Michigan Department of Environment, Great Lakes, and Energy (EGLE)
Water Resources Division

Lawn Maintenance

Description

Lawn maintenance describes the practices performed to promote healthy lawns, which includes mowing, irrigating, pesticide and fertilizer management, soil management, dethatching, and the disposal of organic debris. Proper lawn maintenance results in healthy lawns, which will: trap soil on-site preventing erosion; take up nutrients; reduce the volume and rate of runoff; increase groundwater recharge; and decrease the need for herbicides and pesticides. For the purposes of this Best Management Practices (BMP), "lawn" and "turf" are used interchangeably. This BMP also briefly discusses practices for home gardens and other bare soils.

It is important to note that the focus of this BMP is the maintenance of existing lawns and it does not serve as a recommendation to establish new lawns. In fact, there are many alternatives to lawns that are more economical and environmentally friendly, such as the establishment of native vegetation. Furthermore, buffer zones and turf alternatives are recommended for properties along the shorelines of lakes, rivers, or other waterbodies.

Pollutants Controlled

- Sediment
- Nutrients (e.g., nitrogen, phosphorous, etc.)
- Runoff (volume and rate)
- Pesticides

Advantages and Disadvantages

Advantages

- Proper implementation of maintenance practices: prevent erosion and nutrient runoff and leaching; reduce pesticide, fertilizer, and water applications; and improve water infiltration.

Disadvantages

- Native vegetation, shrubs, and trees provide more runoff and pollutant reduction and better habitat than turf. Furthermore, along shorelines, turf is less efficient at filtering pollutants and trapping soil, which leads to shoreline erosion and loss of aquatic habitats. This makes turf a poor riparian buffer along lakes, rivers, and other waterbodies; other alternatives (e.g., natural shorelines and native vegetation) are recommended in these areas to protect shorelines and aquatic ecosystems.

Other Terms Used to Describe

- Urban Lawn Care
- Rural Lawn Care

Companion and Alternative Practices

This BMP describes a variety of practices that are in many cases individual BMPs. The Pesticide Management BMP walks users through the proper selection of turf species (the first and most important part of an integrated pest management program), as well as the proper use, storage, and disposal of pesticides. The Organic Debris Disposal BMP provides additional information regarding the disposal of all leaves, grass, and pruned branches. The Soil Management to Encourage Vegetation Growth BMP describes the procedures for taking soil samples to determine fertilizer requirements and identify other potential soil deficiencies. The Fertilizer Management BMP describes the proper handling, storage, use, and application of fertilizers as well as calibration procedures.

It is important to note that this BMP assumes that turf is already in place. Information regarding the establishment of turf by seeding is discussed in the Seeding and Mulching BMPs; while the establishment of turf by sodding is discussed in the Sodding BMP. However, as mentioned above there are other alternatives to the establishment of turf. Information regarding the establishment of native vegetation can be found in Landscaping for Water Quality. Meanwhile, the Michigan Natural Shoreline Partnership has information specifically related to shoreline protection and vegetation establishment for property along lakes, rivers, and other waterbodies. Both references include lists of plants that are native to Michigan and thus well adapted to the weather and climate of Michigan. These plant lists include the sun requirements, water needs, size, and bloom time and color for all species listed, all of which can help in the plant selection process to meet site specific conditions and needs.

Application

When to Apply: Apply this BMP throughout the year.

Where to Apply: Apply on all lawns and gardens.

Specifications

The following specifications are provided **to maintain healthy turf areas.** Much of the information is extracted from “Turfgrass Pest Management: A Training Manual for Commercial Applicators – Category 3A”, Michigan State University, Cooperative Extension Service, Bulletin E-2327 (Sichenede, 2012).

Mowing

One of the most common lawn management practices is controlling the height of the turf though mowing. In general, research shows that in order to promote drought tolerance and prevent weeds and pests, taller cutting heights should be implemented (Smitley, 2013). Therefore, a minimum cut height of three (3) inches should be adopted with up to four (4) inches being recommended (Bricault, 2016; Smitley, 2013). Mowing grass to these heights promotes the growth of larger and deeper root systems, which are more tolerant of both drought and pests (Voyle, 2013). Furthermore, the shade provided by the taller grass blades can limit the growth of weeds such as crabgrass (Smitley, 2013). While higher cutting heights are recommended, it important to note that different types of lawns have different mowing requirements, based on the turf species and the intended use for the lawn. Table 1 shows different cutting heights of typical cool-season grasses found in Michigan. These ranges are also important for areas with lawn height restrictions, if higher cutting heights are not allowed, use a different species of grass that is adapted to lower blade heights.

