainfall in the city may not also fall in the source regions, causing people to believe that drought is over when the water supply sources are still severely impacts.

An example is the City of Austin, TX, and the Lower Colorado River. As drought conditions began to ease in the city in 2014, even with flash flooding within city limits, the highland lakes to the west of the city received little rainfall. It wasn't until Spring 2015 when heavy rains fell in the headwaters of the river basin that the lakes filled.

RESOURCES

Despite all the rain, Metro Vancouver water restrictions begin soon
News1130
https://www.citynews1130.com/2017/05/01/despite-rain-metro-vancouver-water-restrictions-begin-soon/

The Drought Is Basically Over, but You Still Have to Follow These Water Restrictions
Los Angeles Magazine
https://www.lamag.com/citythinkblog/drought-basically-still-follow-water-restrictions/

WHY ARE THERE WATER RESTRICTIONS WHEN IT HAS JUST RAINED? EDUCATIONAL VIDEO

So it may have rained yesterday, and yet your city still says you need to reduce your water usage. Why is that? Shouldn't you be able to water again right away?

Well, that's not always the case. During times of drought, especially prolonged drought, surface water (area ponds, lakes and streams) and ground water (aquifers) become depleted. The surrounding soil becomes dried, hardened, and can appear cracked. Suddenly, it rains after that dry period. What happens? The ground has become so hardened, the water immediately runs off. As it runs off, some slowly starts to absorb into the very top layer of the soil. The rest tries to make it into those water bodies. Ponds and lakes that have been depleted, though, also experience the same hardened soil, and so what water does make it to those water bodies is also absorbed. Water level increases may be temporary as water seeps out the bottom of the lake or stream to moisten deep soils and replenish aquifers.

Well, maybe the next rain, right? This time, the soil is able absorb more of the rain, allowing some rain to saturate and start replenishing ground water sources. Likewise, the ponds and lakes can start to hold water and recharge. The recharge will affect ponds first, before it affects area lakes. Then by the next time it rains, ponds are almost completely recharging, and area lakes levels start to increase.

Sometimes, sources for drinking water may be in areas where it is still not raining, even if rain is falling in your city. So while things may look better, you will need to wait until rain falls on those lakes before your city will have enough water to meet needs.

Since many communities depend on local surface water bodies as their drinking water sources, these communities will leave watering restrictions in place until these water bodies, mainly area lakes, begin to show recharge. In some drastic cases, water restrictions may remain in place until lakes are completely full, in order to anticipate future demand or potential drought conditions.