Another important factor to consider when mowing is the condition of the mowing equipment's cutting edge. Sharper edges are less likely to rip or shred grass blades, which helps the grass conserve water and reduce susceptibility to diseases (Bauer and Reyes, 2018; Bricault, 2012). This reduces both the amount of irrigation required as well as the amount of pesticides that need to be applied to maintain a healthy lawn.

When mowing, the general guideline is to never remove more than one third of the total blade height (Lyman and Rieke, 2002). This ensures that there is enough remaining grass blade to support the root system. Table 2 presents a guide for how long to let grass grow between cuttings to achieve the one third cut recommendation.

Recommended turf heights are also influenced by climatological conditions. During hot, dry periods, turf stands need more water. Where uses do not limit mowing height, and to conserve water in grass plants experiencing drought, consider mowing less frequently and at a higher height of cut.

Grass clippings should be left on the grass because they offer a "free" source of nitrogen and will decompose without affecting the quality of the grass. When clippings are regularly removed, fertilization must be increased by 25 to 50 percent. Grass clippings **do *not*** contribute to thatch. Mulching mowers can be used to cut the grass into tiny pieces which degrade faster.

Concerning lawns along lakes, rivers, and other waterbodies, mowing right up to the edge of the waterbody is ***not*** recommended. This can result in increased erosion along the shoreline. Instead the establishment of a buffer zone is recommended. Both the Riparian Buffer BMP and the Michigan Natural Shoreline Partnership provide guidance for the implementation of buffers along waterbodies.

Watering (Irrigation)

Proper irrigation depends on weather conditions, soil type, grass variety preference, and turf use and maintenance practices. It is also important to remember that too much water is as damaging to turf as drought. When turf is saturated, transpiration is slowed, and infectious diseases encouraged. Generally, most turfs require about one (1) inch of water per week. For site-specific water requirements, use a rain gauge to measure rainfall and determine the amount of irrigated water needed. Computer models are also available which can help determine watering requirements. Once the total irrigation requirements have been determined, multiple water applications that sum to the total need should be divided throughout the week (Bricault, 2012). The use of multiple water applications throughout the week instead of a single watering event is recommended to ensure that the water applied in each application soaks soils only to the depth of the lawn root system but not deeper. This allows the turf access to all of the applied water and prevents loss of water to deeper infiltration (Voyle, 2013). The number of required water applications per week is dependent on local soil characteristics. In general, sandy soils require more frequent and lighter waterings, while clay and silt soils can utilize fewer and heavier waterings.

An irrigation system is complex and should be designed only by professionals experienced in their design. Each irrigation system should be custom designed to fit the site conditions, e.g., soils, availability of water, vegetation needing irrigating, etc.

For many purposes, the crude, but effective "footsteps" method can be used. With this method, you need to irrigate when turf begins to wilt and does not spring back when crushed (footsteps linger in turf). Other general watering guidelines are discussed below:

1. The total precipitation and irrigated water should amount to about an inch of water per week. To determine how much water sprinklers deliver, place a coffee can in a straight line from your sprinkler at the edge of the watering area. Turn the water on for 15 minutes and measure the average depth of the water that collects in the can. Multiply this number by four to determine the amount of water that would cover your lawn in one hour. Then calculate the amount of time (in hours) that it would take to apply an inch of water. This is the total time you should run the sprinkler system in a week across multiple applications.

   With sprinkler systems, the uniformity of water application depends on the spacing, choice of sprinkler, water pressure, and wind velocity. System efficiency and effectiveness, in turn, is dependent on uniform application of water.

2. Do not apply water faster than it can soak into the soil. Any water running off the lawn indicates that the application rate is too high.

3. Apply supplemental water several times a week during the morning hours. During hot, droughty periods, turf may benefit from daily, light, afternoon waterings. Water during the heat of the day cools grass plants and replaces evaporated water. In addition, research conducted at Michigan State University found that injury due to patch diseases, including necrotic ring spot, was reduced on susceptible turf that received light, frequent waterings during the summer. Avoid irrigating in the evening, since the warm nights and moisture will promote the spread of lawn diseases (Voyle, 2013).

4. Grass goes dormant (turns brown) in order to survive extended periods of high temperatures with little to no precipitation. While in this state the lawn is still losing water to the atmosphere. To ensure that the lawn survives until more favorable climatological conditions return, approximately ½ inch of water is needed per week (Bricault, 2016). This level of irrigation will not make the lawn return to a green state but will prevent the lawn from dying.

5. When a groundwater well is used, the well should be sited and constructed to avoid potential contamination of the groundwater supply. Locate the well on high ground to exclude the entrance of surface and near-surface water that may be contaminated by

drainage fields, fertilizer, or chemical storage and preparation areas. Adequate groundwater protection should include extending the well casing above grade, using a sanitary well seal or pitless adaptor at the well head, and sealing or grouting between the well casing and borehole. All wells must comply with state water laws and regulations.

Any discharge pipe from the well or to the system must be protected against backflow in the well by installing backflow prevention devices.

6. By law, all abandoned wells must be sealed. Contact the local health department for assistance in sealing abandoned wells.

Dethatching

A layer of thatch exists in all turf between the green vegetation and the soil surface. Thatch is composed of tightly intermingled living and dead stems, leaves, and roots. A small amount of thatch in turf is beneficial in that it reduces soil compaction, moderates soil temperature, and limits evaporation of soil water (Rieke and Lyman, 2002).

Turf-inhabiting organisms such as earthworms break down thatch. However, in highly managed areas excess fertilizer and routine pesticide applications significantly reduce these organisms (Bauer, Brown, and Taylor, 2018). To keep beneficial organisms in the turf, apply fertilizers and pesticides according to BMP specifications.

Because production of thatch is increased and breakdown decreased in intensively-managed turf, excessive thatch can become a problem. Too much thatch restricts the movement of water, air, fertilizers, and pesticides into the soil, encourages disease and insect pests, and reduces cold and heat tolerance. To determine if a stand has excessive thatch, cut a pie-shaped wedge out of the turf, and measure the thickness of the thatch layer. If it is greater than one-half inch thick, take steps to reduce thatch.

To reduce thatch:

Practices that relieve soil compaction also help break down thatch. For small turf areas, vigorous hand-raking will remove thatch. Meanwhile, for larger regions a variety of aerifier and vertical mower machines that are equipped with vertical knives or tines can be used to remove thatch (Rieke and Lyman, 2002). These dethatching machines cut and extract organic debris from turf, restoring habitats for the organisms that naturally break down thatch. Dethatching should be used during cool, moist periods when turf can recover quickly, since dethatching thins turf stands (Bauer, Brown, and Taylor, 2018).

Organic Debris Disposal

The following is summarized from the Organic Debris Disposal BMP. Refer to that BMP for the disposal of all leaves, grass, and pruned branches:

1. Leave grass clippings on the grass. They function as a free source of nutrients. When clippings are regularly removed, fertilization must be increased by 25 to 50 percent

(Bricault, 2016). Grass clippings ***do not*** contribute to thatch. Mulching mowers can be used to cut the grass into tiny pieces which degrade faster.

2. Mulch fallen leaves back into the turf. They provide a source of nutrients for the lawn for the next year and can help reduce the germination of weeds such as crabgrass and dandelions (Finneran, 2014, 2016).

3. Where it is necessary to remove grass clippings or leaves, dispose of them by composting (Lyman and Rieke, 2002). Information on how to construct and maintain a composting pile is discussed in the Organic Debris Disposal BMP.

3. Pruned branches should be disposed of either by chipping or by composting. Wood chips can be used as part of the landscaping.

4. ***Do not*** dispose of organic debris by dumping in or near water bodies. ***Do not*** dump or sweep leaves, grass (or anything else) into sewers--storm sewers discharge into waterbodies. ***Do not*** put debris in the floodplains of rivers or streams. Follow all other Organic Debris Disposal specifications.

Fertilizers

Each species of plant requires a certain amount of nutrients (e.g., nitrogen, phosphorus, etc.) to grow, thrive, and stay green (Bricault, 2016). And if the plants cannot obtain the needed nutrients from the soil, fertilizers are applied to make up the difference. Meanwhile, nutrients which are applied beyond that needed by the plant are either washed off the soil and into lakes, streams and wetlands, or leached into groundwater. Nutrients such as nitrogen and phosphorus which enter surface waters can result in algae blooms and nuisance aquatic plant growth. Meanwhile, nitrogen readily converts to nitrate which, when leached to groundwater, can contaminate drinking water supplies. Coarse soils such as sands and loamy sands are more susceptible to leaching than fine-textured soils such as silts or clays. Phosphorus generally does not leach into groundwater because it binds readily with soil. Therefore, application rates for fertilizers should always be based on soil tests (Finneran, 2016). To take soil samples, follow directions in the Soil Management to Encourage Vegetation Growth BMP. Where soil samples cannot be taken, follow the “Nitrogen guidelines” in the attached Table 3.

The three most commonly applied nutrients for lawn care are nitrogen, phosphorus, and potassium (Bauer, Johnson, and White, 2018). However, under the Michigan Fertilizer Law (1994 PA 451, Part 85, Fertilizers) (MDARD, 2019), the use of phosphorus fertilizers on residential and commercial lawns is restricted. The only acceptable uses of phosphorous fertilizers throughout the state are for:

- Applications on agriculture, gardens, trees, and shrubs
- Applications at specific rates under the following instances:
    - When soil or plant tissue testing indicate phosphorus deficiency.
    - When establishing new turf using seed or sod where soil tests identify a phosphorus deficiency.

- When fertilizing with fertilizers that contain biosolids, manure, or a manipulated manure (composted manure). The application rate is limited to 0.25 pounds of phosphorous per 1,000 square feet.

- On golf courses whose manager(s) have completed a Michigan Department of Agriculture and Rural Development approved training course.

In general, most Michigan soils are phosphorous rich, so additional phosphorus is often not needed (Frank, 2005). And the exceptions listed above cover cases when there is a phosphorous deficiency. Additional information regarding soil testing can be found on the Michigan State University Soil Test website.

All fertilizers report the ratio of nitrogen, phosphorous, and potassium in a three-number code also known as the fertilizer analysis. Common turf fertilizer analyses include 32-0-10, 32-0-4, 29-0-3, 29-0-10, and 24-25-4. These ratios indicate the percent of each nutrient by weight within the fertilizer. So, for example, a 100-pound bag of fertilizer with an analysis of 20-10-5 contains 20 pounds nitrogen, 10 pounds phosphorus, and 5 pounds potassium. Meanwhile, a 20-pound bag with the same fertilizer analysis would contain 4 pounds of nitrogen, 2 pounds of phosphorus, and 1 pound of potassium. The remaining weight of the fertilizer contains other nutrients and fillers. Never apply more than 1.0 pound of nitrogen per 1,000 square feet in any single application of fertilizer.

Fertilizers can also be classified as slow-release or quick-release. This describes the speed at which the nitrogen in the fertilizer is made available to the turf. Quick-release fertilizers provide nearly all their nitrogen shortly after application. This can kickstart a fast, intense growth period but can also result in potential turf burning and increased nitrogen in runoff and leaching if not properly applied (Frank, 2005). On the other hand, slow-release fertilizers slowly break down, releasing nitrogen over time. This promotes a longer, less intense growth period and is less likely to result in high nitrogen levels in runoff and leaching (Brown, 2014).

Another commonly available type of fertilizer is the “Weed and Feed.” These fertilizers combine both nutrients and herbicide applications into one product, in theory saving time and money. However, the use of “Weed and Feed” fertilizers should be carefully considered before application. This is due to a variety of reasons including:

- *Timing:* Optimal application times for both fertilizer and herbicides seldom align. Therefore applying “Weed and Feed” fertilizers to address the spread of a weeds can result in application of more nutrients than are needed by the turf, which increases the level of nutrients that runoff into streams and rivers or leach into the groundwater. Or applying “Weed and Feed” fertilizers for turf nutrient needs could result in the application of herbicide when the targeted weed is not present, which can result in need for additional herbicide applications after weeds appear (Bauer, Johnson, and White, 2018).

- *Post-application Processes:* Fertilizers should be treated with a light watering (approximately ¼ inch) after application to encourage nutrient transfer to the soil. Meanwhile, many herbicides need to remain on the plants, and if watered can be either diluted or washed off plants. Therefore, applying “Weed and Feed” fertilizers can lower the efficiency of the individual nutrient and herbicide applications, resulting in the need for additional applications (Bauer, Johnson, and White, 2018).

- *Over-Application:* Often weeds are found in clusters throughout lawns, which means that the yard-wide application of "Weed and Feed" fertilizer can result in over-application of herbicides (Bauer, Johnson, and White, 2018).

A fertilizer program for lawns should begin in the fall (as opposed to the spring) to promote deep, healthy root systems and hardy lawns (Bricault, 2012). This, in turn, will help grass compete with unwanted grass species and weeds in the spring. Spring applications of fertilizer will help the grass start growing but may promote more top (leaf) growth than root growth. Shallow root systems are unable to sustain lawns through a drought or a harsh winter.

Fertilizers should ***not*** be applied to turf when the soil is frozen because turf cannot utilize the nutrients, and runoff rates are high. Fertilizers should *not* be applied if a ½ inch of rain is expected within the next 24 hours for the same reason.

Concerning lawns along lakes, rivers, and other waterbodies, similar to mowing discussed above, a 35-foot buffer is recommended along the shorelines in which no fertilizer is applied. This reduces the impact of nutrient laden runoff entering the waterbodies. Furthermore, light waterings after fertilizer application will help transfer the fertilizer to the soil and prevent excess nutrients in runoff (Frank, 2015). This is especially true for regions with steep slopes near waterbodies.

Always follow all specifications in the Fertilizer Management BMP for the proper handling, storage, use and application of fertilizers. Calibration procedures are also included in that BMP.

Pesticides

Pesticides are a family of chemicals which kill insects (insecticides), weeds (herbicides), fungus (fungicides), and rodents (rodenticide). Over-application of pesticides can result in fish kills in lakes and streams, contaminated groundwater, and damaged turf.

Pesticide application is a common approach to address pest problems. However, in some situations, hand removing weeds and pests will be as effective as spot treating them. It is also possible to interfere with the pests' habitat by altering the landscaping in a way which will not attract the pest. Using biological controls, such as the pests' predators, should also be considered. Keep in mind that not all pests are "bad." Many insects, for example, are natural predators of more harmful insects.

Furthermore, it is important to remember that a healthy lawn can tolerate or even limit the presence of some pests (Davis, Hotchkiss, and Smitley, 2018). Lawns with access to adequate water and fertilizer and cut to appropriate lawn heights are able to tolerate some pests and limit the growth of weeds such as crabgrass (Smitley, 2013; Voyle, 2013). Nevertheless, if pesticides need to be applied, the following are some general guidelines for pesticide application:

1. Read pesticide packaging to identify which pests are treated as well as the rate and amount of application that is allowed to ensure that the pesticide will target the intended pest and is correctly applied to the affected area (Davis, Hotchkiss, and Smitley, 2018).

2. Depending on the form and type of pesticide used, additional water, drying time, or other steps may be required. Refer to the manufacture specifications to determine any additional steps that should follow application.

3. Different pesticides are more effective at different times of the year. For example, postemergence herbicides are very effective when applied in the fall and spring seasons but less effective during summer months (Calhoun, 2002).

Information regarding integrated pest management techniques, and the proper handling, application, storage and disposal of pesticides can be found in the Pesticide Management BMP.

The local Cooperative Extension Service (CES) office or a reputable private consultant can also be contacted for information on the best way to get rid of your problem pest. These professionals may ask you to bring in sample weeds, leaves, or small branches to help identify the specific pest. CES staff and reputable consultants will then suggest ways to eliminate the problem, following the principles in the Pesticide Management BMP.

Gardens and Other Bare Soils

Ideally, gardens and other bare soils in and around lawns should be covered with a light layer of organic material (such as grass clippings or leaves) to keep soil on-site. Organic material will reduce the impact of raindrops and allow rain to soak into the ground. Furthermore, applying organic material as a cover in late fall will help prevent the germination of winter annual weeds while also providing nutrients to the soil for the next spring (Finneran, 2014). One consideration to keep in mind when applying grass clippings as an organic cover to gardens and other bare soils is the length of time since the last herbicide application. Research has shown that in general, there is a 14-day wait period that should be observed before applying lawn clippings to gardens and other bare soil regions to prevent plant injury (Lyman, and Rieke, 2002). However, refer to the herbicide manufacture specifications to determine if 14 days is long enough or if more time is required. Additional maintenance of gardens and bare soil areas includes sweeping any soil off paved areas (i.e., sidewalks and driveways) to prevent the soil from entering storm sewer systems.

For fertilizing gardens and other bare soils apply 0.2 pound of nitrogen per 100 square feet. An additional 0.18-pound nitrogen per 100 square feet may be needed for corn, tomatoes, and pole crops (beans).

For Unhealthy Turf

The turf manager must first determine the reason for the unhealthy turf, then take steps to address the problem. The Pesticide Management BMP contains a section on monitoring techniques for turf. It may be necessary to take soil samples, following specifications in the Soil Management to Encourage Vegetation Growth BMP to help determine the problem. Make soil amendments, including liming and sulfur additions for pH, and coring for compaction problems following BMP specifications. If soil tests indicate nutrients are lacking, add fertilizers following the Fertilizer Management BMP. If pests are the problem, determine the threshold of the pest, then use the Pesticide Management BMP to control or reduce the pest population. Sometimes unhealthy turf may benefit simply from adjusting irrigation schedules and/or raising mowing heights. Additional resources regarding turf damage from additional sources such as cold and flooding can be found on the Michigan State University Extension Turf Program website.

Shade may also be a problem for turf. The Pesticide Management BMP contains turf species which do better in shade than others. If trees, which provide shade, are hindering the growth of the turf, it may be beneficial to prune lower branches and thin out the crowns of shade-producing trees and shrubs. This increases the amount of light and air movement to the turf. It may also be necessary to aerate or adjust the pH of soils underneath trees, especially in areas where decomposing leaves may turn the soil acid. If all efforts to improve the turf fail, you may want to consider using mulch or shade-tolerant ground covers such as periwinkle, pachysandra, purple winter creeper, and English ivy in the place of turf (Voyle, 2014).

To **irrigate** diseased turf: Managers of diseased turf should replace only the water lost in evapotranspiration (the amount of water that evaporates from turf stands plus the amount of water used in transpiration). Do not saturate the thatch. During hot, dry periods, apply daily a small amount of water (one to two tenths of an inch) during the heat of the day. Since this practice will not deliver a full inch of water per week, regularly check the moisture of deeper soil and apply additional water when necessary.

List of Tables

Literature Cited

Bauer, S. and Reyes, J. 2018. *University of Minnesota Extension: Mowing practices for healthy lawns.* https://extension.umn.edu/lawncare/mowing-practices-healthy-lawns

Bauer, S., Brown, D., and Taylor, D. 2018. *University of Minnesota Extension: How to Control Thatch in your Lawn.* https://extension.umn.edu/lawncare/how-control-thatch-your-lawn

Bauer, S., Johnson, P.G., and White, D.B. 2018. *University of Minnesota Extension: Fertilizing Lawns.* https://extension.umn.edu/lawn-care/fertilizing-lawns#what-is-in-fertilizer%3F-1256811

Bricault, B. 2012. *Michigan State University Extension: Summer Lawn Care (E3180).* https://www.canr.msu.edu/uploads/files/E3180_-_Summer_Lawn_Care.pdf

Bricault, B. 2016. *Michigan State University Extension: Low Maintenance Lawns in the Midwest.* https://www.canr.msu.edu/resources/low_maintenance_lawns_in_the_midwest

Brown, D. 2014. *Michigan State University Extension: Benefits of Using Lawn Fertilizers Containing Slow Release Nitrogen.* https://www.canr.msu.edu/news/benefits_of_using_lawn_fertilizers_containing_slow_release_nitrogen

Calhoun, R. 2002. *Michigan State University Extension: Turf Tips for the Homeowner: Ground Ivy in Lawns (E06TURF).* https://www.canr.msu.edu/uploads/files/e0006turf.pdf

Davis, T., Hotchkiss, E., and Smitley, D. 2018. *Michigan State University Extension: How to Choose and When to Apply Grub Control Products for Your Lawn.* https://www.canr.msu.edu/news/how_to_choose_and_when_to_apply_grub_control_products_for_your_lawn

Feucht, J.R. and Butler, J.D. 1988. *Landscape Management: Planting and Maintenance of Trees, Shrubs and Turfgrasses*. Van Nostrand Reinhold. http://agris.fao.org/agris-search/search.do?recordID=US8918943

Finneran, R. 2014. *Michigan State University Extension: It's not too Late to Mulch Fallen Leaves into Lawns.* https://www.canr.msu.edu/news/its_not_too_late_to_mulch_fallen_leaves_into_lawns

Finneran, R. 2016. *Michigan State University Extension: Mulch Leaves into Turf for a Smart Lawn.* https://www.canr.msu.edu/resources/mulch_leaves_into_turf_for_a_smart_lawn

Frank, K.W. 2005. *Michigan State University Extension: Phosphorus and Home Lawns (E-0021TURF).* https://www.canr.msu.edu/uploads/files/e0021turf.pdf

Frank, K.W., 2015. *Michigan State University Extension: Maintaining Waterfront Turf to Preserve Water Quality (E0011).* https://www.canr.msu.edu/resources/maintaining-waterfront-turf-to-preserve-water-quality

Lyman, G.T. and Rieke, P.E. 2002. *Michigan State University Extension: Turf Tips for the Homeowner: Mowing Lawn Turf (E13TURF).* https://www.canr.msu.edu/uploads/files/e0013turf.pdf

MDARD. 2019. *Fertilizer Law.* https://www.michigan.gov/mdard/0,4610,7-125-1569_16993_19405-370456--,00.html

Michigan State University Extension. 2019. *Turf.* https://www.canr.msu.edu/turf/

Michigan State University Soil Test. 2019. *MSU Soil Test.* https://homesoiltest.msu.edu/

Rieke, P.E. and Lyman G.T. 2002. *Michigan State University: Turf Tips for the Homeowner: Cultivation of Lawns (E03TURF).* https://www.canr.msu.edu/uploads/resources/pdfs/bulletin-e00031.pdf

Sichenede, K. 2012. *Michigan State University Extension: Turfgrass Pest Management: Training Manual for Comm Applicators - Category 3A (E2327).* https://www.canr.msu.edu/resources/turfgrass_pest_management_training_manual_for_comm_applicators_-_category3a

Smitley, D. 2013. *Michigan State University Extension: Mow High for Weed and Grub Control.* https://www.canr.msu.edu/news/mow_high_for_weed_and_grub_control

University of Wisconsin-Extension. 2008. *Lawn & Garden Fertilizers.* *(The link provided was broken and has been removed)*

Voyle, G. 2013. *Michigan State University Extension: Smart Watering for Lawns: Don't let the Lawn Squeeze you Dry.* https://www.canr.msu.edu/news/smart_watering_for_lawns_dont_let_the_lawn_squeeze_you_dry

Voyle, G. 2014. *Michigan State University Extension: Shady Lawn Alternatives.* https://www.canr.msu.edu/news/shady_lawn_alternatives

Table 1: Recommended cutting heights for different grass species.

Cutting Heights for Cool-Season Grasses

Grass Type	Low Cut (inches)	Preferred Cut (inches)	High Cut (inches)
Kentucky bluegrass: common types	1¼	2 to 3	4
Kentucky bluegrass: improved types	¾	2	3
Perennial ryegrass: common types	1½	2 to 3	4
Perennial ryegrass: turf types	¾	1½ to 2	3
Fine fescue	1	1½ to 3	4
Tall fescue: pasture types	2	2½ to 3½	4
Tall fescue: turf types	1¼	1½ to 3	3
Creeping bentgrass	¾	½ to ¾	1
Colonial bentgrass	½	¾ to 1	2
Annual bluegrass	¼	½ to 1	2
Smooth bromegrass	2	3 to 4	5

Source: *Landscape Management* by J.R. Feucht and J.D. Butler, 1988.

Table 2: Mowing guide for following the one-third cut guideline

Mowing Guide

To cut one-third of the leaves

Height of cut (inches)	Mow when turf reaches (inches)	Growth between mowings (inches)
1.0	1.50	0.50
2.0	3.00	1.00
2.5	3.75	1.25
3.0	4.50	1.50
3.5	5.25	1.75

Source: From Michigan State University Extension: Turf Tips for the Homeowner: Mowing Lawn Turf (E13TURF) by G.T. Lyman and P.E. Rieke, 2002.

Table 3: Nitrogen Application Guidelines for When a Soil Test is Not Possible

Time of Application	Grass Clippings Removed (Pounds of Nitrogen per 1,000 Square Feet)	Grass Clippings Not Removed (Pounds of Nitrogen per 1,000 Square Feet)
October 1	1.25	1.00
Late May	1.25	1.00
Late June	0.75	0.50
Late August (optional)	0.75	0.50

Source: Modified from University of Wisconsin-Extension, *Lawn & Garden Fertilizers,* 2008.